period; or, in other words, as the differences of temperature between two short intervals that lie within the daily or yearly period, *minus* the amount of the periodical (or normal) variation. In part 4, vol. ix., of the above-mentioned Bulletin, Dr. Doering has calculated the variability for Concordia (lat. 31° 25′ S., long. 58° 4′ W.), but for three years only. The month of October has the maximum value, 4°·6, and April the minimum, 2°·8. The variability during spring is greatest, viz. 3°·9, and least during autumn, viz. 3°·0, and the mean for the year is 3°·6, or about 0°·4 above that for Buenos Ayres. The hourly observations published by the Meteorological Council, with the daily means ready calculated, afford excellent materials for similar investigations. The preceding number of the Bulletin contains the meteorological observations made at Córdoba during the year 1885. The absolute maximum shade temperature was 100°·9 in December, and the minimum 14°·9 in June, giving an annual range of 86°·0. The maximum solar temperature was 147°·4, in February. The mean relative humidity ranged between 81·7 per cent. in March and 61·1 per cent. in August. The rainfall amounted to 24·26 inches; the wettest month was March, 5·96 inches, and the driest, May, 0·04 inch. Rain fell on 71 days, and snow on one day. The times of rain at the moment of observation, an element much recommended by Dr. Köppen, are also quoted.

THE WORK OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS.[1]

II.

MY only remaining subject is the representation of terranes on maps by means of colours. At present no two organizations and scarcely two individuals use colours in the same way; and it is probably true that every organization and individual publishing many geologic maps has at different times employed the same colour for different terranes, and different colours for the same terrane. It results that the map user can gain no information from the distribution of colours until he has studied the legend; before he can read a new atlas he must learn a new alphabet. The advantage to be gained by substituting a universal language for this confusion of tongues is manifest and great, and has justified the application of much time and attention by the Congress and its Committees. By a series of resolutions a partial scheme has been selected, one colour at a time, and the completion of the plan has been left to the Committee on the Map of Europe. That Committee has prepared a colour legend which is accessible to American geologists in the volume of information published by the American Committee. It is understood in a general way that the Congress reserves final action, and the published legend not only belongs specifically to the map of Europe, but is provisional; still, as this map, if generally approved, will unquestionably be declared by the Congress an authoritative pattern for the guidance of map makers, the plan should be freely criticized at its present stage. The selection of uniform colours is a far more delicate and important matter than the arrangement of taxonomic terms; for while ill-chosen words may quickly fit themselves to new uses, the adoption of an ill-arranged colour scheme must entail continual loss.

In my judgment the scheme provisionally chosen is defective in several particulars, to which I shall presently call attention; but it is necessary to introduce the discussion by a statement of the conditions to be satisfied by a standard colour scheme and a statement of the practical means available. The following are the principal conditions, arranged in an order embodying my estimate of their relative importance:—

(1) The map must be clearly and easily legible. Each colour must be so distinct from each other colour that it can be identified, whatever its surroundings; and all other conventions must be readily discriminated.

(2) The cartographic scheme must be adjustable to the geologic facts; it must not require that the facts be adjusted to it.

(3) The same scheme should serve both for general maps—as, for example, those representing only systems—and for detail maps, representing numerous smaller divisions.

(4) Undue expense should be avoided. The amount and consequent utility of colour cartography is largely limited by its cost.

(5) It should be easily fixed and retained in the mind. This is best accomplished by making it orderly.

(6) Other considerations permitting, the map should please the eye. Since the arrangement of colour areas cannot be foretold, this can only be accomplished by admitting a certain range of choice. If allowed sufficient latitude in the selection of tones, an expert colourist can ameliorate an offensive combination of hues.

(7) Other considerations permitting, the establishment of a universal system should involve the least possible inconvenience. But as the inconvenience of change is temporary, while the inconvenience of a bad system is lasting, this consideration should yield to every other.

The art of mapping geologic terranes by means of colour is well developed, and its methods, viewed from the geologist's stand-point, admit of easy characterization. Colour may be varied in two distinct ways—in hue and in tone. Hues differ in quality, as yellowish-green and bluish-green. Tones differ in strength, as pale green and dark green. A colour is printed either solid or broken; it is said to be broken when applied in a pattern, as in lines or dots, or when it is interrupted by a pattern. The difference between solid and broken colours is a difference of texture. The primary discriminations in mapping are through hue, tone, and texture.

The map engraver produces texture in three ways. In the first way a single impression is made with the broken colour. The white of the paper, displayed where the colour is interrupted, combines with the colour in the general effect, producing a paler tone of the same hue. In the second way two impressions are made, one with solid colour, the other with broken, and the two impressions have the same hue; they may or may not differ in tone. This is monochromatic over-printing, and its general effect agrees in hue with the single impression, but differs in tone, being darker. In the third way two impressions are made, one solid, one broken, and their colours differ in hue. This is bichromatic over-printing, and its general effect differs in hue as well as tone from each of the colours combined in it. The first and second ways produce texture monochromatically, and do not yield a new hue; the third way produces texture bichromatically, and yields a new hue. It is practically impossible to obtain a texture effect without modifying the original tone.

The natural gradation from hue to hue is absolutely continuous, and the number of hues is infinite; the number of tones of each hue is likewise infinite. The number of hues and tones the eye can discriminate is finite, but very great; it is stated that 1000 hues have been distinguished in the solar spectrum. But the number of hues and tones that can be combined in a map is small. As a matter of perception, every colour is modified by the colours adjacent to it. The same hue affords different sensations when differently surrounded, and different hues may afford the same sensation. The same is true of tones; and there is a certain interdependence of hues and tones in this respect. In a geologic map each colour is liable to fall into various combinations, and two colours little differentiated occasion confusion. There is therefore a somewhat narrow limit to the employment of hues and tones. The matter has not been fully worked out, but it is probable that twenty is as large a number of hues as can safely be employed in connection with tones. Texture admits of very great variation. The various colour schemes submitted to the Congress and printed in the report of the Bologna meeting afford, with their manifest permutations, about 200 distinct textures, and I am satisfied from a study of these and others that as many as 100 can be chosen that are not subject to confusion. It follows that a map or atlas expressing few distinctions need use only hues, or only hues and tones, but where numerous distinctions are to be made, recourse must be had to textures.

The printing of a large number of textures of the same hue produces a greater number of tones than can be discriminated, and its effect is to confuse and nullify any distinctions (within the range of that hue) based purely on tone. The printing of a large number of bichromatic textures causes the same result, and it also produces a greater number of hues than can be discriminated. Its effect is to confuse and nullify distinctions based purely on tone, or on hue, or on tone and hue together.

In the colour scheme prepared for the map of Europe, thirty-eight distinctions are made. There are twenty-four hues, and

[1] Vice-Presidential Address read to Section E of the American Association for the Advancement of Science, August 10, 1887, by Mr. G. K. Gilbert. Continued from p. 22.

the remaining fourteen distinctions are accomplished by variations of tone. While it may be possible to select twenty-four hues available for indiscriminate combination, there can be no question that those provisionally printed by the Committee will fail to maintain their distinctness when variously combined upon a map. Under the influence of such chromatic environments as are sure to be encountered, the four yellow hues of the Tertiary cannot be discriminated, and the same difficulty will arise with the two hues of gray assigned to the Carboniferous, and with the hues of gray and brown assigned respectively to the Permian and the Devonian. Some of the tones likewise are not sufficiently distinguished. Two of the blues of the Jurassic, two of the browns of the Devonian, two of the rose tones of the Archæan, and the two violets of the Trias, are open to this criticism. A certain amount of adjustment can be made in the final selection of inks, and probably all the defects from tone can be thus remedied, but the confusion of hues is more difficult to eliminate, for the great number of the hues interferes with the separation of those that are too approximate. To strengthen one contrast is to weaken another.

In order to judge of the availability of the scheme for the production of detail maps, it is necessary to consider the resolutions of the Congress as well as the printed legend. A resolution provides that the subdivisions of a system shall be represented by shades of the colour adopted for the system, or by broken colour or other texture devices; and it is further provided that the shades, whether produced by solid colour or by texture, shall be so arranged that the darkest or strongest represent the lower divisions of the system. The resolution is in French, and the word I have translated shade (*nuance*) is one which applies popularly to either hue or tone, while in the scientific terminology of chromatics it applies to hue only. The Committee on the map has taken it in its popular sense, and has represented some subdivisions by hues, and others by tones; for example, Pliocene and Miocene are assigned two tones of the same hue, while Oligocene and Eocene have each a separate hue. The Upper Cretaceous and part of the Lower Cretaceous are assigned a green hue in two tones, while the Gault and the Wealden, classed as subdivisions of the Lower Cretaceous, have independent hues of green. Of the six reds assigned to volcanic rocks, two agree in hue and differ in tone, while the remainder have distinct hues. As the legend stands, both major and minor distinctions—that is to say, the discrimination of groups, the discrimination of systems, and the discrimination of divisions smaller than systems—are all accomplished by differences of hue; while the discrimination of minor divisions is accomplished indifferently by variation of hue and by variation of tone. The same means performs several functions, and the same function is performed by several means.

It is stating the same thing from another point of view to say that the Congress and its Committees have used the term colour in its popular rather than its scientific sense. Scientifically, a colour is a particular tone of a particular hue, and the number of colours is infinite. Popularly, a colour is an assemblage of contiguous hues and their tones, to which a name has been given. Each hue and tone within the range covered by the name is a shade of the colour. It is in this popular sense that the resolutions assign a colour to each system, and assign shades of the system-colour to the subdivisions of the system.

Now, if in the variation of a system-colour, by textures or otherwise, a single hue is adhered to, the system-colour remains distinct from other system-colours throughout all its modifications and their modifications; but if hues as well as tones are varied, the inevitable result is confusion, for some of the hues of one system-colour will approach too near to hues of other system-colours. With a multiplicity of minor distinctions the main distinction of system from system will be lost.

Another difficulty lies in the fact that the Quaternary and Devonian colours, while strongly contrasted in tone, are nearly identical in hue. This does not affect their use in a general map, but in a detail map the stronger tones of the Quaternary gray will approach too closely the paler tones of the Devonian brown.

These criticisms apply to those features of the scheme which affect its adoption for general and detail maps of European countries. There is one of equal or greater importance affecting its application in other continents. It is adjusted to the rock systems of Europe exclusively, and makes no provision whatever for the systems of other parts of the earth. The geologists of Wisconsin, for example, cannot use it without calling the Keweenawan either Cambrian or Archæan. If they were in doubt which division should hold it, but inclined a little one way or the other, they could express their qualified opinion in the notation provided by the Map Committee; but having attained an unqualified opinion that the terrane belongs to neither of these two categories, they find no means for expressing their conclusions. The scheme cannot be applied to the geology of India, of New Zealand, or of Australia, without misrepresentation. It is not universal but local, and this because it is founded on the fallacy of a world-wide unity of geologic systems.

So far as the geology of the world is concerned, it would be better to adopt no convention at all as regards map colours than to adopt one carrying with it and promulgating a vicious classification. Uniformity is not worth purchasing at the price of falsification. If the members of the Congress cannot agree upon a plan having the flexibility demanded by the geologic facts, it will be best to limit its action to the local problems involved in the map of Europe. I believe, however, that the necessary flexibility is attainable; and before proceeding to further criticism of the Committee's scheme, I will give the outlines of a plan which appears to me to combine the advantage of flexibility with a number of other desirable qualities.

The plan is founded on the universality of geologic time and the diversity of local geologic histories as expressed in rock systems. Geologic periods are arranged in linear order. Each one adjoins the next, and together they constitute continuous geologic time, which we may conceive as represented by a straight line. The stratigraphic systems of a country have likewise an order of succession, and their arrangement is linear. They are not always continuous one with another, but the history recorded by the systems and the breaks between them is continuous, and may be represented by a straight line, equal and parallel to that of geologic time. And so for each country. A colour scale which shall represent each and all of these parallel lines must be itself linear and continuous, and fortunately we have such a scale furnished us in the prismatic spectrum.

I propose, first, that the continuous prismatic spectrum be adopted as the standard universal scale for continuous geologic time. I propose, second, that the conventional time scale, based on the geologic history of Europe, be complemented by a colour scale, prismatic but discontinuous. I would assign to each period, not a certain portion or area of the spectrum, but a specific colour defined by its position in the spectrum. This colour scale will also apply to the geology of Europe. I propose, third, that the students of each geologic district shall assign to the stratigraphic systems of that district a set of prismatic colours so selected from the spectrum as to properly represent the relation of each system to the time scale, provided that relation is approximately known. Under this rule a system corresponding partly with the Cretaceous and partly with the Jurassic will receive a prismatic colour intermediate between those assigned to the Cretaceal and Jural divisions of the time scale. I propose, fourth, that systems whose relations to the standard time scale are not even approximately known be given tentative positions in the time scale and assigned the corresponding colours; and that such provisional colours be distinguished by a special device.

Of this device I will speak later, but before we leave this part of the subject the capability of the plan to express the facts should be more clearly characterized. Continuous geologic time being equated with the continuous spectral band of light, each period is theoretically equated with a segment of that band including all the hues between certain limits. But practically the period is represented in the colour scale only by the central hue of the segment, and there is nothing in the nature of this hue to indicate the length of the segment. Similarly each local system is represented only by the hue corresponding to the middle of the equivalent period, considered as a part of the continuous time scale, and this hue gives no information as to the magnitude of the system or the duration of the corresponding period. When a non-European system is represented on a map with the Devonal colour, all that is expressed is that the middle of its period coincides with the middle of the Devonal period; the whole period may equal the Devonal or may be shorter or may be longer. With this limitation the scheme is able to express the exact facts, or the exact state of opinion, in regard to correlation.

I propose, fifth, that the subdivisions of systems be represented, if their number is small, by distinct tones of the hue assigned to the system, and if their number is great, by monochromatic textures. It having been provided that systems shall be distinguished by means of hues, it is now provided that hues shall have no other function. This secures the integrity of the distinction between systems, whatever the minuteness of subdivision.

The idea of using the spectral colours in their proper order is not novel. It has entered into half the plans submitted to the Congress, but each author has introduced other colours also, or else has undertaken to use the spectrum colours more than once, under the impression that they do not afford the necessary range or variety. This impression is based largely upon the popular meaning of the word colour. It is indeed true that if we limit ourselves to those parts of the spectral series which have univocal names, we have only six or seven distinctions; and it is further true that if we have recourse to binomial designations, such as yellowish green and greenish yellow, we obtain rather indefinite conceptions; but to men of science there are better resources than those afforded by the language of every-day life. The spectrum has been elaborately studied, and the relations of its dark lines to its colours have been determined. Its wave-lengths have, moreover, been measured, and by such means as these we are furnished with three different scales, any one of which is adequate to the precise definition of any hue of the continuous series. What needs to be done is this. When the divisions of the time scale have been decided on, the spectrum must be studied to ascertain the best selection of hues. Their number must, of course, be that of the number of divisions of the time scale, and they must be so chosen that the degree of separateness of adjacent colours shall be everywhere the same, as judged by the normal human eye. Then define each hue by its wave-length or its position in the Kirchhoff scale, and define it also in terms of the best combination of pigments with which it can approximately be reproduced for practical use. It is, of course, impossible to copy the prismatic colours with accuracy, because the colours of pigments are impure, but this difficulty will not seriously interfere with the employment of the prismatic colours as a standard.

The practical question whether the spectrum will give a sufficient number of hues so far separated from each other as to be distinguishable in all the arrangements occurring on maps has received such consideration as I have been able to give it, and it is my judgment that the maximum number of hues that can safely be used falls somewhere between fifteen and twenty. There will certainly be no difficulty in thus constructing a standard colour scale with about a dozen terms.

The employment of the spectral colours in this manner leaves three groups of colours unassigned—the purples, the browns, and the grays. If the spectral colours be arranged on the circumference of a circle so that each diameter of the circle connects hues that are complementary, it is found that they occupy the greater part, but not quite all, of the circumference, and the colour needed to fill the vacant arc is purple. The hues of purple might then, if deemed necessary, be added to one end or the other of the spectrum, thus increasing the range from which to select colours for the time scale.

My sixth proposition is to assign the browns to volcanic rocks. I would leave the grays unassigned.

It will be observed that no intimation has been given as to whether the violet end of the spectrum should apply to the newest system of strata or the oldest. It must of course be definitely assigned to one or the other, but the particular assignment is a matter of indifference.

The main features of the proposed prismatic scheme have now been set forth, and you are fairly entitled to exemption from the minor features, but there is one detail that can hardly be omitted. In one of the main propositions it was provided that some special device should distinguish colours assigned to uncorrelated systems, and I feel it incumbent to show that a suitable device can be found. Of a number that have occurred to me as about equally available, I will mention but a single one—the over-printing, in small dots, widely separated, of the complementary colour. The complementary colour is selected because it does not disturb the relation of the system-colour to the colours of adjacent systems. Bichromatic over-printing produces a hue intermediate between the two hues combined, but the hue mid-way between a system-colour and its complementary colour is white or gray, and if only a small amount of the complementary colour is added, the system-colour merely becomes paler or duller, when viewed from such a distance that the colours blend.

The prismatic colour scheme, having been constructed for the express purpose of securing a degree of flexibility that will fit it for universal use, need not be further compared in that regard with the scheme published by the European Map Committee. Enough has also been said to show that its superior perspicuity is claimed both for general and for detail maps. A few words will suffice to compare the two systems in other respects.

As regards the expense incurred in the production of general maps, neither has any notable advantage, and they are not yet sufficiently developed to permit a comparison as regards the cost of detail maps. Their capability for the production of pleasant colour effects can best be judged when maps have been actually made, but it may be said in a general way that the Committee's scheme will afford more strong contrasts between adjacent colour areas than the prismatic. The maps coloured by the former will be relatively lively, those coloured by the latter relatively quiet. It is provided by the Committee that the volcanic colours shall be not merely red but strong. On a general map volcanic areas cover comparatively small spaces, and strong reds thus disposed will ordinarily add brilliancy; but the detail map of a volcanic district, thus coloured, will be disquietingly suggestive of active eruption.

The alphabet of colours for the prismatic scale will be the more easily learned of the two, because it is orderly, and because its order is already familiar in the spectrum. The Committee's scheme, however, has some old-fashioned mnemonic features which the prismatic lacks. The green of the Cretaceous is connected with greensand, the red of volcanic rocks with fire, and the rose of the Archæan with feldspar; and the gray of the Carboniferous mildly suggests the blackness of coal.

In respect to facility of introduction the Committee's scheme, being essentially a compromise of existing colour scales, has the advantage that to most users it is not entirely novel. The prismatic scheme on the other hand has the advantage of being orderly. It scientifically differentiates the functions of hues and tones, and though each one of its colours may be different from what the individual geologist has previously employed for the indication of the same system, the order of the colours is already familiar to him in another way.

This closes my review of the various works undertaken by the Congress. Some of these have been favoured, others opposed, and reasons have been given. But there is a general consideration or criterion applicable to all, which has nearly escaped mention, although it is of pre-eminent importance. When a matter is proposed for regulation by the Congress, the first question which should be asked is whether it falls within the legitimate purview of a convention of geologists. It manifestly does not if it belongs to some other science rather than to geology, and objection has on this ground been made against the regulation by our Geologic Congress of the nomenclatures of palæontology and mineralogy. But not all geologic matters even are properly subject to settlement by convention. This is peculiarly the case with geologic facts. Science is distinguished from the earlier philosophies of mankind by the peculiarity that it establishes its fundamental data by observation. The old philosophies were founded largely upon assumptions, and it was not deemed illogical—perhaps it was not illogical—to appeal to the authority of an assemblage of experts for the establishment of fundamental assumptions. But for science it is not merely illogical, it is suicidal, to establish facts in any other way than by observation. No vote of the most august scientific body can possibly establish a fact, and no vote can have any weight against a good observation.

Now the entire science of geology, using the phrase in a strict sense, is constituted by the aggregation and arrangement of facts, and none of its results can be rendered more true or be more firmly established, or be prevented from yielding to contradictory facts, by conventional agreement. A classification, if it has any value whatever, is merely a generalized expression of the facts of observation, and is outside the domain of the voter. If it comprises all the essential facts, its sufficiency will eventually be recognized, whether its authority is individual or collective. If it does not comprise them, it will inevitably be superseded, by whatever authority it may have been instituted. For this reason I am opposed to the classification by the Congress of the sedimentary formations, and likewise to the classification of volcanic rocks, and I also regard it as ill-advised that the Congress undertook the preparation of a map of Europe, for that—if more than a work of compilation—is a work of classification.

If we examine the other undertakings of the Congress—the definition and gradation of taxonomic terms, the systematization of terminations, the selection of a scale of colours for geologic maps, and the selection of other conventional signs for the graphic expression of geologic phenomena—we find that they all belong to the means of intercommunication of geologists. They affect only the verbal and graphic technical language of the science. Of the same nature is the arbitrary time scale whose preparation I favour—a conventional terminology for the facts of correlation. So we may say, in general, that the proper function of the Congress is the establishment of common means of expressing the facts of geology. It should not meddle with the facts themselves. It may regulate the art of the geologist, but it must not attempt to regulate his science. Its proper field of work lies in the determination of questions of technology; it is a trespasser if it undertakes the determination of questions of science. It may decree terms, but it must not decree opinions.

TECHNICAL EDUCATION.[1]

THE present century has witnessed a vast and almost incredible change in the great industries of the world, and in the progress of the arts and manufactures. The causes of this great change are various, though mutually dependent upon each other, such as the cessation of the great wars that had for so long ravaged the continent of Europe, which enabled many of the most vigorous minds to be turned to the arts of peace; the rapid growth of population, which rendered the wants of mankind more pressingly felt; and the more general spread of education, which caused the great discoveries that have enriched this period to be eagerly taken advantage of and adopted.

Among the many results which have ensued, is one which must be carefully studied, affecting as it does in a peculiar degree our own country at this time.

Since the latter half of the last century, when by the disappearance of forests in the iron-producing districts, resulting from the use of timber as fuel, maternal Necessity had brought forth an invention in the shape of the process of smelting iron ore with coal, progress in machinery and manufactures had steadily been made. The great natural advantages arising from the conjunction, not only of coal and iron in the same locality, but also their immediate proximity to the limestone required in iron-smelting operations, had greatly contributed to this advance, until this country, instead of importing four-fifths of the whole iron used from Sweden, as was the case in 1750, had become the greatest iron-producing country of the world. The invention of the steam-engine in conjunction with the power-loom and other important machines, greatly contributed to the growth of the factory system, the establishment of the cotton, linen, and woollen industries, and the rapid increase of manufactories in general. Owing to the insular position of Great Britain, and the prohibitive laws in force, until fifty years ago the nature of the machinery used in all these manufactures, as well as the technical knowledge and skill of the workman, was prevented from being carried abroad. Thus, as stated in the recent Report of the Commissioners on Technical Education:—

"When, less than half a century ago, Continental countries began to construct railways, and to erect modern mills and mechanical workshops, they found themselves face to face with a full-grown industrial organization in this country, which was almost a sealed book to those who could not obtain access to our factories."

This artificial state of things was not destined to last, for, on the one hand, these countries were keenly alive to the importance of possessing such manufactures, and were determined to obtain them at all costs; and, on the other, it was greatly to the immediate advantage of our manufacturers to sell freely in such a market as began to be opened to them. At the same time skilled artisans were easily found who were willing to accompany abroad machinery which had been constructed in this country, and thus to become the means of disseminating technical education of the most practical type amongst those who were quite as industrious and frequently better educated than the workmen at home.

The efforts of foreign nations to establish mills and workshops of their own did not cease here; for, recognizing the necessity of specially spreading technical knowledge by all possible means, technical schools, instituted and supported by the State, at which instruction could be obtained free, or at almost nominal cost, were established in numerous places all over the Continent. The larger number of these schools have been institutions at which the scientific principles underlying industrial and manufacturing operations, rather than the actual operations themselves, were taught, although there are also in lesser number special technical schools, such as the weaving schools of Chemnitz in Saxony, of Crefeld in Rhenish Prussia, of Basle in Switzerland. From these various schools, numbers of highly educated men have been sent out year by year, prepared, when becoming foremen, managers, or employers of labour, to take advantage of the latest discoveries and improvements in various branches of industry, and keenly alive to the fact that "knowledge is power."

Notwithstanding all this, an enormous increase of trade and prosperity was enjoyed by this country for many years, and notably was this the case after the first International Exhibition in Hyde Park, in 1851, which Exhibition revealed to visitors from all parts of the world much (some persons of the old school are to be found, who assert *too* much), concerning the perfection of our machinery and processes of manufacture which had been scarcely realized before, even by ourselves. This prosperity apparently reached a climax from ten to fifteen years ago, and, since then, trade has assumed a very different aspect. At first the change was felt in relation to countries whose resources were in some respects comparable with our own, and afterwards with others less favourably situated, and in place of supplying them with manufactured articles and machinery, they began to enter into competition, and in many cases successful competition, with this country, even in markets hitherto considered all our own. Indeed, a positive reflex action has actually occurred in some important branches of industry and foreign iron, machines, hardware, and textile goods are imported for home use. The result of this competition has been keenly felt, and the consequent struggle which has taken place in these times of peace has been, and now is, almost as determined and often as bitter as in an open war. That rather doubtful compliment once paid by a great general to the British soldier, that he never knew when he was beaten, could scarcely be applied to the British manufacturer, since there is a very speedy way of settling this point in a commercial transaction; but the question upon which knowledge has often been wanting and information sometimes too tardily sought, is rather as to the cause and its remedy. In some cases the cause is obviously due to the lower wages and longer hours for which foreign workmen will toil, and it may be mentioned, as pointing to what may be sometimes possible in this case, that in the neighbouring industry of wire-drawing at Warrington, which was threatened with extinction, the German competition was entirely met and overcome by the wire-workers voluntarily accepting a reduction in wages of 10 per cent., after four of their delegates had visited the Black Forest and ascertained for themselves full particulars as to the wire industry of that district.

But, on the other hand, there are branches of manufacture in which the state of foreign workmen and workwomen is so pitiable that no right-thinking person would desire to have increased trade in this country at such a price to our own people, though happily there is not much fear of this, since the movement is rather in the other direction. But the question of wages is only one of many causes, for it has been asserted by excellent authorities that it is not in those branches of industry in which foreign wages are lowest and hours longest that competition presses most heavily upon us. Thus, according to the recently published Consular Reports, we have still something to learn in several directions in the matter of finding out fresh markets and accommodating our productions to native wants, instead of trying to force goods of our own pattern and design where they are either not in accordance with native views and prejudices, or are unsuitable to the locality. Again, it is not only the Germans who stamp the words "best Sheffield steel" upon cast-iron axes and knife-blades: neither in the matter of shoddy-manufacturers can this country afford to throw stones at our foreign rivals.

It is not, however, the object of this address to enter into a discussion of the various causes of trade depression, and still less to presume to say how such an undesirable state of things may be met and overcome, but to consider a subject which has recently been very vigorously brought forward in connexion with this matter under the title of "Technical Education." No branch of education has of late attracted so much attention as this. It has formed not only the text of the Presidential Address of the British Association in 1885, and part of that at the recent

[1] Part of Inaugural Address of session of University College delivered at St. George's Hall, Liverpool, on October 1, 1887, by Prof. Hele Shaw, M.Inst.C.E., of the University College, Liverpool.