is 0·038 foot. For Newlyn, with six years' record, the corresponding figures are 0·194 foot and 0·042 foot. An elaborate comparison of these variations of mean sea-level with the corresponding barometric heights has successfully demonstrated a correlation between the two, and it is estimated that about 0·12 foot of this difference is due to this cause. The residual difference is supposed to be likewise mainly due to an atmospheric cause—the effect of the prevailing winds, locally and regionally. We are thus forced to the conclusion that there is a real difference in mean sea-level between Newlyn and Dunbar, the latter being permanently raised above the former. Indications are given as to how the law of these atmospheric effects should be investigated, but it is clear that further observations over a long period will be required before we are able to calculate and eliminate their effects from the tidal record, at any particular station. The decision to base the levelling on a provisional value of the mean sea-level at one station and not to force it into agreement with the tidal observations at the other two is for these reasons amply justified.

We end by quoting the last paragraph of Sir Charles Close's Introduction :

" It is hoped that all this labour, and the large sum of money spent on the work, will be found to be justified in the future ; and it is believed that England and Wales are now provided with a primary level network which is second to none in the world, and that it will serve all practical requirements and be available in future ages for use in the study of those larger and more important problems which belong to the domain of science." A. E. Y.

The Geographical Journal, Vol.63, no.6, June 1924, pp.491-508

THE CHOICE OF A GRID FOR BRITISH MAPS

Read at the Afternoon Meeting of the Society, 17 March 1924.

I. THE NATIONAL GRID

Colonel H. S. L. Winterbotham, C.M.G., D.S.O.

IN the January number of *Annales de Géographie*, Mr. de Martonne gives certain details of French plans for the new 1/50,000 map. It would appear, from this description, that the projection which characterized the earlier sheets of the 50,000—the polyhedric—is to be abandoned, and to be replaced by an orthomorphic projection. The sheets are to be rectangular and are to show a " national grid."

The United States of America have achieved considerable progress in the spread of their one-inch maps, which are on a polyconic projection, The sheet lines of this series, being defined by meridians and parallels. do not lend themselves to the introduction of a " national grid." Nevertheless, tables have been prepared to facilitate the overprinting of a grid for military, if not for civil, purposes.

Recent military and scientific German periodicals give details of a change of German national mapping policy. A commission or board

under their Home Office deals with mapping questions and represents the opinions not only of the Reich, but of the individual states which compose it, and of the fighting services. This board has recently decided to introduce a " national grid " upon all German maps.

The grid has, in fact, become an important feature of military mapping, and threatens to develop into a national affair. We are, then, to ask ourselves the following questions :

(1) What is a grid ?
(2) Is it of importance to the nation at large ?
(3) If so, what form should it take ?

It is my duty to give you the answer to the first of those three questions.

Before the war, it was customary to add in the margins of maps some system of reference by whose aid to track down a town, a river, or a mountain into a particular square or enclosed figure, and thereby to render unnecessary a vain search over the rest of the map. The usual system of reference was one dividing two opposite margins into similarly lettered parts, the other two into numbered parts.

This was not, however, the only system of reference. There was another which depended upon polar coordinates. Some point, generally the centre of the east margin, is made the pivot for a graduated strip of linen, which can be pulled out straight and revolved so as to read against tangent scales on the other margins. A particular point could then be defined with reference to the tangent marginal scales and to the distance along the rotating arm.

These systems of reference undoubtedly save a great deal of hunting over the map. It must be noted that their value is limited to the sheet on which they appear, that is, a square defined as A.2. gives one no information unless one knows which map it is to which reference is made. Moreover, as experience with town maps shows us, the search even within the square may take time.

When the Expeditionary Force left these shores it was equipped with maps some, at any rate, of which had these marginal letters and numbers. Presently, when the British Army, advancing after its preliminary retreat, came to an enforced stop firstly upon the Aisne and secondly in Flanders, the halts were sufficiently prolonged to make it necessary to issue larger-scaled maps. These maps, on the scale of 1/20,000, called for some more handy and accurate system of reference, to define not only a square but the exact spot in that square at which to look for a particular feature. A committee was appointed to evolve a suitable system of reference, and the task in front of it was one of peculiar difficulty. It had so happened that the Belgian maps were being printed in England. As we always felt that we were on the point of driving the Germans before us into Belgium, we desired to use Belgian sheet lines, which differ from French sheet lines, for maps of French territory lying to the west. But Belgian and French sheet lines are functions of the metre, and British

troops, at that time at any rate, thought mainly in yards. A system of reference, then, was required which should give squares of a definite number of yards, and which would yet fit as nearly as possible upon a map whose dimensions were governed by the metrical system. It was possible to divide a 1/40,000 sheet into squares of 1000 yards so nearly that by a little fudge in the printing the east and west lines of these reference squares were made to coincide with the sheet lines. North and south it was not so possible, and the reference squares projected beyond the sheet lines. The whole area of the 40,000 was then divided, and not quite equally, into twenty-four parts, each of which was given a letter. These parts were then subdivided into so many squares of 1000 yards side. It will be seen from the illustration that twelve of these letters had thirty-six such squares, while twelve had only thirty. On the east and west margins were a row, or line, of half-squares. Each 1000-yard square was subsequently divided into four quarters, which were labelled a, b, c, and d, and each of these little and ultimate squares was divided decimally by eye or scale. A full reference, then, ran in this way :

Sheet 51—M.35.d.34.

It will be observed that it was still necessary to quote the sheet.

Side by side with our system grew the French. Now in French eex and ygrec have a more friendly sound than x and y have to us. The French went, therefore, boldly and logically for a rectangular coordinate system covering the whole area (or a very large part of the area) instead of keeping to a single-sheet system. Their " grid " was a vast grid of kilometre squares—and the sides of them were numbered consecutively, eastwards and northwards, from an origin so remote from the front as to be secure from intrusion. Thus signs were always positive. Inside the squares decimal division was done by eye or scale to the nearest 100 metres, or, on large-scale maps, to the nearest 10 metres.

Here we get a substantial step further than in the British squaring. We have, in fact, progressed from " squaring " to " gridding." The horizon is broadened from a sheet to a country. Quite independently of the map, indeed, the relative positions of objects can be defined on the grid. Let us take an example. A gunner finds that the coordinates of his gun are x and y, and this he does not from the map but from a small survey. A sound ranger reports a hostile gun at x′ and y′. Two minutes with a log-book and the bearing and distance of the target thus disclosed are computed. The problem is very different if it is possible only to use references for identification on (say) a couple of maps. In the one case a result accurate to, say, 20 feet may be expected ; in the other, to 50 yards.

We see, then, that a grid is a system of reference which can be applied to a very wide area (say Great Britain) and which enables the location of any place, on the ground, if you will, or on any map of whatever

scale. It enables one to compute the distance between any two points whose coordinates are known—between John O'Groat's and Land's End, if it be desired—and, equally, to compute the bearing or azimuth. In this guise the grid becomes an old friend. It is nothing but a rectangular coordinate system. We adopted it for the British forces in Italy, and we should have adopted it in France in 1918 had the war not, happily, become a mobile one.

But there are practical difficulties about this grid. It must be composed of squares, and, as the earth is round, continuous and perfect squares cannot be fitted on it. There is a story of certain surveyors (not Royal Engineers) in an Eastern portion of the Empire, who started to divide a wide area of cultivable land into squares by running straight lines out at right angles from a meridian. The unfortunate recipients of lots far from the meridian raised a justifiably loud outcry.

The squares of the grid must remain square on the projection chosen for the grid, but are bound to depart in time from the perfect square on the ground. Nevertheless, the defining lines of the squares can be traced on the ground, for they are as definite mathematical lines as meridians or parallels.

But if you choose one projection, say " A," for your grid, it does not mean that you cannot plot that grid on a different projection, say " B." You have, as it were, traced on the ground those lines which make perfect squares when mapped in projection " A."

If you map on projection B you can survey these grid lines (even though they are imaginary) with the rest of the detail. They may not be perfect squares on projection B, but will, probably, not be sensibly different. It has therefore happened on several occasions—and will doubtless happen again—that survey operations and references are given in terms of projection A, whilst the grid is shown graphically on projection B.

A full grid reference is given by complete easterly and then northerly coordinates, thus :

152034 West—206793 North (to the nearest metre)

But generally at most scales a reference to the nearest 100 yards or so is enough. If our units are yards or metres we can say, then :

1520 2068 (to the nearest hectometre)

(N.B.—We may omit " west " and " north " if they always follow the same sequence.)

Now supposing that it is only the countryside within 10,000 yards or 10 kilometres that we are considering, we can leave out the earlier figures and write :

20 68

There are two matters which deserve particular attention in relation to this grid :

(*a*) The size of the squares. As the referencing is to be the same on any scale, a square has to be chosen which is of about the ideal size on the most important scale, but which will be neither too large nor too small on other scales. Shall it be 1000 yards, a kilometre, 10,000 feet, etc.? The two necessities are that it shall be decimal, and shall be in terms of some unit which can be used with the ordinary surveying instruments. The unit must, in fact, be the yard, the foot, or the metre.

(*b*) What is the best method of abbreviating coordinates to fit different circumstances?

Our present practice is to give every 10-kilometre-square a letter and to add decimal references within the square, thus:

A 4562 (to the nearest 100 metres)

As there are twenty-five letters (or five squares) the alphabet covers a square of 50 kilometres. At every 50 kilometres therefore reference is repeated. If we added two more figures in front, however, instead of letters, we should get say 345762, a reference repeated each 100 kilometres.

Enough has been said, it would seem, to explain what a grid is and how references are made in it.

In England we have for military purposes a grid on the Cassini Soldner projection, with its origin at Dunnose, whereas the small-scale Ordnance Survey maps are on a similar projection with origin at Delamere. It has been necessary to introduce the second (Dunnose) grid because we work at present on a projection which is not orthomorphic. The position is not, however, satisfactory. We soldiers must have a grid. Moreover it must rest on a simple system of coordinates in order to facilitate local surveys, and must be sufficiently precise (in an angular sense) to give instrumental observation its full value. Such a grid is so great a convenience that we shall not be content without. Military operations, like all other large engineering undertakings, require the smooth working of many interdependent parts. In order that every one may be at the correct place, that unforeseen contingencies may be intelligibly reported, and that new combinations may be formed, it must be possible for every unit of the machine to understand quickly and accurately the place of which his commander speaks, writes, telegraphs, or telephones. He may have to go there, to send there for his food, to meet some other person there, to deliver a message there, etc. At present we have a separate military edition, and must make special computations to adapt the trigonometrical data. It is however plain that we can, by using an orthomorphic projection, readopt the Delamere origin of the Ordnance Survey small-scale maps.

Now Ordnance Survey maps already bear a network, not wholly consistent, of two-inch squares. In place of those squares is it not possible to substitute a grid, suitable at once for civil and military purposes? Mr. Hinks will speak on the point of view of the civilian,

but I cannot refrain from emphasizing the real advantages which the man in the street would gain.

For example, A loses his way, he reaches a signpost and sees on it 372435. His map then shows him where he is.

B skids in his car, turns over into a ditch, rises in wrath, finds a telephone office, and asks for breakdown gang at 404983.

C calls up D and tells him to be, with horses for both, at 592176 at 14.00 hours.

There are times, and many, when reference is not required; for example, if one were to say, " Are you going to the Society's Meeting on Grids ? " both time and place are obvious; but there are countless times when references would save much time, and it is noteworthy that our existing street names and numbers are only an unscientific prototype of this referencing.

Had Sir Walter Scott written in times in which a national grid was employed, how much our libraries would have been spared!

II. THE GRID FOR BRITISH MAPS

Colonel E. M. Jack, C.M.G., D.S.O., Director-General of the Ordnance Survey

1. I speak as the official responsible for producing the national maps, who has to combine, as far as possible, the needs of both military and civil users.

We have seen from Colonel Winterbotham's explanation that for military purposes it is essential to have a grid on our maps, with a single system of coordinates to define the positions of all points. For civil purposes it is not essential, but such a system would be of great value, particularly in large towns and crowded areas.

For military purposes we have not to consider æsthetic questions; we can adopt what is best for the purpose in view, even if it makes the map unattractive. For civil purposes these questions however become important. If a map is made unattractive it will not sell well.

It is, however, uneconomical and for many reasons inconvenient to have separate military and civil editions. It is therefore of importance to devise if possible a form of grid which will satisfy military requirements, and at the same time will not affect the public demand for the map.

2. The Ordnance Survey small-scale maps which are in common use, namely the 1-inch, $\frac{1}{2}$-inch, and $\frac{1}{4}$-inch maps, are already provided with a system of squares, in all cases of 2-inch side. It may be asked why these will not serve military requirements. The first reason is that these squares do not form a grid. A grid is a system of squares which extends over the whole area or country, independently of the

sheets of the map. The squares on the Ordnance Survey maps are dependent on the sheet, and have no direct connection with the squares on the adjoining sheet. No common system of coordinates could therefore be based on the Ordnance Survey squares.

The second reason is that it is desirable that the dimensions of the squares in a grid should be on a decimal basis, that is, that they should be measured in multiples, or preferably powers, of ten units. This is not essential, but it is certainly highly desirable, for reasons of simplicity and convenience. When we define the position of a point within a square, we use co-ordinates measured in tenths, hundredths, etc., of a side. If our square has a side of 1000 yards these successive subdivisions are 100 yards, 10 yards, 1 yard, etc., in length. If we were to subdivide the existing square side on the 1-inch map in the same way, the divisions would be 352 yards, 35·2, 3·52, etc. This would have certain inconveniences.

It would seem, therefore, that if military requirements are to be met adequately some change will be required in the squaring on Ordnance Survey maps.

3. In considering the effect of any change in a map in respect of which the convenience of the public and the selling value are matters of importance, we have to take into account the following points :

(1) The effect on the appearance of the map.

(2) The effect on its utility.

(3) Consequential effects, such as alteration in sheet lines.

(4) Financial effect.

It will be useful to consider under these four heads a proposal that has been made in the course of discussions on this subject, to adopt a grid with squares of 10,000 feet side on the 1-inch map, in place of the 2-inch or 2-mile squares. The reason for considering in detail this particular proposal is that it is the only definite one hitherto put forward for solving the problem. Remarks of a similar nature, and in some cases the same remarks, would however be applicable in the case of any change proposed.

(1) *Appearance.*—It is obvious, that so far as size goes, the proposed squares would not affect the appearance of the map at all. They are only slightly smaller than the 2-inch squares. The fact that they do not fit the sheet would however be some disadvantage. I will refer to this point again shortly.

(2) *Utility.*—Before discussing the effect of such squares on the utility of the map, I must digress for a moment.

The present squares were put on the map for the purpose of assisting reference and identification. For this purpose it is evident that the size of the square, within limits, does not matter. But it is believed that they are also largely used as a scale of miles, conveniently distributed over the map.

For the purposes of reference the change to 10,000 feet would therefore be immaterial; but for scale purposes the change would be bad. 10,000 feet conveys nothing to the mind, whereas 2 miles conveys a very definite idea. The very fact that 10,000 feet is not very different from 2 miles (10,560 feet) might be misleading and therefore a disadvantage.

(3) *Change of Sheet Lines.*—As our existing sheets are measured in inches, squares of 10,000 feet side would not fit the sheet exactly. The squares would fall irregularly and differently on every sheet. It is not essential that the squares of a grid should fit the sheet, but it is better that they should do so, especially on a map which is for sale, as the appearance of the map is thereby improved. If the size of the squares on the 1-inch maps were changed, it would almost certainly be necessary eventually to adopt a new size of sheet to conform; and this change would have to extend to the $\frac{1}{2}$-inch and $\frac{1}{4}$-inch series. Such a change is not impossible, but it would involve (as similar changes have in the past) expense to the Ordnance Survey and annoyance to the public. It is not a matter to be undertaken lightly.

(4) *Financial.*—The financial effect would depend on the above. A change which adversely affected the appearance or utility of the map would certainly have an effect on sales, which might be serious.

4. As far as the Ordnance Survey is concerned the crux of this matter is contained in the second point discussed above: the question whether an alteration in the dimensions of our squares from miles to some other unit would materially affect the map from the public users' point of view. The mile is our unit for measuring long distances; the yard and the foot are not. Would such a change have an adverse effect? I want an answer to that question very badly, and I shall be grateful for any help I can get towards obtaining that answer. I hope that any one in this room who has views on the subject, and particularly any one who is not a professional geographer, will say something about it. But though answers in this room will be valuable, I can only get the real answer by questioning many thousands of the public.

If I were to do so, I think it probable that I should get three types of answer.

The first would be that he or she did not know there were squares on the map; had never noticed them. It is evident that a slight change would not affect this class of map user.

The second would be that he found the squares very useful for reference or for locating a point. In this case again a change would be immaterial.

The third would be that he found them useful for measuring distances. In this case a change from miles to feet or yards would be resented.

I do not know in what proportion these answers would be received.

5. In the foregoing remarks I have dwelt solely on the Ordnance

Survey point of view ; the difficulties that would be encountered and the considerations that must be weighed before carrying out such a change in the national maps. I may be unduly apprehensive, but changes sometimes have results that it is difficult to foresee, and it is my duty to be cautious.

But I feel that I have not contributed much to the real subject of this discussion, which is the question of what would be the best grid for British maps. I find it somewhat difficult to do so until the mile question is settled. But, assuming that the mile dimension proves not to be so important as I have suggested (and although I have made rather a point of it I think it quite likely that it may not), and that we adopt a grid with squares in another unit, I must confess to a predilection for yards.

Our choice lies among three units, if we omit the Continental metre ; namely, miles, yards, and feet.

I would discard miles, because it would mean dividing the mile decimally, and the mile does not lend itself to that form of subdivision.

Between feet and yards there is, I think, not much to choose ; but as it is not our custom to reckon long horizontal distances in feet, I would give the preference to yards ; and for this choice there are two other good reasons. First, that the yard is the unit used by the Army for expressing ranges ; and second, I think that a grid in yards is more adaptable to certain other scales which we must consider, even though we may agree that the 1-inch is the most important. I would use a 10,000-yard square on the 1-inch scale, but as this is rather too large for convenience I would subdivide it into four squares of 5000-yard side. On the $\frac{1}{2}$-inch and $\frac{1}{4}$-inch the 10,000-yard square could be used conveniently.

I would give references as at present in the 10,000-yard square. As letters and numbers on the face of the map are to some extent objectionable, I would identify these 10,000-yard squares by marginal letters and numbers applied to the whole series of squares over Great Britain. As there are not enough letters in the alphabet for this purpose, I would suggest using double letters, AA, AB, AC, AD, . . ., BB, BC, BD, etc. Thus a square would be referred to as 45 MT.

III. THE GRID IN CIVIL USE

Arthur R. Hinks, C.B.E., F.R.S., Sec. R.G.S.

The conspirators who have staged this discussion have cast me for the part of the man in the street ; but I am allowed to speak for the *intelligent* civilian. What use would the intelligent civilian make of a grid if he had it on his maps of Great Britain ? Colonel Winterbotham has already explained that a uniform grid extending unbroken over

the whole series of sheets of all the maps on different scales is extraordinarily useful—indeed essential—to the modern soldier, who uses it for (1) identification of points on the map, and transfer of a point from one map to another, perhaps of different scale; (2) for calculation of distance between two points; and (3) for calculation of bearing from one point to the other. The intelligent civilian would if he could—or will when he is taught how—use the same properties of the grid (for indeed I do not know that there are any other uses than these three), but he will use them for different ends and in different proportions. For example, I think that the civilian will not want to compute bearings as much as the soldier, though I shall have a remark on bearings for civilians later. On the other hand, the civilian will make a more extended use of grid references than the soldier normally does, and will tend rather, I think, to longer distances. Let us see how these tendencies may be met for the civilian.

Consider first the unit of measurement. Our non-decimal system of measures, our indiscriminate use of miles, chains, yards, feet, and inches in measuring distances, according as we are motorists, land surveyors, athletes, or builders, added to our ingrained expectation that so many inches on the map shall represent so many miles on the ground, make it impossible to please all parties at once; but so long as our maps remain on the inches-to-the-mile system (with the remarkable exception of the 1/2500, which employs for once a "natural" scale precisely where it is of least use), then I am inclined to think that our grid must be in inches, and give distances in miles. The civilian rarely uses yards above 1000, or feet for horizontal distances above a few hundreds except in geodesy, though for vertical distances he uses feet up to the stratosphere at any rate, and to the profoundest depths of ocean. It is true that he rarely decimalizes the mile, though quite accustomed to doing it for the inch; but, on the other hand, he would be equally unused to the decimal subdivision of Colonel Winterbotham's 10,000 feet. A thousand feet horizontal evokes no mental picture in the civilian's mind, nor does 100 feet: for such distances he thinks in yards. And so, if he has to be taught to use a grid, I believe he will find it simplest to measure the map in inches and decimals, for which the necessary tools are always to hand; and when he wants to translate the grid measures into miles, he will just have to learn to think decimally.

But by far the most common use of the grid will be for map reference. He will be given the coordinates of a signpost or lamp-post; of a house in Laxham Gardens or the Finchley Road; of a theatre in Soho; of a cemetery in ill-defined south-west London; a golf course in Surrey; an inn in the New Forest; a quarry in Dartmoor; a repair shop in the Highlands; and will want to locate it on his map, which may be quarter-inch, half-inch, one-inch, 1/20,000, six-inch, or 1/2500. No unit for the grid square can possibly give convenient-sized squares on all these

different scales. A grid of squares less than one inch obliterates the map ; and bigger than 4 inches is not very convenient. But we should note that if the grid is in inches or simple multiples of half an inch, the necessary plotting can often be done without special scales or coordinate cards. Thus, for example, an inch grid on the one-inch map, and a $2\frac{1}{2}$-inch (10 miles) grid on the quarter-inch map are convenient. For the half-inch map a 5-inch (10 miles) gives rather too large a square, though the edges or all the lines of the squares may be " ticked " or divided into half-inches without damage to legibility. But it would probably be better to have a $2\frac{1}{2}$-inch (5 miles) grid on the half-inch map, and tick off the inch divisions. An inch scale divided decimally would serve for more accurate plotting with a minimum of mental arithmetic.

It is perhaps worth noting that the existing 2-inch squares on the one-inch-to-the-mile map would serve civilian needs fairly well on this map, if they had been numbered as alternate lines of a mile grid instead of for area references on individual sheets.

Turn now to the origin and numbering of the grid. The Ordnance Survey is committed to the central meridian of Delamere, but would presumably adopt a fictitious zero away in the south-west to avoid negative signs. The capital city lies so far east that it cannot hope for the central meridian. So long as the sheet lines remain as at present it cannot even hope that either of the recognized " centres " of London, Charing Cross or the Cross of Saint Paul's, shall have a good round number as its grid reference. But I would urge that if it ever comes to re-drawing the map of Great Britain, it would be worth while, in the general recomputation that must take place, to shift the central meridian just enough to make a north–south grid line pass accurately through Charing Cross or Saint Paul's, and choose the origin so that the grid reference was something simple like 400,100. The grid for maps of London is so important that it is worth a little trouble to get it neat and appropriate.

At any rate, the full grid reference for Great Britain must involve whole numbers to three figures, besides the decimals, in each coordinate, and the zero should be so far south-westward that all coordinates in any part of Great Britain run into hundreds.

My feeling is that the civilian will use the complete and full map reference more than the soldier—or at any rate the British soldier—has done up to the present. The British military system confines its figures within a ten-unit square. These ten-unit squares are bunched together in 50 (not 100) unit squares, and the ten-unit squares are lettered with the twenty-five letters of the alphabet, omitting I. The letters therefore repeat after fifty units. The method has somewhat the aspect of an improvisation ; but it is illogical ; and if it works well for military needs, it seems to me quite unsuited for civilian use. No civilian can be expected to remember that the squares surrounding K, for example, are lettered

E, A, F, L, P, O, J, D, as we work round clockwise from the north. The letters in the centre of each 10-unit square ruin the appearance of the map ; and one hopes they will disappear. It is doubtless unnecessary to say that the grid must be an integral part of the projection. British sheets are rectangular, and the convergence of the meridians is so considerable in our northern latitudes that they are likely to remain so. Indeed, the introduction of the grid must almost inevitably kill the otherwise attractive sheet bounded by meridians and parallels. The meridians and parallels will remain more or less oblique to the sheet edges, to puzzle and mislead the uninstructed. But the grid must be square to the sheet-lines, and the sheet-lines must be grid lines. An oblique grid not fitting the sheet-lines would look too much like the early stages in another war. If the unit is the mile (or rather its equivalent upon the map) then the grid should be numbered in miles ; but as they will be reckoned from an arbitrary zero, it seems unnecessary to label them East and North, because that provokes questions about the arbitrary zero, best left unasked. Sufficient to print on each sheet that on the arbitrary scale the coordinates of St. Paul's or Charing Cross are so and so. The numbers should, I think, be engraved within the outer margin, or they look like an addition to, instead of an integral part of, the map ; and they should take precedence of the division in latitude and longitude. But this latter division should be retained ; and I think that it would be well if the precise geographical coordinates of the sheet corners were engraved at the corners, which would give information that has never so far been obtainable for British maps, and is useful in teaching. These coordinates depend, of course, upon the projection : a subject on which there is much to be said, but which is out of bounds on this occasion.

The grid introduces (or brings more conspicuously to light) a third kind of north : grid-north. It is desirable that the angular deviations of true and magnetic north from grid-north should be engraved on the east and west margins of the sheet, in figures rather than in the diagram hitherto used. The diagram was never big enough to measure accurately, and it was in the past sometimes found to be more conventional than accurate. A plain statement of the figures will perhaps in time eradicate the notion that the edges of O.S. sheets are " practically " north and south.

The civilian sometimes wants to lay out a meridian or other true bearing ; and developments of direction-finding and similar refinements of wireless may very likely increase the need for calculating azimuths. The grid, rightly and cautiously used, will assist. And similarly, calculations of the distances between coordinate points may become more common in future than they are now. But the principal use of the grid in civil life will be, I think, for convenient reference. We may look forward to the time when every signpost, bridge, railway station, post-

office, church, police-station, and letter-box throughout the country, every lamp-post and street corner in town, has an abbreviated map reference painted upon it; when all postal guides, directions, and every kind of summary of local information prints the grid references of post-offices, public telephones, fire-alarms, ambulances, or police-stations; of museums, theatres, libraries, banks, doctors, and dentists, and what not. The applications to local administration would be endless. There are many private addresses that badly need a map reference; and not a few public buildings. The advantages are perhaps most conspicuous in great centres of population; but they are no less real in the country. Properties for sale, historic buildings and ancient monuments to be scheduled, fossil or plant finds to be recorded, soil and mineral and water surveys to be indexed; they all come within the scope of a grid, and call for its establishment.

And may a civilian end by expressing the hope that one grid may be found sufficient for both military and civil needs? It is possible that the requirements of air defence may be the deciding factor, and that the great distances involved may require the mile rather than multiples of yards or feet.

In the above notes I have argued on the assumption that British maps will remain in terms of British measures, which forbid any really logical system. So long as this is so, it does not appear to me that a grid in metric units has any substantial advantages sufficient to outweigh its disadvantages. If ever the maps of the Ordnance Survey were re-drawn on " natural " scales, the grids would almost necessarily be metric. But that conversion is probably distant, if one may argue from past experience.

Finally, I should say that I have tried to picture the needs and the conveniences of the civilian, without much consideration of what may in the end prove to be the compelling factor: the necessities of the soldier and of the surveyor. No one, I think, would advocate the expense of a double series of gridded maps: one for civil and one for military use. And if military necessity overrides civil convenience, it will not be a great matter for the civilian. The primary need is the grid for reference, and the unit of measure of the grid is secondary. But if there should be a balance of opinion on the military question, then the civil convenience may turn the scale.

Before the papers the PRESIDENT (the EARL OF RONALDSHAY) said: The question for discussion this afternoon is that of the choice of a grid for British maps, to be dealt with by three speakers. Colonel Winterbotham will open the discussion and will deal with the question largely from a military point of view, and, what is of importance perhaps to some of us who are present this afternoon, he will explain precisely what a grid is. Then Colonel Jack will continue the exposition of the subject and will, naturally, deal with it largely from the point of view of the Ordnance Survey and discuss the type of grid

which might conveniently be introduced in the case of Ordnance Survey maps. Finally, Mr. Hinks will have something to say upon the matter, dealing with it from the point of view of the intelligent layman, and he will suggest to us those points which are likely to be of chief interest to the ordinary civilian user of maps. With these very few words of introduction I will now ask Colonel Winterbotham if he will open the discussion on the subject.

The papers printed above were then read, and discussion followed.

Sir CHARLES CLOSE : I have had the opportunity of reading the papers by Colonel Winterbotham, Colonel Jack, and Mr. Hinks, and I think I occupy a sort of midway position. In these papers some of the considerations affecting the construction of a grid have been clearly put ; but there are some others that might be emphasized. My own belief is that the public does not use the existing grid on the small-scale maps. That grid was put on for military needs and fulfils no civil purposes. It might be used if there were an index of names accompanying each sheet, as was suggested some years ago, though the war interfered with the carrying out of the project, so that there is now no such index. It also appears, from a civilian point of view, quite immaterial what the size of the grid square is. In fact, I doubt if the grid is used to measure distances, whilst on the 1-inch map the size of the grid is not mentioned on the sheet. The existing grid was put on entirely at the instance of the surveyors, there being no civil demand for it.

It is not possible to have a grid which will serve the purposes of small-scale maps and of large-scale maps, unless it is drawn askew on the large-scales. I mention that because Mr. Hinks quite naturally spoke of the convenience that would ensue if we had a system of coordinates for general maps. The large-scale maps, that is the 6-inch and 25-inch, are plotted on a large number of distinct meridians. Before the war we were reducing the number of those, but there are still in use in Great Britain some thirty-five distinct meridians on which the large-scale maps are plotted.

As regards small-scale maps the question of the grid is difficult to free from that of the projection, though I believe we have been warned that we may not say anything about the projection. Nevertheless, an opportunity may occur in the course of a few years of considering the question of the small-scale projection, and I should, therefore, like to say a few words on both subjects. The small-scale maps of Scotland are—or were, with the exception of the $\frac{1}{4}$-inch—plotted on Bonne's projection, and those of England and Wales on the projection by rectangular coordinates. You cannot fit the old-type 1-inch maps of England on to the 1-inch maps of Scotland. There is, of course, no difficulty in plotting Great Britain on one projection. Now, if, as appears to be the case, military requirements demand an orthomorphic map, the matter is very simple. The adoption of a transverse Mercator's projection along some selected meridian would give rise to scale errors of about the same size as those of the existing maps, only the error wonld be in two directions instead of one. The best central meridian would be that through Delamere Forest, or the meridian 2° W. of Greenwich—it is not very material which. We could put a negative error along this meridian and halve the maximum error, which would then be in the neighbourhood of 1/2000 ; that is, the maps would have a smaller maximum linear error than they have at present, and no local angular error. Then the grid could be continuous.

As regards the size of the grid, I am in favour of 10,000-yard squares with subdivision into 5,000 yards ; ten of these subdivisions would go to the

length of a sheet, and six or seven to the depth ; or, if the three to two proportion is still desired, the sides could be nine and six. The existing 1-inch sheets are awkward as to length and depth ; 47,520 yards by 31,680. An origin for numbering the grid would, of course, be chosen, as has been mentioned by Mr. Hinks, well to the south-west or south-east to avoid changing sign.

I believe that the alteration of projection and the adoption of a general grid for small-scale maps, in the strict sense, would be to the good from every point of view, and I do not think it would affect the public use of maps at all. But as regards the large-scale maps the matter is more difficult, although, of course, it would be possible to plot the orthomorphic grid on the large-scale Cassini. Nevertheless it would be rather cumbrous to look at.

Major-General Sir JOHN T. BURNETT STUART : I have a shrewd suspicion that I have been produced here by Colonel Winterbotham as a sort of military exhibit to illustrate the interest which the General Staff takes in the national grid. If so, that is a very proper use to have put me to. Exact systems of map reference are of the utmost importance to soldiers, and I often wonder how we got on for so long without them ; and if the Ordnance Survey can superimpose on their wonderful maps a national system of reference like that just described to us, I can see all sorts of ways in which it would be of the greatest use to the public as well. The ordinary citizen will not get used to it all at once, of course, and he may even look askance at it to begin with. It will be some time, I think, before the soldier can with confidence invite his young lady to meet him at 206,793 at 2020 hrs. But that will come in time.

Apart from the fact that a universal adoption of gridded maps will save the Army the expense of producing them specially for themselves, anything which brings ordinary public demand into line with the requirements of national defence is to the advantage of all of us. We have learnt by bitter experience what a national war means, and if war comes again—which it may do, however much we may try to avoid it—any knowledge of military value, such as accurate map-reading and reference, which the citizen can bring with him when called on to defend his country, will help us to carry on.

Mr. G. S. LAIRD CLOWES (Survey of Egypt) : To a stranger who has just come from a metric country this discussion has been extraordinarily interesting as exemplifying the endless difficulties involved in the use of decimal measures to meet the requirements of modern life. It is not a question whether the metre or the kilometre is a more convenient measure than the yard or the mile, but this whole discussion has really turned on the difficulties caused by the inconvenient relationship of the inch to the mile and the mile to the yard.

In the Survey of Egypt, very soon after the late war, it was decided that future maps should be gridded. With metric maps it was obvious that the unit of the grid must be the kilometre square with appropriate multiples and sub-multiples according to the scale used. After that, all that was necessary was a small amount of discussion as to the most convenient origin, the best positions for reference numbers, and such details. Further, the fact that the grid and the maps are metric and consequently decimal, has enabled Egypt to dispense with the old complicated key-maps, one for each scale, and the old method of numbering, also different for each scale. Under the grid system each map is named by the coordinates of its south-west corner, and one small-scale skeleton map with its grids forms a key-map for all maps on all

scales. A point whose coordinates are, for example, 1234 in one direction and 5678 in the other lies on sheet 12–56 of a smaller scale and on sheet 123–567 of a larger scale.

But now to leave Egypt and the easy way and to get to the question of a grid of England. Surely the only cause which could be so potent as to induce the Ordnance Survey to change its system of sheet-lines and re-draw its maps would be the demand either by the Army or civilians for maps on decimal or so-called "natural" scales. Until such a change should become necessary the question, surely, is simply the application of a grid to the existing Ordnance sheets as they stand.

The example of a 10,000-foot grid, which has been described to us by Colonel Winterbotham, would seem to have been chosen so that the facts might be stated with a complete absence of bias, for it is a grid which would seem to have no attractions for either the soldier or the civilian. I can only imagine that it might be supported by builders when they have learned the use of grids. Does not the question really lie between a mile-to-the-inch grid, which will fit the existing sheets and of which a skeleton already exists in the form of the 2-inch reference squares, and the 10,000-yard grid, which will give distances in a unit convenient to the Army? From all we have heard this afternoon, I think this last is a statement which may fairly be made. The mile grid gives distances in a convenient unit for civil life, but how often does the civilian want the difference between two points as the crow flies? Surely it is the road distance which he much more often requires, and on the Ordnance 1-inch maps that is given by the milestones on the main roads. To my mind, those milestones also form a scale conveniently distributed over the map and more convenient for approximate eye-measurements than the existing 2-mile squares, which last can only be used for eye-measurements in the direction of the cardinal points. Sir Charles Close has already told us that the introduction of these squares was a purely military measure, so I do not think I need say anything further about their civil importance. I had already noticed that they had only comparatively recently been introduced into the Ordnance maps, and that in the maps of Scotland they did not traverse the whole sheet.

Further, in some of the latest Ordnance maps the 2-mile squares do not exactly fit the sheet, or rather there is a row of half-squares down one or both sides. The fact that these sheets have been produced without objection ought to dispose, to some extent, of the suggestion that a grid, such as the 10,000-yard grid, which does not fit the sheet, would interfere with the popularity of the maps amongst civilians. Almost every atlas one opens has a different manner of subdividing its sheets for reference and a different method of reference to those subdivisions. Sometimes there are two numbers, sometimes two letters, and, more commonly, a combination of number and letter, but I defy any one present to tell me on what part of an unknown sheet the square E–10 or 5–8 will lie.

In view of this diversity and of the great adaptability shown by the man in the street in absorbing these different systems, may we not hope that he will in time be able to absorb and use for reference a system of 10,000-yard squares with coordinate numbering? I say advisedly "use for reference," for that is what civilians use squares for. One can believe that in a few years' time a man might say that his house lies in square 572–873; but from that to the stage where a certain lamp-post is normally referred to and identified by its exact coordinates, correct to yards, is a very far cry! So as it is the

yard which suits the Army as a measure of distance, and as it is to the fighting services alone that the maps of England can ever be of really vital, life and death importance, I as a civilian submit that the grid should be the 10,000-yard grid.

Colonel F. W. PIRRIE: I agree that the 10,000-yard grid seems to be the most suitable, subdivided according to the scale of the map. During the War I spent some years in Mesopotamia, and many officers came to me and said, "What is the true North on this squared map?" and it was often impossible to reply without reference to triangulation records or taking local observations for azimuth. In the case of all maps where latitude and longitude lines are not shown at intervals in addition to the grid, unless steps are taken to enter along the marginal lines and also along the central vertical line the true bearings of these lines, it is impossible for officers to find out readily and quickly what is true North at different localities in the sheets. I did not have any access to the letterpress of the papers, so it is impossible for me to say more. I can only add that I think that if we have a yard grid it will be a stepping-stone to a metric grid, if we require one later on. I think it would be a mistake to introduce a metric grid at the present time, because people are not accustomed to it.

Colonel WINTERBOTHAM: May I refer to two points which have arisen? We were told that a foot-grid could not have been suggested by a soldier. I suggested it myself! As a matter of fact, the War Office is quite ready to adopt a grid based on that unit, because the unit of the grid is not of intrinsic importance to the Army at large. Very few during the war used the grid as a measure from one point to another on the map, because, as was ably said by an earlier speaker, you very seldom do lie east or west or north or south of the point to which you want to get the distance. The unit in which the grid is defined is not then of vital importance to the man who is giving or reading a reference. The choice must in fact be dictated by the surveyor. In military work the grid is extraordinarily useful in so far as it helps the gunner or the sapper to do his local surveys, perhaps for gunnery purposes, perhaps for some engineering undertaking, and to fit them into the existing trig. work of the area of operations. It is a unit suitable for such purposes which is wanted for a national grid. The foot is the national survey unit, but if it suits the Ordnance Survey and the civilian better to use yards, then we shall be willing to have the grid in yards. All we want to do is to get a grid which soldiers and civilians alike can use, so that if the occasion arises we shall all of us know all about it.

The PRESIDENT: If no one wishes to add anything further to the discussion, I will express the gratitude of the meeting to Colonel Winterbotham, Colonel Jack, and Mr. Hinks for the lucid manner in which they have put these questions before us, each from his particular point of view. Colonel Winterbotham has dealt with the matter mainly from the military point of view, and nobody, I feel, can have any doubt as to the essential importance of a grid to the Army. My own feeling with regard to the man in the street is that he will require a good deal of educating in the matter before he takes very kindly to a national grid. It is quite true that his spokesman this afternoon, Mr. Hinks, discoursed with great intelligence upon this subject, but I think the man in the street who listened to his mouthpiece must have felt as gratified as surprised at the knowledge which he possessed of the subject. No doubt the time may come when the man in the street will see the practical advantages of the use of this particular device to assist him in reading his

map, but, as I say, I think that time has hardly come yet. Therefore I am sure that the discussion this afternoon has done a good deal to throw light upon this subject, and we have certainly had interesting points of view placed before us in connection with it. Every one here is most grateful to the three authors of the joint paper for the time which they have given to placing it before us, and I express our gratitude to them.

The Geographical Journal, Vol.65,no.1, January 1925, p.78

The Quarter-sheets of the Six-inch O.S. Map.

THIS Society had been asked by several persons and associations to join in the protest against the withdrawal from publication of the 6-inch quarter-sheets: but after hearing the explanation of the Director-General the Council did not feel that it was a matter in which they could properly intervene. We are now informed that it has been decided to resume publication of these maps in quarter-sheets, and those counties which have been republished recently in full-sheet form will revert to quarter-sheet form on a reprint or revision, whichever occurs first. We understand that the original decision was taken entirely for reasons of economy in printing, storage, and distribution, and trust that the reversal of this policy is made possible by the liberality of the Treasury.

The Geographical Journal, Vol.65, no.2, February 1925, pp.160-162

Ordnance Survey of Scotland, "Popular" Edition. One-inch map. Sheets Nos. 90, 91, and 93. *Price* 1*s.* 6*d. each.*

Conventional Signs and Writing for the Revised One-inch Map of Great Britain (Popular Edition), 1924. *Price* 6*d.*

Index to the Popular Edition Sheets of Scotland, 1924. *Price* 2*d.*

The one-inch "popular" Ordnance Survey maps of Scotland are just beginning to appear, and are worthy of particular note because they are so happy a blend of traditional symbol and technical progress. The Scottish small-scale maps have always had their own distinctive features. For example, they have, in the past, been on Bonne's projection whilst the English were on Cassini's. The lettering too has been distinctive and more attractive. No doubt the experience of carrying a new style over England shows where change is advisable on beginning Scotland, and then again Scotland must always be a temptation to the cartographer with its special opportunities of mountain, loch, and forest. The popular edition, on reaching Scotland, is but following precedent in its introduction of modification.

Perhaps the most important divergence from tradition is in the alteration of projection. The whole of the one-inch map of Great Britain is now to be