H. E. SOPER.

MEANS FOR COMPILING TABULAR AND STATISTICAL DATA.

APPLICATION FILED JULY 23, 1918.

1,351,692.

Patented Aug. 31, 1920.

2 SHEETS—SHEET 1.

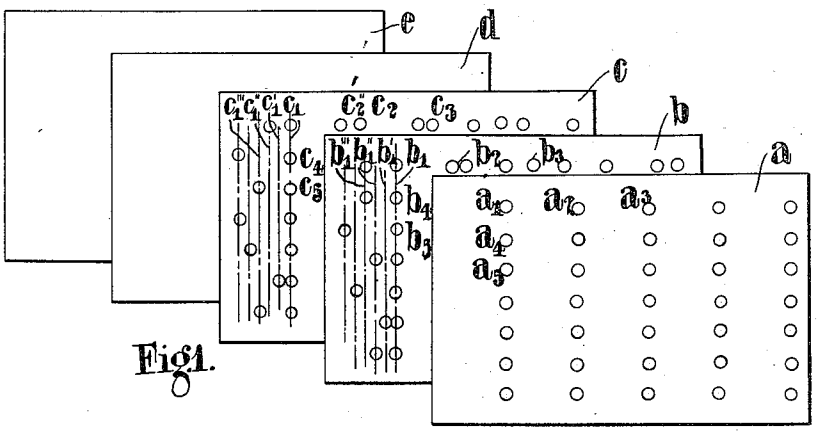


Fig.1.

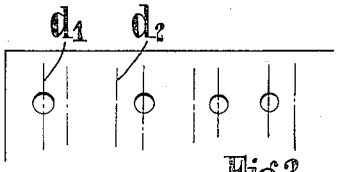


Fig.2.

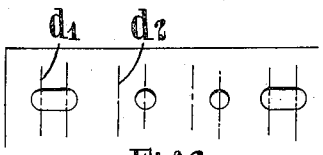


Fig.3.

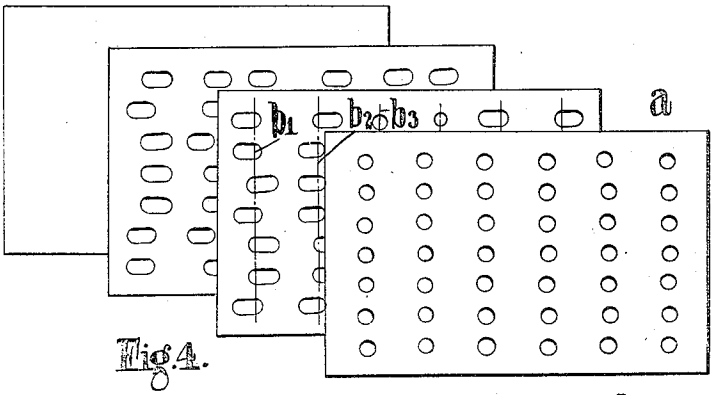


Fig.4.

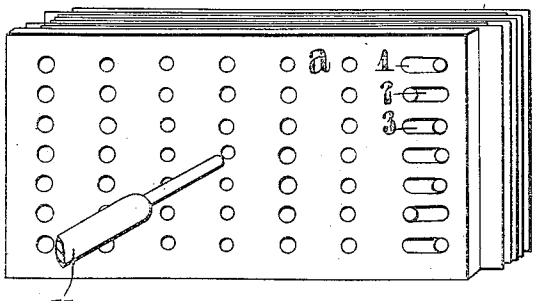


Fig.7.

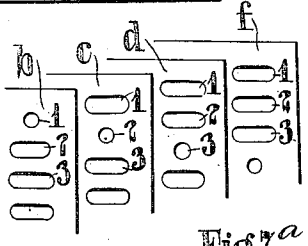


Fig.7a

INVENTOR

H. E. Soper.

BY H. P. Hosbake.

ATTORNEY

H. E. SOPER.

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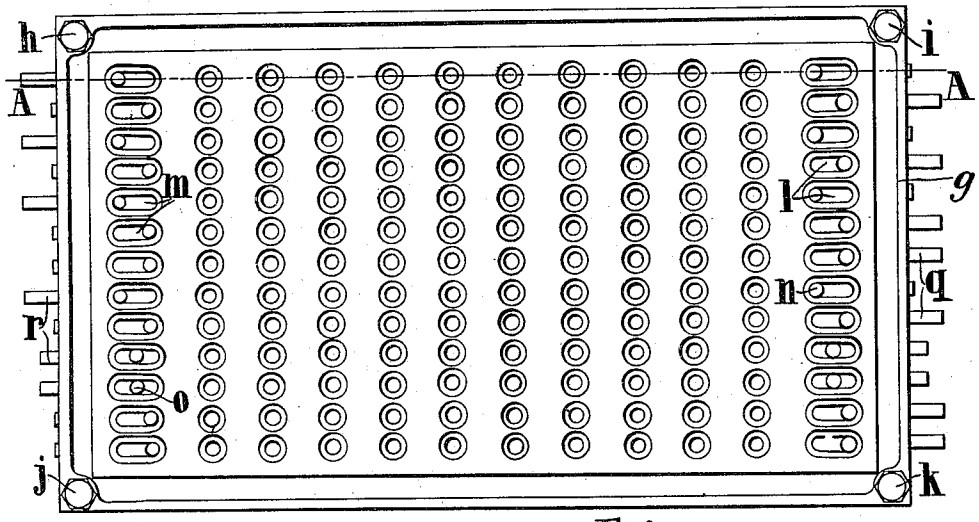


Fig. 5.

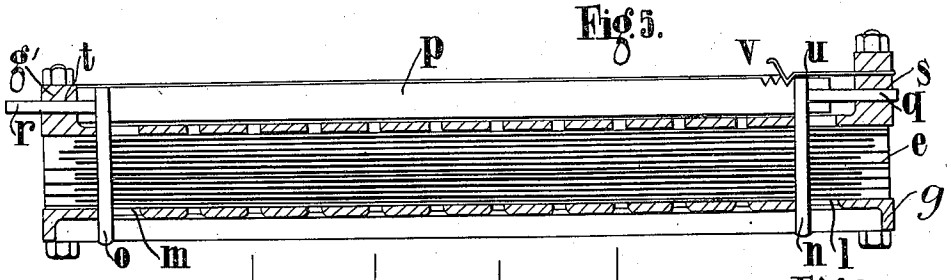


Fig. 6.

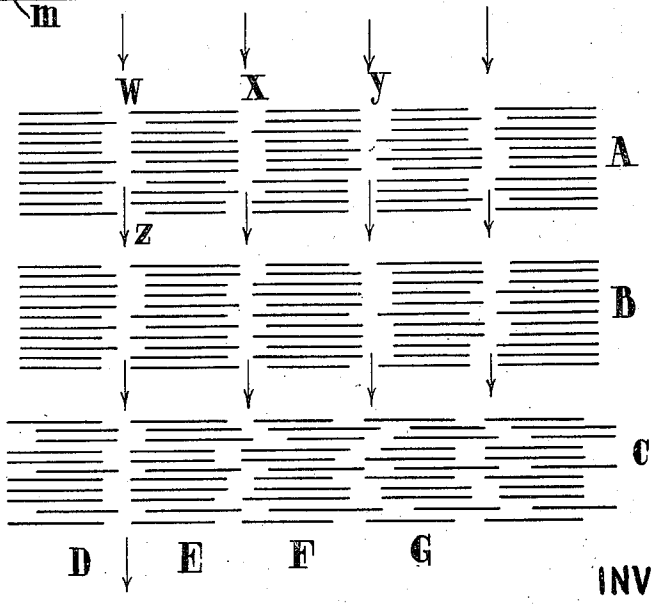


Fig. 8.

INVENTOR

H.E. Soper.

BY L.R. Kerslake.

ATTORNEY

UNITED STATES PATENT OFFICE.

HERBERT EDWARD SOPER, OF LONDON, ENGLAND.

MEANS FOR COMPILING TABULAR AND STATISTICAL DATA.

1,351,692. Specification of Letters Patent. Patented Aug. 31, 1920.

Application filed July 23, 1918. Serial No. 246,372.

To all whom it may concern:

Be it known that I, HERBERT EDWARD SOPER, a subject of the King of Great Britain and Ireland, and residing at 8 Causton road, Highgate, London, N. 6, England, have invented certain new and useful Improvements in the Means for Compiling Tabular and Statistical Data, of which the following is a specification.

My invention relates to compiling data when this is of the kind in which each successive case or entry is expressible in terms of the alternative categories of a limited number of characters.

There appear to be two distinct purposes for which such data is compiled and I have in view both of these purposes in devising my instrument.

First, the instrument may be required for the purpose of identification and used for this end it may be called an index or table.

Thus, an event, a book, a person, an invention, a legal case, a scientific investigation, may have several classifications as date, place, subject matter or other characteristics and the searcher knowing all, or it may be some only, of these characteristics may require by consulting the index to arrive at the individual object of his search or ascertain, it may be, the other particulars. Where the classifications are numerous, the known methods for securing this end, as the multiple entry index or the card index, are cumbrous in their compilation and laborious in their use.

Second, the purpose to be served may be of a statistical nature and the instrument will in this instance be called upon to give the counts of the cases falling within the various categories, taken singly or in combination. The known methods of putting the data upon cards, each card representing a case or entry, and afterward sorting the cards, have drawbacks when the number of cards is large. Both the sorting operations and the counting operations are difficult and either necessitate considerable manipulation of the cards or else suffer from the uncertainty of the operations, which are not positive in their nature but depend, for the correct return of the statistics, upon the precarious sliding of individual slotted cards, keyed in a stack, under the motive force of their gravity or momentum alone.

My data compiling instrument serves either of the two purposes above mentioned and has for one of its objects to render the recording operation of a simple nature. This may be said in my invention to comprise the drilling of a single hole in its serial position upon the face of the instrument.

Another object is to reduce to their simplest terms the operations of sorting, observing and counting, and to render these certain and reliable. The leaves employed in my instrument are all positively held or positively moved in the sorting operation and the various cases may appear thereafter simultaneously as distinct and separated points of light distributed over the face of the instrument, thus rendering extremely simple the operation of counting. In neither the recording nor the observing operations are leaves removed from the apparatus, nor are they at any time free to move by gravity or impulse.

A further object I have in view is to economize the material upon which the records are made and this is attained in virtue of the need for removing the leaves having been obviated and also the need for any mechanical card selecting agency. Thus the leaves do not require to be made specially robust or heavy as is the case to adapt them to the methods of sorting and counting as hitherto practised.

My invention may be briefly described as comprising a number of character bearing sheets held one against the other in a file, all of which sheets coöperate to record the particulars of any single entry in the manner now to be explained.

Each sheet is normally held by positive means in what will be called its first position, but each sheet may be moved independently of the remainder by positive means into a second position near to the first, or into a third or into ulterior adjacent positions, if in certain modes of classification this is desirable. Each position, or in some cases each position after the first, answers to a category or division of the character which has been allotted to the sheet and the combination of categories of the several characters which belong to the case or entry are reproduced in the file by appropriate displacements of the component sheets. When these positions, appropriate to the entry, have been assigned to the various sheets, a hole is drilled through the assemblage of severally displaced sheets at a point upon the face following in serial order the previous entries. The succes-

sive points, corresponding to the series of entries, are disposed at suitable equal intervals in row or column or in row and column, and determined, if desired, by a perforated metal plate fixed to the immovable parts or frame of the instrument and covering the face.

It will be apparent that if after the data are compiled the sheets are moved into any positions indicating a combination of categories, those cases will be brought to view which bear that complex, being distinguished by clear holes through the file, which may be rendered easily visible by a white or luminous screen placed at a short distance behind the file.

No other holes but those appertaining to such cases will appear, provided, of course, as is presupposed, that the rows and columns are spaced at sufficient distance to prevent the holes proper to one point or perforation coming under the adjacent points.

In the compilation of such data as mathematical tables, the first and second position for each sheet will, in many uses of the instrument, be sufficient, for it is clear that any number may be expressed in the binary scale, comprising only the two digits 0 and 1 in each order. A sheet answering to any order may therefore express 0 in its first position and 1 in its second position.

In other data it is convenient to reserve the first position as a null indication. The sheets are all returned initially to their null position and holes are drilled at every point in row and in column. The second and further positions indicate the categories; and when these are known only in part, or where in statistical work counts of wider classes are required, those categories which are unknown or are ignored, (since their sheets are in the null position) do not obstruct the holes but allow the search or other processes to be carried on as if the character were not recorded.

I prefer two positions besides the null position for registering the more general class of data, for not only are a great many classifications double (as male female, married single) but merely antithetical (as deaf not-deaf), but categories of three or more alternatives are readily reduced to binary classifications as has already been explained in the case of numerals, and it will contribute to economy to increase the number of sheets and allow each the same number of positions rather to increase the distance between rows or columns (and so reduce the capacity of the file) for the sake of a few characters with an exceptional number of alternative categories.

Whatever the number of positions into which my sheets may be moved, it is evident that the amount of displacement from one position to the next needs only to be a little greater than the diameter of a hole, the purpose being to expose a new portion of the sheet to the perforating instrument applied at the point.

When my instrument is used as an index or table it may be required to yield the full particles of any case which has been identified by certain of the particulars, or directly by its serial position in the array of points. This can be accomplished by displacing the sheets in order, from the nearer to the more remote, so as successively to expose to view the holes in the several sheets, and to expose finally the clear hole through the file as originally drilled. The several displacements which are observed to have been made will then indicate into which category of each character the case falls.

I prefer, however, to arrange the registration in the following manner for recovering the full classification of an entry: I employ besides a null position, a second and third position only, and I dispose these one on either side of the null position so that a sheet will register which of two alternative categories of the character a case falls into by a small displacement, say alternatively to right or to left of the null position. The hole then made I run into the null position hole so as to form a slot or extended hole. The register on each sheet will now take the form of a number of short slots each extending either to right or to left of a central null hole identifying a case. By placing a style through the file of sheets at the position allotted to the individual whose characteristics are sought, these sheets can be displaced, each either to right or left, according to the direction of the recording slot, the contrary motion being hindered by the style, and such permitted displacements being ascertained, determine the full particulars of the individual that have been recorded.

In order that my invention may be more clearly understood, reference is now made to drawings:—

Figure 1 in which the sheets composing a file and the index plate thereof are shown extended.

Figs. 2 and 3 are part views of individual sheets showing different ways in which the sheets may be perforated.

Fig. 4 is a perspective view of a plurality of sheets composing a file adapted for recording the more general class of statistical data.

Fig. 5 is a front elevation of a complete instrument in accordance with the invention.

Fig. 6 is a corresponding section.

Figs. 7 and 7[a] are views illustrating the means employed for moving the sheets in the file illustrated in Figs. 5 and 6.

Fig. 8 is a diagrammatic view showing how a plurality of instruments may be ar-

ranged one behind another in order to economize space.

In Fig. 1 illustrating one method are shown the character bearing sheets, b, c, d, parted and seen in perspective to display the perforations therein, recording upon each sheet the data appertaining to the several individual entries in respect of the character borne by that sheet. The manner of making the perforations appropriate to each entry will now be described.

The sheets are supported by suitable means and can be retained one against the other and against the metal plate or cover a perforated upon its face with holes a_1, a_2, a_3, a_4, etc., at suitable equal distances in row and in column, such position holes being severally allotted to the individual cases entered from the statistics. The sheets can also be moved separately, by suitable means, and in the case illustrated, each can be displaced at will a distance of one, two, three, four or five steps to the right from its initial position.

When in their initial or null positions, the sheets are perforated through their mass by means of a drill set square to the surface of the plate a and directed through each hole upon its surface in succession. The sheets b, c will therefore receive holes in like positions to the holes in the plate and these are indicated at b_1, b_2, b_3, b_4, c_1, c_2, c_3, c_4, in the drawing where the sheets have been distended for view.

It follows that clear holes appear through all the entry positions when the sheets are all in their null positions and moreover, any sheet which is left in its undisplaced position will allow the passage of light through the holes in the subsequent working of the apparatus as if the sheet were not there.

It is next necessary to pre-arrange which of the characters are to be shown by the several sheets and which divisions shown by the several displacements of each sheet. By way of illustration we may suppose that the first sheet registers occupational class and that this character has five divisions to which will answer displacements of the sheet, one, two, three or five steps. The second sheet may register health in five grades and the third nationality and so on. If there are more than five categories of any character, two or more sheets may be reserved for recording all the divisions of such a character in the form of the apparatus now illustrated.

The entries from the statistics may now be recorded and we will suppose that the first individual, to be entered at a_1 is placed in the third division of the occupational classes. The first sheet b, recording occupational classes, is displaced three steps to the right and retained there. The individual, according to the data, possesses, let us suppose, the second grade of health. The second sheet c recording health must then be moved two steps to the right. When all the sheets which correspond to data recorded of the individual have been in similar fashion displaced each the number of steps appropriate to the classification of the individual, a hole is drilled through the mass of so displaced sheets at the position a_1. The perforations resulting from drilling the severally displaced sheets are illustrated in Fig. 1 at b_1''', c_1'', the first three steps from the null hole b_1 and the second four steps from the null hole c_1.

The next individual is treated in like manner and when the sheets have been appropriately displaced a hole is drilled at the second position say a_2.

When all the individuals have had their classifications transferred to the register at the positions a_1, a_2, a_3, a_4 . . . appointed to them, the apparatus is ready for use either for counting or identifying as the case may be.

For example, if it be desired to count all the individuals in the third occupational class, who possessed the second grade of health the sheet b must be put in its third displaced position and the sheet c in its second, and the remaining sheets must be returned to their null positions. All such individuals, among whom will be the individual a_1, will then be brought to view by having clear holes through their positions, while other individuals, as for example b_4 who may possess one of the characters, in this instance, occupational class, but differ in another as in health grade, or individuals as b_5 who differ both in occupational class and in health grade, will by virtue of these differences oppose one or more obstructing sheets to the clear passage through the holes a_4, a_5 and the clear holes in the undisplaced sheets d, e, etc. The number sought is therefore the number of clear holes through the file which may be readily counted by the eye.

The further particulars of any individual sorted out in the manner above described may be ascertained for identification by moving each of the remaining sheets in turn one step at a time from its null position until the sheet is in the position to admit light through the record hole. In this way the sheets will have been brought back to the positions given to them when the record was made and the full particulars thereby ascertained.

In Fig. 2 is illustrated the type of perforations upon a sheet in an instrument used as a mathematical table, the recorded numbers being expressed in the binary scale. The successive values of the argument or arguments are marked against the position holes

a_1, a_2, etc., on the face of the file and the sheets record the values of the corresponding function in this scale. As an example, the holes may be marked with the numbers 1, 2, 3, etc., to 10000 and the sheets may record the logarithms of those numbers. Since the logarithm of 2 expressed in the binary scale is .010011 . . . the first sheet recording 0 is left in its first position, the second recording 1 is displaced one step to the right, and so on, before the drilling of the hole at position marked 2. Since every digit is 0 or 1 in this scale, and the digits are supposed to be all known and all used, the leaves need to have one displaced position only and the register appears as a hole either in the first or in the second, that is, the displaced position. In the illustration 1 is registered at d_1, and 0 at d_2.

In Fig. 3 the holes which express the digit 1 in the sheet illustrated in Fig. 2 are shown as slotted back to the 0 position. By this expedient the recovery of the record is facilitated. The sheets are first all returned to 0 when clear holes will appear through the file at every position upon the face of the plate. The position hole marked with the given argument being found, a style H is inserted as may be seen by reference to Fig. 7 and the several sheets urged to the right. Those sheets which are free to move report the digit 1 in their orders. Those which are held by the style report 0.

In Fig. 4 is illustrated the preferred manner of recording the more general class of statistical data, adapted for sorting out all the individuals possessing one known character or any combination of known characters and at the same time adapted to the easy recovery of the data appertaining to any selected individual.

Each sheet has two positions only besides the null position, one on either side thereof, recording two alternative categories and the holes corresponding with the null position and the record are run together to form a slot. As shown at b_1, the slot comprises the null hole and the record hole obtained by a displacement of the sheet to the right. As shown at b_2 the slot comprises the null hole and the record hole obtained by a displacement of the sheet to the left. As shown at b_3 the record is wanting and the null hole only appears. Where the categories are more than two in number as for instance in "age in years" in which classification the number of categories may exceed one hundred, these are enumerated in the binary (or in this manner of recording it may be the ternary) scale and a sheet employed for each order that may be required. For example, since $2^7=128$, seven sheets will suffice to particularize the age in years of any individual and since 92 is expressed in the binary scale by the digits 1011100 this age will be recorded against an individual by a displacement of the third, fourth, fifth and seventh order sheets, say to the right and a displacement of the first, second and sixth order sheets to the left.

The slots enable the particulars of any individual to be quickly aescertained by the insertion of the style as already explained in reference to the sheets illustrated in Fig. 3, and by the thrust of the individual sheets, in this case either to the left or to the right, as permitted by the style. It is apparent that this expedient cannot be employed in records arranged as illustrated in Fig. 1 since in this case a slot joining the record hole of a larger category, as for instance the hole b_1''' to the null hole will in effect produce perforations at the record points b_1', b_1'', of the smaller categories and so falsify the indications of the instrument used for sorting. It will be clear that in order to permit the use of the slot for recovering individual data without falsifying the sorting indications in the manner explained, it must be a condition that the sheets are allowed a displacement of one step only in one direction from the null position and recourse must be had to two or more sheets for recording characters whose alternative divisions are greater in number than the directions from the null position in which the sheets are arranged to be displaced.

Figs. 7 and 7ª illustrate convenient means for moving any sheet at will independently of the remainder and in particular for giving the displacements required in the method of tabulation described in reference to Fig. 4. The cover plate a, Fig. 7, has short marginal slots 1, 2, 3 and the several sheets b, c, d, f, etc., have longer marginal slots 1, 2, 3, etc., behind the cover-plate and shown parted in Fig. 7ª to register with those in the plate with the exception that the first sheet b has a central hole 1 in place of the first or top slot; the second sheet c has a central hole 2 in place of the second slot from the top, and so on. When the sheets are assembled behind the plate with the slots in register with those in the plate, any single sheet, for example the third sheet d, can be moved to right or left by inserting a pin not shown in the hole 3 of d which will appear in the middle of the slot 3 of the plate a, and urging the pin to right or left. The remaining sheets b, c, f, etc., will not be displaced by the pin in virtue of the slots in them at the position 3.

Fig. 5 shows in elevation a complete instrument made in accordance with the invention and arranged to record the data in the manner described in reference to Fig. 4. Fig. 6 is a section through A—A of Fig. 5.

The sheets e which may be of thin metal are contained between two flanged metal plates g, g', clamped at suitable distance by

bolts *h i j k*. The metal plates are provided with a large number of small holes in true register arranged in rows and columns the distance between columns being rather larger than the distance between rows. These holes are arranged in close proximity since their number determines the number of entries that can be made upon the register. They are shown at a_1, a_2, a_3, a_4, etc., in the illustration exaggerated in size and in spacing distance. Marginally, on either side, the plates are perforated with slots *l*, *m*, which are alined with the rows of holes. The sheets also, on either side, have marginal slots or central holes, in the manner and for the purpose described in reference to Fig. 7. The central holes at either end of a sheet are engaged by pins *n*, *o*, passing through the slots in the sheets and plates and the two pins are rigidly connected together by a thin metal strip *p* on the upper side of which they are welded. The thin strips thus lie between the rows of holes and do not impede the passage of light through the holes. The strip is supported by the pins *q r* attached to its ends and sliding in the holes *s t* in the flange of the back plate. The sheets are thus supported, in the instance illustrated, by the pins *n o*, and by moving one of the pairs of these pins to right or left by pressing on pin *r* or *q* the engaged sheet, in this case the first sheet, is displaced to right or left independently of the other sheets, which are not so engaged by said pair of pins *n o* in virtue of the slots or larger perforations in them. The three positions central (or null), right and left of the pins are accurately determined and secured by the pawl or spring *u* which engages one of the three notches *v* in the strip *p*.

The data are recorded and the slots formed in the manner already described in reference to Fig. 4. The sheets are displaced to right or left by the aid of one of the pairs of pins—*n*, *o*—by pressing the pins *r* or *q* owing to the connection of the metal strip, *p*, or left central, in accordance with the characters given for the individual and a hole is drilled by a suitable drill or rimer through the file at the position of entry allotted to the individual. While the drill or rimer is spinning the sheets are returned to their null position by the pins—*n*, *o*—by which means the slots are conveniently formed.

The complete data being recorded, the instrument may be used for statistical counts. Certain sheets are displaced by the pins answering to the combination of characters to be sorted out and the remaining sheets are left in their null positions. The individuals reporting these characteristics are thereupon instantly disclosed by the passage of light through the clear holes answering to the individuals and the number is quickly counted. A luminous screen put at the back of the instrument and a frosted glass plate held against the front or face will assist this operation.

Or the instrument may be used in the manner of an index for the purpose of searching out an individual entry whose characters are known or, it may be, known in part only. The known characters are set up and the individuals possessing these brought into view. The further particulars, if any, recorded by the instrument may then be ascertained for each of such individuals in turn by the explained use of the style and pins. Such further particulars may suffice to identify the individual searched for, or this may be arrived at by the direct examination of some individuals reduced now to a small number by the aid of the instrument.

It will be appreciated that the method of search by combined characters which my instrument permits possesses great advantages in expediting the work over systems of indexing employing cross references or multiple entry. At the same time, since each datum is recorded once only the end is attained in an economical manner and with little cost in space and material.

In Fig. 8 is shown how my instruments may be arranged to economize space where very large numbers have to be dealt with. Where the numbers are such as to require the use of two or more files, these are arranged one behind the other with the holes in the cover plates alined. Any one file can be searched without obstruction by the remainder since the rays of light will pass through the holes in such remaining files when their sheets are returned to the null positions.

This is illustrated in the figure which shows diagrammatically a horizontal section through the alined rows of holes in three files placed one behind the other. The lines represent the sheets and the discontinuities in them, the slots in the sheets recording the data in the manner described in reference to Fig. 4. The sheets of the file A and of the file B have all been returned to their null positions and clear holes appear in every entry position on the faces of the files as illustrated at *w x y z*. The file C is in use and the sheets having been displaced as shown, the individual D is brought to view by having a clear hole through his position, while the individuals E F G are obscured. The light by which the individual D is identified passes through the clear holes *w z* in the files A and B which therefore do not affect the use of the file C. In similar manner the file B can be searched without obstruction by A and C.

Other means for dealing with large num-

bers of entries may be employed. Thus for instance I may use rolls of thin paper and provide perforations upon their margins for feeding them into a counting frame as described above and for giving the requisite displacements to the individual sheets.

It will be understood that I do not of necessity hold the several character-bearing sheets in contact with one another since, as was explained in reference to Fig. 8, the rays of light are transmitted or alternatively obscured when the sheets are in register at whatever distance they may be separated one from another.

Again, it will be understood that other displacements of the sheets than those described are open to choice for expressing the divisions of the characters. For example, a sheet may be displaced in its own plane from right to left and also in its own plane in a direction at right angles to this, if suitable supporting and displacing means are provided.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. Means for compiling data of the kind specified, comprising a number of sheets superposed in a file, each sheet answering to a character into one of whose alternative categories and individual entry from the data may be placed; means for giving definitive displacements in its plane to each sheet at will without displacing the other sheets, such displacements by their distances and direction answering in predetermined manner to the several categories into which the character borne by the sheet is divided; said sheets having successive entries recorded thereon by means comprising a single hole extending through the mass of sheets when these have been given the displacements appropriate to the classification of the entry, said entries being distinguished by their position in serial order upon the face of the file.

2. Means for compiling data as claimed in claim 1, in which a null position is provided for each character-bearing sheet and holes are drilled through the sheet at every entry position, when the sheet is in its null position for the purpose described.

3. Means for compiling data as claimed in claim 1, in which a perforated sheet or plate or a pair of perforated plates covering the file of sheets is provided for the purpose described.

4. Means for compiling data as claimed in claim 1, comprising sheets provided with perforations at selected points other sheets provided with larger perforations and pins passing through the larger perforations and engaged in the smaller perforations in such manner that the desired movement of a sheet to be selected may be effected by means of the pins engaged in the smaller perforations without moving the remaining sheets in the file.

5. Means for compiling statistical data as claimed in claim 2, in which the holes indicating the characters are connected with the holes corresponding with the null position so as to form a slot in order that a style may be used for recovering the data, substantially as described.

In testimony whereof I have signed my name to this specification.

HERBERT EDWARD SOPER.