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THE
MECHANISM OF STATISTICS.

BY
ROBERT E. MATHESON,
BARRISTER-AT-LAW,

Secretary to the General Register Office, and Assistant Registrar-General ; Secretary
to the Census Department, and one of the Commissioners for taking the
Census of Ireland in 1881.

[Read before the Statistical and Social Inquiry Society of Ireland.]

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PRINTED BY ALEX. THOM & CO. (LIMITED), 87, 88, & 89, ABBEY-ST.
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It has fallen to my lot to serve in a Department where every variety of statistical work is to be found, and where the practical problems of how information is to be collected, tabulated, and published at a minimum expenditure of time, labour, and cost, have to be solved.

As public attention has been much directed recently to this subject, especially in connection with the approaching Census, it has occurred to me that it would be a useful service to embody in a paper the results of many years thought and practical experience in the manipulation of figures, and that such a work might not only be acceptable to Statisticians in these countries, but helpful to the many statistical authorities in foreign lands.

Your distinguished President, Doctor Grimshaw, Registrar-General and Chief Census Commissioner for Ireland, has kindly expressed his approval of my project and encouraged me to undertake the work.

I offer my contribution therefore, not by any means as an exhaustive treatise on the subject, but in the hope that it may lead to the reciprocation of ideas and the comparison of methods of working, and thus conduce to the interests of statistical science.

Houses of the Oireachtas

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PLATE II.—Occupations Tabulation Sheet, with appliance of Folding Flaps, devised by Mr. Matheson.

PLATE III.—Tate's Improved Arithmometer.

PLATE IV.—Slide Rule arranged by Major-General Hannington.

Examples of Tabulation Processes Resolved into Enumeration Work.

EXAMPLE I.—AGRICULTURAL STATISTICS, IRELAND.

SECTION OF ENUMERATOR'S SUMMARY FORM USED PRIOR TO 1885 WHEN CLASSIFICATION OF HOLDINGS WAS DONE IN CENTRAL OFFICE.

No. on Form A.	Parishes.	Townlands.	No. of Holdings in each Townland.	Area of Townland in Statute Acres.

SECTION OF ENUMERATOR'S SUMMARY FORM NOW IN USE WHERE CLASSIFICATION OF HOLDINGS IS DONE BY THE LOCAL ENUMERATORS.

No. on Form A.	TOWNLANDS.	NUMBER OF HOLDINGS IN EACH TOWNLAND.									Total Number * of Holdings.	Area of Townland in Statute Acres.
		Not exceed- ing 1 acre.	Above 1 and not exceed- ing 5 acres.	Above 5 and not exceed- ing 15 acres.	Above 15 and not exceed- ing 30 acres.	Above 30 and not exceed- ing 50 acres.	Above 50 and not exceed- ing 100 acres.	Above 100 and not exceed- ing 200 acres.	Above 200 and not exceed- ing 500 acres.	Above 500 acres.		

EXAMPLE II.—CENSUS OF IRELAND.

SECTION OF ENUMERATION FORM FOR HOUSES USED IN 1871 WHEN CLASSIFICATION OF HOUSES WAS DONE IN CENTRAL OFFICE.

HOUSES.						
Walls, whether of Stone, Brick, Timber, or Mud.	Roofing, whether of Slate, Tiles, Thatch, or other Material.	No. of Stories, including Basement.*	No. of Rooms.	No. of Windows in Front.	Total No. of Outside Windows.*	Class of House. [This Column will be filled in the Census Office.]
(3.)	(4.)	(7.)	(8.)	(9.)	(10.)	

* The particulars in these Columns were not taken into account in estimating the Class of House.

SECTION OF ENUMERATION FORM FOR HOUSES USED IN 1881 WHERE CLASSIFICATION OF HOUSES WAS DONE BY THE LOCAL ENUMERATORS.

PARTICULARS OF INHABITED HOUSES.					
WALLS.	ROOF.	ROOMS.	WINDOWS IN FRONT.	Tot the Figures you have entered in columns 6, 7, 8, & 9, and enter the Total for each House in this column.	CLASS OF HOUSE.
If Walls are of Stone, Brick, or Concrete, enter the figure 1 in this column; if they are of Mud, Wood, or other perishable material, enter the figure 0.	If Roof is of Slate, Iron, or Tiles, enter the figure 1 in this column; if it is of Thatch, Wood, or other perishable material, enter the figure 0.	Enter in this column :— For each House with one Room only, the figure 1; For Houses with 2, 3, or 4 Rooms, the figure 2; 5 or 6 " " 3; 7, 8, or 9 " " 4; 10, 11, or 12 " " 5; 13 or more " " 6	State in this column the exact Number of Windows in Front of House.		When Total in Col. 10 is :— 1 or 2, enter in this Col. "4th" 3, 4, or 5, " " "3rd" 6, 7, 8, 9, 10, or 11, " " "2nd" 12, or over, " " "1st"
(Col. 6.)	(Col. 7.)	(Col. 8.)	(Col. 9.)	(Col. 10.)	(Col. 11.)

THE MECHANISM OF STATISTICS.

CHAPTER I.

COLLECTION OF INFORMATION.

STATISTICAL INFORMATION is collected under very varying circumstances. In some cases it is obtained from Records permanently kept by Government or Local Officers, in some it is collected orally from the public and reduced to writing by the enumerator, while in others it is obtained in writing from the public in returns specially furnished.

The principal collections made in the General Register Office, Dublin, illustrate these several conditions.

Information obtained from Permanent Records.

In the case of the vital statistics, the information is recorded from day to day in official registers kept by regular officers acting under statute and having jurisdiction for recognized districts. The copies of these records are transmitted at stated intervals in obedience to fixed regulations to the Central Office, where the particulars required are extracted by skilled statistical operators, and the machinery when once started requires but little change.

The publications intended to convey prompt information regarding existence of disease and sanitary requirements, are compiled from special abstract returns furnished from the records by the local officers at stated periods, and when the forms and instructions for these returns have once been settled, the difficulties in getting them out to date are matters of administrative rather than statistical concern.

This, so far as collection is concerned, is the simplest form under which information is obtained.

The great requisites are :—

1. Accurate lists of component parts of districts.
2. Maps.
3. Forms with clearly defined headings.
4. Definite instructions as to filling and transmission.

During the earlier years of registration in Ireland some confusion prevailed amongst Registrars as to the limits of their respective districts, and births and deaths were in some cases registered in wrong districts. This defect came under notice in 1873, and was remedied by the construction, at my suggestion, of official lists of the component parts of

each Registrar's District, which now form a fixed standard for reference. The lists show the names of all the Townlands in the District, together with the Electoral Divisions, Baronies, Parishes, and Counties into which it extends.

Information obtained orally.

The case of the Agricultural Statistics affords an example of the second class of collections above referred to. No statute exists to compel the giving of information, which is afforded voluntarily. The particulars are ascertained orally from the occupier of the land or his representative, and a written record is made by the Enumerator of the information so obtained. The details are given on the understanding that they will be treated as confidential, and the record is used for statistical purposes only.

The principal Enumeration takes place once in every year and is conducted by the police, so that with slight changes the machinery for one year answers for the next.

The Superintendents are instructed to divide their Districts for the purposes of the Enumeration according to the Townlands Lists of the preceding year, care being taken that the Townlands allotted to an Enumerator *adjoin* each other, and that every Enumeration District is of convenient size.

Blank Forms are supplied, in which Superintendents enter the names of the Townlands allotted to each Enumerator, the Enumeration Districts being, *as far as practicable*, co-extensive with Electoral Divisions. These Forms are prepared in *duplicate*—one is sent to the Central Office and the other given to the Enumerator.

The Superintendents are furnished with Ordnance Maps and printed instructions for the guidance of the Enumerators.

Information furnished in writing by the Public.

Information collected under the conditions indicated in the third class of cases above noted, is illustrated by the Decennial Census—the most difficult and complicated of all our statistical works. There the information is furnished in writing by the public directly. The Enumeration takes place at long intervals, so that the machinery for one Census differs from the preceding. Householders, houses, enumerators, enumeration districts, territorial areas, have all more or less changed, and the work has to be planned and executed *de novo*.

It is the collection and publication of information under such circumstances that tests the skill of the statistician, and the public who purchase the published volumes of results have little idea of the labour and thought which has been expended to produce them.

As in the preceding cases the principal points to be looked to are:—

1. Accurate Lists of component parts of Districts, and of streets in towns or cities.
2. Maps.
3. Forms with clear headings and instructions to the public for filling them.
4. Definite instructions to Enumerators and Superintendents of Enumeration.

To these two others may be added, viz. :—

The timely supply of the forms so as to admit of their proper distribution to the public.

The simultaneous collection of the Returns throughout the country.

In the General Report of the Census of Ireland, 1881, will be found a detailed statement of the preliminary steps taken in connection with a successful enumeration of a population of about 5,000,000

Secondary Inquiries.

Before leaving the subject of collection of information, I may refer briefly to the instituting of secondary inquiries.

The attempt to obtain too detailed information at first, when it is sought in writing directly from the public, is sure to end in failure, and when such information is desired, the better way is to leave the matter for secondary inquiry, directed specially from the Central Office.

As an illustration I may mention the minute statistics relating to the Deaf and Dumb and the Blind in Ireland, which have always been obtained in this way, the householder's schedule simply containing a record of the fact of the person being so afflicted.

The detailed statistics of Cancer published by the Registrar-General are also the result of secondary information.

CHAPTER II.

ARRANGEMENT OF RETURNS.

Where Areas of Collection and Publication are the same.

WHERE the areas of collection are the same as the areas of publication, but little difficulty arises in the arrangement of the Returns prior to commencing the process of tabulation.

This is the case with the Returns of Births and Deaths in England and Ireland, which are filed, paged, and bound by Districts as permanent records, and only used for statistical purposes as a secondary object.

Where Areas of Collection differ from Areas of Publication.

Where the areas of collection differ from the areas of publication, the matter is not so simple.

This is the case with the Irish Agricultural Statistics. The returns are collected by Constabulary Districts and Sub-districts, but in no case is the information published for these areas—the publication being for Poor Law Unions and Counties.

To facilitate the arrangement of the returns in the Central Office, the enumerators are instructed to keep the returns for towns in separate files, also to keep distinct the returns for the townlands in each Electoral Division.

When the returns are received they must be sorted into Unions and Counties before they can be tabulated.

Where there are various groups of Areas of Publication differing from Areas of Collection.

Where it is desired to publish information according to various groups of areas, these groups intersecting each other, and all being dissimilar from the areas of collection, the work of arrangement of the returns becomes one of great nicety to prevent confusion and facilitate the tabulation.

A better illustration could not perhaps be taken than the case of the Irish Census Returns in 1881. The areas of collection were the Police Districts and Sub-districts, but there were no less than five distinct groups of territorial divisions forming the areas of publication, for which the particulars had to be extracted, viz. :—

1. *The Civil Division.*—Consisting of townlands, civil parishes, baronies, counties, and provinces, with cities or towns, and counties of towns.
2. *The Poor Law Division.*—Consisting of townlands, electoral divisions, dispensary districts, and unions.
3. *The Registration Division.*—Consisting of townlands, electoral divisions, Registrars' districts, registration counties, and registration provinces.

4. *The Judicial Division*.—Consisting of townlands, petty sessions districts, quarter sessions districts, and counties.

5. *The Ecclesiastical Division*.—Consisting of ecclesiastical parishes and dioceses.

In such a case as this, the point is to find out a unit common to all. This in Ireland is the townland. At the date of the Census there were 60,644 of these areas varying in size from nearly 8,000 acres to under one acre. All the groups of divisions above named were built up of townlands [or streets] or portions of same.

The Police were instructed to stitch together the householders' returns at the left hand corner in files by townlands or streets or portions thereof. When a townland or street was situate partly within and partly without a parliamentary borough, city, municipal town, or township, the Enumerator was directed to make a separate file for each portion; also when a street was divided by a parish or ward boundary, to make each portion into a separate file.

When the returns were received in the Central Office, the townland or street files were all re-sorted into parish bundles, and where the parish extended into two or more electoral divisions, the portions relating to each electoral division were tied up separately. Much of the success of the after-stages of the work in 1881 was attributable to the careful way in which this operation was performed.

I have referred to this in detail as some of my readers in other countries may have to contend with similar difficulties.

CHAPTER III.

TABULATION AND SUMMARIZATION.

Tabulation by Enumerators.

WHERE a rough abstract is required for immediate publication, this is best obtained from summaries furnished by enumerators giving totals for the territorial areas under their jurisdiction. After general examination these may be totalled in the Central Office without reference to the original detailed returns, and the desired results placed before the public subject to subsequent revision.

It is from summaries of this kind that Quarterly Returns of Births and Deaths are published by the Registrar-General. The Annual Abstracts of Live Stock and Tillage issued in connection with the Irish Agricultural Statistics are compiled from summaries furnished by the Enumerators, and the Preliminary Report of the Census of 1881, giving the rough results of the enumeration, was prepared from similar data.

In addition to the assistance which can be rendered by local officers and enumerators in furnishing summaries of their work, it is frequently possible to utilize their services in reducing the subsequent tabulation in the Central Office by so constructing the enumeration forms that the tabulation may be done as part of the enumeration.

As an example of what can be effected in this direction I may mention a plan devised by me in connection with the Agricultural Statistics. For many years this work of classification of holdings was done in the Central Office, and occupied the time of more than one clerk. By a reconstruction of the enumeration form this was made part of the enumeration work, causing a reduction in the annual expenditure of over £250. By another contrivance of a similar nature I got rid of the tedious and expensive classification of houses in the Census of 1881. This work, which occupied a staff of clerks in the Central Office in 1871, and cost a large sum of money, was, in 1881, done by the local enumerators without increase of labour.

The precise character of these changes is shown in Plate I.

Process of Simple Extraction.

In the simpler kinds of tabulation the forms may be ruled with columns for the several heads of information to be extracted, the width of the columns being proportioned to the probable number of marks to be made in each, a column for total being also provided. Where the population is exhausted, the tot of the columns should agree with the total of the townland or other territorial area being dealt with.

In these cases strokes are the best for marks, each five strokes being kept together by making the fifth across the other four, to facilitate counting.

The sexes may be distinguished either by having separate sheets or by separate columns. In the tabulation of deaths in the Registrar-General's Office, the different quarters to which the deaths belong are distinguished by different coloured inks and different positions of the stroke.

Compound Extraction.

Compound extractions are more frequent than simple. In these cases there are headings not only at the top of the form but at the sides also. As an example, may be taken the tabulation of occupations at the Decennial Census of 1881 in combination with ages, sexes, religion, and education. The age-periods, names of religious bodies, and degrees of education were provided for by headings at the top of the form, while the occupations were ranged at the side, and the sexes distinguished by the use of different sheets.

Compound Extraction with Signs.

It sometimes happens that a combination of information is desired which cannot be provided for by the ordinary Compound Extraction.

I shall cite as an instance the Census Registry of Ages and Religions by sexes, families, and degrees of education. The age-periods, and names of religious bodies occupy the top headings, the side space is required (for purposes of checking) for the number of each family on the file. In this case the three degrees of education and the sexes were distinguished by signs thus:—

I	Male who could neither read nor write.
Γ	„ „ „ read only.
F	„ „ „ both read and write.
O	Female who could neither read nor write
O ⁻	„ „ „ read only.
O ⁼	„ „ „ both read and write.

Foot and Side Notes.

A convenient mode of extracting detail, where an analysis is required of a general heading, is by means of notes at foot or on the side of the Tabulation Sheet. The religions included under the head of "All other Persuasions" were extracted on the Irish Census of 1881 in this manner. The detail of ages of persons dying violent deaths for publication in the Registrar-General's Annual Report is also obtained in this way.

Items ascertained by Subtraction.

Much useless labour may be saved by a judicious use of the process of subtraction. For instance, in the Census Tabulation of Birthplaces the inhabitants of each County who were born therein were ascertained in this way. The persons born elsewhere were first carefully registered and the result deducted from the total population of the County—the difference being the persons who were natives. The same plan was followed in the extraction of Conjugal Conditions. The married and widowed were tabulated and added together, the result being deducted from the total—the balance represented the unmarried.

Checks.

It is necessary in all statistical work to have checks wherever possible upon the accuracy of the tabulation. Foremost among these may be mentioned the abstract which the Enumerator should be required to furnish for each local area enumerated by him. This abstract should contain an analysis of the file of original returns to which it refers, and it thus becomes a most important check on the extraction in the Central Office.

Another check is that obtained by the extraction of the same particulars in two different ways. Thus, for instance, the Education was extracted on the Irish Census of 1881 in conjunction with the Ages of the people, and also extracted in conjunction with the Religions, the one extraction forming a check on the other.

Checks are necessary not only to prevent accidental errors in tabulation, but also to guard against wilful falsification. This latter is not an impossible contingency in a temporary department where a high daily average is required to be kept up.

On one of the Irish Censuses a clerk was found fabricating entries in his tabulation sheet. He was detected by means of the check afforded by the enumerator's abstract. On another occasion one of the outdoor workers was discovered altering correct figures in the office abstracts to agree with incorrect work. In this case the offender was caught by the check obtained from another extraction.

Instructions to Tabulators.

It is as important to have definite instructions to clerks engaged in the tabulation work as to enumerators in the work of collection. A printed memorandum of the principal points to be attended to should be handed to each clerk with his tabulation sheet.

This matter is specially important in the classification of diseases or the extraction of occupations. For the latter special books of instructions were issued on the Census of 1881, both in England and Ireland. In Ireland we found it useful to index the book of instructions down the margin so that the clerk could readily turn to the particular occupation he was in search of.

Summarizing Processes.

When the tabulation is completed, the next stage is combining the sheets to form the larger areas required for publication.

This is best done by the folding process. Say there are ten sheets and ten columns in each sheet to be summarized—column 1 for each sheet is folded down and entered in column 1 of a blank sheet. Column 2 is treated in the same way, and so on till all is completed.

Great care must be taken to have the sheets uniformly ruled, otherwise serious errors may be made.

OCCUPATIONS TABULATION SHEET,

[Reducing Combined Width of Sheets for each Sex from 4' 10" to 2' 8 $\frac{1}{2}$ ".]

PLATE II.

A photograph of a document titled "REGISTRY OF OCCUPATIONS, 1881". The document is heavily watermarked with the phrase "this is the oil" in a large, stylized, diagonal font. The text on the document is mostly illegible due to the watermark and the quality of the scan. The document appears to be a historical record or a form related to occupations in 1881. The title is at the top, followed by a subtitle "IN THE REGISTRY OF OCCUPATIONS, 1881". Below this, there are several lines of text, including "REGISTRY OF OCCUPATIONS, 1881" and "IN THE REGISTRY OF OCCUPATIONS, 1881". The document is divided into sections by horizontal lines. The watermark "this is the oil" is repeated multiple times across the page. The document is a historical record or a form related to occupations in 1881. The title is at the top, followed by a subtitle "IN THE REGISTRY OF OCCUPATIONS, 1881". Below this, there are several lines of text, including "REGISTRY OF OCCUPATIONS, 1881" and "IN THE REGISTRY OF OCCUPATIONS, 1881". The document is divided into sections by horizontal lines. The watermark "this is the oil" is repeated multiple times across the page. The document is a historical record or a form related to occupations in 1881. The title is at the top, followed by a subtitle "IN THE REGISTRY OF OCCUPATIONS, 1881". Below this, there are several lines of text, including "REGISTRY OF OCCUPATIONS, 1881" and "IN THE REGISTRY OF OCCUPATIONS, 1881". The document is divided into sections by horizontal lines. The watermark "this is the oil" is repeated multiple times across the page.

CHAPTER IV.

MECHANICAL APPLIANCES.

I SHALL now refer to the question of mechanical appliances in aid of the work of tabulation and calculation.

Appliance of Folding Flaps.

On the Irish Census of 1881 a great difficulty presented itself in connection with the tabulation of occupations. There were eight sheets, four for males and four for females, and it was found that when sufficient columns for extraction of all the particulars as to age, religion, and education were provided, the sheets if laid side by side would extend far beyond the stretch of the clerk or his power to see the headings.

This difficulty was overcome by an appliance of folding flaps, which brought within reach all the sheets, and enabled the clerk to see all his headings at once. This device proved a complete success, and my chief, Doctor Grimshaw, did me the honor of exhibiting a specimen of it at the Demographical Congress held at Vienna in 1887. [See Plate II.]

Racks for Cross-totting.

Another simple appliance which, for certain classes of work, saves much time and trouble is the rack for cross-totting. When the form is large, and it is required to cross-tot alternate columns, there is a great danger of mistake by adding the figures in a wrong column—such, for instance, as where the figures for males and females appear in alternate columns, and have each to be cross-totted. The rack is made from one of the forms by cutting out the alternate columns with a knife or scissors. This, when laid down on the sheet containing the figures, only leaves exposed those which are to be added together.

Arithmometers.

The Arithmometer or Calculating Machine is a most useful instrument both to the actuary and the statistician. The working of the machine in multiplication is simply astounding, the results being produced with unfailing accuracy. In the computation of percentages it is very useful, and saves a vast amount of labour, and with the use of logarithms much of the ordinary work of calculation can be done. Its use is particularly advantageous where an extended series of rates are required, as in calculating the birth and death rates for those districts for which a fresh estimate of population is made in each year.

There are various kinds of these machines before the public. In the General Register Office, Edinburgh, the French machine of M. Thomas de Colmar is in use. In the General Register Office, London, in addition to the French machines, a German machine is used.

For the General Register Office, Dublin, the Treasury authorized the purchase of Tate's English machine, an admirable instrument, with several patented improvements, made of hard metal to resist wear, and capable of being worked at a high speed without danger of error.

This machine is supplied by Messrs. C. and E. Layton, Farringdon-street, London, E.C., by whose courtesy I am enabled to append a pictorial representation of the instrument. [See Plate III.]

A short time ago I had the pleasure of inspecting Edmondson's Circular Calculating Machine, a specimen of which was placed on exhibition in Dublin.

The Arithmometers vary in price according to make and size. The cost of Tate's Arithmometer (in London) is Fifty Guineas.

Slide Rules.

The Slide Rule, arranged by the late Major-General Hannington, and executed by Messrs. Aston and Mander, 25, Old Compton-street, Soho, London, W., is a most useful instrument to the statistician. It solves at sight all questions of ratio. In an interesting paper, Professor Galbraith, F.T.C.D., shows how it can be applied to Rule of Three, Multiplication, Division, Interest and Discount, Percentage, Proportional Parts, Stocks, Foreign Exchange, and Square Root.

The prices of this machine are—

120" Rule,	£4.
60" Rule,	£2.
30" Rule,	£1 10s.

Cases are extra and made to order, varying in price from five shillings. An extra charge is made for the Square Root Slide.

For general office work the 60" Rule, containing nine rods in the stock, is recommended as the most suitable.

Messrs. Aston and Mander have kindly placed at my disposal a block of the Slide Rule from which the accompanying drawing of the instrument [Plate IV.] has been produced.

Mathematical Tables.

In most statistical works the operator has to deal not only with actual figures but with percentages, and other calculations based thereon. For these processes much assistance can be derived from Mathematical Tables.

The following may be mentioned :—

Tables of Logarithms.

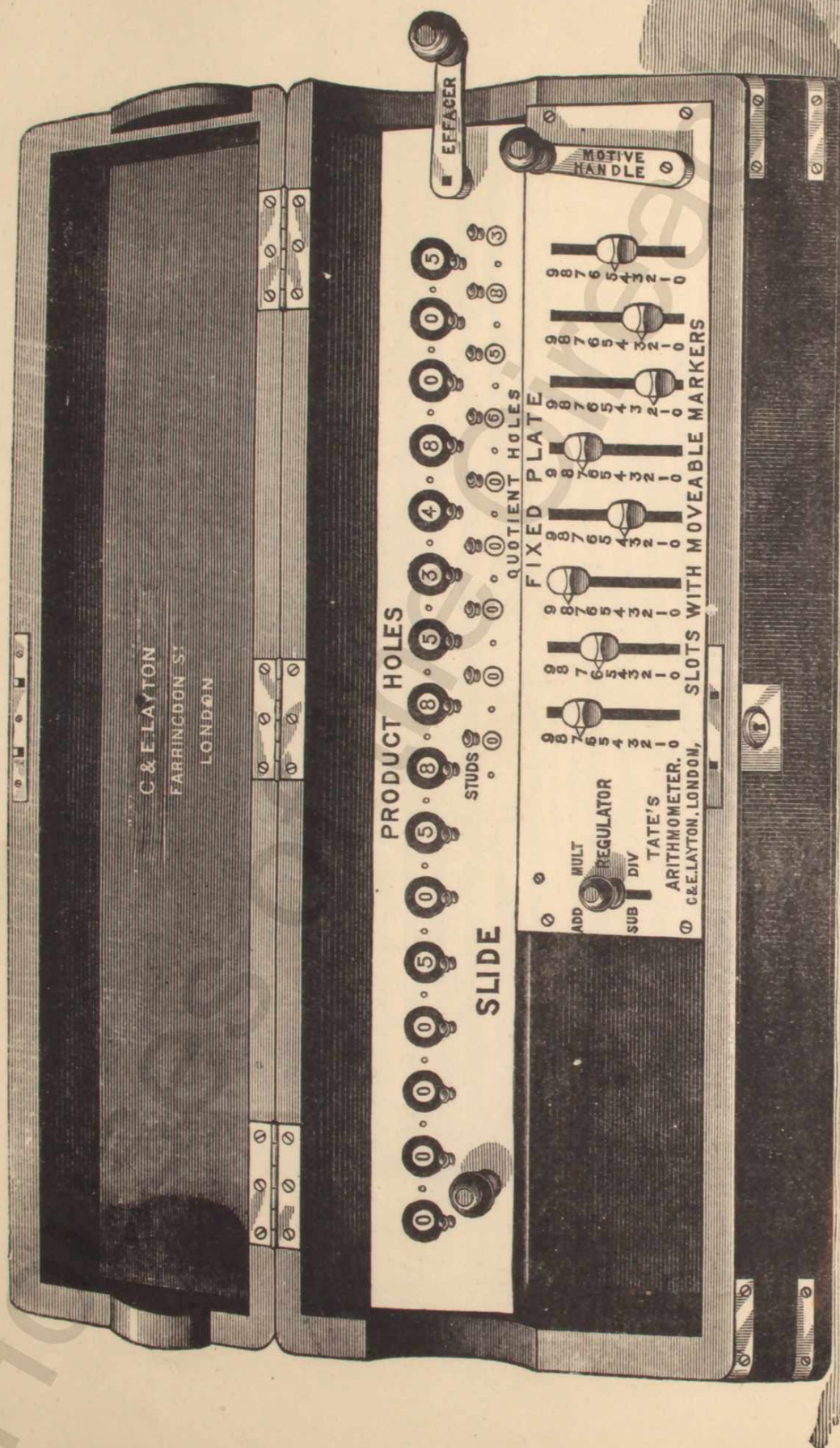
Oake's Tables of the Reciprocals of numbers, from 1 to 100,000, with their differences, by which the reciprocals of numbers may be obtained up to 10,000,000.

Crelle's Tables, giving the Products and Quotients in the case of any two numbers, each less than 1,000.

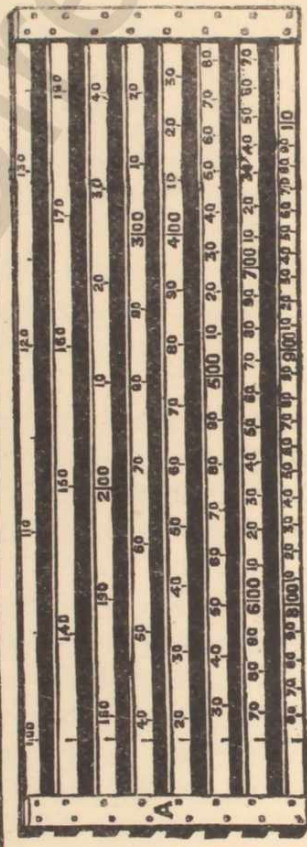
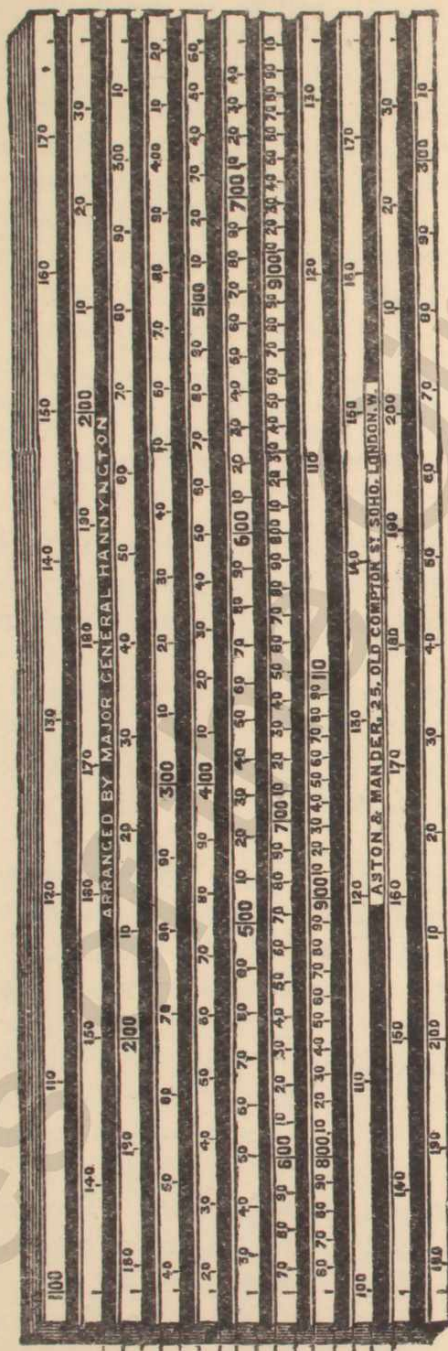
Eason's Index Lightning Calculator affords a simple and rapid means of calculating values up to £5,000.

TATE'S IMPROVED ARITHMOMETER.

PLATE III.



EXTENDED SLIDE RULE, ARRANGED BY MAJOR-GENERAL HANNYNGTON.



CHAPTER V.

PUBLICATION OF INFORMATION.

Form of Tables.

The question of the form of publication should not be left for decision till the work of tabulation is completed. It should be settled, not only before the tabulation is commenced, but before the enumeration forms are issued, and in the preparation of these forms the intended form of publication should be taken into account.

The Hon. S. S. Cox, in an able speech delivered in the House of Representatives in July last, with respect to the forthcoming Eleventh Census of the United States of America, stated—

“Much expense has heretofore been incurred on account of a plan for the use of material not being considered in connexion with the collection thereof. All such plans for the utilization of the material of the Census should be in perfect harmony with the plan of the collection, and the same mind should pass on all points, otherwise there will be incongruity, inequalities, and inharmony in the whole work.”

In framing the tables, the probable use for which they will be required by statesmen and the public should be considered, all the facts desired included in the tables, and those facts presented in the best possible shape.

In looking through the numerous volumes of statistical work which are constantly being issued in this and other countries, one sometimes sees space taken up with information which is of little practical use, while search is made in vain for some item of information which is important.

As an instance of what may be done in the direction of condensing and recasting ponderous volumes of statistics, I may refer to the Irish Criminal and Judicial Statistics, which, previous to 1882, appeared in an exceedingly bulky and inconvenient shape. At that date the duty of reporting on them was assigned to Dr. Grimshaw, who, after much personal labour, excised the unnecessary detail, and presented his report in a readable and handy volume, for which he received deserved commendation from the highest authorities.

In a great national work, such as the Census of a country, where various subjects are treated of, the question arises as to whether it is better to publish according to subjects or according to localities. In other words, whether it is better to issue volumes dealing only with particular subjects, or to issue books for areas containing complete statistics on all the subjects for those areas. The latter plan has been followed with advantage in the last two Irish Censuses, and in my judgment it is much the preferable one, as it enables the public to purchase, at a small cost, the statistics for the particular county or division in which they are most interested.

In sending Tables for publication care should be taken that the headings correctly describe the contents of the Table; the Tables should be numbered throughout.

Revision of Printer's MS. and Proofs.

In connection with the preparation of the printer's manuscript I may draw attention to the fact that much time can be saved, and liability to error avoided, by so constructing the summarization forms that the last summary can be made to serve for the printer without fresh copying. This is specially the case in lengthy tables where a great number of details are given.

The revision of the printer's MS. is a matter which tests the ability of the Superintendent. Where information is presented in combination in complex tables the mistakes which may occur are sometimes very ludicrous.

These errors may be errors in extraction owing to the clerk putting his marks in wrong columns, errors in summarization owing to the forms being badly ruled or wrongly folded, or errors owing to bad writing in the returns.

I remember, in revising the printer's MS. of the Tables of Occupations in 1871, where the elements of occupation, age, sex, religion and education, and conjugal condition (as to females) were extracted in combination, discovering such grotesque mistakes as a Commercial Clerk who could neither read nor write, a Clergyman under 15 years of age, and a Monk belonging to the Methodist Church. Another case came under notice where, owing to bad writing in the original return, a Tailor was recorded as a Sailor. Such entries as males dying of puerperal fever would, if placed on record in the Blue Books, afford considerable amusement at the expense of the statistician. Where facts referring to a single individual appear in the Tables they should be carefully checked with the original Return. On the Census of 1861 much surprise was occasioned by the appearance in the Tables as a Protestant, of a well-known Roman Catholic official of high rank.

The Superintendent has again to guard against other classes of errors. In most statistical works not only are actual figures given but comparisons instituted with previous Returns. In these cases great care has to be taken to see that the figures really represent the same areas in each case. Thus, in urban districts where houses and population are compared by municipal divisions such as wards, the transfer of a street from one ward to another would completely vitiate the comparison. Experience has shown that this is not an impossible occurrence.

Expedition in Publication.

In the publication of statistics, as in other matters, the maxim *bis dat qui cito dat* applies. To be of practical use the figures must be got out at the earliest possible date consistent with their being presented in a complete form. Sometimes our official Reports are a year behind for no other reason than that they have never been brought up to date. On my appointment as Secretary to the General Register Office in 1877 I found this to be the case with the Annual Reports of the department. By a little extra exertion the year was pulled up and the Report for 1878 published in June, 1879.

The Press have done service to the public by drawing attention to this important point in their columns, and good results generally have followed their action.

Where a large number of Tables are being published it will be found very useful to have a printed book giving the headings of the Tables, the names of the persons responsible for them, the date when the printer's MS. is handed in, together with columns for the dates of the several stages of the printing in each case.

In the General Register Office, where as many as sixty-nine separate publications are issued yearly dealing with various subjects, we have used with advantage a tabular form known as a "tell-tale," showing the date when the MS. of each should be ready, the date of publication of the last Return, of its presentation to Government, and its issue to the public. This simple contrivance enables the chief officers of the department to keep the work thoroughly in hand and up to date.

CHAPTER VI.

ILLUSTRATION OF STATISTICAL WORKS.

THE illustration of statistical works has of late years occupied the attention of statisticians who have endeavoured to bring the results of their labours within the reach of the public generally by means of graphic methods.

Among these may be mentioned diagrams, maps, plans, lithographs, and photographs.

Diagrams.

Much ingenuity has been exhibited in the construction of the various forms of diagrams to be found in the statistical books of our own and foreign countries.

The form of diagram most suitable for any particular case largely depends upon the combination of facts requiring to be illustrated.

The simplest form is that of lines traversing a sheet spaced according to a scale. These lines may be either plain black, broken or dotted, or they may be of different colours or any combination of these.

Specimens of neat work of this kind will be found in the Reports of the Bureau of Statistics at Rome, presided over by that eminent statistician Signor Bodio. The Statistical Atlas of the Kingdom of Italy, issued from his office in 1882, contains a number of these diagrams, exhibiting much artistic skill.

A graphic delineation, on this principle, of the death-rate per 100,000 of the population in Scotland from small-pox, measles, scarlet fever, whooping-cough, diphtheria, typhus fever, typhoid fever, diarrhoea and dysentery, will be found in the 32nd Detailed Annual Report of the Registrar-General for Scotland, recently issued.

Another simple form of diagram is that of vertical columns. These columns may be either plain outline and shading or may be of various colours, or any combination of these. It is a very effective mode of illustration, and by sub-dividing the sheet a number of separate diagrams of this sort can be presented to the eye at once.

This form of diagram was adopted in the General Report of the Census of Ireland, 1881, in which appear nine diagrams dealing with agriculture, house accommodation, religious profession, education, school attendance, and infirmities. A neatly-executed diagram of this kind, exhibiting the course of the mortality from diphtheria and scarlet fever in Philadelphia, appears in the Report of the Director of the Department of Public Safety for the year 1887.

Dr. Janssens of Brussels appends to his Annual Report on the deaths in that city a diagram combining the line and column plans, which presents a good effect to the eye.

The circle and other figures have been used for graphic illustration. The use of geometrical figures for this purpose conveys of course to the statistician the information desired, but I much doubt whether diagrams of this sort come within the comprehension of the general public for whose special benefit the illustration is intended.

Maps.

The map is more suitable than the diagram in some cases, while the diagram is to be preferred to the map in others.

The map, with various degrees of shading or various colours, can be used effectively to illustrate density of population, comparative state of education, state of house accommodation, prevalence of disease, &c. In the Irish Census Reports of 1881, maps of one colour, with lines of colour of different thickness, were found to answer well. These maps, however, were of rather rough execution.

Specimens of fine work of this sort will be found in the Report of the United States Census, 1881, on "Forest Trees"; indeed the maps used throughout the Census publications for that country are admirable.

Plans.

The plan is suitable for dealing with urban statistics, such, for instance, as cases of a particular disease which may be represented on the plan of a city by coloured dots or patches of colour, presenting at a glance the locality in which particular diseases are prevalent. As a good specimen of the effect produced by a well-executed plan of this sort, I may mention the chart showing the mortality from diarrhœa per 1,000 persons living in each enumeration district in the borough of Salford during the nine years 1879-1887, contained in the Annual Report for 1887, by Dr. John Tatham, Medical Officer of Health.

In the Report of the State Board of Connecticut for 1883, a clear plan of the city of Hartford is appended, illustrating an epidemic of diphtheria. The street lines are printed in black, the river courses in blue; the sewers are shown by red lines, and the deaths by red and blue dots.

The Report on the Cholera Epidemic in Japan in 1886, by M. Nagayo Sensai, Director of the Central Sanitary Bureau, Home Department, is accompanied by plans of Tokyo and Osaka. The groundwork is pale yellow, on which the cholera cases are indicated by blue dots.

Lithographs.

Lithography and Chromo-Lithography have been much used by statisticians in illustration of their works. As examples, I may mention the beautifully executed plates illustrative of the *Micrococcus Scarlatinae*, which accompany a paper on the Etiology of Scarlatina by Dr. Klein, F.R.S., printed in the Supplement to the Sixteenth Report of the Local Government Board for England.

Our American friends have used the Chromo-Lithograph for another purpose. In the report on Alaska (Vol. VIII. of the Tenth United States Census), well executed Chromo-Lithographs of the races of natives in that territory are given, which add materially to the most interesting matter of the report.

Photographs.

Photographs are invaluable in some cases. They have been effectively used by the Surgeon-General of the United States Army to illustrate his Medical and Surgical History of the War of the Rebellion. The Third Part of that valuable work contains, in addition to elegant Chromo-Lithographs, many photographs illustrative of the Post-mortem Records of the Continued Fevers.

CHAPTER VII.

OFFICE STAFF.

I shall now discuss the question of the staff needed for statistical operations.

Constitution of Statistical Bureau.

In a permanent Statistical Bureau, under the Heads, there must be Superintendents or Chiefs of Divisions, with superior qualifications, and extensive knowledge of the social condition of the country. Next to these, there must be qualified clerks to do the work of tabulation and calculation. The purely mechanical labour may be assigned to officials of an inferior grade. In the case of a large statistical office called into existence for a temporary purpose, these conditions may be varied. Under the Heads and Superintendents temporary clerical labour must of necessity be extensively employed. This is the case with the Decennial Census in the United Kingdom, and the question then arises how this large bulk of clerical work is to be provided for.

Employment of Boys and Females.

On the Census of 1871 I tried the experiment of employing boys on the simpler stages of the tabulation work. It proved a success, and in the Census of 1881 it was tried on a large scale, there being as many as 89 boys so employed.

The question of the employment of females also arises. It is well known that for quickness of eye and neat work the fair sex are often more than a match for male workers. The arrangements of the buildings did not allow of the employment of women indoors, on the Irish Census of 1881, but a number of them were successfully employed outdoor on summarization work, &c.

Out-door Workers.

The summarization, and purely mechanical work of calculation, can advantageously be done by outdoor workers on piecework rates.

The great difficulty is to fix these rates on the one hand to yield a fair remuneration to the worker, and on the other to secure that the duty shall not be extravagantly paid for by the State. The rates should be carefully tested by actual work done by expert workers before they are fixed.

Outdoor workers can be utilized in another way, viz. : to supplement the force of the office staff by employing them indoor after official hours on tabulation, at piecework rates, under due supervision. By this plan the staff of a branch of the work can be increased without extra accommodation.

Office Arrangements and Discipline.

In dealing with large statistical operations such as the Census, the great point is to know how to transfer the clerks from one branch to another till all the primary stages are completed. On these stages numbers tell proportionately, the only limit being that the staff must

not be increased to such an extent that the clerks will not have time to acquire rapidity at the work before it is completed. In such cases great care is needed in the selection of the clerks for the after work, and the stimulus of increased pay, and promotion where possible, is greatly to be desired.

In dealing with statistical departments called into existence for a temporary purpose, such as the Census, where good work is expected to be produced from untrained workers, one great point is the maintenance of strict office discipline. This should be enforced by means of printed rules, and under these rules those entrusted with the direction of the work should have ample powers of reprimand, suspension, or removal.

CHAPTER VIII.

GENERAL REMARKS.

It remains for me to offer a few general remarks.

Necessity for Timely Preparation.

I would observe first of all that the great requisite in undertaking statistical work is the due consideration beforehand of the arrangements, otherwise the statistical operator will be overwhelmed with an avalanche of matter, and not become aware, till too late, of the defects in his forms, which, if the forms had been considered in time in connection with the subsequent stages, might have been foreseen and provided against.

In short, the whole arrangements from the beginning to the end should be carefully laid down before a single form is issued, or a shilling expended in enumeration work.

The Hon. S. S. Cox, in the speech before alluded to, called attention to the necessity of making timely preparation for the eleventh Census of the United States. He observed that two years was none too long a time for preparation, and that expense would be saved if the work was commenced in proper time.

On the Irish Census of 1881 a good deal was done in the direction of making provision for the work in advance, but the time allowed was insufficient. Since 1881 the Government have made the Secretary of the General Register Office a permanent Census officer. This was a wise step, but requires to be supplemented for the forthcoming Census by the early appointment of the Superintendents who are to be entrusted with the charge of divisions of the work.

Charging one Department with all Statistical Work.

I would further remark that the same permanent department should be charged with the compilation of all the statistical work of the country. The Registrar-General for Ireland, referring in his Twenty-third Annual Report to the different classes of statistics allotted to his office, observes :—
 “This arrangement is advantageous in several ways. It is an economical arrangement, as the services of an experienced staff are obtained for all these operations by transferring the clerks from the work for one Report to that of another, till all for each year are completed. It has also another great advantage. These statistical inquiries all bear more or less upon each other, and the placing of them all under the control of one office enables it to review effectually the social and economic condition of the country, and become practically a Social Intelligence Department of the State.”

Our Continental friends have not been slow to perceive these advantages, and in many of the European States there is a Statistical Bureau regulated on this principle.

Completion of Official Statistics.

Steps should be taken to complete all the statistics necessary to show the social and economic condition of each country. It is not when some political exigency or national calamity calls into requisition the

statistics relating to particular facts that it is the time to begin to collect them. If delayed till then, besides the impossibility of obtaining reliable information with regard to past periods, the statistics collected under such pressure are apt to be regarded with suspicion.

We can best learn our deficiencies by comparison with our neighbours, and, in studying the statistical reports of other countries, we may find many things in which we are lacking.

In England public attention was recently directed to the absence of authentic labour statistics, and the result has been the publication, by the Board of Trade, of an interesting report on the subject.

Professor Körosi, the eminent statistician at the head of the Statistical Bureau at Buda-Pesth, has done good service in his "*Projet d'un Recensement du Monde*," by comparing the statistics collected at the Censuses of the various countries. He has constructed a statistical thermometer in which he has ranged the several states according to the number of separate heads of inquiry instituted. It affords us gratification to know that in this thermometer Ireland stands at a high figure.

Efforts to Popularize the Study of Statistics.

I shall now refer to the efforts which have been made to popularize the study of statistics, and extract, from the mass of Government Blue Books, comparative tables presenting the state of the country in a convenient form.

Amongst these I may name the exhaustive Statistical Tables for the United Kingdom and for Ireland compiled from the various official returns which are published annually in that admirable encyclopædia of information, "*Thom's Official Directory*." No commendation of this standard work of reference is needed to residents in this country, to whom its value is so well known.

I may also mention "*The Statistical Survey of Ireland from 1840 to 1888*," by Dr. Grimshaw, being his presidential address to the Statistical and Social Inquiry Society of Ireland in November, 1888. In no other work is to be found such a comprehensive review of the social and economic condition of this country during the last forty-eight years.

In conclusion, I trust that the remarks which I have ventured to submit for the consideration of my colleagues in the statistical world may be helpful, and that by the interchange of ideas we may be enabled to advance the interests of statistical science in the cause of which we are labouring.

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