FINGERPRINT DIRECTORIES

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BY

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D.C.L. OXFORD, AND HON. SC.D. CAMBRIDGE

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TO

SIR WILLIAM J. HERSCHEL, BART.

(Formerly of the Bengal Civil Service)

MY DEAR SIR WILLIAM—I do myself the pleasure of dedicating this book to you, in recognition of your initiative in employing fingerprints as official signatures, nearly forty years ago, and in grateful remembrance of the invaluable help you freely gave me when I began to study them.—Very sincerely yours,

FRANCIS GALTON.

42 RUTLAND GATE, LONDON, S.W.
May 1895.

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CHAPTER I

INTRODUCTORY

THIS volume relates to classified collections of cards, or to orderly entries in books, for discovering the names of persons through their fingerprints, — the prints made by those persons on any previous occasion, with their names appended, having been preserved and arranged in one or other of the ways about to be described.

A fingerprint directory may be compared to that portion of the well-known *London Post Office Directory*, where the name of any householder can be discovered by referring to his address. All the three thousand and more streets, squares, etc. in London are arranged alphabetically, and the houses in each of them are entered in numerical order, the names of the respective householders being appended. So, although there are at least 150,000 householders in London, the name of any one of them can be found with facility from his address.

A directory by fingerprints is far from being so precise and discriminative, but its powers are many

times greater than might be supposed. I find that in one of the directories made by myself, which refers to 2632 different persons, the average time occupied in searching for and finding a print is less than three minutes.

It may seem surprising that fingerprints should admit of being so classified as to afford an easy clue to the discovery of the name of a person who afterwards withholds or falsifies it. Probably some time will elapse before experience shall have led to a just appreciation of the power of a fingerprint directory. It was the same with the anthropometric method of Bertillon, which failed for some years to win general confidence. It is not unlikely that the first alphabetical index ever made caused astonishment and raised objections from sceptics, though the use of dictionaries is now so common that their efficiency as a means of reference is accepted as a matter of course.

Although it is probable that no two fingerprints in the whole world are so alike that an expert would fail to distinguish between them, it is not professed in this book to show that useful directories may be based upon single fingerprints. The proposed directories are based upon complete sets, each set containing the prints of all ten digits. The principle of the classification is to rely primarily on three or four well-marked appearances, which variously occur in the several fingers, and only secondarily, and that to a very limited degree, on the numerous *minutiæ* by which each fingerprint differs from all others, and

which have been proved in my previous books to be permanent.

The method according to which fingerprint directories may be most easily and surely constructed, has at length passed beyond the stage of an academic question, having developed during the past year into one of practical and immediate importance. Materials are at this moment collecting in the offices of the Metropolitan Police in Scotland Yard, for the gradual formation of many hundred separate fingerprint directories, in the form of classified cards or papers. Each card refers to a separate adult male prisoner, and contains his measurements, fingerprints, and other particulars helpful towards his future identification. Each card is then assigned, according to the Bertillon system of dealing with measurements, into one or other of 243 different receptacles. The reason of this number is that the primary measurements made of each prisoner are five in number, and each several measurement is ranked as *small*, *medium*, or *large*, as the case may be, consequently the number of receptacles required is three multiplied into itself five times over; that is 243. Every one of the 243 receptacles will ultimately contain some hundreds of cards. Suppose 121,500 prisoners to be ultimately placed on the register, then each receptacle will contain an average of 500 cards; some more, others less. The cards in each several receptacle will then be classified and treated as a separate fingerprint directory.

Another set of receptacles is required for adult

female prisoners, and two other large ones for prisoners of either sex, who have not ceased growing, and whose measures cannot be safely treated by the Bertillon method.

In addition to this large work now in hand in England, an extension of the fingerprint method for discovering old offenders is under serious consideration in Bengal, and elsewhere in India. It is to be anticipated, when the facility and the art of fingerprint classification have become generally understood, that the use of these directories will spread to foreign countries, a fingerprint being an automatic sign-manual subject to no fault of observation or clerical error, and trustworthy throughout life. These directories would, moreover, be serviceable for other purposes than those of ordinary criminal identification, as for checking fraudulent re-enlistments in the army, of which more will be said later on, and for identifying pensioners.

It is, therefore, timely to write a book, containing numerous facsimilies of fingerprints, to illustrate and explain my methods of classification more fully than was done in those chapters of my book *Finger Prints* that referred to them. There is an especial need for doing so, as my earlier methods have been revised by much subsequent experience and largely during the past year. It ought materially to assist those who may be charged with the duty of searching for the antecedents of men who are unknown, but suspected of being on the criminal register. It may enlist interest as a topic of curious inquiry, especially

among those members of the legal profession whose duty it is to prosecute or to defend prisoners, or to pass judgments upon them. It ought also to interest the visiting magistrates and the officials of the sixty-three English prisons at which fingerprints are now taken by trained warders, to be forwarded to the central bureau for classification by experts.

The methods I have used undoubtedly admit of many improvements, and I shall myself suggest important ones; still, they are the result of prolonged trials and much painstaking. They are therefore more likely to fulfil their purpose than any one alternative scheme that has not been worked out under similar conditions. In short, those who will consent to stand on my shoulders, are likely to see their way to improvements more surely than if they do not accept that aid.

It must not be supposed that the classification of sets of fingerprints for the purpose of a directory is especially difficult. The art of classifying rapidly and correctly, like every other art, requires instruction and practice, but it does so in no exceptional degree. I can speak with much more assurance on this point than was possible three years ago, when I wrote my first book on *Finger Prints*, or even than was possible one year ago, at the time when that Committee was sitting, extracts from whose remarkably able Report form the bulk of the next chapter. Having studied, and during the last few months having restudied many thousands of sets of fingerprints, and therefore many tens of thousands of

individual ones, I can say with confidence that it is rare to find a pattern whose peculiarities are not due to a few easily recognisable characteristics, occurring singly or in combinations of two or three. It is true that patterns occasionally fall between two of my primary index headings, and that a double reference may be needed; but these ambiguous patterns are recognised at a glance, and the alternative references that have to be made are obvious.

CHAPTER II

REPORT OF A DEPARTMENTAL COMMITTEE

In order to put the reader in possession of the present state of the arrangements briefly alluded to in the foregoing chapter, copious extracts will be given from the Report of a Committee appointed by the Secretary of State for the Home Department, to inquire into the best means available for identifying Habitual Criminals. The Report was presented on the 12th February 1894, and is published as a Blue Book (C 7263). Its recommendations have been adopted by the Government, and I therefore gladly accept the Report as the basis upon which to rest this book. Permission was asked, and kindly granted by the Controller of H.M. Stationery Office, to make these numerous pages of extracts, which cover nearly all that was said about *fingerprints in the Report.* But the reader who is interested in the subject of identification generally, ought certainly to procure the entire Report, which only costs tenpence. He will there find a full and clear account of the system of classification by measurements, as well as the evidence taken upon it.

The warrant appointing the Committee ran as follows—

I hereby nominate and appoint Charles Edward Troup, Esquire, of the Home Office; Major Arthur Griffiths, Inspector of Prisons; and Melville Leslie Macnaghten, Esquire, Chief Constable in the Metropolitan Police Force; as a Committee to inquire (*a*) into the method of registering and identifying habitual criminals now in use in England; (*b*) into the "Anthropometric" system of classified registration and identification in use in France and other countries; (*c*) into the suggested system of identification by means of a record of finger marks: to report to me whether the anthropometric system or the finger-mark system can with advantage be adopted in England either in substitution for or to supplement the existing methods, and if so, what arrangements should be adopted for putting them into practice, and what rules should be made under section 8 of the Penal Servitude Act, 1891, for the photographing and measuring of prisoners.

I further appoint the said Charles Edward Troup, Esquire, to be Chairman, and Harry Butler Simpson, Esquire, of the Home Office, to be Secretary of the said Committee. Given at Whitehall, this twenty-first day of October, 1893.

H. H. ASQUITH.

After a brief preamble the Report says—

We shall, in the first instance, state the results of our inquiries into the methods of identifying habitual criminals now in use in England, into the Bertillon system as practised in France, and into the method of identification by fingerprints suggested by Mr. Francis Galton. We shall then proceed to make a recommendation as to the system which may, we think, most advantageously be adopted in England—the system we propose to recommend being one which borrows M. Bertillon's admirable method of classification, and at the same time embodies the practical results of Mr. Galton's investigations—and we shall conclude by suggesting in detail the arrangements to be followed

and the rules to be made in the event of our recommendation being adopted by you.

The remarks that immediately follow the above, including the account of the Bertillon system, is extremely interesting in itself, but does not concern us here. Then we come to—

The second system on which we are specially directed to report is that now associated with the name of Mr. Francis Galton, F.R.S., though first suggested and to some extent applied practically by Sir William Herschel. In Mr. Galton's *Finger Prints*, published by Messrs. Macmillan & Co. in 1892, a very full account of this system is given; but, as the author investigated the subject originally from the anthropological point of view, and was chiefly interested in its bearings on questions of heredity and racial distinctions, the book is likely to give a somewhat exaggerated impression of the complexity and difficulty of the method as applied to purposes of criminal investigation. A visit to Mr. Galton's laboratory is indispensable in order to appreciate the accuracy and clearness with which the fingerprints can be taken and the real simplicity of the method. We have during this inquiry paid several visits to Mr. Galton's laboratory; he has given us every possible assistance in discussing the details of the method and in further investigating certain points which seemed to us to require elucidation. He also accompanied us with his assistant to Pentonville Prison, and superintended the taking of the fingerprints of more than a hundred prisoners.

The materials on which Mr. Galton works are impressions taken from the bulbs immediately below the tips of the fingers and thumbs. The papillary ridges which cover the palms of the hands form at this point patterns of well-marked form and of a curious variety and shape; of these patterns impressions or "imprints" can be taken on paper or cardboard by means of printers' ink, so as to show the directions, terminations, and junctions of the ridges with much greater clearness than can be seen on the hand itself; and these imprints can be examined through a lens or microscope, or can be enlarged to any size by

means of photography. The patterns and the ridges of which they are composed possess two qualities which adapt them in a singular way for use in deciding questions of identity. In each individual they retain their peculiarities, as it would appear, absolutely unchangeable throughout life, and in different individuals they show an infinite variety of forms and peculiarities.

Both these qualities have formed the subject of special investigation by Mr. Galton; and having carefully examined his data, we think his conclusions may be entirely accepted. The persistence of the ridges and patterns has been proved by the examination of imprints taken from the fingers of various persons after intervals of years and minutely compared in every detail. The cases taken extend over the whole of life, from infancy to extreme old age, not of course in one individual, as no records are available of older date than thirty years, but the different cases taken together cover the whole period. In all the cases examined there was only one instance in which a minute detail was found to vary—a case where a ridge which bifurcated in an impression taken at the age of $2\frac{1}{2}$ was found to have united at the age of 15. In all the cases where the fingerprints of adults taken at different ages have been compared the correspondence has been found to be exact.

In studying the variety in the fingerprints of different individuals, account has to be taken not only of the general form of the pattern and of the number of ridges between fixed points, but also of all the *minutiæ* appearing in each fingerprint—breaks, junctions, bifurcations, etc.—which are equally persistent with the general form of the pattern. We cannot here set out the details of Mr. Galton's reasoning as to the number of possible variations in a single fingerprint, but it is sufficient to state that the conclusion at which he arrives is that the chance of two fingerprints being identical is less than 1 in 64,000,000,000, that is to say, if the number of the human race is reckoned at 1,600,000,000, there is a smaller chance than one to four that the print of one finger of any person should be exactly like that of any finger of any other person. If, therefore, two fingerprints are compared and are found to coincide exactly, it is practically certain that they are prints of the same finger of the same person; if they differ, the inference

is equally certain that they are made by different fingers. The prints of one finger, if clearly taken, are therefore enough to decide the question of identity or non-identity, and if the prints of three or more fingers be taken and compared, all possibility of error is absolutely eliminated. We are clearly of opinion that for the purpose of *proving* identity the fingerprints examined and compared by an expert furnish a method far more certain than any other. They are incomparably more certain than personal recognition or identification by photograph. Under the Bertillon system it is conceivable, though most improbable, that two persons might have measurements coinciding within the limits which have to be allowed for error, and that they might also have the same distinctive marks; but it is wholly inconceivable that two persons should show an exact coincidence in the prints of two or three, not to speak of ten, fingers.

There is, however, the further question how far the fingerprints can be used for the purpose of *tracing* identity, that is to say, how far they can be classified. Mr. Galton founds his classification on three forms or types of pattern, to one or other of which every fingerprint may be assigned, viz., "arches," "loops," and "whorls." In all digits the ridges immediately adjoining the third joint run across the finger, while those towards the tip follow the form of the nail in a rounded arch, but in the space left at the centre of the bulb the ridges have various curvatures forming the pattern of the fingerprint. The pattern is an "arch" when the ridges in the centre run from one side to the other of the bulb without making any backward turn or twist; a loop, when there is a single backward turn but no twist; and a whorl, when there is a turn through at least one circle, or a double turn in the form of a duplex spiral.

[Three illustrations are given in the Report, but are not reproduced here; the reader will obtain much fuller information by referring to Plates 1, 2, and 3 of this book.]

In reading off the patterns and translating them into symbols Mr. Galton takes the prints of the ten fingers in the following order: the first, second, and third finger of the right hand, the first, second, and third finger of the left hand, the thumb and little finger of the right hand, the thumb and little finger of the left hand; and marking an arch as "*a*," a loop as "*l*," and a

whorl as "*w*," he obtains a formula for each person in some such form as *alw, all; wl, ll.*

In order, however, to give greater variety in the formulæ, he distinguishes on the forefingers between loops coming from the radial or thumb-side of the hand, and loops from the ulnar or little-finger side, the former being marked "*r*," and the latter "*u*." In the other fingers so large a proportion of the loops come from the ulnar side, that nothing would be gained by carrying this distinction further. As examples of the formulæ thus obtained, we give those of Mr. Galton himself, and of the members and Secretary of the Committee.

(1) *wlw, ull; wl, wl.*[1]
(2) *wll, ull$_y$; ll, ll.*
(3) *rll, ull; wl, ll.*
(4) *rwl, rll; wl, wl.*
(5) *rlw, ulw; ll, ll.*

Each person thus possesses a formula which is, as it were, a personal name, that may be read from his fingerprints, and for the purpose of an index these formulæ are arranged in alphabetical order, like the names in the alphabetical list in a directory.

A difficulty is caused in some of the formulæ by transitional forms of patterns, but this Mr. Galton meets by adding to the letter that best represents the pattern a second letter representing the alternative interpretation. Thus, in the second formula given above, l_y represents a pattern which he considers to be a loop, but which might possibly be read as a whorl. With this precaution a form transitional between one pattern and another presents no more difficulty than a name which is spelt different ways; and just as in an alphabetical list of names we should look under "Thomson" for a name we had failed to find under "Thompson," so the formula in question would be treated as though there were some doubt as to the right way of spelling it.

The number of possible formulæ, if the arches, whorls, and loops occurred quite indiscriminately, would be 104,976, and if that were so there would be no difficulty in classifying in this

[1] Two misprinted letters in the Report are corrected here.—F. G.

way 100,000 imprints, or even a much greater number. Unfortunately for the purpose in view the different patterns do not occur indiscriminately. The arches are much less frequent than the other patterns; there is a tendency for particular patterns to occur more frequently in particular fingers; and there is also apparently a tendency in certain hands to repeat the same pattern on all the fingers. The result is that in the collection of 2645 cards examined by Mr. Galton, while a considerable number of formulæ occurred only once, there were no less than twelve particular formulæ which occurred oftener than twenty-six times, that is in more than 1 per cent of the cases, while one formula (*ull, ull; ll, ll*) occurred 164 times or in 6 per cent of the imprints. It is therefore clear that while this mode of classification is useful for a small collection it would be insufficient to index a larger collection consisting of many thousand cards. To carry further the comparison with the alphabetical list of names already suggested, it is as if, in a list of proper names, the name "Smith" made 5 per cent and "Jones" and "Thomson" 3 per cent of the whole, and it was therefore necessary to find further names for indexing the persons bearing the same surname. At our suggestion, Mr. Galton carried further an investigation which he had already begun as to how far a sub-classification of the commoner formulæ is possible. He has devised for this purpose an ingenious system, depending partly on the number of ridges in each loop and partly on minutiæ in the core of the pattern. Some account of this is given in Appendix G. [one of the Appendices to the Report. It is not reproduced here, as the method is much more fully explained further on in the book.—F. G.]; here it must suffice to say that on testing him with duplicates of fingerprints of the *ull, ull; ll, ll* type, we found that he was able without difficulty to select the proper card; that is to say, he readily picked out by means of one set of imprints the card containing the imprints of the same person from among the 164 cards of the *ull, ull; ll, ll* type. He showed himself able, in fact, by fingerprints alone, to discover at once the identity of any one of the 164 persons whose formulæ were of that type which presents by far the greatest difficulty in classification.

The conclusion at which we have arrived is that for a small

collection of cards, say, under 1000, Mr. Galton's system is admirable. Even if no sub-classification be adopted, it is always found that on some one or other of the fingers the pattern contains some well-marked peculiarity, and there is no difficulty in running through fifty or sixty cards (to take the most numerous type) and ascertaining at a glance whether on any of them this particular feature presents itself. If, however, Mr. Galton's system of classification is to be applied to a larger collection than 1000 cards, it becomes necessary to introduce the sub-classification. This could certainly only be carried out by a thoroughly trained expert, and, though the results of our trials in Mr. Galton's collection of 2500 cards were eminently satisfactory, it is still a question how far the same method could deal effectively with a much larger collection.

It remains to mention one or two practical points on which we had to satisfy ourselves before deciding that Mr. Galton's system could be used for the purpose of proving or of tracing identity.

(i) It has been suggested that the fingerprints could easily be altered or removed, and if this were so it would be a fatal objection to their use. We thoroughly satisfied ourselves that they could not be altered so as to cause any possibility of mis-identification; they can of course be altogether destroyed, but this would be a difficult and painful operation, and would at once afford a new personal mark of a most distinctive character. Cuts and ulcers destroy a portion of the ridges, but generally leave the pattern perfectly distinguishable; in any case they could not possibly cause such a change as might lead to a mis-identification. In the classification of imprints a finger in which the pattern is destroyed assists the classification; it is represented by the symbol x, and gives a further set of formulæ in which the constantly recurring *a's* and *l's* are varied by an occasional x. [I have since altered this notation, as will be explained further on.—F.G.]

(ii) It may also be objected that this mode of identification would be rendered futile by the liability of the ridges to become obscured in the hands of persons engaged in manual labour. It is true that this is in some degree the case as regards persons employed in hard manual labour, but it does not affect the majority of habitual criminals, who when at liberty are not

distinguished for their application to manual labour, and who are not employed in prison in forms of labour which produce this result. We took at Pentonville the fingerprints of 100 prisoners, most of whom were engaged in oakum picking, some were stokers, and some bakers and tailors. In every case we obtained perfectly clear and complete fingerprints, the only two exceptions being a prisoner who had lost a hand and another who had lost one of his fingers.

(iii) It has further been suggested that the fingerprints are too complicated and difficult to be understood and used by warders or policemen. This is true as regards identification and classification, and would be a serious objection if this part of the work had to be done in prisons or police stations; but it is obvious that the classification and comparison of the imprints would be carried out entirely at headquarters and by an expert. All that the warders would have to do would be to take the fingerprints—a simple mechanical process which any warder could learn without difficulty. At Pentonville a warder with no previous practice whatever took in an hour thirty-five sets of impressions of three fingers, each in duplicate, and every one of these were easily decipherable.

(iv) One more objection which has been made to the use of fingerprints is that they could not be used for purposes of proof in courts of law. We are not by any means sure that this is the case. If enlarged photographs of fingerprints were produced, and were explained by counsel to a jury, we believe that at the cost of some time and trouble proof of identity could be established; but for the purpose now in view this is not necessary. What is required is in the first place assistance in tracing the criminal, and secondly a check to prevent the occurrence of mistakes in the ordinary process of identification by means of personal recognition. In tracing a criminal the fingerprints would be of much assistance. For verifying identifications they would give a test, which in the hands of a skilled person would be unimpeachable.

It seems impossible to insist too strongly on the absolute certainty of the criterion of identity afforded by the fingerprints. Considered merely as a test of identity and not as a detective agency—there being no longer any question of classification—

their use becomes at once extremely simple, and in the hands of an expert free from any danger of error. Apart altogether, therefore, from their use in tracing habitual criminals, it would be a very easy matter to use them much more extensively as a check to all identifications. If the prints of three fingers only of every criminal prisoner were taken before his discharge, and kept with his papers in the prison, it would be impossible afterwards wrongly to attribute the conviction to any other person. This would cover, for instance, the case of Callaghan mentioned on page 14 [of the Report], a case which would not come within the scope of the system we propose to recommend for the identification of habitual criminals. So if the fingerprints of pensioners were taken and kept with their papers, an absolute test would be available if any question of fraudulent drawing of the pension (*e.g.* after the death of the pensioner) should ever arise.

These last suggestions, however, go somewhat beyond the main point which we have still to deal with in our report. We have completed our account of the three systems of identification mentioned in the first part of the reference, and we shall now proceed to answer in explicit terms the questions put in the latter part of your Commission.

I.—WHETHER THE ANTHROPOMETRIC SYSTEM OR THE FINGERPRINT SYSTEM CAN WITH ADVANTAGE BE ADOPTED IN ENGLAND?

The conclusion at which we have arrived with regard to the English methods is that they are on the whole fairly effective; that the majority of old offenders who are arrested for new offences are in the long run identified, and that cases of misidentification are extremely rare. On the other hand, some of the methods in use involve the expenditure of much labour and time, and in spite of the best that can be done, it is clear that a certain proportion of old offenders, small in some districts, considerable in others, escape identification altogether. If a system can be adopted which will secure the prompt and easy recognition of every old offender the ends of justice will be furthered, a great administrative improvement will be effected, and much expense will ultimately be saved.

Before considering the question further, it may be well to

say at once that in no circumstances can the system of M. Bertillon be adopted in its entirety, on account of the fundamental differences between French and English judicial procedure. In Paris every person arrested for any offence is at once subjected to the process of measurement, and is sometimes photographed before being brought before any magistrate. It would not be consistent with English ideas to entrust to the police an arbitrary power of measuring or photographing every person arrested without authority from a magistrate and without regard to the necessity for the purposes of justice of discovering his antecedents and character. Nor do we think that, if the Bertillon system is adopted in principle, its indiscriminate application will be necessary for the purpose in view. The enormous number of measurements taken appears to us to be likely even in France to cause ultimate difficulty, and in England so extensive an application of the system would certainly hamper its first introduction.

In deciding what system should be adopted, three main conditions may be laid down:—

1. The descriptions, measurements or marks, which are the basis of the system, must be such as can be taken readily and with sufficient accuracy by prison warders or police officers of ordinary intelligence.
2. The classification of the descriptions must be such that on the arrest of an old offender who gives a false name his record may be found readily and with certainty.
3. When the case has been found among the classified descriptions, it is desirable that convincing evidence of identity should be afforded.

The 1st and 3rd of these conditions are met completely by Mr. Galton's fingerprint method. The taking of fingerprints is an easy mechanical process which with very short instruction could be performed by any prison warder. While in M. Bertillon's system a margin greater or less has always to be allowed for errors on the part of the operator, no such allowance has to be made in Mr. Galton's. Fingerprints are an absolute impression taken direct from the body itself; if a print be taken at all it must necessarily be correct. While the working of this system would require a person of special skill and training at head-

quarters, it would have the enormous advantage of requiring no special skill or knowledge on the part of the operators in the prison, who would merely forward to headquarters an actual impression taken mechanically from the hand of the prisoner. With regard to the third condition again, as we have already pointed out, Mr. Galton's system affords ample materials for conclusive proof of identity: the imprints of the ten finger-tips give such enormous scope for variation that if two sets are found to correspond exactly within the portions common to the two impressions, it becomes impossible to doubt the identity of the persons. It is true that this evidence can only be deciphered in detail by an expert, and that it could not at present be substituted in legal procedure for the ordinary evidence of identity from personal recognition; but this would not affect its value as a complete check on the accuracy of the ordinary evidence.

The Committee were so much impressed by the excellence of Mr. Galton's system in completely answering these conditions that they would have been glad if, going beyond Mr. Galton's own suggestion, they could have adopted his system as the sole basis of identification.

When, however, the second condition is approached, serious difficulties arise. The method of classifying fingermarks proposed by Mr. Galton affords, as we have seen, an admirable means of indexing a comparatively small collection, and the difficulty which arises from the transitional forms is not insuperable; but when the method is applied to a large collection amounting to many thousands, as would be the case in a criminal register, the difficulty arising from the inequality of the classes becomes serious. One class alone includes 6 per cent of the whole number of imprints, and several other classes include 2 or 3 per cent each. In a collection of, say, 25,000 imprints (and it is probable that the number will be greater than this) it would be found that 1500 imprints would fall into one class, while there would be several other classes each containing between 500 and 1000 imprints. The sub-classification of the largest class, which Mr. Galton at our suggestion carefully worked out, is very elaborate, and in the matter of the counting of the number of the ridges in the loops, it seems to us open to some uncertainty; and we believe we are only following Mr. Galton's

own opinion in saying that it would not be desirable to adopt it for a very large collection if any better system is available.

On the other hand, the strongest point in favour of M. Bertillon's system is the method of classification. If absolutely invariable and accurate measurements could be obtained, then from the measurements of any person the card giving his name and antecedents could be found in M. Bertillon's cabinet as certainly and almost as quickly as an accurately spelt word could be found in the dictionary. Absolute perfection is of course not obtainable, all measurements being subject to error arising from actual variations in the body and from want of skill in the operator; but these causes affect some measurements in a much slighter degree than others, and by selecting five measurements which are least subject to variation in adults, and which can be taken with the greatest accuracy by ordinary operators, M. Bertillon has obtained a primary basis of classification as nearly perfect as possible. By means of these five measurements, each divided into "long," "medium," and "short," M. Bertillon obtains 243 classes, represented by the 243 drawers in his cabinet, and these classes are approximately equal. Where a measurement lies near the margin of two classes it may be necessary to search for the case in two of the drawers; if two measurements be on the margin it may be necessary to search in four of the drawers, but even in the extreme case where each of the five measurements lies on the doubtful margin between two classes it would be necessary to search in only thirty-two out of the 243 drawers. It seems impossible to us to improve on M. Bertillon's system so far as this primary classification is concerned. Other measurements were suggested to us by Mr. Galton and Dr. Garson, which have special points of superiority to those of the middle finger and the foot, but on the whole the balance of advantage appears to be in favour of the five chosen by M. Bertillon, even apart from the fact that it is desirable for international purposes to have the same basis of classification in England as in France. The taking of measurements, though it requires some training, does not require any high degree of skill, and we are thoroughly satisfied after seeing the process in operation in France that there would be no difficulty in training English warders of ordinary intelligence to take

them with the required accuracy. On this point we would refer also to the evidence of Dr. Garson, who has practical experience in training assistants in anthropometry.

The case is different, however, when we come to the further sub-divisions of the Bertillon classification, those by the height, the length of the little finger, and the colour of the eye. The length of the little finger is closely correlated with the length of the middle finger; in most cases where the one is long, the other is long also. The height again is a very unsatisfactory measurement: it is subject to variations in the same person, and it may be altered by trickery on the part of the person measured. By the Metropolitan Police a margin for error of two inches in each direction is allowed in classifying cases by height. Even with the greater accuracy of the French measurement a considerable margin has to be given. The accurate description of the colour of the eye is still more difficult. The seven colours taken by M. Bertillon can be discriminated only by persons having much practical experience, and even then many doubtful and transitional cases must occur.

In adapting M. Bertillon's system to English use we think it would be desirable to abandon these criteria and make the final classification dependent on the fingerprints.

Our recommendation, therefore, is that the prisoners who are to be included in the register should be measured as regards the length and breadth of the head, the length of the left middle finger, the length of the left forearm, and the length of the left foot; that these should form the primary classification, giving 243 nearly equal classes; that the fingerprints of each prisoner should be taken and that the sub-divisions should be by means of Mr. Galton's method of classifying the fingerprints. The measurements and fingerprints should be taken in prison by prison warders, and should be afterwards classified and used for identification in a central registry for the whole of England.

We think that this system should not in the first instance be applied to all persons convicted of crime, but only to all convicts and to habitual criminals, that is, persons coming within section 7 of the Prevention of Crimes Act, 1871. The Registrar might also have a discretion, on application by the police, to add to the register a limited number of other prisoners who, though only

once convicted, are reasonably believed to belong to the class of travelling thieves.

We further recommend that in all cases photographs should be taken; they are of much use in making the search in the register, and, when the case is found, they afford in most cases a ready and obvious evidence of identity. The fingerprints will, however, afford in most cases the scientific proof of identity, and, wherever the system is applied, will render a wrong identification practically impossible.

This completes the discussion of Question I; the Report then proceeds to discuss Questions II and III.

II.—WHETHER THE PROPOSED NEW METHOD SHOULD BE IN SUBSTITUTION FOR OR SUPPLEMENTARY TO THE EXISTING METHOD?

The latter plan is recommended, at least for a long time to come.

III.—WHAT MEANS SHOULD BE ADOPTED FOR PUTTING IN PRACTICE THE METHOD OF IDENTIFICATION RECOMMENDED?

It seems best to give the reply almost in full, because the two systems of measurements and of fingerprints are so closely combined that it is difficult to detach references to the former without prejudice to the latter. It will also be of interest to the reader to have the case more fully before him.

We now propose to describe in detail the arrangements which we think should be followed if the preceding recommendation is adopted. No doubt some of our proposals will have to be modified as practical experience suggests improvements, and it will be important that the possibility of improvement should be kept steadily in view.

In the first place, it will be necessary before their discharge to measure, etc. those convicted prisoners whom it is proposed to put on the register. The process will be—

1. *To photograph them as at present.*—It has been strongly represented that the photograph of the side face should not be taken, as now, by means of a mirror, but should be, as in France, a second distinct photograph on the same plate. This has the advantage, first, of giving a clearer portrait and showing very distinctly the forms of the ear and nose, which are the most important features for purposes of identification; and, secondly, of not reversing the sides of the face, a change which sometimes causes confusion. It would, however, involve some additional expense; and the photographs which have been sent us by the Austrian Government, as well as many taken in English prisons, show that very good results are obtainable by means of the mirror. The important point is that there should be a perfectly clear side photograph showing distinctly the profile and the form of the ear.

2. *To take the five measurements required for purposes of classification*, viz. the length of the head, the width of the head, the length of the left middle finger, the length of the left forearm, the length of the left foot.

This should be done in accordance with the instructions printed in Appendix E [of the Report, not reproduced here.—F. G.], which have been adapted from those issued by M. Bertillon.

The measurements should be taken with the same instruments as in France, and should be stated in millimetres. The millimetre gives exactly the degree of accuracy that is required, and its use will much facilitate identification in international cases. It would of course be possible to take the measurements in inches, and in twentieth parts of an inch, but this would give awkward and complex figures; while if millimetres are taken, a single number represents each result. It requires no knowledge of the metric system on the part of the operator, who has merely to read off the figures from the instrument. The evidence of Dr. Garson, who has had large practical experience in training Englishmen to take measurements in millimetres, is convincing on this point.

3. *To take the fingerprints* by Mr. Galton's method. This

should be done in accordance with the instructions in Appendix F [of the Report, reprinted in part, p. 43.—F. G.].

4. *A description* should also be taken as at present, but somewhat briefer, including the height in feet and inches, colour of hair, eye, and complexion, and the distinctive marks. This is not required for the purpose of classification; but it is necessary (*a*) in case the arrest of the criminal should be required while he is at large, and his description has to be published for this purpose; (*b*) in case his identity should be disputed, when the distinctive marks often supply the evidence which can most easily and most satisfactorily be put before a jury.

The marks noted should, however, be those only which are definite and distinctive; their position, size, and direction should be given accurately and abbreviations should be used [according to the suggestions made in the Report, but not reprinted here.—F. G.]. They should be arranged in a fixed order, beginning with the head, then the hands and arms, then the body, and last the legs and feet.

These measurements, etc. should be recorded on a card of the size now used by Mr. Galton (12 inches by 5). On the back of this card will be the fingerprints, on the face the other particulars. This card will be prepared in duplicate and forwarded to the Central Registry. One card will be placed in an alphabetical register for use when the prisoner's name and antecedents are known. The other will be arranged in the classified index register.

The arrangement of this index register will be the same as M. Bertillon's, a cabinet of drawers first divided vertically into three divisions according to length of head, and horizontally according to width of head. The nine sections thus formed will be divided vertically according to length of finger and horizontally according to length of forearm, and again vertically according to length of foot. There will thus be 243 drawers each containing one class of cards. The figures which are to determine the "long," "medium," and "short" of the several classes might be borrowed in the first instance from M. Bertillon, but in that case on account of racial differences they would have ultimately to be altered in order to keep the classes equal in size. It would be best therefore that the

measurements taken in this country by Mr. Galton and by the Anthropological Institute should be utilised, and correct figures for England fixed from the outset.

At the outset, while the number of cards is few, it may suffice to use only four measurements for classification, omitting the foot, and thus making only eighty-one classes. In any case, however, the measurement of the foot should be recorded, so that it may be available afterwards if required for further classification.

Before each card is put away in its proper drawer the finger-print formula will be determined according to Mr. Galton's method. This will be noted conspicuously on the face of the card in the right-hand top corner above the photograph. The cards in each drawer will then be arranged in accordance with Mr. Galton's method, that is, following the alphabetical order of the formulæ.

At first. there will be only one cabinet for all adult male criminals, but it will soon become necessary to form a separate one for older men, say for persons born before the year 1830. The age of criminals is often wrongly given, and it would be necessary at first to search this cabinet in all cases of persons apparently above 50 who may not be found in the ordinary cabinet, but such searches would become gradually rarer as the older convicts die out, and ultimately all the older cases would be eliminated.

The separate cabinet for older criminals will be required, even if the deaths of all habitual criminals, so far as known to the police and prison authorities, are reported from time to time to the Registrar, and their cards withdrawn from the registers. We strongly recommend that the police should be called on to report all such deaths known to them, and that in other ways efforts should be made to reduce the bulk of the records; but, even when the utmost has been done in this direction, there will remain so many cases where old offenders disappear or die unrecognised, that unless there is a separate classification for the older cases the registers would, in the course of years, become seriously encumbered with a mass of obsolete and useless records.

There will be a separate cabinet for women, but as the numbers are smaller the arrangement would be simpler, and the

fifth measurement may be omitted so far as the classification is concerned.

As regards boys and lads whose bones have not attained their full growth, it may be best to measure and classify them separately, as is done by M. Bertillon, and to allow for growth in the search for the card. We are disposed, however, to recommend as an experiment that for this class, which is small compared with the number of adults, a separate index based entirely on Mr. Galton's method might be formed.

The register having thus been constituted, it will be necessary, before it can be used to discover the antecedents of unknown offenders charged with crime, that rules to authorise the measuring and photographing of untried prisoners should be made by the Secretary of State under section 8 of the Penal Servitude Act, 1891. On this subject a recommendation is made below in accordance with the reference to the Committee. Assuming the rules to be made, the steps in each case will be as follows: When the antecedents of a prisoner charged with crime are unknown, and it is suspected that he is an old offender, the police will apply to the magistrate at the first hearing of the case to make an order for the accused to be measured and photographed, and the magistrate, if satisfied that it is a proper case, will, on remanding the prisoner or committing him for trial, make an order for that purpose. On reception in prison the prison authorities, acting on the magistrate's order, will take the measurements, fingerprints, description, and photograph of the accused in the same way as in the case of habitual criminals about to be discharged, and they will be noted on an inquiry card similar to that already described [in the Report, but not reprinted here.—F. G.], but distinguished from it by a difference of colour. This will be forwarded to the Registrar. On its receipt search will first be made in the alphabetical register under the name given by the prisoner, and if he should have given the name of a person previously convicted, the identity can at once be proved or disproved by the measurements, fingerprints, and photograph. If he is not found by means of his name, search will be made in the index register. If the case is found, information will be given to the police who have charge of the case, of the prisoner's previous convictions, and of the

means by which his identity can be established. If the case is not found after adequate search—a sufficient margin for errors in the measurements being allowed—it will be practically certain that he is not an habitual criminal within the class included in the register, and information to this effect may be given to the police.

We do not anticipate that the adoption of this system will increase materially the number of prisoners detained in prison on remand. It is already the practice to remand prisoners suspected of being old offenders for at least one week, often for several successive weeks, for purposes of inquiry. Under the new system the number remanded for one week might be somewhat increased, but this would probably be more than counterbalanced by the smaller number who would be remanded more than once, as the search in the register would in every case be completed within the first week.

Nor do we anticipate that any serious difficulty would arise from resistance on the part of prisoners to measurement or any other process which may lead to identification. It has been stated in evidence that prisoners have in some cases resisted being photographed, but the number who do so is not large, and they usually base their resistance on the ground that they cannot legally be required to submit. If it is once made clear to them that the rules are enforced under statutory powers, the cases of resistance would, we believe, become extremely rare. This is the view of all the governors and other persons experienced in the management of prisoners whom we have consulted. In the last resort the measurements and fingerprints could, we are satisfied, be taken even when active resistance is offered by the prisoner. Resistance to measurement would interfere less with the process, and could be more easily overcome than resistance to photography; and, as regards the fingerprints, an ingenious mechanical contrivance has been suggested by Mr. Galton for taking the fingerprints of a recalcitrant prisoner, though we do not think it will be necessary to have recourse to this.

Then follow remarks to show the advantage of placing the proposed anthropometric register, and

doing the work connected with it, in Scotland Yard rather than at the Home Office. These may be omitted here.

A word must also be said as to the cost of the new system. At its first introduction it must inevitably involve some expense, but this, as we shall show, will be much smaller than might be supposed, and we confidently anticipate that it will gradually supersede the existing method of identification and in the long run effect a considerable economy. In the meantime the additional cost will fall under two heads, the cost of taking the measurements in the prisons and the cost of keeping the register at New Scotland Yard.

As regards the former, the number of convicts and habitual criminals to be measured, etc. before discharge will, judging from the numbers entered in the Habitual Criminals Register in recent years, be about 4000, or say for safety, 4500. It is impossible to say how many unconvicted prisoners will have to be measured, etc. while on remand or waiting trial, but if we take the same number, 4500, it will, we think, be a liberal allowance. We may assume therefore 9000 prisoners, convicted or unconvicted, to be measured and to have their fingerprints taken in the year. In M. Bertillon's office, the measuring, taking of marks, etc. occupies two clerks on the average rather less than ten minutes. As it is proposed not to take so many measurements in England, we may perhaps safely assume that the time spent will not be more, and if we may add five minutes for the fingerprints—a skilled operator can take the complete fingerprints in duplicate in two minutes—we have then 9000 measurements to take, each occupying two warders for fifteen minutes,—that is, occupying two warders for 2250 hours, or for 281 days of eight hours in the year. If, therefore, all the prisoners were concentrated in one prison the whole work could be done by two additional warders. The work will, of course, be distributed over sixty-three prisons, and the arrangements to be made for its performance will be a matter of prison adminstration not more difficult than those involved in any slight increase of prison work. It will be for the prison authorities to decide whether it can all be done by the existing staff,—it is proposed that the measurements

etc. should be taken in the morning, when the reception officers have usually comparatively little to do—or whether in one or two central prisons an addition to the staff will be necessary. In the end, it may fairly be anticipated that the work of measurement and of taking fingerprints will occupy even less time than the present laborious method of taking distinctive marks, which occupies from seven to ten minutes and sometimes longer.

There will, it should be added, be one or two minor items of expenditure in introducing the new system in the prisons, particularly the cost of instruments for use in each prison, that of taking some additional photographs of untried prisoners, and the expense of bringing warders for a few weeks to London to learn the methods of measurement, etc. For the latter purpose it will probably be well to establish for a time at Pentonville, where the larger number of convicts and habitual criminals are discharged, a sort of school where selected warders from country prisons may be given the necessary training.

As regards the Central Registry, we can best estimate the cost by a comparison with M. Bertillon's office. He employs eight assistants, who in the morning take measurements and in the afternoon attend to the registers and make searches. The work of the registry therefore (as distinguished from the measuring) only occupies the time of four men, or of five if M. Bertillon himself be included. But M. Bertillon now receives and classifies in each year about 15,000 measurements from Paris and about 70,000 from the departments. In the English registry it is proposed to limit the cases to be entered on the registry to about 4000 or 4500 in the year. It seems, therefore, safe to say that for some time at least one or two men will be able to do all the work of the Central Registry. This increase will appear very small when it is borne in mind that, since the Convict Office undertook in 1889 the extra work of registering the habitual criminals discharged in the Metropolis, the staff has been increased by six officers, four men having been added for this purpose in 1889 and two in 1892; and it is understood that in order to maintain this work a further increase of staff is now considered necessary.

In addition to this we are strongly of opinion that it is

essential to the complete success of the registry to secure, at all events at the outset, the services of an expert practised in the methods of scientific anthropometry, and if possible one who has had practice in training other persons in making scientific measurments. We have the utmost confidence in the skill and ability of the officers in the Convict Supervision Office, and we think it might be possible, by sending two or three intelligent officers to learn the system at Paris in M. Bertillon's office, to secure the necessary knowledge and training to start the new system, if we are content to follow strictly on his lines. But we feel sure that it would be better that the Convict Office should have from the first the assistance and guidance of a scientific adviser in England. He would be able from the outset to settle such questions as the limits to be adopted in England for the class of large, medium, and small (as already mentioned, the Anthropological Institute have data available for this purpose); he would be able to superintend the training of warders in taking measurements, and he would instruct the officer in charge of the registry in the decipherment and classification of fingerprints. Moreover, when practical experience has been obtained of the use of the fingerprints, he would be able to revise the suggestions which we have made as to the respective place of the Bertillon and the Galton methods in the system, and might possibly find it advantageous to extend the Galton method of classification further than, with the limited experience we possess of its practical application, we have ventured to propose. On every ground therefore we think it desirable that the English Anthropometric Office should from the first have the advantage of scientific guidance not inferior to that which the French Service d'Identification enjoys in having M. Bertillon at its head.

It gives me much pleasure to mention that Dr. Garson, a Vice-President of the Anthropological Institute, and who has had large experience of measurements, has been appointed for the purpose mentioned.

The modifications of the existing rules that should be made under section 8 of the Penal Servitude Act, 1891, for photographing and measuring prisoners are

next described. They afford no difficulty. The Report lastly says :—

In conclusion, we have only to say that the method of identification which we have recommended, or any other scientific method that may be adopted, must not be expected to produce its full results until after a considerable time. When it has been several years in operation, when the warders employed to make the measurements have acquired experience and skill, and when a large mass of records has accumulated, then, and not till then, is it likely to work as smoothly and to produce results at least as satisfactory as those obtained by M. Bertillon in France. Even in France, though Bertillonage is now in full operation in Paris, its application to the country as a whole is still, as we have said, incomplete. The success of a similar system in England can come only with time, and by means of the hearty co-operation of all concerned in its working. We may confidently anticipate that, if fairly tried, it will show very satisfactory results within a few years in the metropolis, but the success of its application to the country generally will depend on the voluntary co-operation of the independent county and borough police forces. This we feel sure will not be withheld ; when the principles of the system are understood and its usefulness appreciated, we believe it will not only save much time and labour to the police in the performance of an important duty, but will give them material assistance in tracing and detecting the antecedents of the guilty, and will afford, so far as its scope extends, an absolute safeguard to the innocent.

We trust that, when the system is to some extent established in England, it may speedily be extended to Scotland and to Ireland.

It will be well to add my evidence.

HOME OFFICE, *Monday*, 18*th December* 1893.

Present—Mr. C. E. Troup, Major A. Griffiths, Mr. M. L. Macnaghten, Mr. H. B. Simpson (*Secretary*), Mr. Francis Galton, F.R.S.

151. *Chairman.*—You have studied the subject of fingerprints for a good many years, have you not?—I have; I took up the subject in 1888.

152. You took it up originally chiefly from the point of view of heredity and racial distinctions?—Yes, subsequently I became interested in the matter of personal identity. I gave a lecture on personal identity before the Royal Institution in 1888, in which I described M. Bertillon's plan and added some views of my own.

153. The questions we are going to ask you now will be chiefly on one or two points upon which we want to have your evidence formally on the notes. They will be merely supplementary to the explanations you have given us already, when we visited your laboratory. The first thing we should like to hear you about is this—there are two qualities in the fingermarks which you think specially suit them for the purposes of establishing identity; the one is the persistence of the marks, and the other is the enormous variety in different individuals?—Quite so.

154. First, we should like you just to tell us in a word or two the evidence you have of the practically absolute persistence of the marks?—I hand you an album which contains all the evidence I possess, or nearly all, upon which those conclusions are based that are given in my book entitled *Finger Prints;* they are the prints of the fingers taken of the same persons at the beginning and end of different intervals of time. They refer to ten different persons, the interval between the first and the second impressions varying in the different cases from nine to thirty-one years. I have also this other packet of prints from eight different natives of India, which were taken at Hooghli in Bengal in 1878, and again in 1892.

155. That is an interval of fourteen years?—Of fourteen years—these are the originals—they have been photographically enlarged, and the enlargements are published in my book on *Decipherment of Blurred Finger Prints.* Extracts from those in the album were published in a memoir read before the Royal Society in 1891, and part of them were reproduced on a still more enlarged scale in my book *Finger Prints.*

156. And these examples go over the whole of life, do they not—I mean in periods?—They do, from childhood to past eighty. Here is a case of a gentleman in advanced life who took his impression in sealing-wax in 1873, and again in 1890, he being then past eighty. I show some of my earlier attempts, in proof of the carefulness of the way in which the prints have been worked out. These were enlarged, some by a camera lucida and the others by a pantagraph, from already enlarged photographs, and I have in each case marked the points of resemblance; the results have been published in my book on fingerprints. I especially draw attention to part of the palm of a hand of a child in 1877 and afterwards as a youth in 1890. I have divided the numerous points of comparison into groups bounded by coloured outlines in order to distinguish them and placed numbers corresponding to each. There are no less than 111 coincidences in these two prints.

157. In every case there is a coincidence?—Not a single exception.

158. You have never found a single discrepancy?—But one; to which I have given much prominence in my book on *Finger Prints.*

159. That was the case of a child $2\frac{1}{2}$ years old?—Yes, two ridges had merged into one by the time he had reached the age of 15.

160. But with that exception you never found any single discrepancy?—No.

161. And there has been no discrepancy in adults?—Not the slightest.

162. It has only been in that case of a child?—That is the only case I have met with.

163. *Mr. Macnaghten.*—And this was after an interval of thirteen years; 1877 to 1890?—Yes.

164. *Chairman.*—Then you think the evidence of persistence throughout life is practically complete?—I think so; indeed I am sure of it.

165. Then have you gone into the question of how far they are affected by accidental injuries?—Yes, by accident and by age. I have a great many cases here in which the deteriorations by age alone are shown, and others by age and hard work combined, but you will see on looking them through—these are south-country labourers—that in every case the pattern can be made out though there has been much deterioration in the clearness of the ridges. Now I show a case of a burn, it occurred to my assistant Sergeant Randall; he burnt his finger badly and took impressions subsequently, first when the burn was recent, then when it was healing, and again when it was almost healed; the finger is perfectly healed now.

166. Do the original marks re-appear exactly as before?—Just as before; there is not the slightest alteration.

167. After being obscured for some time by the burn all the ridges re-appear exactly, with no variation whatever?—Exactly, not the slightest.

168. When there is an injury leaving a permanent mark, if it is a very bad one, it may possibly obscure the pattern altogether?—One kind of injury obscures, but others only distort. Of the kind that obscures I show you some instances here (*showing*).

169. *Mr. Macnaghten.*—Is that one obscured?—Well, this barely obscures the pattern; I could make out the pattern.

170. You have marked that with a Z, with a whorl underneath it?—Yes.

171. You can see there is a whorl?—You can clearly see there is a whorl here, but I can show you more difficult cases to deal with than this. In my book on fingerprints I have given a case in which a tailor——

172. *Chairman.*—But the point that we want to get at is this,—the injury may obscure the pattern or distort the pattern, but does it ever produce alterations in the ridges such as to cause any confusion?—Rarely so as to cause any confusion. A cut must be deep in order to leave a permanent mark; an injury, whether it is an ulcer or a burn, must go deep, because the

glands, whose ducts are included in the ridges and which appear to be the cause of the ridges, lie deep. When a deep cut is healed the ridges are distorted, much as the strata of a geological section are distorted by a subsidence or by a fault, but they are quite easy to trace.

173. It is always perfectly easy to tell that that is the result of an injury?—Oh, quite so.

174. You can never mistake it for an alteration of the pattern?—Never, not only is it easy to tell that it is the result of an injury, but the very sign-manual of the injury is remarkably definite.

175. In fact, it becomes an additional mark; it even assists the classification, does it not?—Quite so.

176. Then supposing that it were applied to prisoners, would it be possible for a person to obliterate the marks altogether?—It would be possible for a person to obliterate the marks altogether; in that way declaring that his antecedents were more or less suspicious or dangerous. If they were obliterated only to the extent to which Randall's burn has obliterated them, I presume a week in the hospital would entirely restore them, proper precaution being taken.

177. In fact he could hardly destroy them altogether except by cutting off his finger tips?—Except by serious injury; an injury that would take away the sensitiveness of the finger.

178. Then practically there would be no probability of any considerable number of people doing this?—I cannot think so; it is a matter of judgment, but I do not think so.

179. *Mr. Macnaghten.*—No, no, I quite agree with you.—Let me say that the indications on the inner surface of the hand are so numerous, that if out of the whole hand half an inch square were left intact, there would be enough in that to prove identity by comparison, but it would not do for indexing purposes.

180. *Chairman.*—That brings us to the second question we wished to go into, the amount of variety in the fingerprints. I think you might tell us the results of your calculations on that point, we need not go into the details?—It is extremely difficult to answer the question in a few words, because some patterns are very common and others are very rare. I am now speaking of

the patterns as distinguished only by the letters A, L, W, of which I submit various specimens.

181. Well, I rather wanted to go into the question of how far the identity of two fingerprints established the identity of the person?—The probability of identity or the reverse that is given by comparing the details of fingerprints is enormous; I made a mistake in one paragraph (p. 110) in my book on fingerprints, where by accident it was understated tenfold. It may be of interest to show the original experiments I made to determine the degree of trustworthiness of the evidence afforded by the details in fingerprints; their principle is described in that book.

182. The net result of your experiments was to show that the chances of two fingerprints being the same, within a limited area, was one in sixty-four thousand millions, is not that so?—Yes; that was the result of the calculation that I made upon a trustworthy basis. Still, I always fear these large numbers; I merely gave those figures as a perfectly reasonable result after very careful experiments; but I do not cling to them at all.

183. At any rate, the probability is absolutely enormous?—Yes; it is enormously greater than what in popular language begins to rank as certainty.

184. And if one takes two or three fingers into account, it is so enormous that it can hardly be put down in figures?—It is like comparing the ground plans of towns, each of which consists of very many streets, many bifurcations, and of totally independent architecture; it is impossible to mistake the plan of even one town for that of another; much less to do so in two or three consecutive cases.

185. It is something like the chance of two cities being constructed by accident on exactly the same plan; that is what it comes to?—Exactly.

186. But to make out evidence of identity from these minutiæ it must be done by an expert; is not that so?—It must be done by an expert if it is to be done exhaustively. If it is to be done sufficiently to give a strong moral probability, a man with very little training could, without photographic enlargements, do it well enough to make it worth while to send it to an expert or otherwise to incur some expense to obtain fuller evidence.

187. Of course if it were to be actually used in a court of

law as evidence, you would have to have it enlarged by photography and fully explained to the jury?—A fingerprint should be very much enlarged by photography for easy explanation to a jury.

188. For ordinary purposes—supposing a warder states he can identify a particular man—in order to make sure that he is not making a mistake, it would be quite enough for any ordinary person to compare the two sets of fingerprints?—Quite so; supposing he had had some little experience in making these comparisons. A person who is quite raw does not know where to fix his attention; pointers of this kind (*showing*) greatly facilitate. Any person who examines minutiæ, and on whom some responsibility is thrown to do it well, ought to possess himself of a watchmaker's lens, or its equivalent, and a few of these rude tripod pointers, one of whose feet is a pin to place on the particular point to which he wants to attend.

189. Well, coming to the question of cataloguing, that involves the settling of patterns, does it not?—If this simple A, L, and W principle is adopted, a set of patterns is wanted for reference such as those on the table. There should also be typical specimens of those patterns about which doubt may reasonably arise. Then, by putting below each specimen the letter that is intended to represent it, uniformity in treatment can be ensured.

190. What is the proportion of patterns in which doubt has actually occurred? In what number of fingerprints would you find an ambiguous case, would it be one case in twenty?—Ambiguity has many grades. When my superintendent marks the prints and hands them over to me, I have to make a correction—but seldom a serious one—in about one in fifteen sets of fingerprints.

191. That would be one in 150 fingerprints?—Yes.

192. How often would you have to refer to these specimens to settle a pattern; should you say once in a hundred sets?—Though I have prepared these specimens only lately, I do not think I should have to refer to them often now.

193. You know the work so well now?—I am very familiar with it, and find certain ambiguous cases to recur so frequently, that when you have determined how to name them, they cease to be ambiguous.

194. It is only a question of learning which of the classes these ambiguous patterns belong to?—Quite so. May I take this opportunity of making an explanation? I was at a little disadvantage when the Committee was appointed, as I had not then determined how to class many of these ambiguous cases. My plan has been to leave it to Randall to write the title to each card and for me afterwards to revise them. Then I noted the more or less ambiguous cases; where there was decidedly room for doubt we conferred together sometimes. Then the cases of doubt became fewer and fewer, and I had intended at the end to have leisurely accumulated and photographed a good set of the doubtful cases, and finally to fix how they should be classed. But when the Committee was appointed it was necessary for me to catalogue with haste my collection, although these ambiguous cases had not been so thoroughly worked out as I should have liked.

195. Then do you think there would be any difficulty, supposing these were used for identifying prisoners, in getting one or two persons who in a reasonably short time might learn to work at deciphering patterns?—My experience is this: seven persons have been more or less connected with me in various parts of this inquiry, and I found that after a few days they all acquired very fair knowledge; it was the want of a good set of specimens of ambiguous cases that prevented them from making further advance in that brief time. As an example of what has been done for me by others, I submit a small portion of the voluminous work by Mr. Collins, in which not only the A, L, W method of indexing was taken into account, but the particular pattern in a series of fifty-three standard patterns, which is a far more difficult task, yet he acquired the art very quickly.

196. Is this outline necessary in working these fingermarks? —I think not, if the A, L, W method only is used.

197. A learner ought to practise it?—A learner ought to practise it a little. It must be recollected that I wrote my book on fingerprints, in which the importance of outlining was emphasised, a year and a half ago, at all events, it was out of my hands eighteen months ago, and I have studied the subject a good deal since; some things are now superseded that were said in that book.

198. You would dispense with the outlines except by way of practice in getting the forms into a beginner's head?—Quite so.

199. Then your method of indexing is taking the ten fingers and appending to them the letters A, L, or W, according to the pattern of each?—Yes.

200. But on the forefinger you use the letters R and U according as it comes, R from the radial or thumb side, U from the ulnar side?—Yes.

201. And that would give you possible combinations amounting to over 100,000 if they occurred quite indiscriminately?—With ten digits their number is $4^2 \times 3^8 = 104,976$, say 105,000, with six digits it is $4^2 \times 3^4 = 1290$, but only a fraction of the possible combinations are actually met with.

202. That is if they occurred absolutely indiscriminately?—If they occurred absolutely indiscriminately the 105,000 possible titles would be equally frequent.

203. But as a matter of fact, they do not occur indiscriminately or anything like it?—No. One combination is very common.

204. That is all loops. It occurs in about 6 per cent?—Yes, that is the percentage for "all loops" of the U kind only.

205. What is the reason of your making a distinction between R and U in the forefinger and not in the other fingers?—Because R occurs very rarely in any digit except the forefinger.

206. Very rarely?—Very rarely, and from trying to pick out the instances and finding so few the mind becomes lulled, as it were, with a sense of security and overlooks them when they do occur; for that reason I have thought it better to avoid them hitherto in my particular way of working.

207. In fact it adds very much to the labour of getting correct formulæ without really assisting the classification very much?—Quite so; that is the reason why I have discarded it, but I am not at all clear that I should recommend the same plan as that which I have used, for your purpose. I think it might be better to do away with the letters R and U, and to substitute for them other letters that mean respectively sloping downwards from the upper right-hand corner of the paper to the left-hand lower corner, or vice versâ. It would be much simpler to get rid of the R and U, which have opposite significations in

the two hands, and therefore strain the attention. In the way I now propose you would only deal with one signification. You would not care for the difference between radial and ulnar, but only for the direction of the slope, whether it was downwards to the right or to the left. The disadvantage would be that it is not physiologically accurate, but this is so only in appearance, because the way in which the title is written carries on its face its physiological meaning, telling which is the right and which is the left hand; if you desired to translate the title into R and U language, it could be done very easily.

208. I suppose you think it is desirable that we should take all of the ten fingers; it very much increases the extent of the classification to take the whole ten?—On that point I have a misgiving; the gain is not so very great of ten over six as it appears at first sight. Here you will find a number of the observed occurrences in a classification by six fingers.

209. Which are the six you take; the three first fingers of both hands, omitting the thumb and little finger?—Yes, the thumb and little finger sub-divide the rarer cases, but you may not want that particular kind of sub-division. If only six are taken it does not largely increase the number of the commoner cases. The commonest case, which is that of *ull, ull; ll, ll*, is raised from 164 out of 2644 cases to 243. In other words, it is only made half as common again. That is the only case which creates much difficulty if you are dealing with drawers that each contain not more than, say, 300 specimens, and I doubt if it is worth while under those circumstances to take the trouble of recording four more fingers.

210. Then you think, for the purposes we have in view, a record of six fingers would practically be sufficient?—If I understand your purpose rightly, that it is to divide primarily by measurement into 243 different drawers, so that each drawer shall contain not more than a few hundred cards.

211. Do you think the six fingers would work up to a thousand?—A thousand is rather large. The six-finger system would work even then if in the commoner cases the ridges in any one finger were counted or measured. I am a little doubtful about the advantage of indexing the whole ten if you desire to expedite matters and secure the greatest economy of time.

212. You mean that the time taken occupied in taking the six fingers would be very much less than the time taken in taking the ten?—Yes; and there is also the largeness of the card.

213. There can be very little more time taken in putting down the five fingers than in putting down the three?—You have to roll them all individually afterwards.

214. *Major Griffiths.*—The whole thing does not take more than a minute, does it?—If you do not fear the little additional time it is so much gained.

215. *Chairman.*—It is only on the ground of saving time that you would take the six rather than the ten?—Yes.

216. *Major Griffiths.*—It might lead to confusion—they might take wrong fingers?—Yes, certainly—it is better to have one impression at all events of the little fingers.

217. There is no fear about the time, it is a question of a minute, more or less. In taking the distinctive marks they sometimes occupy ten minutes?—A print of ten fingers also means a large card, as you are aware.

218. We are glad of the other side of the card for the measurements and for the photograph?—Yes.

219. *Chairman.*—What is the reason for not taking the formula from left to right?—The practice of beginning as I do has grown into use for more than one reason peculiar to myself. Thus, I wanted many thousand prints from persons of different races, and the only chance of getting them was to ask for what could very easily be given. This led me to ask for the first three fingers of the right hand only, and so the practice of beginning with these was started. It has been persevered in, because of the great variety of pattern in the forefinger; it is the only one that frequently has an R. If you begin with the little finger nearly all your formulæ would begin with an L of the U kind.

220. Except a few W's?—Yes, but only a very small proportion of them and hardly any A's. I may as well now put in evidence a number of prints of palms and of complete hands.

221. But the palms must be a good deal more difficult to take than simply the finger-tips?—There must be a pad with a somewhat rounded surface to press upon, and soft paper like this should be used; it does not take much trouble.

222. Is it long since you took up the question of sub-classification?—In one sense I took it up from the very beginning.

223. But the mode of classifying by counting the number of ridges in the loop?—It was only when you met and asked me about sub-classification that I took it up in that way; I have counted ridges before, but not for the purpose of sub-classification.

224. But you think now that this sub-classification by counting ridges is the most practically useful one?—If the number of ridges in the first finger alone is counted, it would sub-divide the common titles into manageable groups, if you are only dealing with about 500 cases.

225. Take the ring finger, about how many classes would it give?—*In the ring finger the number of ridges between* the two selected termini (namely, the summit of the core of the loop and the place where the surrounding ridges diverge to enclose it) varies from two to twenty-six or more; the classes are about equally numerous between three and sixteen; there are thus fully fourteen available grades.

226. Fourteen nearly equal classes?—Yes; if you counted to the nearest ridge there would be fourteen classes and more; if you allowed for an error of one or two ridges, there would be, say, five very well-marked classes.

227. But perhaps the best way would be simply to arrange the cards in order of the number of ridges?—Yes; in order of the number of ridges in some one specified finger.

228. Then you would find the card somewhere near the place?—Quite so.

229. Do you think it needs a good deal more practice and skill to do that than to do the primary classification of A, L, and W?—It is extremely simple. The chief difficulty lies in the prints being on so small a scale that you require a lens, which some people may not be capable of using.

230. And can it usually be done pretty accurately?—Yes, I have found in going through a set of 164 cases of *ull, ull; ll, ll,* on which Randall and myself worked independently, that there were no cases of a discrepancy between us of more than two ridges; there were four cases, I think, of an error of two and about eighteen of an error of one.

231. Generally speaking, you came very close?—Yes, we came very close when we had gained a mutual understanding about the exact principle by which the two termini should be chosen.

232. I think I have gone over all the points I have noted. We have one or two questions about Bertillon's system still.—I shall be glad to reply to them.

233. Before we come to that, are there any other remarks about the fingerprints you would like to make?—No, I think I have said all that I wish to say.

234. You have an arrangement by which you think it would be possible to take the fingerprints of a prisoner who resisted altogether?—I have.

235. Not fully worked out yet?—Not worked out on a resisting person.

236. But still you think it might be used?—I think so. I do not, however, rightly understand the degree and the sort of resistance to be feared. In experiments I have made with two small rollers set in a handle, one to ink the fingers and the other with paper round it to receive the impression, a print can be obtained in an instant.

237. So that probably by holding the hand of the prisoner you might get the print?—I should think so. Another way would be to cut out holes or slits in a brass plate and to press the fingers upon them; then their bulbs would show through the holes and could be printed fairly well in that position.

[The rest of my evidence, which bore chiefly upon measurement, is omitted here.—F. G.]

From the Appendix to the Report

It remains to give two of the Appendices to the Report.

(1) Instructions for taking Fingerprints

Every prison where fingerprints are to be taken will be supplied with a plate of copper, $10\frac{1}{2}$ *inches by* 7, *or of such other size as experience may show to be most convenient, screwed down by its corners and both ends to a board* 1 *inch thick, an ordinary printer's roller,* 9 *inches in length and* 3 *in diameter, two tubes of ordinary printer's ink, some benzole, and a stock of cards* 12 *inches by* 5, *as indicated in the Report.*[1]

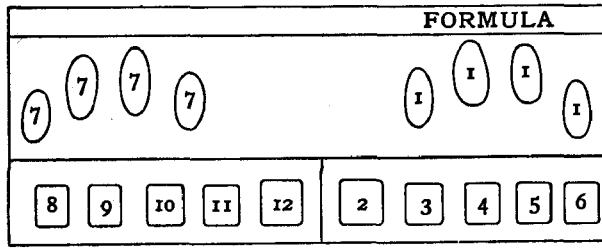


Fig. 1.

1. Squeeze less than a drop of ink [that is, less *in bulk* than a drop of water.—F. G.] on the copper plate and work it with the roller till it forms an even layer over the surface. The layer of ink must be so thin as to allow the copper colour of the plate to show through it.

2. Take the prisoner's right hand and lay the bulbs of the four fingers flat on the inked plate, pressing them gently but firmly with your own hand. Then lay the inked fingers flat on the upper right-hand division of the card, pressing them as before with your own hand, so that imprints of the four finger bulbs may be taken at the places marked 1 in the above woodcut.

[1] This illustration is simplified from that given in the Report, because folded paper is being used in Scotland Yard instead of large cards, and the fingerprints are differently arranged. The card suggested in the Report is nearly the same as those used in my laboratory, but another method has been planned that is likely to prove more convenient.

3. Then take the thumb of the right hand, roll the bulb slightly on the inked slab and roll it again on the lower part of the card at the part marked 2. Do the same with each of the fingers in succession, so that imprints of them may be taken at 3, 4, 5, and 6. These imprints will be more extended than those taken at 1, but are sometimes not so sharp.

4. Repeat the process with the prisoner's left hand, except that it will probably be found more convenient in taking the *separate* imprints of the fingers to begin with the little finger at 8. In any case, however, the left-hand thumb must be printed on the card at 12.

5. Care should be taken in the lower range of imprints that the whole of the finger bulbs should be laid on the card well above the line that cuts off a margin at the bottom.

6. Both the roller and the slab must be thoroughly cleaned with benzole, dried with a rag, and put out of the way of dust when done with.

7. The fingers may also be readily cleaned with benzole or turpentine after the imprints have been taken.

(2) Memorandum as to the Reading of Fingerprint Formulæ

(Revised by Mr. Galton)

The following memorandum is intended as the basis of the instructions for the assistants in the Central Registry who have to deal with fingerprints. It is not to be regarded as final, but merely as a brief statement of Mr. Galton's method in its present stage. Alterations in detail will be made as the process is developed in practice.

Symbols

[I omit the brief description here given of the symbols, because they will be very fully described and illustrated in Chap. III.—F. G.]

Reading Patterns

The assistant must acquire knowledge of the types of pattern mentioned above by examination of a large number of actual fingerprints. He should fix his attention first on the outline of

the pattern, and then on its core, and never allow it to dwell on non-essentials, however conspicuous they may be, such as differences due to the impressions having been taken from slightly different parts of the finger, or being blacker in some parts than others. He should also practice tracing patterns in the manner described in *Finger Prints*, p. 69. He will be supplied with a book containing photographic reproductions of the forms of pattern which are transitional between the types mentioned above, showing in each case to which type the form is to be assigned. When a knowledge of these forms is acquired in this way, few cases will occur which cannot be assigned with certainty to one or other of the main types.

In reading off imprints, first determine to which type the pattern belongs, and write down the symbol *a*, *l*, *r*, *u*, or *w*, as the case may be.

In the case of a transitional form, note below the line the other possible interpretation, *e.g.* l_y, w_x. These symbols should be added even in cases where there is no doubt as to the type to which the print belongs, but where they may aid the searches in the register by indicating a well-marked feature.

Writing Formulæ

In writing the formula for the set of ten fingerprints the symbols will be written in the following order: the first, second, and third finger of right hand; the first, second, and third finger of left hand; the thumb and little finger of right hand; the thumb and little finger of left hand. They will thus fall into four groups, divided as in the following example, *ull, alw; wl, wl.*

The formula will be noted at the right-hand top corner of the card.

Arrangement of Cards

The drawer in which each card is placed is determined by the measurements on the Bertillon method. The cards in each drawer will be arranged in the alphabetical order of the fingerprint formulæ.

Search

When a *search* card giving the fingerprints and measurements of an unidentified prisoner is received, the formula will be written

down in the same way. Special care must be taken in this case to note transitional forms of pattern.

The drawer in which the original card will be found is determined by means of the measurements in accordance with the Bertillon method. When this is done, the card or cards in the drawer having the same formula as the search card should be taken out.

If several cards are found having that formula, seek some distinctive feature, either already noted in the formula (*e.g.* w_r) or in the patterns themselves, and look through the cards bearing that formula to see whether any of them has this feature.

When one card has been selected, compare carefully the prints of several of the fingers with those on the search card, to ascertain whether they are imprints of the same hands.

A minute comparison of the details in the prints requires the use of a lens (a watchmaker's lens is convenient); also of two or more pairs of "pointers" to mark down corresponding points in the two imprints, from which, as from starting-points, others may be successively laid down. A pointer consists of a wooden arm a little thicker than a pencil, from 6 to 10 inches long, having a common pin inserted firmly into its pointed end and then bent downwards. The arm is fixed to a short cross-bar (3 or 4 inches long), which rests on two nails with smooth heads. Thus the pointer is a tripod. The arms of the two pointers in each pair should be of different lengths, to prevent their cross-bars from interference when they are both in use on the same print.

If the card is not found under the same formula, and if there are any transitional forms in the prints on the search card, search should be made under the other formula or formulæ indicated by transitional symbols.

If the card is not found there, it is not in the drawer.

Sub-division

When the cards in one drawer bearing the same formula become very numerous, a sub-division will be necessary.

This will occur first with the formula *ull, ull; ll, ll.*

The principle of sub-division is to select one finger—the same in all cases (say the right forefinger), and having with the aid of the pointers determined (1) the central ridge of the loop, (2) the

corner where the ridges, passing over the loop, diverge from those passing below it, to count the number of intervening ridges. The cards having this formula are then arranged according to number of ridges.

When there is no central ridge, but a narrow loop or "staple," the counting is to begin from the further shoulder of the staple.

In searching, count the ridges in the same finger in the same way, and search those of the cards of the *ull, ull ; ll, ll* formula having the same number of ridges. Allowance must be made for a possible error of two in counting the ridges. Thus, if the number counted is 7, it is necessary first to look through the cards having 7, then those having 6 and 8, then those having 5 and 9. [This is more fully explained in Chap. III.—F. G.]

CHAPTER III

CONDITIONS AND REQUIREMENTS

THE long extracts from the lucid Report of the Committee, that formed the bulk of the last chapter, will have put the reader in possession of the main conditions and requirements that relate to what are here called Fingerprint Directories. These will be considered in fuller detail in the present and the following chapters, according to recent experience.

The methods about to be described are due to varied and repeated experiments, chiefly upon two collections, the one of 300 complete sets of fingerprints, and the other of 2632.[1]

My inquiry as to the most suitable methods of classification has all along been compelled to follow a devious route, not a few methods that promised well at first proving impracticable on trial, while unexpected by-ways were discovered and found to be effectual. The almost endless variety of shape in the whorls strongly suggested that the classification

[1] The latter is the same as the one referred to (p. 13) as containing 2645 sets. The slight difference in number is due to the weeding out of a few cards, that found a more suitable place in other collections, and of a few imperfect sets. There has also been some rearrangement of the frontier between arches and loops, which has slightly altered the number of the *ull*, *ull*; *ll*, *ll* sets.

of sets ought to be principally based upon them, while the frequency of a monotonous form of loop seemed to offer by far the most serious difficulty. Experience, however, first falsified and then wholly reversed those views. The varied forms of whorls were found to be connected with one another by so many transitional patterns that they could not be sub-classified with any approach to accuracy in the way that had been anticipated; nay, more, in the one particular formula of "all-whorls," in which sub-classification was especially needed, the general appearance of the whorls is so deficient in variety that most of the suggested sub-classes would have failed to divide them sufficiently. On the other hand, it turned out that the plainer forms of loop, which predominate largely over other forms in the exceptionally numerous class of *ull, ull; ll, ll* (just as plain whorls do in that of *www, www; ww, ww*), admit of being classed numerically by the simple expedient of recording the number of ridges in each of them that are crossed by an imaginary line drawn between two definite termini.

Another trouble in the course of the inquiry arose from the unexpected fact that certain characteristics in a particular print are by no means sure to arrest the attention in another print, taken from the same finger, with different pressure and a different amount of ink. It required much experience to ascertain which of the peculiarities were the most surely and easily recognisable, and therefore those to which sub-classification ought to be confined (see p. 109).

A further difficulty was occasioned by the very different frequency of the various formulæ. As many as 493 sets in my collection of 2632 are solitary instances of their respective formulæ, and give no trouble at all, whereas no less than 156 sets fall under the single formula of *ull, ull; ll, ll.* It is, therefore, of the highest importance to adopt a system that shall waste as little labour as possible, the minuteness of description necessary to discriminate between the 156 sets as above, being altogether thrown away on the 493, and more or less so on the rest. The following table shows the distribution of the sets under the primary formulæ, and gives data for discussing the desirable degree of sub-classification.

No. of sets that fall under a single formula		No. of those formulæ in 2632 sets.	Total sets out of the		No. of sets that fall under a single formula		No. of those formulæ in 2632 sets.	Total sets out of the	
in 2632 sets.	in 1000 sets.		2632.	1000.	in 2632 sets.	in 1000 sets.		2632.	1000.
1	0·4	493	493	187	21	8·0	1	21	8
2	0·8	136	272	103	22	8·4	...	...	...
3	1·1	62	186	71	23	8·7	1	23	8
4	1·5	32	128	49	24	9·1	2	48	18
5	1·9	25	125	48	25	9·5	1	25	10
6	2·3	13	78	30	26	9·9	...	...	...
7	2·7	10	70	27	27	10·1	1	27	10
8	3·0	10	80	30	28	10·6	2	56	21
9	3·4	3	27	10	29	11·0	...	...	...
10	*3·8*	*5*	*50*	*19*	*30*	*11·4*	...	...	...
11	4·2	6	66	25	...	...	...	...	...
12	4·6	4	48	18	32	12·2	1	32	12
13	4·9	3	39	15	36	13·7	2	72	27
14	5·3	3	42	16	44	16·7	1	44	17
15	5·7	5	75	29	49	18·6	1	49	19
16	6·1	...	...	...	63	23·9	1	63	24
17	6·5	4	68	26	93	35·3	1	93	35
18	6·8	1	18	7	156	59·3	1	156	59
19	7·2	2	38	14					
20	7·6	1	20	8	Totals . .		834	2632	1000

The efficiency of a directory depends on its power

of breaking up, with the maximum of surety and the minimum of labour, a collection of sets into groups, of which even the largest shall be "easily manageable," so that when a group is designated as that in which the set searched for must be, if it exists anywhere in the collection, it shall be quickly discovered.

So far as an "easily manageable" number is constant, it is clear that the minuteness of description necessary to break a directory into fragments, none of which shall exceed that constant number, must depend upon the size of the directory, which therefore has to be regarded before discussing the amount of painstaking necessary to effect what is wanted.

But an "easily manageable" number does not depend wholly on the size of the directory; it partly depends on its character and form. The form that was recommended by the Committee is a card catalogue, such as I myself have been in the habit of employing; in other words, a collection of separate cards, stacked behind one another in the alphabetical order of their formulæ. The batch of cards which bear the same formula as the search card are picked out, laid on a table, and successively scrutinised through a lens, paying attention only to some *one* conspicuous peculiarity in some *one* of the fingers that has been selected for the purpose. This is a rapid process, to be carried on until the print sought for has been found, or an assurance obtained that no such print is there. [A card catalogue has the great and obvious

merit of allowing new cards to be interpolated, and useless cards to be withdrawn, without confusing the order of the whole.]

I timed myself in making searches, for the most part among the 156 sets of *ull, ull; ll, ll,* in the larger catalogue. The whole batch of cards was laid before me on the table, and a duplicate impression of some one of them was submitted by my assistant to serve as a search card. Eight trials were made, during which the total number of cards looked through before the right one was found was 373 (it varied from 12 to 104); while the total time occupied in the searches, including that of fixing on the minutiæ to be looked for, and memorising them, was thirty-six minutes and a few seconds. Hence it is easy to make a search through ten cards in a minute, passing them rapidly under the lens for the most part, but occasionally dwelling longer on one of them, and now and then referring back to the search card to refresh the memory. The trouble of opening the drawer or other receptacle, and picking out the batch of cards that bear the formula of the search card, is most profitably done by an assistant. It would seem from this that ten cards is an unnecessarily low limit of the "easily manageable number," but for all that I am inclined to adopt it, because the eye is more fatigued by looking carefully and rapidly through many successive batches of prints than by other operations. The fatigue, such as it is, admits of being greatly reduced by strict attention to optical and mechanical details, so that each print shall come

easily and surely into the right position and focus under the lens.

About one and a half minute is required to verify the supposed duplicate with sufficient strictness to fulfil legal requirements. It amply suffices for this purpose to compare ten well-marked particulars, each consisting of a small group of minutiæ, or of independent peculiarities. Thus, an island or an enclosure comprises three distinct minutiæ, namely, the beginning of a ridge, the end of a ridge, and the distance between them. Owing to the tenfold increase of the chance of finding suitable particulars in a set of ten prints, the ease of verifying a complete set is very much greater than that of verifying a single print with an equal degree of assurance.

But the common card catalogue is by no means the only form of directory. Thus the fingerprints may not be impressed on the face of the cards, but on paper which is afterwards folded, so that the prints are inside, while the formulæ, measures, and other data are legibly written on the outside. It would in that case be much more convenient to be mainly guided by the inscriptions than to unfold and refold the ten papers.

Again, a hack catalogue, consisting of small cards easy to manipulate, is desirable for the ordinary purposes of search and verification. It would be much more compact and easy to manipulate than the large card catalogue, and would relieve it from wear and tear and dirt. Subjoined is a specimen of what is meant, true to scale.

Right.			Left.			Right.		Left.	
Fore.	Mid.	Ring.	Fore.	Mid.	Ring.	Thumb.	Little.	Thumb.	Little.
a	*l*	*l*	*u*	*l*	*l*	*w*	*l*	*l*	*l*
t		*v*			*y*	*sqv*	*v*		*vy*

Head length.	Head breadth.	Left mid finger.	Left cubit.	Left foot.
181	*153·5*	*114*	*463*	*253*
M	*L*	*L*	*M*	*S*

Register. .

Specimen of a card suitable for a hack catalogue, containing all data necessary for search and for subsequent verification. On its face are the primary and secondary fingerprint formulæ (as will hereafter be explained), the five measures, and their respective classes (*note*, the classes in this specimen apply to measures made in Bengal), and the register number of the person measured. On its back are the simultaneously dabbed impressions of the four fingers of the right hand.

The number ten would continue to be the limit of an easily manageable number in this case.

Other hack catalogues may have to be compiled where no fingerprints are available for the backs of the cards. Then the final search and verification would probably have to be made in a collection of documents preserved in the order of their registration (p. 23), in which case, as it would be necessary to avoid the turning over of many pages, the discriminative

power of the inscriptions on the small cards would have to be sufficiently exact to almost individualise the person. The same would be true if the contents of one of the small cards were published, or transmitted to a foreign country for purposes of proximate identification. In these cases, the limit of the largest number of sets that are likely to be comprised under any one formula ought to be as low as two or three.

Thus there are at least four varieties of card catalogues: (1) Large cards with the ten digits impressed on each; (2) folded cards or papers with the ten digits impressed on the inside of each; (3) small cards with the dabbed prints of four fingers on the back of each; (4) small cards without any print at all. Besides these, (5) a reprint of formulæ that have accumulated during some specified time, may be needed in the form of a book directory.

The sizes of directory kept in view in the following remarks are such as contain respectively 300, 500, 1000, and 3000 sets.

When a directory of the smallest of these sizes is used in the way intended, namely, as subordinate to a primary classification by the Bertillon method of measurements into 243 equal groups,[1] it would refer to 243 × 300, or to upwards of 70,000 persons.

[1] I assume the groups to be approximately equal in number, though I cannot find any evidence or authoritative statement that those in the Bertillon collection are so. Their equality is distinctly *implied* in the often-repeated account of the power of Bertillonage, but the exact state of the case is nowhere definitely stated, so far as I know. Neither is there any description of the way by which equality is assured. The tendency of all or most of the measures to be of the same class, whether *long*, *medium*, or *short*, is met in

That of 500 would refer to 243 × 500 or 121,500 persons. That of 1000 sets would similarly deal with 243,000 persons; this is a convenient size to select for discussion, because the results give percentages to one place of decimals, without any calculation, also because it was especially mentioned in the Report of the Committee (Chap. II. p. 14).

The largest size, that of 3000 sets, was chosen for several reasons. One is the possibility that the exact and delicate measurements needed for the Bertillon method may under certain conditions fall short of the accuracy necessary to its success. Thus, the duty of measuring has to be entrusted in England to the warders of prisons, scattered all over the country, and not to a few incessantly practised experts, working, as in Paris, for many hours every day in the same room under skilled supervision. It is possible, therefore, that the margin to be allowed for error of measurement will prove to be so large that the number of transitional cases, and consequently of repeated references, when five measures are used, may become so onerous as to make it advisable to rĕduce the number of measures and to rely more on fingerprints. It is well, therefore, to consider in good

Bengal by a very elaborate scheme of limits. For example, if the previous four measures were all "long," the accepted range of a *medium* foot-length is from 270 to 263 millimetres; if the four previous measures were all "medium," the range would be from 247½ to 243; if they were all "short," it would be from 230½ to 225 millimetres. The limits differ so greatly in these three extreme cases that a particularly long foot in the third case, say one of 245 millimetres, would be reckoned as a medium foot in the second case, and as a particularly short foot in the first case. These figures are derived from a terse yet full report on criminal identification by E. R. Henry, Inspector-General of Police, Calcutta, 1894.

time the possibility of obtaining effectual results from larger fingerprint directories than were contemplated in the Report of the Committee. If only four measures are used, instead of the five as now proposed, the number of the Bertillon groups would be eighty-one; if three measures were used, the number would be twenty-seven; if two measures—say the breadth and length of the head—the number of the Bertillon groups would be nine. In these three cases, the ability to make good use of fingerprint directories of the 3000 size would enable us to deal with as many as 243,000, 81,000, and 27,000 persons in the three cases respectively.

Another motive for examining into the feasibility of large directories refers to the juvenile offenders, whose measures will change by growth, and are therefore not to be depended on for a directory (see p. 25).

Again, I trust that the fingerprint method may in time be used for discovering fraudulent re-enlistments by deserters. Recruits are growing youths, whose measurements cannot be relied upon with the exception of those of the length and breadth of head.[1] The number of recruits who desert, taking their uniform with them and pocketing their bounty

[1] The simplicity and precision of the spring callipers, contrived and used in Bengal, is truly remarkable. After five minutes' practice any intelligent person can obtain more trustworthy measures with them than an expert can obtain with the sliding arrangement. There is a shake in the latter which increases by use. The spring callipers are identical with those of Bertillon, except that a spring is introduced to pull the arms together with uniform pressure, and a light index slides on the graduated arc, which is pushed forward by the arm of the calliper, and is left at its maximum opening, to be read off at leisure. I have made many sets of measures with it, ten sets in each case, and it is rare that the difference between the highest and lowest measure in a

money, is appallingly large, while those who enlist and are subsequently proved to be deserters from other regiments, presumably with the intention of repeating the process, is about 200 annually. The real number is probably much larger than 200, for the practice of fraudulent enlistment would not have become so common as even that figure implies, unless the chance of detection was known to be small. The facts, in round numbers (see *General Annual Return of the British Army* for 1893, p. 36), are that about 35,000 soldiers annually enlist, and that nearly 5000 of them desert, half of whom are recaught, while the others are not. The real number of fraudulent re-enlistments must be partly a matter of speculation, but for the reasons just given, it may fairly be estimated that the undiscovered cases are at least twice as numerous as those that are found out, giving a total of 600 annually. There is therefore abundant justification for a considerable effort to check the practice. Let us then consider what is needed to ascertain whether each of the 35,000 men who annually enlist is or is not on the register of deserters. The register of deserters would be increased by 5000 annually, or by less than twenty daily, but the cards of men who had been on it for, say five years, might be regularly sorted out. It will further be supposed, for argument sake, that only the two head measures

set exceeds half a millimetre. They would be trustworthy and simple instruments for the rapid measurement of recruits. Measures of the length and breadth of head are more constant and exact than those of any other bodily dimension. Moreover, they are always obtainable. A living man may have lost his finger, arm, or foot, but he cannot have lost his head.

are utilised, though body-marks would, in all probability, be employed as well. Then the requirement is to make 35,000 searches annually, or an average of some 130 daily, excluding Sundays and holidays, in a collection of (5 multiplied into 5000) 25,000 cards. The 25,000 would be divided into nine equal groups by the head measures, and each group would contain somewhat less than the 3000 cards of the larger-sized directory to be discriminated by finger-prints.

One hundred and thirty searches daily, at four minutes for each search, amounts to nine hours' continuous work. That much could be got through by two experts, who would have time besides to classify the twenty daily accessions. But the estimate takes no account of the daily fluctuations in the number of searches to be made, which would occasionally throw an avalanche of work on the office, much greater than the two experts could possibly deal with in a day.

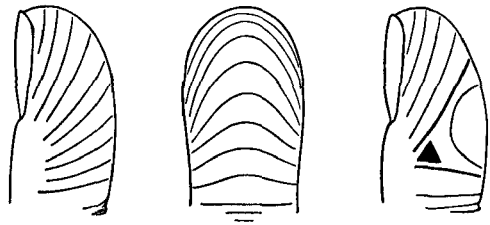
CHAPTER IV*

PRIMARY CLASSIFICATION

A READING-GLASS, say of 6-inch focus, is needed for studying the prints in this book, because it is not sufficient, in a considerable proportion of the cases, to obtain a blurred notion of the run of the ridges, every ridge should be distinguished clearly. It is also necessary to have at hand a common pocket lens, of about $2\frac{1}{2}$ inch focus; that is to say, of fully twice the power of the reading-glass, for occasional scrutiny.[1] A higher power (p. 86) is wanted for counting ridges easily. It is a great mistake to use stronger powers than are really needed, for they entail at least three inconveniences: (1) The field of clear definition becomes reduced in size; (2) the distance of the lens from the paper, and its parallelism with it, must be more carefully attended to; (3) the eye has to be brought so near to the print that the shadow of the head cuts off much light that would otherwise fall upon it, while abundance of light is important.

[1] In place of a reading-glass I employ strong spectacles; my usual lens is of the sort used by watchmakers.

The Deltas.—In studying a fingerprint the first objects to look for are its "deltas," to ascertain whether the pattern has two, one, or none of them. The deltas are formed as follows: The ridges run in approximately straight and parallel lines across the palmar sides of the fingers, from the joint that connects the fingers with the hand down to the farthest finger joint. The ridges would continue to run in straight and parallel courses across the fingers, up to their extreme tips, were it not for the nail, by whose insertion the ridges are squeezed downwards on both



ARCH (side view). ARCH (front view). INTERSPACE (side view).

FIG. 2.

sides, the ridges that run across the tip being thereby greatly arched, while those that follow are successively less so. In about one-seventh of the prints this diminution of curvature proceeds steadily until the last traces of it are lost a little way past the base of the nail, at about the level of the joint. Such patterns are called *Arches.* In the remaining six-sevenths of the prints the gradual transition from an arch to a straight line fails to be carried out; there is a sudden break in the orderly sequence of steadily diminishing curvatures, and an interspace is left. The topmost boundary of the interspace is formed by the lower-

most of the arches, and its lowermost boundary is formed by the uppermost straight ridge. Within this interspace lies a *Loop* or a *Whorl*, as the case may be. Now the existence of an interspace implies a divergence of the ridges by which it is embraced, whether through the sudden separation of two ridges that had previously lain alongside of one another, or by a single ridge forking into two. Just in front of the place where the divergence begins, and before the sweep of the pattern is reached, there are usually one or more short ridges variously disposed. The plot to

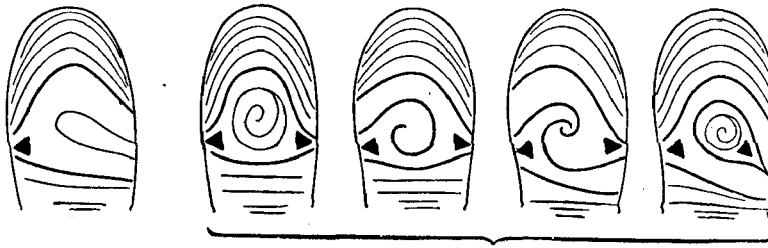


Fig. 3.

which the first of these forms a more or less defined base, and of which the two divergent ridges form the sides, is a small and rudely-shaped triangle, which is of the utmost importance as a point of reference when analysing the pattern of a fingerprint. I call the plot by the geographical term of a *delta*, that being the name of the triangular letter Δ, which is the equivalent of our D in the Greek alphabet.

In order that the print should never fail to include such delta, or pair of deltas, as may exist, it is necessary that the sides of the bulbs of the fingers, as well as their faces, should be imprinted. This is effected

by slightly rolling each finger separately, first on the inked slab, and then on the card, thereby obtaining what map-makers would call a cylindrical projection of a part of the finger.

The four fingers of each hand are printed twice over, first by dabbing them down simultaneously, and then by rolling them separately. It is difficult to take a good impression of the thumb simultaneously with the four fingers, so a dabbed impression of the thumb is not attempted, but only the rolled one. The dabbed and the rolled prints have their respective uses, which are supplementary to one another. The simultaneously dabbed impressions of the four fingers of a hand afford an intrinsic assurance whether they are those of the right or of the left hand, also as to their order in the hand,—fore, middle, ring, or little finger, which the separately rolled prints do not. A mistake might easily occur in recording either of these important details, which could not be discovered from the rolled impressions. It is also a convenience, when the prints are not as good as they should be, to possess double imprints, as details that are indistinct in the one may be better seen in the other. A striking example will be given in the chapter on Ambiguous Patterns (p. 110) of an error that might have arisen from relying wholly on a dabbed print.

An Arch contains no delta; a Loop has one, and a Whorl has two.

The learner should mix water-colour, fill a pen with it, and dot the deltas of his own fingers and those of such friends as will allow him, and trace the

courses of the divergent ridges until the outline of the pattern they enclose is sufficiently apparent. (Water-colour washes off easily; ink stains.)

In my book *Finger Prints* I over-estimated the importance of drawing these outlines with completeness; I used to draw them on many loops and on every whorl, but the great trouble of doing this is discarded in my present way of working. I never draw them now, though I commonly find it necessary to follow their course in Whorls for a short distance with the eye, occasionally aided by a pointer. It seriously disfigures a print to ink it. A beginner ought, however, to practise himself in drawing outlines on the fingers themselves, on waste prints, or on tracing-paper laid over the prints in this book, until he feels that his eye and judgment can be depended on to pick out the deltas surely and quickly, and to correctly follow the earlier portion of the ridges that diverge from them.

A warning must here be given as to the insignificance of certain conspicuous white streaks, which will be noticed in a few of the specimens of fingerprints given in this book (see Figs. 6, 11, 26, 35, 52, 56, 72). They are due to wrinkles or depressions in the skin, which of course take no ink, and therefore leave chasms in the impression. These streaks almost always occur in the fingerprints of old people. It is easy to distinguish them from scars, because they are unaccompanied by that dislocation or puckering of the ridges which characterises scars, of which we shall have to speak further on (p. 103).

A. *Arches.*—The main feature of arches is the absence of deltas, and consequently of enclosed patterns of conspicuous size. Their ridges are disposed with much symmetry about a median line that is usually somewhat inclined to the axis of the finger, and they run from one side of the finger to the other. They do not, in any noteworthy numbers, double back to the side from which they came, nor do they make spirals or circles. This definition covers the two varieties of arch shown in the diagram, described severally as the plain and the tented arch. These are distinguished

TWO FORMS OF ARCH (no delta).

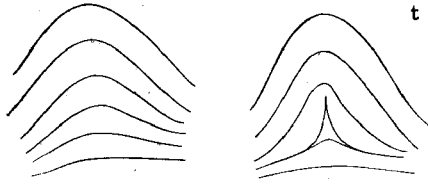


FIG. 4.

in the secondary classification, explained in the next chapter, but are treated alike in the primary formulæ. The plain arch requires no further description, the tented arch is so called on account of a vertical upthrust, as it were, from the middle of the base of the arch, which causes the ridge immediately above it to assume a shape not unlike the outline of a common tent. The remaining ridges of the pattern are but little disturbed. The tented arch is hardly ever found in a thumb.

It would have been possible to place the plain and tented arches in different primary classes, assigning different letters to them, but it was inexpedient

to do so. The total number of arches is so small that their subdivision is not needed; besides, the plain and tented forms are not so sharply differentiated as is desirable in primary classification.

Turning to Plate I. and using the lens, it will be found that Figs. 1 to 6, and 11, 12 are plain arches of a typical form, and that 22, 23, and 24 are equally well-marked specimens of the tented arch. Many of the other specimens in the Plate depart more or less from the pure arch, still they should all be ranked under the letter A, except Fig. 18, that has somehow got misplaced;[1] it is a loop.

While reading the present chapter it is much more important to grasp family likenesses than to dwell on individual differences; the latter will be discussed in the next chapter. The reader should therefore compare Plates 1, 2, and 3 very frequently until he feels himself able to distinguish the great majority of arches, loops, and whorls at a glance.

It must be understood that the specimens in these and the other Plates are taken from *rolled* impressions. They are facsimiles of the originals as nearly as the photographic printing process can make them.

L. *Loops* have one, and only one delta. Their ridges double back upon their previous courses, making a half turn or a little more; consequently the

[1] The label on which this loop was printed probably became pasted on the card sent to the photographer, owing to its temporary adherence to the print of an arch, which afterwards dropped off unnoticed.

pattern, as a rule, has an open mouth directed downwards, and either towards the right side of the finger or towards its left. If there be no open mouth, it is because the ridges that form the outline of the pattern reunite at an acute angle, enclosing a pear-shaped space. They never make what will hereafter be called a *complete circuit*, that being the characteristic of whorls. In other words, if we suppose miniature carriages to run along the ridges of a loop, their courses will not have been directed to every point of the compass, but only to half or a little more

FOUR FORMS OF LOOP (one delta).

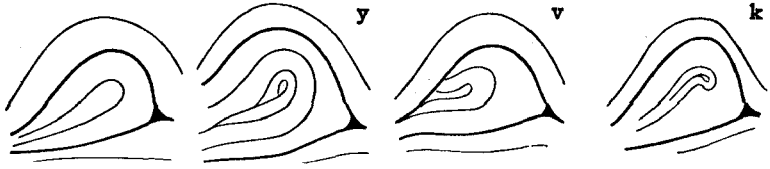


FIG. 5.

of those points, as will be more fully explained directly. Loops are much more varied than arches. Four of their most noteworthy varieties, with descriptive names below them, are shown in the diagram, but these variations are not recognised in the primary formulæ. The small letters in their upper right-hand corners refer to secondary classification, and will be explained in the next chapter. The prints, here and elsewhere, are taken indiscriminately from either of the two hands, consequently the direction towards which the open mouth of any loop is turned is not to be regarded here. Figs. 29, 30, 35, 36 are good cases of plain loops; 43, 44, 45 of eyed loops; 37,

38, 39 of invaded, and 48 of a hooked loop. Fig. 42 is somewhat ambiguous, though it belongs to a familiar type. Here it has been reckoned primarily as a loop rather than as an arch; more will be said about this type later on (p. 102).

W. *Whorls.*—These are far more varied in shape than loops, so much so that it will seem strange that patterns which differ so greatly as those in Plate 3 should be grouped under the same head. But wide as the differences are in many of these well-

PARTIAL AND COMPLETE CIRCUITS.

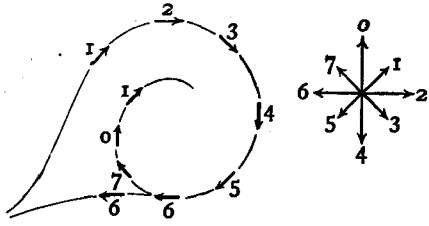


FIG. 6 *a*.

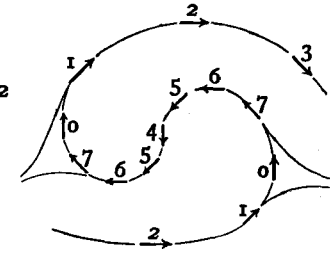


FIG. 6 *b*.

marked cases, each is connected with the rest by so large an abundance of intermediate forms that every attempted subdivision has failed in practice. The features common to all whorls are that they have two deltas, and that some of their ridges make a complete circuit. This phrase has already been used, and will now be further explained and illustrated by the annexed diagram.

The term of a "complete circuit," when applied to any carriage or ship that has made one, means that it has had its head directed in turns to every point of the compass. A compass card is inserted between

the two Figs. *a* and *b* in the diagram, with its eight principal points distinguished by numbers ranging from 0 to 7 inclusive. Arrow-heads, with the appropriate numbers attached, are drawn alongside the curves in the two Figs. *a* and *b*. Fig. *a* comprises two alternative courses, the one is pear-shaped; the second, after following the same course as the first more than half-way round, springs away from it and curls into a spiral. On attending to the arrow-heads with their attached numbers, it will be seen that the direction of the course, while it is following the outline of the pear-shaped figure, passes through six points of the compass, namely from 1 to 6, but it nowhere passes through either 0 or 7; therefore the pear-shaped course is not a complete circuit. On the other hand, the alternative course that ends in the spiral does make one. In Fig. *b* a pattern is shown that might not be thought, at first sight, to form a complete circuit; but on studying it more closely, the above condition is seen to be just satisfied. The weakest point in the circuit is where the ridge runs in the direction 4; if the pattern had been a little more flattened out, that direction could not have been followed. Still, the two deltas remain, therefore I always rank patterns of this kind as whorls, adding, if desired, a suffix to the W, to serve as a warning, such as will be described in the next chapter.

The next diagram shows eight varieties of whorl, which are far from exhausting the list of those that could be drawn, but they will suffice. It will be seen

that all of them fulfil the requirements of two deltas and a circuit. The reader is strongly advised to lay tracing-paper over the whorls in Plate 3, and partly draw some of their outlines; for, until he has practised himself at this, he will fail to analyse the curves in the way they are drawn here. The four diagrams in the top line correspond, not exactly but generally, to Figs. 59, 60, 49, 69; similarly those in the bottom line to 66, 55, 61, and 64. Though this analysis is

EIGHT FORMS OF WHORL (two deltas).

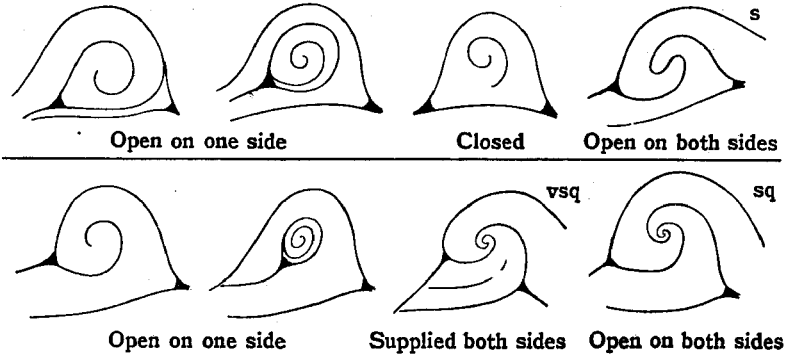


FIG. 7.

not wanted for the purposes of primary classification, but for those described in the next chapter, it is well for the reader to take prefatory pains. It will serve to practise his eye in discerning the characteristics of whorls.

R and U (employed in the primary formulæ for forefingers only).—Having now dealt with the three principal divisions of arches, loops, and whorls, the next step is to describe the two great subdivisions of loops which partially enter into the primary formulæ as R and U. There is no such thing as a loop that

points directly downwards. The nearest approach to such a pattern is a tented arch, but the cores of tented arches are trumpet-shaped, broadening at their mouths until they are flattened into straight lines, whereas loops grow narrower. The downward direction in loops, whether to one side or to the other, divides them into two unmistakably different groups, without any transitional cases, and is therefore a feature of eminent value for purposes of classification. The way in which I have hitherto applied it, and that which is described in the Report of the Committee (p. 12), will now be explained, but I have grave doubts whether for the mere purposes of a directory that method should be retained, instead of being simplified in the way that will be described in the chapter on Suggested Improvements.

The view with which I have hitherto regarded the direction of the slope is in relation to the hand itself, whether it inclines downwards towards the radial or thumb side, or towards the ulnar or little finger side, briefly denoting the slope by R or U, as the case may be. The advantages of this method are mainly scientific, enabling comparisons to be made between the fingers in the two hands on equal terms, such as those in Chap. VIII. of my book *Finger Prints*. It also ensures that the formulæ shall be read off in the same way, and as easily, from the ridges on the hand itself, as from the (reversed) impression of them. The disadvantages are that a slope in the same direction as regards the paper has opposite meanings

in the prints of the two hands, the slope which is R in the one being U in the other.

Another peculiarity in my old method (on which I have changed my views, so far as mere directories are concerned, as is discussed in Chap. VII. on Suggested Improvements) is that of reading the fingerprints in the order described in the Report of the Committee (see pp. 11, 45), according to which the first finger to be noted is the right forefinger, it being in the forefinger alone, whether of the right or of the left hand, that the R slope is frequent. Out of seven cases of loops in these fingers, R occurs three times, the U slope appearing in the other four. In the remaining fingers and the two thumbs the R slope is rare, and may be overlooked in the primary formulæ. Consequently, my method has been to ignore the direction of the slope of loops in all those digits, symbolising them in the primary formula indiscriminately by an L, and reserving R and U for the forefingers. Though L is alone used for the other eight digits, a descriptive suffix may be added to express a radial slope, as will be explained in the next chapter.

A few symbols are occasionally wanted to replace one or other of those already described.

D, or damaged, is applied when the print is illegible, either on account of wounds or the wearing away of the ridges, or even on account of very bad printing. References in such a case would have to be made to the possible alternative readings, which are four in number (A, R, U, W) in the case of a forefinger, and three (A, L, W) in that of any other digit.

Z means that the end of the finger is deficient from which the prints should have been taken. It equally applies to the loss of the whole finger or hand.

X means that the print cannot be classified on account of some exceptional peculiarity. It may be well to possess this symbol for occasional use in the search card. I never have occasion to employ it myself. The use of *x* as a suffix in the registered card will be explained in the next chapter.

A very legible method of indicating the nine different possible combinations of A, L, and W in the thumb and little finger of the same hand is by numerals; thus—

1, *aa*; 2, *al*; 3, *aw*;
4, *la*; 5, *ll*; 6, *lw*;
7, *wa*; 8, *wl*; 9, *ww*.

Consequently 85 means WL, LL; 59 means LL, WW, and so on. This notation is found particularly convenient in a directory, and is employed in the specimen given in Chap. VIII.

[A precisely similar notation is applicable to the Bertillon classes of the first four measures, short, medium, and long being substituted for arch, loop, and whorl. Consequently 85 would mean long, medium, medium, medium, as applied in order to those four measures. Six measures would require three numerals.]

The result of the primary classification, by which the right forefinger is reckoned either as A, R, U, or W, is to break up a collection of sets of fingerprints into four large subdivisions, containing severally 14, 23, 30, and 33 per cent of the entire number. Thus

a directory fits into a cabinet of eight drawers, one for A, two for each of the other three letters, and one to hold the few cases in which a D or a Z appears (which are better stacked apart from the main collection); also to afford storage room for emergencies. My collection of 2632 cards is arranged in such a cabinet in the alphabetical order of their primary formulæ.

We are now in a position to estimate the efficiency of primary formulæ in dealing with directories of various sizes, according to various limitations of the largest number of cards that may be comprised under one formula. The case of a directory of 500 sets will be specially considered, because it forms (subject to three classes of exceptions, shortly to be explained and disposed of) the largest directory that may be dealt with by primary formulæ alone, under the condition that the highest permissible number of cards under any one formula must be less than ten. Directories of this size refer to a register containing altogether 243×500 or 121,500 cases, which are as many as are likely to be required for criminal purposes for some years to come.

In making the following calculations, the sets are always supposed to be distributed in the directory proportionately to those in my directory of 2632 sets.

The facts on which the calculations will be based are obtained from the table (p. 50), whence it appears that in a collection of 1000 sets only three formulæ are to be found that severally contain more than twenty cards, the respective numbers being 59, 35,

and 24, making a total of 118 sets. Consequently in a directory of 500 sets those are the only formulæ that would contain more than ten cards, the respective numbers being $29\frac{1}{2}$, $17\frac{1}{2}$, and 12, making a total of 59 sets. (The fractions are retained here and further on, only to show more clearly the process of calculation.) Therefore 59 sets out of the 500 do not fall within the permissible limits, while the remaining 441 do. Our problem is to subdivide these three sets into three, two, and two sub-groups respectively, making seven sub-groups in all. How this can be done in a simple and straightforward way, by a process of counting ridges, will be the first topic in the next chapter. For the moment I will assume this to have been already explained and proved. Then, subject to this supplementary determination being applied to 59 out of the 500 sets, or to about one set in every nine, occupying less than half a minute in each case, a register of 120,000 persons can be so divided by means of the five Bertillon measures, and by the primary fingerprint formulæ, that the number of entries under one head shall never exceed ten.

It, moreover, appears from the following table (which is derived from that in p. 50) that the average number of entries under each head would be three; for—

[TABLE

In Directories of						
1000 Sets.			500 Sets.			
No. that fall under one formula		No. of sets.	No. that fall under one formula		Assumed average No. in each set. (A)	No. of sets. (B)
more than	not more than		more than	not more than		
0	2	458	0	1	0·5	229·0
2	4	116	1	2	1·5	58·0
4	6	103	2	3	2·5	51·5
6	8	63	3	4	3·5	31·5
8	10	36	4	5	4·5	18·0
10	12	31	5	6	5·5	15·5
12	14	39	6	7	6·5	19·5
14 and under 20		36	7 and under 10		8·5	18·0
3 exceptional formulæ, in all		118	3 exceptional formulæ, supposed for brevity to be divided into 7 equal groups, each including 8·43 sets.		8·43	59·0
		1000				500·0

multiplying the several entries in column A into the corresponding entries in B, the sum of their products is 1492·1, which when divided by 500 gives three as the average number of sets under each formula, in a directory of 500 sets, the minimum number being one and the maximum less than ten.

Before concluding this chapter it will be well to record the ten formulæ which severally contain at least ten cases in a directory of 1000 sets, or 1 per cent of the entire number; they comprise between them 211 sets out of the 1000, or between one-fifth and one-quarter of the whole.

Order of frequency.	Commonest formulæ.	Number of times in which they occur in every 1000 sets.
1	*ull, ull; ll, ll*	59
2	*rll, rll; ll, ll*	35
3	*ull, rll; ll, ll*	24
4	*www, www; ww, ww*	19
5	*rll, ull; ll, ll*	17
6	*ulw, ull; ll, ll*	14
7	*ulw, ulw; ll, ll*	12
8	*www, www; wl, wl*	11
9	*wll, ull; ll, ll*	10
10	*ull, all; ll, ll*	10
		211

It will be noticed that loops occur in abundance in all of these formulæ except in Nos. 4 and 8, that the three commonest formulæ consist entirely of loops, and that even No. 8 has two loops. Therefore the power of sub-classifying loops enables us to deal with a directory of 1000 and not only of 500 sets, with the exception of the one case of all-whorls, which will be considered later (p. 95).

Therefore the ruling problem in dealing with a directory of 1000 sets, mainly by the primary formulæ and when ten is taken as the largest permissible number under any one formula, is to sub-classify the batch of cards No. 1 (that consists wholly of sets of loops of the ulnar kind) into at least six divisions. If this can be done, Nos. 2 and 3 can be easily classified into four groups, and Nos. 5 to 10 into two groups each, while the remainder will give no trouble at all. The solution of a six-fold classification of No. 1 will be the first to be considered in the following chapter on Secondary Classification.

CHAPTER V

SECONDARY CLASSIFICATION

THE methods will now be explained by which a batch of cards bearing the same primary formula admit of sub-classification, or at least of differentiation.

Counting ridges in loops.—Loops admit of being sub-classified by this process, which, though seemingly delicate, gives valuable results even in prints that are greatly blurred.

The prints in Plate 4 have been photographically enlarged to enable the reader to count them with a common reading glass, but he must use a lens (see p. 86) to count those in Plate 2, and elsewhere in this book. Straight lines are drawn in Plate 4, connecting the termini between which the count has to be made, and the number of ridges crossed by these straight lines is inscribed in the upper left-hand corners of the prints. The terminus from which the count begins is reckoned as 0; it proceeds thence up to, and including, the other terminus.

The inner terminus lies at the top of the core of the loop, the outer terminus at the delta, but it is necessary to define their positions more exactly, as follows.

Inner terminus.—There are two cases—

(a) The core of the loop may consist of an uneven number of ridges, as in each of the two figures, $a1$ and $a2$; then, the top of the central ridge is the inner terminus.

(b) The core may be a circumflex or "staple"; then, the shoulder of the staple that is *farthest* from the delta is taken for the inner terminus, the nearer shoulder counting as a separate ridge.

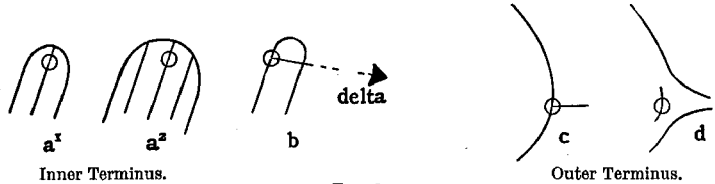


FIG. 8.

Outer terminus.—Here also are two cases—

(c) Where the upper and lower sides of the delta are formed by the bifurcation of a single ridge. Here the point of bifurcation forms the outer terminus. It sometimes happens that successive forks or branches are thrown off from the same ridge, first at an acute angle and then progressively becoming more obtuse. In this case the branch to be considered as forming one side of the delta, is the first that makes not less than a right angle with the stem.

(d) Where the upper and lower sides of the delta are formed by two ridges that had previously run side by side, and then suddenly diverge. Here the base of the delta is the outer terminus. The nearest ridge in front of the place where the divergence begins, even if it be a mere dot, and whether or

no it is independent of, or springs from one of the divergent ridges, is considered to form the base of the delta, and the outer terminus.

If scrupulous care is taken by the beginner, first in selecting the termini that best fulfil the above conditions, and afterwards in counting the ridges, his eye will soon become accustomed to the work, and the process may then be effected both quickly and trustworthily. It is usually easy to determine narrow limits within which the number of ridges will always be held to lie.

The results of the 156 cases of *ull, ull; ll, ll,* in my collection of 2632 sets, show that every number of ridge between three and sixteen inclusive, occurs with approximately equal frequency. There are thirteen cases of three ridges; eleven cases of sixteen, and from seven to sixteen cases of each of the intermediate numbers; there are moreover seven cases in which the number of ridges is less than three (to which some ambiguous forms between loop and arch might be added), and eight cases in which the number of ridges is more than sixteen, forming altogether sixteen approximately equal divisions. Allowing a margin for the risk of erroneously counting, either in excess or deficiency, of as many as two ridges, each search between four and fifteen inclusive must extend through five divisions; that for either three or sixteen, through four divisions; and that for "under three" or "above sixteen," through three divisions, making an average of about $4\frac{1}{2}$ divisions to be searched on each occasion, and practically dividing the batch

into separate groups equal in number to 16 divided by $4\frac{1}{2}$, that is to 3·55. More briefly, each group is less than a third, but more than a quarter of the whole. It follows that the process of counting the ridges in the impressed loop of one finger alone, say in the right forefinger, or if that be not a loop, then in the first finger that is, will break up every batch in a collection of 1000 sets, excepting the *ull, ull; ll, ll,* and the all-whorls, into sub-groups, each containing less than ten sets. The former of these batches requires that the ridges in the middle finger should be counted as well. Their number is partly correlated with those in the forefinger, but it is sufficiently independent to halve the previous groups, and so to reduce the fifty-nine sets into portions, each of which shall be less than ten.

In the directory of 2632 sets, where the *ull, ull; ll, ll* cases are 156 in number, I have counted the ridges in the ring finger as well as in the fore and middle. A specimen of the results is given in the table below. The entries include all the cases in which the number of ridges in the right forefinger were four, eight, twelve, and sixteen respectively. The subsequent entries under *m* and *r* are the number of ridges in the middle and ring fingers of the same hand. They are offered as a sample, to show the increase of differentiation that is obtained by including the ridges on those fingers in the formula.

No. of Ridges in the Right Forefinger.												
4			8			12			16			
F.	M.	R.	F.	M.	R.	F.	M.	R.	F.	M.	R.
4	2	20	8	7	10	12	4	8	16	4	11
4	4	8	8	9	14	12	7	8	16	8	17
4	5	6	8	9	17	12	7	13	16	11	10
4	5	11	8	10	16	12	8	12	16	13	11
4	6	8	8	11	10	12	9	21	16	13	13
4	7	23	8	12	20	12	11	14	16	15	19
4	10	8	8	15	17	12	12	7	16	16	11
4	10	9				12	12	13	16	17	16
4	11	13				12	12	18	16	18	17
4	11	13				12	13	12	16	18	17
4	12	15				12	14	14	16	18	26
4	13	18				12	15	10			
4	13	19				12	15	17			
4	15	18				12	15	21			
4	16	16				12	16	21			
4	16	21				12	19	18			

Trials were made to discover whether the advantages of the more open scale, that would be afforded by entering the *sum* of the ridges in the fore, middle, and ring fingers, would counterbalance other disadvantages, including the trouble and risk of error of adding them together. The scale was found to range through thirty grades, or nearly twice as many as in the above. On the other hand, while the number of sets in the several grades was very irregular, it distinctly tended to a maximum between the numbers thirty-three and forty-one, where it reached twelve once and nine twice. If it were merely a question of average error, the classification of the sets in order of the numbers of the summed ridges might be recommended, but this is not the only consideration;

it is more important to regard the *maximum* error that *need be feared*, which amounts probably to nearly three times as much in the sum of three counts as in one count. It would be wrong here to apply the well-known rule of using the square root of three, instead of three, as the multiplier, because a chief source of error is a constant bias, either to under-count or to over-count, affecting all three counts alike. Therefore I cannot speak in favour of the method.

The conclusion to be drawn from what has been said, is that in a card catalogue of 1000 sets in which ten is accepted as the limit of an easily manageable number, the ridges ought to be counted in the loop on one of the digits in each of those eight formulæ other than the *ull, ull; ll, ll* which contain loops, and which are printed in p. 77, including between them 123 sets out of the 1000. Again, that in the *ull, ull; ll, ll* formula the ridges in the middle finger should be counted as well. These numbers should be conspicuously written near to the formulæ, in order that the sets contained under each of the eight several formulæ may be easily stacked in the order of those numbers.

The forefinger shows no loop in two of the above eight formulæ (from which the all-whorls which will be spoken of later are excluded), namely, in *www, www; wl, wl*, and in *wll; ull; ll, ll*, here it would be well that the first finger that shows a loop should be selected as that in which the ridges are to be counted. This rule would be convenient for general applica-

tion if the practice of counting were extended to other formulæ than the above, when forming large directories.

I give here the number of ridges in each of the twenty-four prints in Plates 2 and 5 respectively.

NUMBER OF RIDGES BETWEEN THE OUTER AND INNER TERMINI.

Plate 2.

3	3	13[c]	17
5	4[a]	11	17
13	10[b]	18	17
14	9	4	11
19	15	22	22
28	25	7[d]	10[e]

Plate 5.

18	16	11	9
17	19	2	16
15	14	20	24
20	19[g]	17	7
18	12	4	4
13[f]	13	13	18

a, *b*, are long loops; the count must follow strictly the line that connects the termini.

c. Note the outer terminus.

d. This is not a true loop, but an *akv* pattern.

e. The inner terminus is the top of the hook.

f. Note the hook in the innermost ridges only.

g. Disregard subsidiary ridges, that appear sometimes, as here, between the true ridges.

The time occupied in counting the whole of the forty-eight prints was twenty-two minutes on the first trial and nineteen on the second, or at the rate of less than half a minute for each print. It is not fatiguing to count, when the optical arrangements are well adjusted, once for all.

In blurred prints it may be necessary to guess, here and there; there is usually enough to be seen to give fair precision to the guess.

Measurements of the distance between the two termini are not trustworthy, the distance being affected by age, and somewhat by obesity and pressure.

We have thus disposed of the 1000-set directory (with the exception of the all-whorls), and *a fortiori* of all smaller directories, supposing the number of an easily manageable batch of cards to be taken as less than ten.

The consideration of the 3000-set directory, and the case where the easily manageable number is limited to three, must be postponed till the end of the chapter, after the descriptive suffixes shall have been explained, which perform an essential service under those conditions.

In the meantime, the arrangements should be described which I have thus far found most suitable for counting ridges easily and surely.

The reader will probably succeed in counting the ridges in the prints in this book with the aid of a lens of $2\frac{1}{2}$-inch focus, as mentioned in p. 60, but a higher power is wanted for steady and continuous work. Some doubt lies between using a plain lens with a wide and flat field of view, such as a Codrington lens, and a compound microscope of low power and an exceptionally wide field of view. When there is plenty of light the lens should be used, for it is much the quickest to work with, but in the dull days of a London winter the microscope may be the best. A

good installation would comprise both. In either case it is important to employ the optical equivalent to a fine line that shall cut both the termini, for its presence steadies the eye and compels the count to follow the true direction. Careful attention should be given to every petty mechanical detail that conduces to easy and rapid work.

Lens.—That which I preferentially use is a Codrington, of $1\frac{1}{4}$-inch "equivalent focus"; the distance between the bottom of the lens and the print is $\frac{3}{4}$ inch. The lens is mounted on a short arm that slides up and down a rod which is fixed vertically into the face of a shallow horizontal ring, $1\frac{1}{2}$ inch in internal diameter and 2 inches or more in external. The centre of the lens stands over the centre of the ring, and the arm that carries it is clamped firmly at the right elevation. A disc of glass is fixed into the bottom of the ring, so as to be nearly or quite flush with it. Two rather fine cross lines are etched on the bottom of the glass, and are blackened. This little apparatus (which ought to be rather heavy) is laid on the print and moved about until (1) the intersection of the cross lines lies roughly half-way between the termini, and (2) one of the cross lines runs over both of the termini; then both the termini will be equally in focus. A raised support for the print, such as a box, should be laid on the table to bring the print to the height most suitable to the observer. I find it easy to count a succession of fingerprints with this apparatus at the average rate of twenty-two seconds per print, so even the three letters in *ull* are disposed of

in little more than a minute. The necessity of good light has already been mentioned.

Microscope.—I have used two: the first one was small and light, and was mounted and used much in the same way as the lens, but its power proved to be insufficient, and its field of view was too small. Lately I have begun to employ one that was made specially for me by Beck, 68 Cornhill, E.C. It magnifies between ten and eleven times, and its field of view is so unusually wide that it takes in an area of $\frac{3}{4}$ inch in diameter (or a sixpence) with clear definition. Its body is 8 inches long, its diameter is $1\frac{1}{4}$ inch, and the bottom of the object-glass stands $2\frac{3}{4}$ inches above the object viewed. The eye-piece carries cross wires, and fits very easily, that it may be rotated with all facility. The microscope is fixed at the end of a projecting arm, to give plenty of room for moving the large cards on which the prints are made, either backwards and forwards or from side to side. The print is slid into position under a light pointer, C, which stands vertically under the axis of the microscope. This pointer rests on three legs, C being one, and A and B the other two. When A and B are dropped into two conical holes in the table, the position of C never varies. After the print has been slid into place, so that C is roughly half-way between the termini, either A or B may be lifted out of its hole and pushed to one side, to throw C out of the field of view. Then the print is more correctly adjusted, while looking through the microscope. The advantages of the microscope are that

the head of the observer throws no shade upon the print, and that it can be used with facility in artificial light. Its action is perfectly good in all respects except speed. The mechanical arrangements of my instrument are home-made and rough, being still subject to improvements in design. As it is, each print occupies on an average forty seconds, or nearly twice as much time as when the lens is used.

Descriptive Suffixes

The method to be followed when the smallest manageable number is less than ten, or when the directory exceeds 1000 cases, consists in writing descriptive suffixes under the primary formulæ. Whenever a thoroughly well-marked peculiarity occurs in the print of any one finger, the appropriate suffix is to be written down, but *only in those cases.* The result may sometimes be made classificatory as well as descriptive. This is especially the case with the number of ridges just described, which is first written as a suffix, though copied and inscribed afresh in a more conspicuous manner. In this chapter the suffixes, such as L*v*, are printed for typographical convenience, as affixes in the form of L*v*, the italics being used for distinction. There would be much confusion to the eye, and some risk of error, if they were hand-written as affixes. However, this risk did not exist in the specimen of a book directory which is given in Chap. VIII.; there the printing agrees with the manuscript.

By the help of easily legible suffixes a large batch of cards may be rapidly looked through by the naked eye. They make it easy to pick out of numerous cards, comprised under the same formula, the two or three sets that alone fulfil those requirements of the search card which are expressed by the suffixes. Then, those two or three sets have to be scrutinised, and if one of them possesses the selected minutiæ, the final act of verification has to be completed as described above (p. 53). A very few peculiarities have been selected for suffixes, and only such as were found after much experience to be both trustworthy and serviceable. Occurring, as they do, more or less indiscriminately in any one of the ten digits, the variety and order in which they appear in different sets of prints is very distinctive. A reference to the specimen directory, which has been compiled with sufficient minuteness almost to discriminate between individual sets, in a collection of 3000, will show their power of differentiation. Even if the suffixes were not various and descriptive, but were replaced by an asterisk or other mark, whose meaning was, "this is not the common form," those asterisks would be of considerable help.

The trouble and loss of time caused by writing suffixes is small, and fully compensated for by the subsequent ease of search, even in small directories. The practice of writing them has the additional merit of greatly decreasing the risk of error in assigning the primary formulæ, for by ensuring a deliberate inspection of the print it serves as

a sovereign remedy against a slap-dash way of work.

The time occupied in assigning the titles and writing them out, suffixes and all, in the very elaborate specimen given in Chap. VIII., was at the rate of nearly, but not quite, forty in the hour.

An alphabetical list of the suffixes, with a brief definition of their meanings, is given below, together with a reference to the pages where they are fully explained.

INDEX TO THE SUFFIXES.

	PAGE
A. This pattern might with equal justice have been recorded as A	92
a. Has a likeness to A	92
b. The end of the single spiral, or the two ends of the double spiral are blunted	94
c. The upper part of the innermost core of the loop is a circumflex, or staple, quite detached from the ridge that envelops it	98
d. Partly damaged otherwise than by a cut or smash (see D, p. 72)	102
f. The innermost core of the loop forks like a tuning-fork. It may afterwards reunite, enclosing a space like the eye of a needle	97
g. The core to the whorl is very large	95
i. The innermost core of the loop is a rod, whose head is altogether separated from the enveloping ridge	97
k. The body of the loop is curved like a hook; or it may be, only some of its inner ridges are hooked	102
ko. A coil	102
L. This pattern might with equal justice have been recorded as L	92
l. Has a likeness to a loop	92
o. The core of the whorl is a detached ring	95

PAGE

p. Compound of two patterns, either superimposed or adjacent. Very rarely needed . . . . . —

q. The core of the spiral is made by the ridges that form it being twisted up into a point 94

R. This pattern might with equal justice have been recorded as R, or as L*r* 92

r. The mouth of the loop, or the tail of the whorl, points downwards towards the radial side. If the whorl is not distinctly tailed, the *r* condition is made manifest by all the ridges entering from the *r* side 93

s. The whorl is fed by ridges from both sides . . . 94

t. A tented form; suffixed to A to express a tented arch 65, 109

U. This pattern might with equal justice have been recorded as U 92

u. Is hardly ever used; its absence when *r* is absent also, has no definite signification, for it might either mean that the case is of the very common, and therefore not noteworthy form; or, if the pattern be a whorl, that its character is undetermined or uncertain. There are rare cases of superimposed or else of adjacent loops pointing in opposite directions that could be expressed by *pru* (see *p* above) 92

v. Invasion of ridges from the side of the loop or whorl, in violation of the usual rule that they enter through its mouth alone. *v* is also applied to cases in which the innermost ridges have a protrusion at the side, forming a pocket 100

W. This pattern might with equal justice have been recorded as a whorl 92

w. Has a likeness to a whorl 92

y. The core of the loop or whorl, or even sometimes of the arch, has an eye shaped like the outline of a pear or the rim of a racquet 99

x. Interpretation questionable; the pattern is peculiar . 105

† Scar left by a cut 103

* Effects of a bad smash (see *d*) 103

One of the uses of suffixes, as will be seen from the above, is to express transitional cases, and consequently those that are ambiguous. Every set, however ambiguous it may be, has, of necessity, to be classed under some one particular formula. There is only a single printed card disposable, and that card has to go into some one receptacle. Let us suppose that the right ring finger appears to deserve the name of an Arch, just as much as that of a Loop, and as a choice between them has to be made, it is registered as an Arch. In process of time the prints of the same person may appear on a search card. The ambiguity is obvious to the searcher, who knows that he may have to refer to two formulæ, otherwise alike, that contain respectively A or L for the right ring finger. Let the A form be the first that is searched, then it will be a great help to the searcher to know that, if the set he is looking for is in that batch, it is pretty sure to have an *l* suffixed to the A, to signify that, although it is entered as an A, it might with equal justice have been entered as an L. Or, if he searches first among the batch bearing the formula with an L, he especially looks for a card with the suffix *a* attached to the L in question. Similarly as regards R, U, and W. The small letters *a*, *l*, *r*, *u*, *w* are used to express a likeness to A, L, R, U, W rather than equivalence to them. The difference between the large and small letters merely indicates a difference of degree and of judgment, but the indefiniteness of meaning leads to no confusion, while the option of using different letters in appropriate cases is a con-

venience. This option has, however, not been utilised in the specimen directory.

r is a very useful and important suffix, signifying "radial direction," that is, towards the thumb side of the hand. The opposite, *u*, is not used; it would be fatiguing to enter it on account of the predominant frequency of the ulnar direction, and, if entered, would confuse the eye, few suffixes being easier to glance through than many. Loops in the forefinger are always written in the primary formulæ as R or U; in the other digits they are written as L with the suffix *r*, when they point downward to the radial side, and as L *without any suffix when they point to the* ulnar side. Arches sometimes have a distinct trend, due to the tendency of an inconsiderable number of ridges to recurve upon themselves, and forming a nascent loop (Figs. 10, 19, 20, 21). If the trend be to the radial side, *r* is suffixed to the A.

In whorls the *r* is largely and usefully employed. It may be that a tailed whorl is enclosed within a loop (diagram, p. 70, and Figs. 55, 56, 62, 63, in Plate 3; 145, 151, but hardly 146, in Plate 7), in which case its direction is unmistakable; then, if that direction be radial, an *r* is suffixed to the W. Or the whorl may be a single spiral, fed with ridges wholly from one side (Figs. 63, 65); then if that side is radial, the *r* is used. These two cases run into one another, the transitional form being that where (as in Fig. 62) one side of the enclosing loop coincides with one side of the enclosed whorl. Here the *r* would be equally applicable, whether we regarded the direction

of the tail or the supply of ridges from the side; a radial condition in the one being necessarily accompanied by a radial condition in the other. The absence of *r* does not necessarily mean the presence of *u*, it merely asserts that there is no unmistakable *r* character about the whorl. No notice is taken of any pattern that is doubtful in this respect.

The suffix *s* means that the ridges in the whorl obviously reach it from both sides, under one or other of the following conditions:—

1. The ridges from either side may double back upon themselves, so that the contributory portions have blunted ends (as is the case in Figs. 67, 69, 70, 71, 72, and 157, 163). This peculiarity is denoted by the addition of a *b*, thus *bs*.

2. The ridges from the two sides may become twisted together almost to a point (as in Figs. 61, 64, 158, 164). This is expressed by adding a *q*, thus *sq*.

3. The ridges may not arrive fairly from both sides of the finger, but (as in Figs. 61, 164) half of them may spring from one side of the tail of a tailed whorl. This peculiarity is expressed by the addition of *v*, thus *vs*, consequently Fig. 61 is *vsq* (see also diagram, p. 70). (There is more to be said later on about *v*, principally in connection with loops.) It is important not to refine too much about the *v* and *s* qualifications. The omission of a suffix is of little harm; the insertion of a wrong one is. Cases should be disregarded as ambiguous, no suffix being attached to them, when the outline followed from the inner delta to a point above the outer delta, or below it, as

the case may be, does not suggest the same suffix as it does when the outline is followed in the opposite direction. The test in question is rapidly made and effective.

g is a large core to a whorl, as in Figs. 54, 159, 165.

o. The core of a simple spiral, but rarely that of a double spiral, such as is indicated by *s*, consists sometimes of one or more complete circles or rings, as in Figs. 52, 53, 55, 59, 146, 147, 152. This appearance is symbolised by *o*. Proceeding outwards from the core, the rings soon give place to spirals; they hardly ever continue long without doing so. Therefore all that is necessary to justify an *o* is the existence of at least one complete and detached ring about the core of a whorl.

No suffixes are used to describe any other of the very numerous forms of whorl.

It is mainly through the help of the *r* and *s* suffixes that it is possible to discriminate between the all-whorls which occur nineteen times in every 1000 cases (p. 77). The whorls in that particular group are curiously monotonous in their general aspect and size, the conspicuous characteristics of *b*, *q*, and *v* appearing rarely, and being therefore of little service in differentiation; neither is any method of counting ridges of value, for their numbers are much alike. But when the whorls are looked at carefully, and their contours followed a short way with a pointer, the variety in their *r* and *s* characteristics becomes distinctive. It may even be pressed into the service of

sub-classification, the sets admitting of being arranged in the order of the number of the *r*'s that they severally contain, irrespectively of the fingers on which those *r*'s appear.

i, *f*, and *c*. It has been seen that the method of counting ridges in loops suffices for the requirements of card catalogues, even of considerable size, and will almost discriminate single sets in small ones; but it is insufficient by itself to deal with a book catalogue of 3000 names (see table, p. 50). Other suffixes are needed, especially for *ull*, *ull*; *ll*, *ll*, and

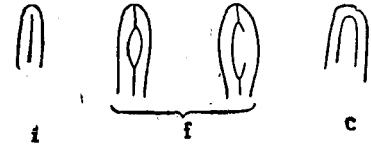


FIG. 9.

that in the face of the fact that the general aspect of the loops in this particular set is monotonous, very different from the appearance of the loops that are associated with whorls. After many trials the most satisfactory results were yielded by a notation founded on three very distinct peculiarities in the core of the loops, one or more specimens of which are usually found in each set of prints. I have made trials of noting more than these three peculiarities, but prefer to use three only. It is *particularly important* to limit this notation to thoroughly satisfactory specimens, disregarding all the rest. Imperfect cases are dangerous, for a little difference in pressure or in the quantity of ink used, may then alter the appearance

of the peculiarities in question. Several examples of each of the three peculiarities are given in Plate 5. The diagrams will show their nature clearly.

i. The first of these is a central rod, whose head stands *quite* distinct and separate from the nearest ridge that curves round it. The two top lines of Plate 5 are examples of this. When the distance between the rod and circumflex is small, a low *col* is apt to connect them, which sometimes may take the ink and leave a mark, and at other times not. Moreover, the crest of such a col is usually curved, so that any mark it may leave perverts the appearance of a central rod. But when the distance between the rod and the circumflex is equal to the breadth of an ordinary furrow, the presence of a col need not be feared, and the impressions taken after long intervals of time, and under various conditions, will agree in the appearance of a rod. The descriptive suffix of *i* expresses that the core of the loop is a central and detached rod, as in the figure.

f. The central rod, whether or no it touches the ridge that curves round it, occasionally makes a fork; it may then reunite, enclosing a small space like the eye of a needle; or the eye may be imperfectly formed, while it is still evident that the core is other than a simple straight rod. It is not worth while to symbolise these conditions severally; they are all expressed by the same symbol *f.* Examples of this form are given in the two middle lines of Plate 5.

c. The core may be a simple circumflex or

"staple," wholly detached, head and shoulders, from the ridge that curves round it. This is expressed by *c*. Examples of it occupy the two lower lines of Plate 5.

The numerous specimens in Plate 5 will show the ease of the *i*, *f*, *c* notation, when the prints are clear, as in my experience they nearly always are. Still, I have shrunk from utilising this notation except in the troublesome cases of all-loops, where no good substitute for it has as yet been made out.

Judging from my directory of 2632 cards it may be safely concluded that an addition of this notation, even to six digits, and much more to all ten, in the *ull, ull; ll, ll* sets, suffices to discriminate them in one of 3000 with the higher of the two degrees of accuracy specified in Chap. III.; that is to say, doubt would be limited to one, two, or three sets (see specimen directory in Chap. VIII.).

In a large directory it might be well to treat the *ull, ull; ll, ll* sets apart, and perhaps the *rll, rll; ll, ll* sets also, by making (as I have done) a book catalogue of them. Each open page of a copy-book corresponds to a different number of ridges in the right forefinger. Each line of an open page corresponds to a different number of ridges in the middle finger, and the columns in the page correspond to those in the forefinger; but only roughly so, for there is not room lengthways to fit the entries accurately to the columns. Each set is then so far described by its place in the copy-book that there is no need to write the number of ridges. Its identity is preserved by an attached

number (in the example below it is 236), which refers to its order of insertion in the batch, thus :—

. *i* .	*f* . .	236

The sets would in this case be arranged in their receptacle according to the order of entry, and not according to the number of ridges in the forefinger (p. 41, Questions 227, 228). When making a search, the proper page and part of the page has to be sought; then the eye quickly glances over the *area* in the page where the set is to be looked for. This is also done to the two pages before and after. A set is very easily picked out by this method. As there are sixteen pages, and the number of entries in each is approximately equal, the 180 cases in a directory of 3000 sets would contribute only eleven or twelve entries to each page. A much larger number could be inserted without overcrowding.

y, *v*, *vy*. The peculiarities now to be considered are conspicuous and frequent.

y. Of all the suffixes which are employed, none is more generally useful than *y*. It is a formation of the inner part of the loop into an eyed form (see diagram, *y*, p. 67, as well as that in p. 100); that is to say, into a form that suggests the eye of a needle. In an ordinary loop the axial ridges, after recurving, follow a path parallel to their former course; but, in the *y* form, the ridges reunite after recurving, and enclose a minute plot. Sometimes a similar appearance is

caused by the axis of the loop branching, on the one side into a short stump, or into a process of a more or less spiral shape, and on the other side prolonging itself into a ridge that curves round and encloses the stump or process. But let the cause of the small enclosed plot or eye be what it may, its existence is unmistakable, and well deserves a descriptive suffix. The two first lines of Plate 6 are illustrations of *y* (see also 43 to 47 in Plate 2).

The same suffix of *y* is occasionally appropriate to arches, in which a small circle or twist makes its

FIG. 10.

appearance between two ridges, but is too insignificant to rank as a whorl, as in Fig. 17, and even 15, in Plate 1.

Whorls have often a small eye-shaped core, which may be recorded as *y*. The transitional cases between loops and whorls are largely due to the presence in loops of a strongly-marked *y*, doubt arising whether its outline does or does not make a complete circuit (p. 68). The enlarged prints in the bottom line of Plate 8 are examples of the transition in question. I should rank the two left-hand figures as L*y*, and the two right-hand ones as W*y*.

v expresses an invading system of ridges (see

diagram, *v*, p. 67). In a common loop the ridges enter through the open mouth of the loop, curve round, and make their exits in parallel lines to their entrances (Figs. 29, 30, 35, 36, etc.). Sometimes, however, a system of ridges, instead of entering at the mouth, springs out of one of the sides, and displacing the ridges that are in front of it, destroys the symmetry of the pattern (Figs. 37, 38, 39, etc.). Sometimes one or more of the central ridges in an otherwise common loop form a pocket (Figs. 46, 130, 136, 142), and force the adjacent ridges out of an even course; this also is designated by *v*. The two middle lines of Plate 6 are examples of *v*.

vy is appropriate to cases in which both of the above characteristics appear, as when instead of the stump or process, spoken of above, being the cause of a *y*, the outline of the stump is substituted for the stump itself, and a pocket formed thereby.

The difference between *y* and *vy* is by no means important, but it is convenient to be able to distinguish marked cases of either form. When searching for a simple *y*, in a particular finger, among many cards bearing the same primary formula, the fact of finding a *vy* may or may not give the needed clue; but if there were two cases similar in other respects, the one having a *y* in its formula and the other a *vy*, the former would be examined first. Or again, a *vy* in the registered set may be so completely inappropriate to the search pattern as to disprove identity. The two bottom lines of Plate 6 are illustrations of *vy*.

k. A curvature sometimes affects the whole of a loop, forming it into more or less of a hook. This infallibly arrests the attention, and therefore well deserves a suffix; it is described as *k* (Figs. 48, Plate 2; 160, 161, 166, 167, Plate 7). The same suffix is applied even if the hooks affect only the inner ridges of the loop. The transitional cases between hook and no hook are very few, so this characteristic has considerable discriminative power. It may frequently be used in combination with other symbols, and applied not only to loops, but to whorls and arches, signifying an inner curl or hook. Thus a pattern is seen in 42, Plate 1, and in 149, 155, Plate 7, which is by no means very rare, and is the most difficult of all to classify justly. It is neither a whorl nor a loop, and is certainly not an arch of the common kind, but has similitudes to all three. In some cases the predominant likeness is to one of them, in others to another. Most frequently, as in Fig. 42, it resembles an arch affected both by *k* and by *v*. I should then designate it as A with the suffix *kv*; in other cases as L or as W, with the suffix *akv*.

ko. A curious form of whorl consisting of a coil of ridges is sometimes enclosed in a more or less complete ring (Figs. 148, and in some degree, 154). It has an exceedingly characteristic appearance, partaking of a *k*, and, in some sense, of an *o* also. I have been in the habit of symbolising it by the suffix *ko*, which has a distinctive look and suggests the two first letters of the word coil; it serves its purpose well.

D and *d.* When a print is so damaged that it

cannot be read, or when the finger is so damaged that a legible print cannot be taken of it, the primary symbol of D takes the place in the formula which would be otherwise occupied by A L R U or W; but when the damage is not so great, though still considerable and apparently permanent, *d* is used as a suffix to the principal symbol. *d* is applied to every sort of damage except cuts and smashes. It is used especially when the ridges have become much disintegrated by advanced age, or by certain kinds of manual work, like tailoring.

† Simple cuts leave scars combined with dislocation of the ridges, and are symbolised by a dagger (Figs. 1, 9, 27, 28, 63, 150, 156, 162, 168). These scars are frequently met with in men's hands, and should be noted, even though they are quite small.

* is used for the scars left on fingers that have been more or less smashed, in combination with D or *d*. I have omitted to give a good example of this, but Fig. 150 will perhaps suffice as an indication.

The effects left by a cut are remarkably permanent, judging from such evidence as I possess, of only a few years' standing. The two pairs of prints at the bottom of Plate 9 are good illustrations of this. The upper pair are enlarged from the prints made by a boy, in the one case, when he was aged 14 years and 3 months; in the other case when he was 16 years and 6 months, that is, 2 years and 3 months later. He was 9 years old when the cut was made. The two cards were successively put in front of the same camera, without changing its focus, so the scale

on which they are enlarged is the same, the difference in their size being due to the growth of the boy in the interval between the two dates. The ridges are numbered along the top and one side, for convenience of comparison. I cannot trace the slightest difference between the scars in the two prints. The scar affects at least twenty-eight ridges, and at the point of severance of every one of these the character and extent of dislocation is the same in both. These features deserve careful study through a lens.

[It is not within the province of this volume to speak of the permanence of ordinary *minutiæ*, which was the subject of a large part of my previous books. Nevertheless, the reader will find it interesting to compare these prints minutely. He will, for instance, find a minute dot between the ridges 9 and 10 in both prints. Unfortunately, the larger dot between 22 and 23 in the first print falls just outside the area here shown in the second one, and cannot be compared in these reproductions. The originals show all these more clearly than the Plate.]

The lower pair of specimens are not quite so well suited for comparison, as the scar is wider at the top, and the prints are not very sharp: the scale of enlargement has not been carefully attended to. The originals were taken, one in the middle of January 1891, the other at the very end of December 1894, consequently the interval falls short of four years by only three weeks. The person was 6 years old when the cut was made. I thought, or fancied, at first that very faint signs existed of some slight healing about

the part where the scar is broadest, but as no such signs appear at the delicate ending of the cut, where, if anywhere, they would be the most conspicuous, I ascribe the very faint signs (if indeed they exist) to imperfect printing.

[From a purely surgical point of view, prints taken of cuts and wounds at various stages after the skin had healed might prove instructive. It is a far simpler method of illustration than photography, and is more exact too, being true to scale and nowhere out of focus.]

The remaining suffixes are—

x. When there is something very questionable or peculiar about a pattern, *x* is used.

Several good specimens of the various peculiarities described above will be found in Plate 7.

It must be understood that the office of suffixes is equivalent to that of adjectives rather than substantives; therefore two or more suffixes can be used together, as has already been exemplified in *sq*, *akv*, etc. But a too free use of suffixes defeats its own end by confusing the eye. They should be used, as already said, for *unmistakable* cases only.

At the close of the last chapter the effects of the primary formulæ were discussed, when dealing with directories of 1000 sets, the limit in number of an easily manageable batch of cards being taken as ten. We have now to consider how far the primary formulæ with suffixes attached can deal with directories of

3000 sets, when the limit of an easily manageable number is either ten or else as low as three. There are two ways of doing this; the one is by experiments made with my directory of 2632 sets, which is near enough to 3000 to justify inference, and the other is to exhibit, as will be done in Chap. VIII., the discriminative powers of the suffixes in a small directory of 300 sets.

My experience with the former has already been mentioned, namely, that with the limit of ten and with the aid of an assistant in taking out the appropriate batch of cards and laying them on the table, an average of three minutes is ample for picking out from it the duplicate of any search card. To this should of course be added the one and a half minute (p. 53) required for conclusive verification, such as would justify legal conviction. I could, under the above conditions, easily make a dozen searches in an hour. As regards the special case of *ull, ull; ll, ll,* with the aid of the copy-book (p. 98) the process is much quicker. I cannot be more definite as to time in respect to the plan of *i, f, c,* as used above, because the symbols with which I chiefly experimented were different, being somewhat more complex on the one hand, and referring to fewer fingers on the other.

In the case of book directories, the MS. which I have had compiled for the 2632 sets is perfectly effective, for it usually discriminates individual cases. It happens, however, not to be quite as legible and well arranged as might be. Improvements in these particulars would materially facilitate reference. If

it were type-written, and made to look like the printed directory in Chap. VIII., it would be more effective even than it is now, and a three minutes' allowance for each search would be unduly long.

The general conclusion is that a fingerprint directory in the form either of cards or of a book, even of 3000 sets or more, that shall discriminate to within two or three sets, is perfectly feasible.

There remains an important consideration to be borne in mind. Errors must be sedulously guarded against in writing out the primary formulæ, to which end it seems very desirable, if not necessary, that the formulæ written by one person on each register card should be checked by another. The first person is stimulated by the dread of being convicted of error, and the second person by a sportsmanlike instinct to discover error. Also, ambiguous cases are sure to occur now and then, which deserve discussion before finally docketing them with a formula. Though it requires a full hour to write out the formulæ and suffixes upon forty cards, a much less time is needed to check what is already written.

CHAPTER VI

AMBIGUOUS PATTERNS

THE chief peculiarities of individual Arches, Loops, and Whorls having now been described, it becomes easy to discuss the frontiers of the primary classes and the debatable country between them.

A to L. The frontier between A and L ceases to be distinct at the point where A is just short of developing into a nascent loop. In the figures 169 to 172 that point is just, but only just passed, so all those figures would count as loops with an *a* suffixed. The debatable ground lies between these and unmistakable arches, and, in that debatable ground, A is held to predominate over L under any one of the following conditions—

1. When the loop is formed by no more than one complete bend or staple, which may, however, be perfectly distinct, and may also enclose a rod (Fig. 21, Plate 1).

2. When it consists of two or even three imperfect bends (19, 20), especially if they converge and unite.

3. Offsets at acute angles (Fig. 10) from the

same ridge or from the same furrow do not rank as heads to loops (see p. 79).

4. When two symmetrically disposed loops are enclosed in the same curved ridge (Figs. 173, 174) they are counted as an imperfect form of tented arch, being noted as A with the suffix *t*, or *tur*.

Generally speaking A is held to predominate whenever the pattern has no continuous contour, even though there may be a fairly distinct delta (Fig. 20), but it would be proper to write the suffix *l* to this.

A to W. Between A and W a very small, or else an imperfect circle, or a dot sometimes appears between two ridges of a pattern which is an arch in all other respects (Figs. 15, 17, and perhaps 18, which is ambiguous, and might be called a loop). If the diameter of the whorl does not exceed the width of one of the adjacent ridge intervals, the pattern does not lose the right to be called an A, but should, for distinction's sake, have a *y* suffixed to it. W is certainly reached when the little circle contains a central dot, as in Fig. 175, which I should call W*ky*.

L to W. Between L and W a large class of transitional cases have been sufficiently discussed in speaking (p. 68) of complete and incomplete circuits. The bottom line of prints in Plate 8 illustrates these.

The specimens 176 to 179 show the relationships between whorls to which the suffix *bs* is applied (Fig. 178), with loops. In Fig. 176 we see a loop that throws off a curious crest from the upper part of its outline, and which is here and elsewhere a striking appearance; but in Fig. 177 the same peculiarity is

much less distinct, while the number of cases that exist between extreme distinctness and extreme indistinctness is so great that crests are not allowed to have a suffix. Their conspicuousness in individual cases certainly depends to a considerable degree on the printing, whether more or less ink and pressure are used. When, however, the ridges cease to be given off from the outside of the contour of the loop, and recurve upon themselves as in Fig. 178, forming a blunted end to that part of the pattern, the result is a well-defined whorl. Another intermediate form between a loop and a whorl is produced in another way, and is recorded by *vy*, as already explained (p. 101).

There is a certain form of whorl whose dabbed impression is apt to include only that part of it which simulates a loop. The pair of prints at the top of Plate 9 are enlargements of those taken from the dabbed and the rolled impressions respectively of the same finger in one of my sets. They were made at my laboratory in the ordinary way, and the peculiarity to which the attention of the reader is called, was unnoticed until they were about to be registered. This is a suggestive example of the necessity of writing formulæ from rolled and not from dabbed prints.

This pattern is not very uncommon; indeed, I have reason to think that if the finger were rolled still more to one side than is customary at present, it would appear much more frequently. I do not, however, find that it has created real difficulty.

CHAPTER VII

SUGGESTED IMPROVEMENTS

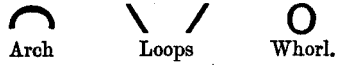
THE order in which fingerprints have hitherto been read off is—

LEFT HAND.					RIGHT HAND.				
l	*r*	*m*	*f*	*Th*	*Th*	*f*	*m*	*r*	*l*
10	6	5	4	9	7	1	2	3	8

where the headings of *l*, *r*, *m*, *f*, *Th* stand respectively for little finger, ring, middle, fore, and thumb. The reasons for having adopted this order will be found in my replies to Questions 219, 220 put by the Committee (p. 40), but I am now sure that for the mere purposes of a directory it is not the best. The eye is unnecessarily fatigued by beginning from four different starting-points in succession, and by travelling along four successively different directions. I should much prefer to read the prints straight through from left to right, like words in a line. The advantages of the present method, described in p. 40, do not compensate for its disadvantages.

As regards the R and U notation, I am now decidedly in favour of the plan tentatively suggested in my answer to Question 207 (p. 38), namely, that it would be far better, on the grounds of diminishing error and fatigue, to regard the slope of the print relatively to the paper on which it is made, and not relatively to the Radial or Ulnar direction in the hand that made it. The slope relatively to the paper admits of uniform interpretation; the slope relatively to the hand does not, for what is R in the one hand is U in the other.

The notation I propose for loops is simply a short diagonal line, practically parallel to the slope, and I would simplify at the same time the notations for arches and whorls; thus—



These symbols should be drawn at the top of each print for the convenience of verification, and be copied, either in the same shape or else as translated into the numerals 1, 2, 3, 4, to replace the present formula.

The relief to eye and brain caused by this simple and, so to speak, natural notation and order of writing, is extraordinary. The pencil seems inclined to gallop over the cards automatically, because the attention is no longer strained by an endeavour to interpret the prints into alien symbols. The hand has merely to make abbreviated copies of what the eye sees, and thought is almost passive while doing so.

The proposed change would require modifications

in the secondary classification, because *r* ceases now to be an available suffix for whorls. There are two alternatives; the one is to note the direction of tailed spirals, and not to regard any simple spirals that are not tailed; the other is to use graphic symbols to express the varieties of the latter. The convenient method of describing the patterns of the thumb and little finger in the same hand by a single numeral (p. 73) would cease to be possible, because the number of contingencies is raised from nine to sixteen.

The new system requires to be well worked out and tested before it would be proper to give effect to the proposed change. I have not done so as yet with the necessary fulness and care, and am therefore unwilling to say more. Of course the notation of a set of fingerprints, according to any method, admits of more or less full translation into that of any other. Also, the main facts derived in this book through the old notation will apply, *mutatis mutandis*, to the new one.

Physical indexes or directories.—It has been shown in Chap. V. that sufficient data to almost individualise a particular man out of many more than 243×1000, or a quarter of a million of men, admit of being expressed by a few letters and symbols. When the entries (p. 54) are printed in ordinary type, they need not occupy more space than the face of a railway ticket. It seems, then, reasonable to print them for certain purposes, in order to place upon record the means of proximate identifica-

tion of many persons whom it might hereafter prove desirable to identify. International delays in identification could be saved in this way. I do not propose now to discuss the different circumstances under which a printed physical index might be consulted with advantage, the object of these remarks being merely to point out that such an index admits of being printed very compactly.

Photographic camera.—It may be of service to those who have to deal with fingerprints to describe the very effectual quarter-plate camera that I now chiefly use, which was made for me by Dalmeyer. It enlarges up to fully six times. Its body is vertical, and is so short that the operator's hands are able to adjust the print that has to be enlarged while his eye is looking down on its image on the focussing glass. Even when enlarging six times, the distance between the print and its image is only $22\frac{1}{2}$ inches. There is no trouble about a focussing cloth, a light card-board screen dropped on the camera sufficiently shielding the ground-glass from the outer light. The objective is one of Dalmeyer's portrait lenses of 2·76 inches equivalent focus. When the camera is used to enlarge, the conditions for taking reduced portraits are reversed. The camera is made to act backwards,

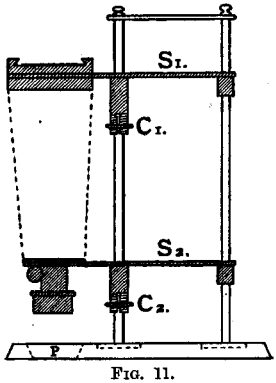


FIG. 11.

The bar S_1 is fixed to the end of the camera; two short tubes are soldered into S_1 to enable it to slide smoothly up or down the vertical rods. The tube to the left is partly "split," and has a screw clamp, C_1, to fix it tightly in position. S_2 and C_2 provide for the adjustment of the object-glass. A large hole in the base board is filled with a conical plug, P, to be removed when using the instrument for enlargements from transparencies.

as it were; the focussing glass occupies the place of the large object to be copied, and the fingerprint that of the reduced image. It is manipulated and clamped with the utmost facility, being put into working conditions as quickly as if it were a microscope taken from under a glass shade. The definition is sharp. A well-known arrangement is introduced into the plate holder for taking two separate prints successively on the two halves of the same quarter-plate, in which case each print admits of being enlarged about two and a half times. The camera will reduce to two-thirds, but unless the object to be reduced is itself small, say not more than two inches in diameter, the definition becomes faulty.

Such an instrument might be a very useful adjunct to an Identification Bureau, charged with the occasional duty of supplying authentic enlargements of a registered and a search impression to courts of law. The same quarter-plate would contain, as has just been pointed out, reproductions of the two prints it is desired to compare, enlarged to a size that is convenient for study, such as those in Plate 9. Other prints could of course be obtained from the same negative, enlarged on paper to a much increased scale, for submission to the jury.

CHAPTER VIII

SPECIMEN DIRECTORY OF 300 SETS

THE descriptive suffixes in the following directory are, with few exceptions, sufficiently elaborate to deal not only with 300 but with 3000 sets in so minute a manner that doubt shall rarely lie between more than two prints. The exceptions are, that in the *ull, ull; ll, ll* sets, the number of ridges in the middle and ring fingers should have been added; which was not done on account of the narrowness of the column. In the *rll, rll; ll, ll* sets the number of ridges in the middle finger should have been added, and those in the fore-finger should have been inserted in the rest of the common formulæ (p. 77). The proportionate number of the various sets in this small directory approximates to, but could hardly have been expected to be identical with, those in the collection of 2632. In that collection the number of formulæ beginning with A, R, U, and W respectively, was 14, 20, 30, and 33 per cent; here it is 15, 22, 33, and 30.

The notation and the order of reading the fingers has already been explained (p. 111). F.M.R. signify the fore, middle, and ring fingers; Th. the thumb; L.

the little finger. For the notation in column 3, see p. 73. It is there shown that 1 stands for *aa*; 2, for *al*; 3, for *aw*; 4, for *la*; 5, for *ll*; 6, for *lw*; 7, for *wa*; 8, for *wl*; 9, for *ww*.

The entries in column 4 are to be understood to be suffixed to those in column 1, the entries in column 5 to be suffixed to those in column 2, and those in column 6 and 7 to be suffixed to the four letters signified by the two numbers in column 3.

Thus the entry—

A a l | *a l l* | 55 | . *l* . | . . *yw* | *v* . | *vw* . | 3550

is to be read as signifying—

$$A\,a\,\underset{l}{l},\quad a\,l\,\underset{yw}{l};\quad l\,\underset{v}{l},\quad l\,\underset{vw}{l}.\quad 3550.$$

DIRECTORY OF 300 SETS [1]

1	2	3	4	5	6	7	8
Right Hand.	Left Hand.	Th. L. right. Th. L. left.	Right Hand.	Left Hand.	Right Hand.	Left Hand.	Register.
F.M.R.	F.M.R.		F.M.R.	F.M.R.	Th. L.	Th. L.	
A a a	a a a	1 2	. . .	. d d	. dl	. d	3516
	a a l	5 2	. . .	. . 2	2 .	ll .	2301
		5 4	. . .	. . a	. .	. .	1995
A a l	a a l	5 5	. . .	. . 2	. .	. .	3640
		8 5	. . 2a	r . 2	s .	v .	2740
	a l l	5 5	. l .	. . yw	v .	vw .	3550
		8 5	. l v	. . .	. .	. .	3639
	r l l	5 5	k . .	. . vy	. .	. .	3598
		8 5	t ll y	. . .	. .	. .	3647
	u a l	5 4	. . .	. *d .	. .	. .	3570
	u l l	5 5	. ll .	. . .	. .	. .	1892
		6 8	. . ry	2 . .	v .	svq y	3490
A a w	a a l	5 5	. . b	. . .	v .	. .	3542
	a l w	5 5	. . .	. . .	v .	. .	3658
A l a	a a a	4 4	u 3 .	. . .	. .	. .	3548
A l l	a a l	5 5	. 2a .	. . .	. .	. .	2512
	a l l	5 2	. . r	. . 3	. .	. a	1956

[1] 295 of these are pasted in two volumes; the remaining 5, which are numbered *6995* to *6999*, are supplementary.

1	2	3	4			5			6		7		8
A l l	a l l	5 5	.	.	.	.	3	.	.	.	.	.	2991
		5 5	.	a	y	.	.	.	.	.	.	.	2754
		5 5	.	.	.	u	.	.	.	.	.	.	3525
		5 5	.	.	.	.	†	.	.	v	2a	.	3559
	a l w	8 5	.	.	.	.	.	pl	b	.	.	.	2357
	r a l	8 5	.	.	.	.	.	.	b	.	.	.	2614
	r l l	5 5	tr	.	.	.	.	v	.	.	.	.	3504
		5 5	.	3a	.	.	.	.	.	.	.	.	3670
		5 5	2u	.	.	.	.	.	.	.	.	.	3628
		5 5	1u	.	.	.	.	.	.	.	.	.	1743
		5 5	.	a	.	2a	a	.	.	.	.	.	2247
	u a l	5 5	t	.	.	.	tr	.	.	y	.	.	2815
		5 5	t	v	vy	.	kvt	.	.	.	.	.	3113
	u l l	2 2	.	.	y	.	.	.	2l	.	.	.	3602
		5 2	t	.	.	.	.	.	.	.	.	.	*6998*
		5 5	u	.	.	.	.	rk	.	.	.	.	3499
		5 5	t	.	.	.	.	.	.	.	.	.	2378
		5 5	t	2	.	.	.	3a	.	.	†	.	741
		5 5	t	.	.	.	.	.	.	.	.	.	3569
		8 5	r	.	.	.	.	.	s	.	.	.	1353
		8 5	.	.	r†	.	†	.	.	.	.	.	3552
		8 5	.	.	a3	.	†	.	sb	.	.	.	3132
		8 5	.	.	.	.	†	.	.	.	.	.	293
A l w	a l w	2 2	.	.	.	.	3	vyl	.	v	.	.	3614
	r l l	9 5	kv	.	.	.	.	vy	†	.	.	vy	3622
	r l w	5 5	.	.	.	.	.	.	.	.	v	.	3491
		5 5	k	.	.	.	.	yl	v	v	.	.	3575
	u l l	9 5	kv	.	.	.	.	.	.	.	.	.	446
R a l	r l l	5 5	.	.	.	.	.	.	.	.	.	.	3663
		8 5	.	.	.	.	3	†	sb	.	.	.	3632
R a w		5 5	3a	.	.	.	.	.	.	.	.	.	3616
R l l	a a l	5 5	2a	.	.	r	.	d	.	.	.	.	3517
	r l l	5 2	3	.	.	.	r3	.	.	.	.	.	3596
		5 5	2at	.	.	.	.	.	.	.	.	.	2046
		5 5	2a	.	vy	at	†	.	.	.	†	.	3566
		5 5	3	.	v	.	.	y	.	.	.	.	3641
		5 5	4	.	.	.	.	.	†	.	.	.	275
		5 5	4	.	.	2	.	.	v	.	.	.	2350
		5 5	5	.	.	.	.	.	.	.	.	.	3518
		5 5	5	r	.	.	r	.	.	.	.	.	3580
		5 5	5	.	y	.	.	.	.	.	.	.	*6997*
		5 5	6kv	.	v	.	.	.	.	.	.	.	3509
		5 5	6	.	.	.	.	.	.	.	.	.	2220
		5 5	7	.	.	.	.	.	.	.	.	.	1954
		5 5	11y	.	.	.	y	.	.	.	.	.	2294
		5 5	12	.	vy	.	ky	y	v	.	.	.	3531
		5 8	.	.	.	.	r	.	.	.	lvb	.	3549
		5 8	.	.	.	.	.	.	.	.	rg	.	976
		5 8	.	kr	.	.	.	.	.	.	bs	.	3611
		8 5	.	.	.	y	.	.	b	.	.	.	3524
	r l w	8 8	.	.	.	.	.	s	b	.	sb	.	3005
	r w w	8 8	k	.	v	vk	sb	sb	.	.	sb	.	2351
	u l l	5 5	†	.	.	a2	.	.	.	.	.	.	3637
		5 5	.	.	y	†	.	vy	.	.	.	.	3636

1	2	3	4			5			6		7		8
R l l	u l l	5 5	.	.	.	.	.	.	.	.	.	.	3633
		5 5	.	.	.	.	.	.	.	.	.	.	3665
		5 5	k	.	r	2	.	r	yr	v	yr	.	3657
		5 5	.	.	.	.	.	.	.	.	.	.	3562
		5 5	.	.	.	3a	.	.	.	.	.	.	3537
		5 8	.	.	.	.	.	.	.	.	s	.	3653
		8 5	.	.	y	.	.	.	sq	v	v	.	3668
		8 5	.	.	.	.	.	.	.	.	.	.	3372
		8 5	.	y	y	.	v	y	.	.	.	.	3298
		8 5	y	.	.	.	.	.	.	.	.	.	2329
		8 5	2a	.	.	kw	k	v	.	v	.	.	405
		8 8	wy	.	.	.	r	.	sq	.	s	.	2207
	u l w	8 5	.	.	y	.	.	.	.	.	v	.	1025
	w l l	8 5	.	.	v	s	.	.	.	.	.	.	3667
		8 5	.	.	.	r	.	.	g	.	.	.	3621
		8 5	.	.	.	b	†	.	g	.	.	.	3567
	w w l	5 5	.	.	yw	r	r	y	.	.	.	.	3532
R l w	a l l	5 5	.	.	ld	t	.	y	.	.	.	.	3594
	r l l	5 5	k	.	.	k	.	.	.	.	.	.	3100
		5 8	.	.	.	.	.	.	.	.	b†	.	73
		9 8	.	.	.	.	.	.	o	.	sb	.	3527
	r l w	9 8	.	.	.	y	.	.	sb	.	r	.	3530
	u l l	5 5	kvw	r	ly	3ay	.	.	v	.	.	.	3660
		5 5	.	r	ly	.	.	.	.	.	.	.	1510
		8 5	3	.	.	.	vy	vy	.	.	.	.	2302
		8 8	3	†	.	.	.	y	g	.	s	.	3526
	u l w	5 5	.	.	.	d	.	.	.	.	.	.	1718
		8 8	vy	.	.	.	†	.	.	.	rg	.	3627
	w l l	5 5	.	.	y	r	.	.	.	.	.	.	2832
	w l w	8 8	.	.	.	r	.	.	g	.	sb	.	3512
	w w l	5 8	.	.	.	r	sq	y	v	v	sq	y	3576
	w w w	9 5	†k	.	.	rko	s	s	sb	.	.	.	1985
R w l	r l l	5 5	.	ly	.	.	.	.	.	.	.	.	3585
	r w l	5 5	y	.	.	vy	.	y	.	.	.	.	3605
R w w	r l l	8 8	v	bs	.	.	.	.	b†	.	svb	.	1446
	u l l	5 5	.	.	.	y	.	.	.	.	.	,	3590
	u w w	5 5	.	.	.	†	s	s	.	.	.	†	3572
	w w w	8 8	.	.	.	.	.	.	.	v	sq	.	605
		8 8	.	.	.	ko	s	.	.	.	s†	v	3506
U a a	a a a	4 4	.	.	.	.	.	.	.	.	.	.	3534
l	r l l	5 5	.	t	.	at	.	.	.	.	.	.	1004
	u l l	8 8	.	l	.	.	.	.	.	.	sb	.	3483
U a w		5 5	.	r	.	.	.	.	.	.	.	.	3529
U l a	u l a	5 5	2a	†	.	.	.	2l	a	.	.	.	3536
U l l	a a l	2 2	2a	.	2	.	.	.	.	.	.	.	2744
		5 2	.	.	.	t	.	2	.	.	.	a	3533
	a l a	5 2	.	.	.	.	.	.	.	.	.	2	2470
	a l l	5 5	.	.	.	.	.	.	.	.	.	.	3612
		5 5	.	.	.	u	.	y	.	.	.	.	3607
		5 5	.	.	.	.	.	.	.	.	.	.	3603
		5 5	.	.	.	t	.	.	.	.	.	.	3547
		5 5	3	.	.	.	.	.	.	.	.	.	2566
	r a l	5 5	.	.	.	.	t	3	.	.	.	.	3652
	r l l	5 5	.	.	.	k	.	.	.	.	.	.	3662

1	2	3	4	5	6	7	8
U 1 1	r 1 1	5 5	. . .	. . .	. .	. .	3555
		5 5	. . .	3 . y	. .	. .	3597
		5 8	. . .	. . .	. .	bl .	3456
		5 8	. . .	. . .	v .	sb .	3439
		5 8	kv . .	at . kw	. .	sb .	2843
		8 5	. . .	. . w	g .	. .	3339
		8 5	. . .	. . .	. .	. .	3538
		8 8	. . v	. . .	sb .	sb .	3563
		8 8	. . wvy	3 . .	b .	. .	2348
	r 1 w	5 8	. . v	3a . .	v .	sb v	3565
	u a 1	8 8	. . .	. r2 .	. .	sq .	3642
	u 1 1	5 5	2ai f yc	c . .	. .	. .	3519
		5 5	3i f .	i i .	. .	. .	3649
	u 1 1	5 5	4i . .	i . .	. .	. .	3588
		5 5	4k i r	. . .	. .	. .	2492
		5 5	5c . i	i . .	. .	. .	3584
		5 5	5c . .	c f .	. .	. .	3544
		5 5	6c i i	. . .	. .	. .	3207
		5 5	6† . .	. . c	. .	. .	3587
		5 5	10f . i	c f .	. .	. .	3447
		5 5	10i . .	. . .	. .	. .	3591
		5 5	10c . vyc	i c .	. .	. .	3617
		5 5	11f . c	i . .	. .	. .	3557
		5 5	12 c i	c † v	. .	. .	3513
		5 5	12i c f	y . i	† .	. .	349
		5 5	12c i .	i . .	. .	. .	3493
		5 5	13i . .	f d d	. .	. .	3601
		5 5	13f . .	. . i	. .	. .	3586
		5 5	13 i .	kv f .	. .	. .	3608
		5 5	14 c c	. f .	. .	. .	3626
		5 5	15c i †v	. . .	. y	. .	3634
		5 5	16 c .	. f .	. .	. .	1486
		5 5	17f . yi	yi . .	. .	. .	3508
		5 5	18c . yi	i i yi	. .	. .	2856
		5 6	. . y	† . .	. .	. q	3648
		5 8	. . .	. . .	. .	g .	2419
		8 5	. . .	† . .	sq .	. .	72
		8 5	. † .	. r .	. .	. .	66
		8 5	. . .	2a . .	. .	. .	1530
		8 5	k . vy	3 . y	. .	. .	3553
		8 5	. . .	. . .	sb d	. .	3615
		8 8	. . y	. . .	. vy	s .	3610
		8 8	. . y	. † .	. .	sq .	3638
		9 9	. . v	k . vy	. .	sb .	1519
	u 1 w	5 5	. . .	ky r .	. .	† .	3086
		5 5	. . .	. . .	. .	. .	3578
		8 9	v . y	. . .	s .	r .	2598
	w 1 1	5 5	. . .	r . .	. .	. .	3043
		5 8	v . .	r atr .	v .	r .	2484
		8 8	. . .	. . v	. .	sg v	2421
		8 9	. . v	ko . .	. .	qr .	3650
	www	5 8	v v v	r ko .	vw .	sq .	3560
U 1 w	r a w	5 6	3a . .	. . .	. .	. .	3573
	r 1 1	8 8	. . .	. . .	. .	sb .	3520
		8 8	. . .	k r .	. v	vs v	3624

1	2	3	4	5	6	7	8
U l w	r l l	9 8	. k .	. . vy	. .	bs vy	3618
	r l w	8 8	. . .	. . y	b .	ls .	3623
		8 8	. . .	avk . ryl	† .	s .	3498
	u a l	5 5	. . ko	wy l vy	. a	. 2	3540
	u l l	5 5	v v .	. † .	. .	3a .	2454
		5 5	. . .	2a . vy	. .	. .	1870
		5 5	2 . .	. . .	v yw	. .	3535
		5 5	. . .	3a . .	. .	. .	3503
		5 5	. . y	. . v	. .	. .	3543
		5 5	. . .	. . .	. .	. .	*960*
		5 6	. . .	. . yw	v .	v .	3568
		8 5	. . r	. . yw	. y	. .	664
		8 5	v . .	. . y	d .	† .	2383
		8 8	. . .	. . .	o .	s .	3625
		9 8	kv . .	. . v	. o	rq .	3619
	u l w	2 2	. . .	. . y†	. .	. .	3539
		5 5	. . .	. . y	v .	. .	151
		6 5	. . .	. . .	. .	. .	3644
		8 5	. . .	. . .	. .	kv v	3511
		8 5	. . .	. . .	b .	. .	3528
		8 8	. . .	. . s	. .	r vy	2196
		9 6	. . .	. . sq	. .	. yl	2336
	uww	3 6	v . .	. akv .	. .	. .	1110
		9 8	. . .	. . .	. .	r .	3672
	w l w	6 6	v . .	vs . .	v .	. .	356
	www	9 6	. . r	r s .	q .	. .	3620
U w w	*r w l*	8 8	d . .	. v .	. .	. .	*6995*
	u l l	9 5	. y .	. † vy	lvy .	. v	2707
	w l w	5 5	. s .	r . .	. .	. .	2165
		6 9	. . .	r . .	v .	sv .	3216
W l l	a a l	8 5	kr . .	. . v	sb .	. .	3669
	r l l	5 5	. . .	vy . .	v .	v .	3521
		5 5	. . y	y . .	. .	. .	3561
		8 8	kvr . .	2 † .	g .	gs .	3554
		8 8	uk . .	. . .	. .	rb .	2917
		8 8	k k .	. . v	. .	gr .	3645
		8 8	r . v	. . vy	b .	sb .	2927
	u l l	8 8	. . .	w . .	. .	r .	3004
		8 8	rky . y	. . .	. .	ro .	3448
		8 8	. . .	. . .	g .	bs .	3604
	u l w	5 5	. . wy	v . ly	v .	. .	3522
		8 5	. . v	. . s	. .	. .	2836
	w l l	5 5	. . ry	r . y	. .	v .	2730
		5 5	. . .	r r .	. .	wvq .	3494
		5 5	. . v	ro . .	. .	. .	3501
		5 8	r . .	r† . .	. .	s .	1199
		8 5	r . .	gr . .	g .	. .	3551
		8 8	r . v	r . v	. .	s .	3545
		8 8	. . .	r v .	b .	sb .	3643
	w l w	5 5	. . vy	s . s	v .	. .	3609
		8 8	ko . .	r kyw .	. .	r .	*6996*
		9 8	r . vy	r . .	. .	s .	3599
	www	5 8	. . .	r r .	. .	g .	3671
		8 8	r . y	s . .	. †	r .	1127

1	2	3	4			5			6		7		8
W l w	a l l	8 8	r	2a	ry	.	2	.	.	2	vs	.	619
	r l w	8 8	r	.	.	kv	†	.	.	v	s	v	122
		8 8	ry	.	.	.	.	.	o	.	rq	.	3021
	u l l	8 5	r	.	r	.	.	.	sb	v	.	.	3629
		8 8	.	.	.	.	.	.	.	.	r	.	12
		8 8	r	.	.	v	.	y	s	.	sq	v	3577
	u l w	5 5	.	.	.	.	y	.	.	.	.	.	3592
		6 6	r	.	.	.	.	.	.	.	.	.	3635
		8 5	r	.	.	.	.	.	b	.	.	.	3651
		8 8	uy	.	.	.	v	s	.	.	s	†	916
		9 9	.	.	.	v†	.	.	s	.	sq	.	2491
	u w l	8 5	r	.	ld	.	.	.	.	.	v	.	3666
	w l l	5 5	s	.	.	r	.	.	.	.	.	.	3654
		8 5	.	v	.	.	.	y	.	.	.	.	3564
		8 5	.	.	.	r	.	.	.	.	.	.	3510
		8 8	r	.	.	r	.	.	r	vy	r	.	587
		8 8	.	.	.	r	.	y	q	v	sq	v	3581
		8 8	r	yw	.	.	v	y	g	.	g	.	3583
		8 8	.	.	.	.	.	v	.	.	svq	.	3606
	w l w	5 5	.	v	.	ry	v	.	.	.	.	.	*6999*
		5 5	r	.	.	sv	.	s	.	y	a	v	2560
		5 5	r	†	.	r	.	.	.	.	.	.	3646
		5 5	r	.	.	r	.	.	.	.	.	.	3020
		8 5	r	.	.	r	.	.	s	.	.	.	3664
		8 8	.	.	.	ko	.	.	b	.	sb	.	2291
		8 8	r	v	y	r	.	.	g	.	r	.	3236
		9 8	.	.	.	s	.	.	.	.	s	vy	2256
	w w l	8 8	rb	.	g	rb	s	.	b	.	bs	.	3571
		9 5	o	.	o	s	.	y	.	.	.	.	1109
W l w	w w w	8 8	r†	.	.	ly	.	†	o	v	vs	.	738
		8 8	or	.	o	sq	.	o	.	v	rq	.	3497
		9 5	r	.	.	.	b	b	.	.	.	.	3496
		9 6	.	v	.	s	r	.	s	.	v	.	3556
		9 9	.	v	.	.	s	.	.	.	s	.	2003
		9 9	.	.	.	r	rb	.	b	.	s	.	2855
W w l	w l l	8 5	.	.	.	r	†	y	.	.	.	.	278
		8 8	.	g	.	.	.	.	s	.	lv	.	1730
	w w w	8 8	.	b	.	b	x	x	b	.	lb	.	889
Www	r l w	5 5	r	.	.	k	.	.	.	.	.	v	638
	r ww	8 8	.	.	.	.	r	s	.	.	s	v	3582
	u l l	8 5	r	.	.	v	y	y	.	v	v	.	3661
		8 8	.	.	.	.	.	vy	.	v	sq	.	3659
	u l w	8 5	.	.	.	†	.	.	.	y	.	.	3505
		9 8	r	r	r	v	.	s	.	d	vs	v	620
	u ww	5 5	r	.	.	v	.	s	v	y	.	.	1518
		9 8	r	.	.	akv	r	.	.	.	sb	.	3579
	w l w	5 5	r	.	.	r	.	.	.	.	.	.	3600
		8 8	s	s	.	r	.	s	o	.	rg	.	3630
		8 8	r	.	.	r	v	s	.	v	r	.	3541
		8 8	.	.	.	.	.	.	b	.	b	.	3515
	w w l	5 5	r	.	.	r	.	w†	v	.	.	.	3631
		5 5	.	r	y	r	.	vw	v	.	v	.	3656
		5 6	.	.	.	.	.	.	.	.	.	.	3514
		9 5	r	.	.	r	.	.	.	g	.	.	2938
	w w w	5 5	r	.	.	.	.	.	v	v	.	.	1929

1	2	3	4	5	6	7	8
Www	www	5 5	o . o	o s .	. vy	. .	3595
		6 6	. . .	s s .	. .	. .	2411
		8 5	. . .	r . .	. .	. v	2538
		8 8	r . .	rd yd y	sq v	sb v	3500
		9 5	r . .	rb s .	. .	. v	2899
		9 6	. . .	sb . .	sb .	. .	3574
		9 8	r . .	r s .	. .	s yw	3613
		9 8	. . .	. . .	. .	s v	3003
		9 8	. . .	sq sq .	. .	sb .	3492
		9 9	r . .	r s .	. .	sq .	3507
		9 9	r s .	r s .	o o	sq .	3589

MEMOIRS AND BOOKS ON FINGER PRINTS ALREADY PUBLISHED BY THE AUTHOR.

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1. "Personal Identification." *Journal Royal Institution*, 25th May 1888, and *Nature*, 28th June 1888.

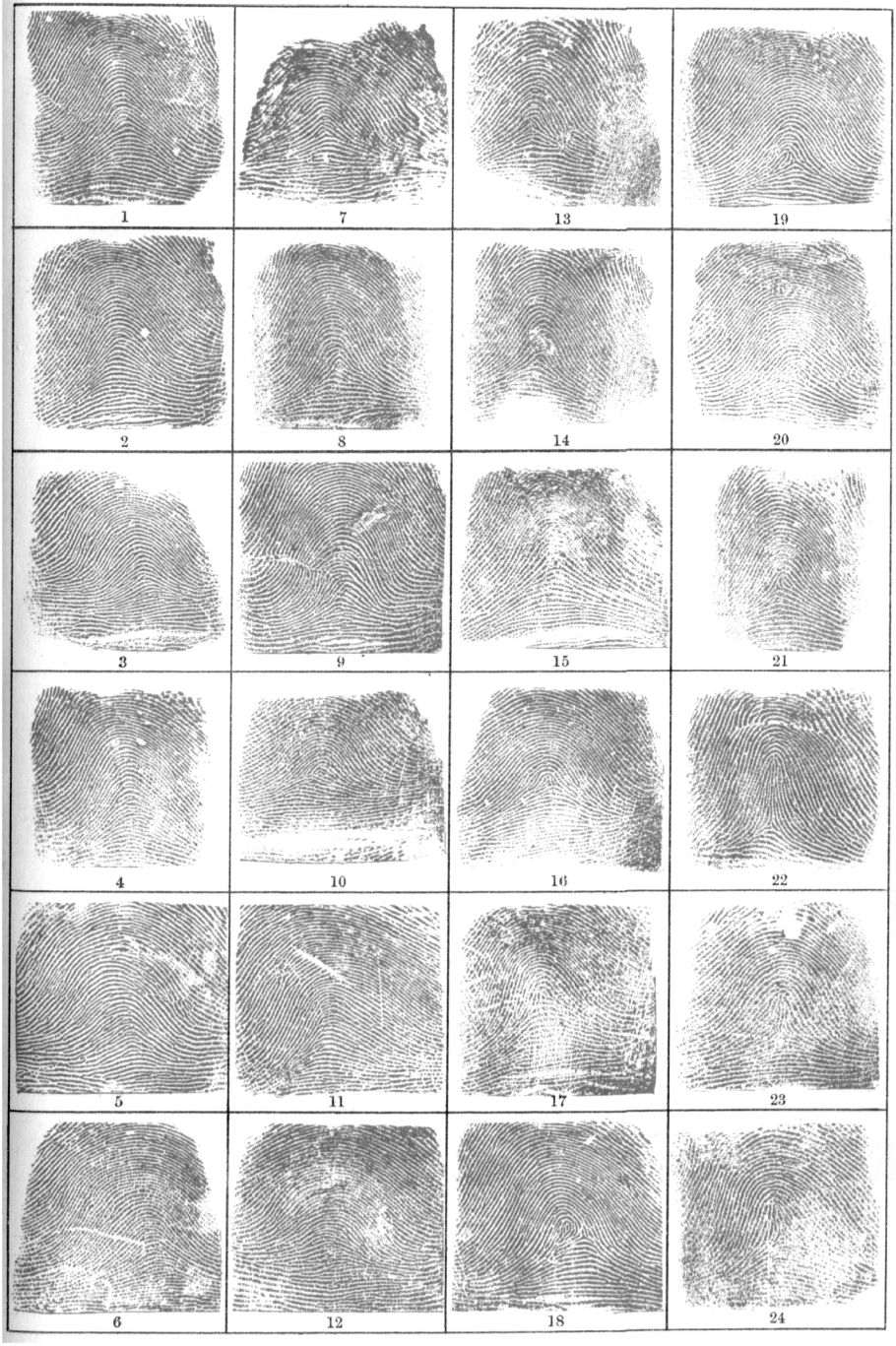
2. "Patterns in Thumb and Finger Marks." *Phil. Trans. Royal Soc.*, vol. clxxxii. (1891), pp. 1-23. [This almost wholly referred to thumb marks.]

3. "Method of Indexing Finger Marks." *Proc. Royal Soc.*, vol. xlix. (1891).

4. "Identification by Finger Tips." *Nineteenth Century*, August 1891.

5. "Finger Prints." *Macmillan and Co.*, 1892.

6. Decipherment of Blurred Finger Prints." *Macmillan and Co.*, 1893.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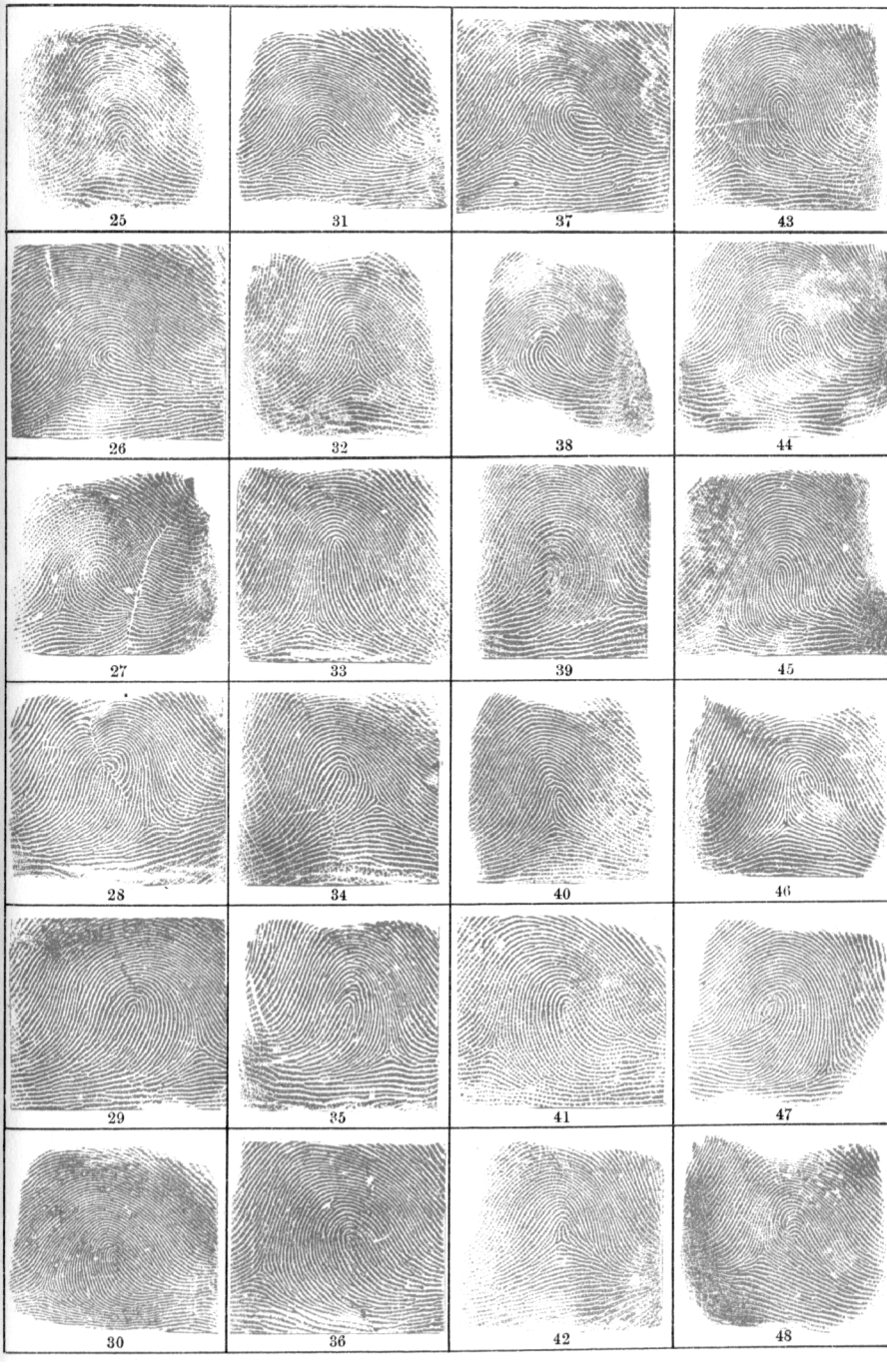
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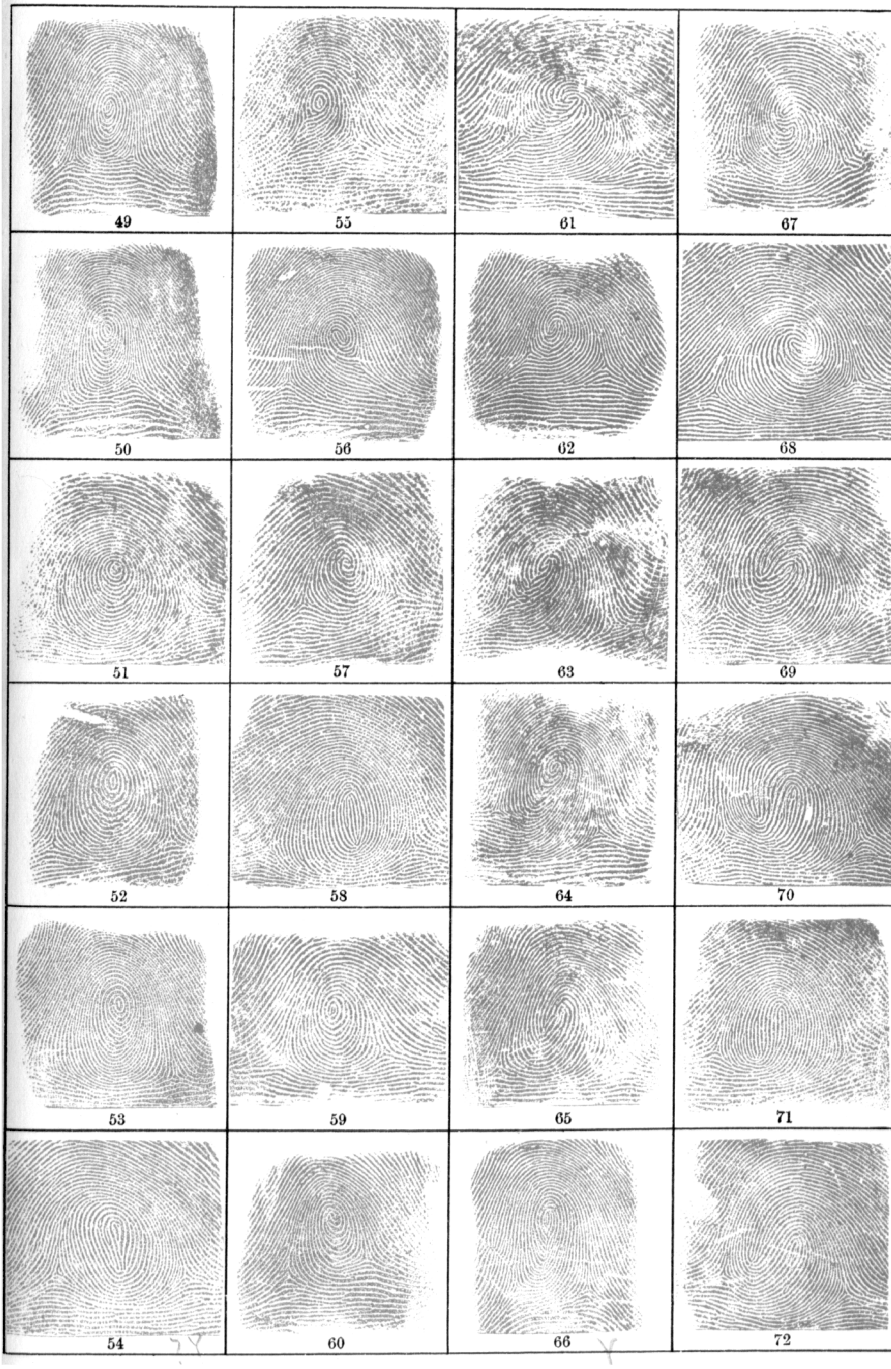
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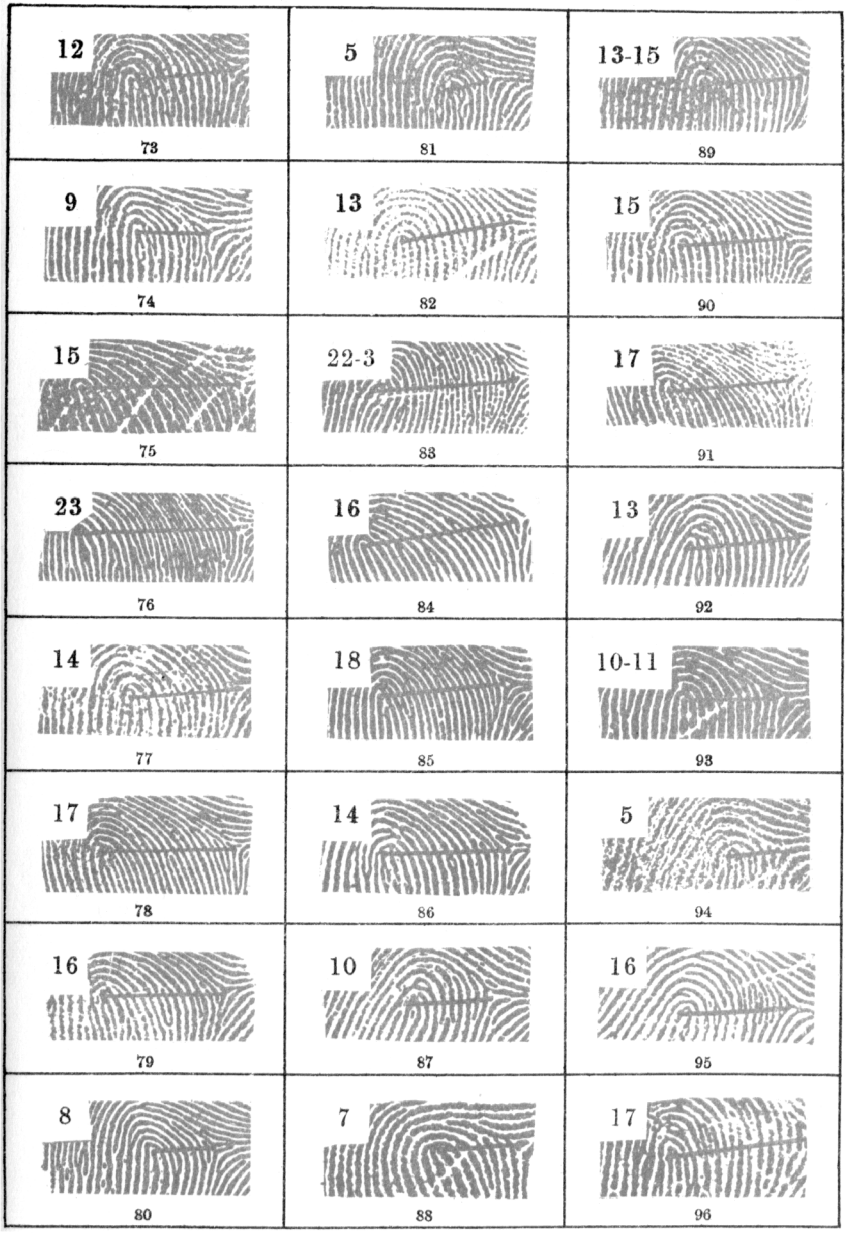
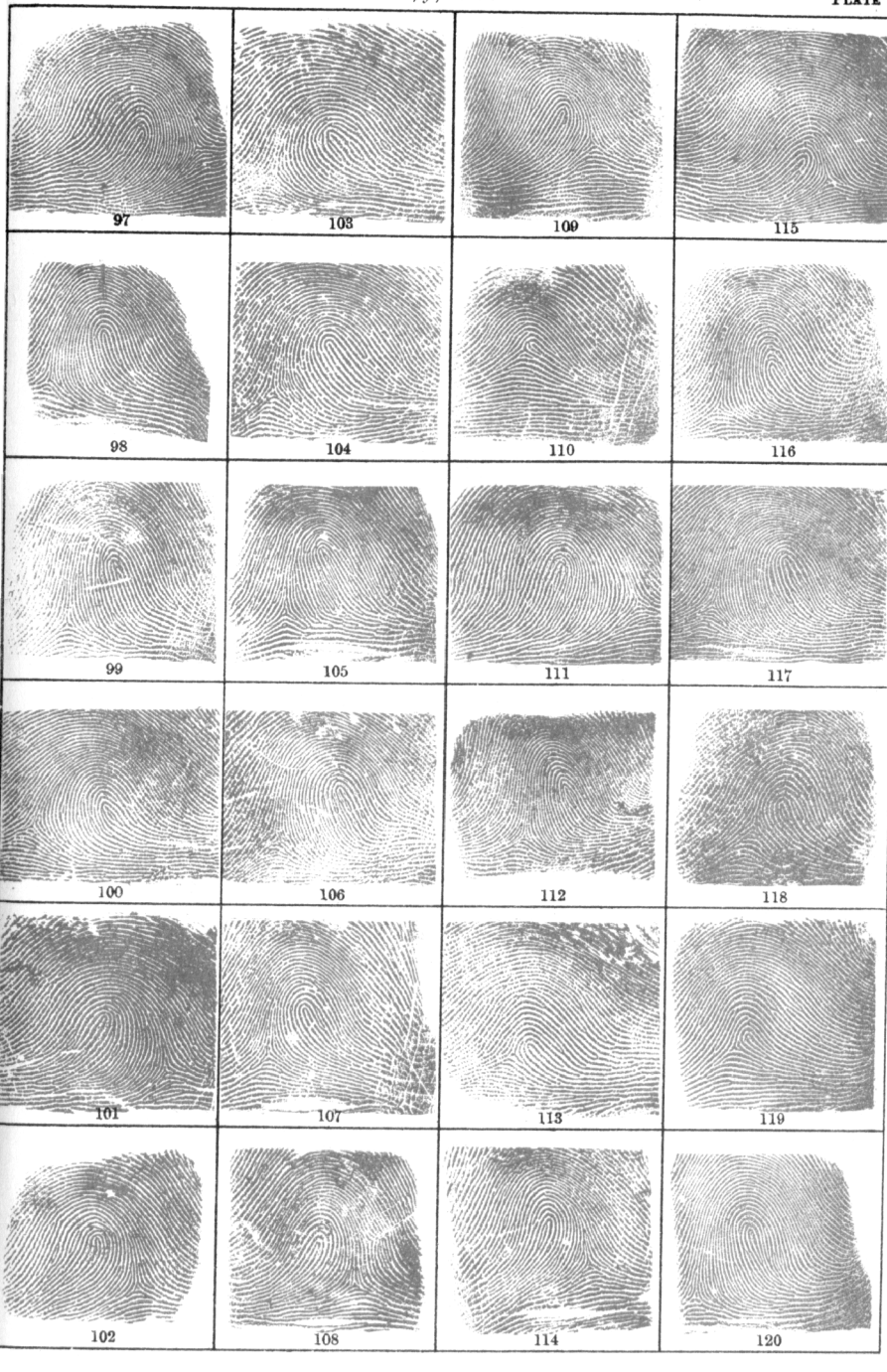


These prints are enlarged to about twice their natural size, for the more easy counting of the ridges.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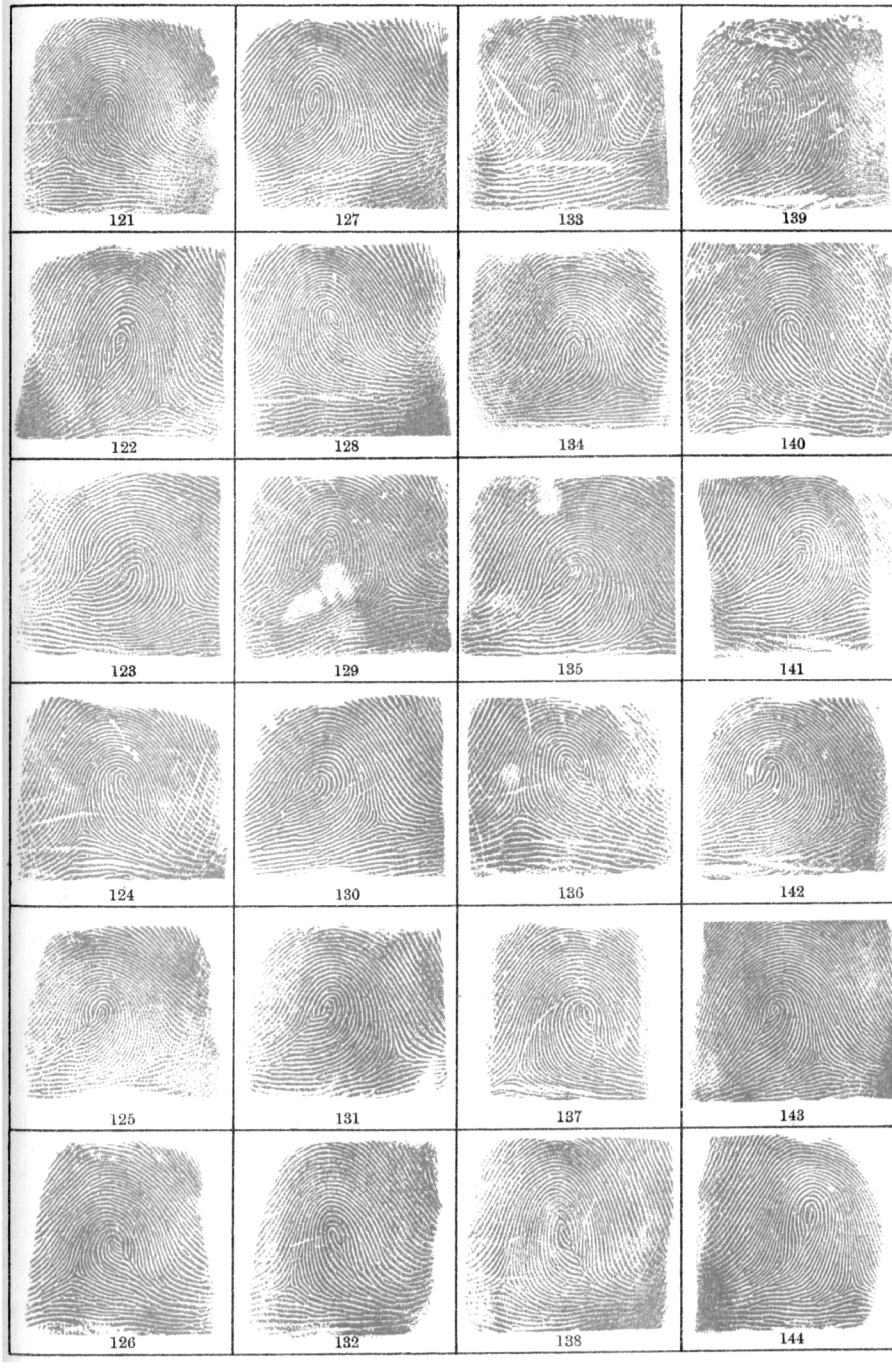
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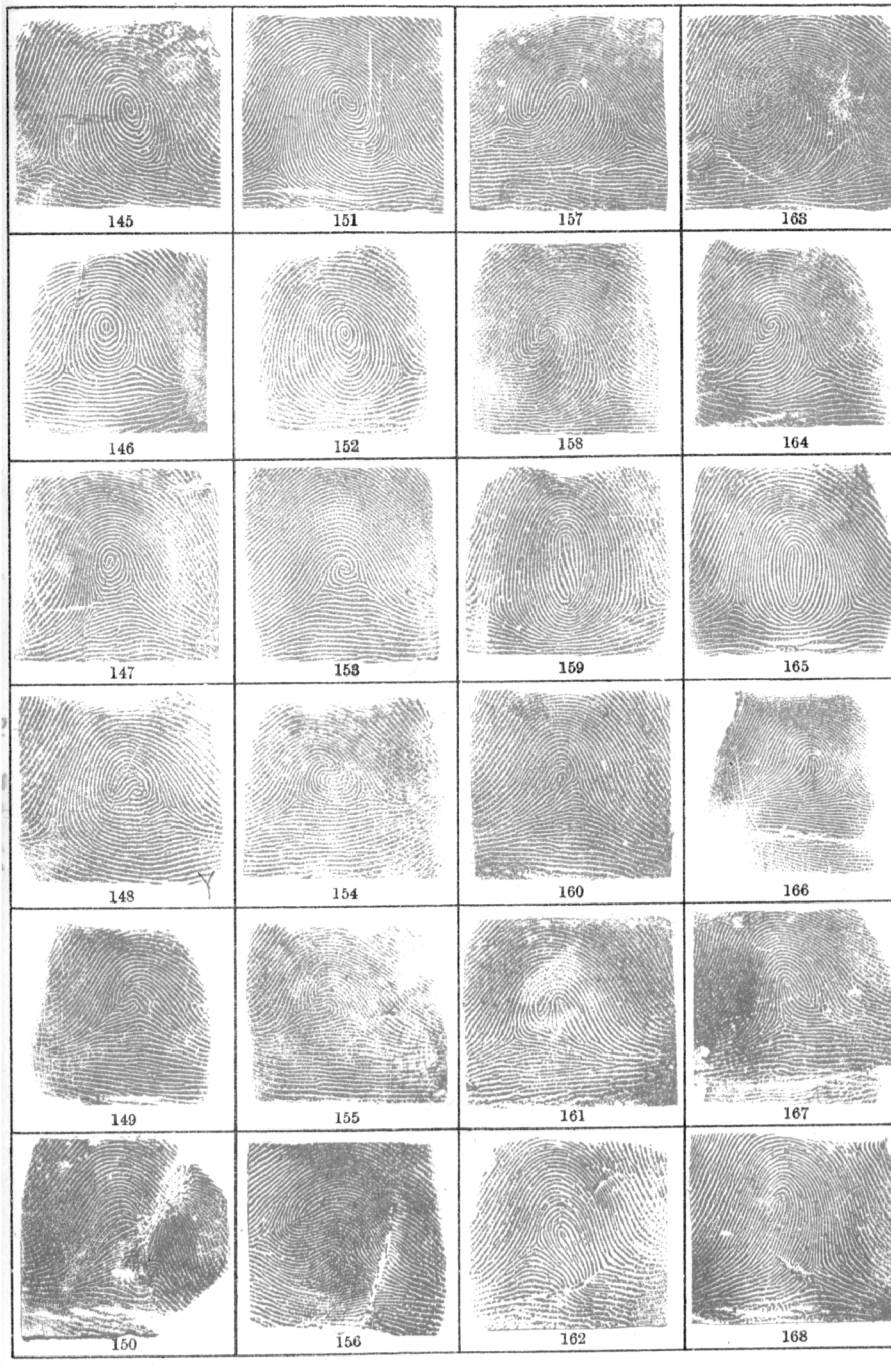
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Loops, *y*

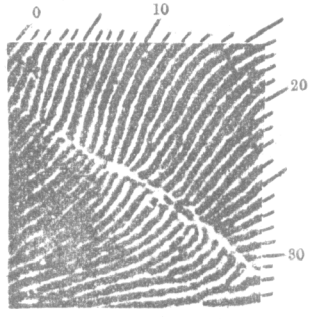
Whorls, *y*

Apparently a Loop

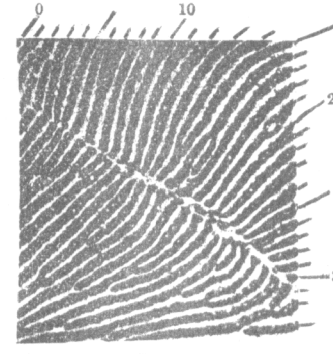
Really a Whorl

A dabbed and a rolled print of the same finger.

PERMANENCE OF A SCAR IN A GROWING BOY AFTER AN INTERVAL OF 2 YEARS AND 3 MONTHS



In 1892
Aged 14 years and 3 months



In 1894
Aged 16 years and 6 months

PERMANENCE OF A SCAR IN AN ADULT AFTER AN INTERVAL OF NEARLY 4 YEARS

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