

CHAPTER XV

PERSONAL IDENTIFICATION AND DESCRIPTION

"It became gradually clear that three facts had to be established before it would be possible to advocate the use of finger-prints for criminal or other investigations. First it must be proved, not assumed, that the pattern of a finger-print is constant throughout life. Secondly that the variety of patterns is really very great. Thirdly that they admit of being so classified, or 'lexiconised,' that when a set of them is submitted to an expert, it would be possible for him to tell, by reference to a suitable dictionary, or its equivalent, whether a similar set had been already registered. These things I did, but they required much labour." Galton: *Memories of my Life*, p. 254.

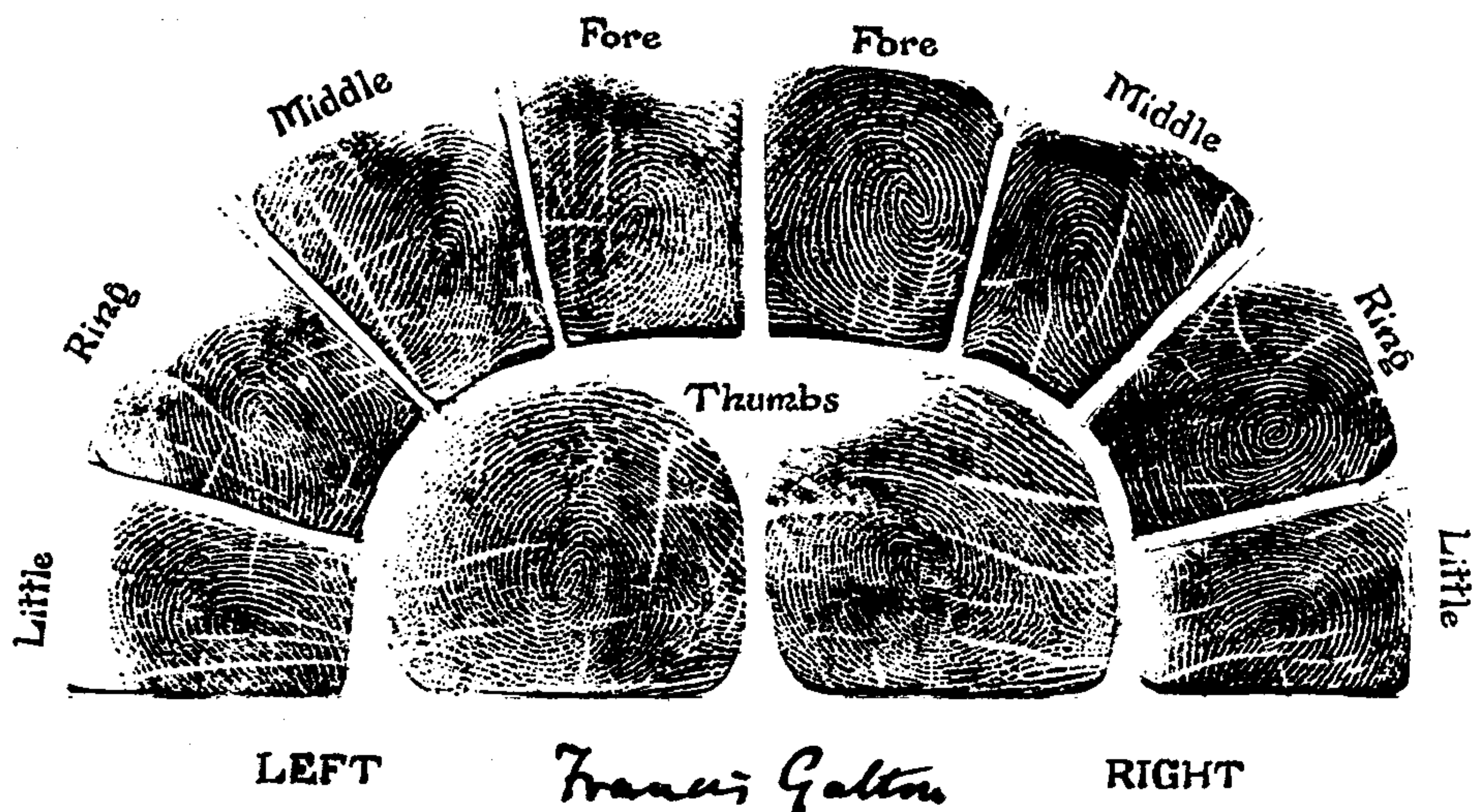


Fig. 15.

§ I. *History and Controversy.*

The writer must confess to having felt not a little puzzled when he had to determine in what order to present Galton's work on Personal Identification. It is not only that his work was scattered over very numerous publications, but that in order to make it effective Galton had to step into the public arena; and this had its usual consequences, namely controversy and misrepresentation, factors which had hitherto played but a small part in Galton's career. On the whole it is strange how little controversy intruded on Galton's long and quiet years of study; this was in part due to the peace-loving mind of the man, but there were also other causes at work. In the first place he was labouring most of his life in an entirely untilled field, and there could be no friction therefore with other pioneers. In the next place his fellow scientists were slow to realise that the new logical tools he was

forging would ultimately be applied in their own fields of work, and when that application came, whether in anthropology, psychology, biology, sociology or medicine, there would be sure to be friction, and resulting controversy—heated and bitter. That experience was left to his lieutenants and their disciples.

In the matter of finger-print identification, however, Galton was not only sharpening a new tool, but urging on all and sundry its application to practical problems. The tool was soon seen to be so efficient that it had to be adopted, but its very efficiency raised jealousy and controversy, as to whom the merit of its introduction must be attributed. I shall endeavour in this chapter not only to put before my readers the history of the adoption of finger-print identification in this country, but the means Galton took to popularise the idea, and finally provide a *résumé* of his scientific contributions to the subject which form the foundation on which all later work in this field has been based.

Investigations with regard to finger-prints occupied much of Galton's time during the years from 1887 to 1895. I say advisedly from 1887, because soon after the opening of his second Anthropometric Laboratory, he began the collection of those thousands of finger-prints, on the study of which so many of his conclusions depended*. It may be safely said that no one had in the early 'nineties so vast a collection of finger-prints as Francis Galton, a collection covering not only our own English race, but also Welsh, Hindoos, Jews, Negroes, and special groups such as idiots, criminals, etc. That collection started by Galton has continued to grow to the present day, although now it is chiefly, but not entirely, confined to hereditary data. I have already indicated how Galton in the 'eighties was occupied with the problem of portraiture and personal identity (see Vol. II, Chapter XII), and it was from the standpoints (a) of ethnology, (b) of heredity, that he first approached the problem of the papillary ridges on the fingers. It is well known now that finger-prints may be classified into certain types, which Galton called "genera," and that variations appear to cluster round these typical forms. It would have been a great achievement to show that in certain human races only one "genus" occurs, or indeed that the "genera" occur in very different proportions. Galton failed in racial collections of fairly considerable numbers to detect any *marked* differentiation of this kind. I am not prepared to assert that with larger collections and more modern statistical methods *some* differentiation might not still be found; it is hard to believe that from the very origin of *Homo* these genera have

* This collection in large indexed cabinets exists in the *Galtoniana*, and I should be very grateful to any one whose finger-prints were taken thirty to forty years ago, if they would call in at the Galton Laboratory, University College, W.C.1, and allow their fingers to be reprinted. Galton in delivering his Presidential Address to the Anthropological Institute, January 22, 1889, refers to his lecture of 1888 as "of last spring" and mentions that he is taking the two thumb prints and describes the technique he has adopted. His work therefore began certainly in 1888 and I suspect experimentally in 1887 before his lecture of May, 1888. The earliest *dated* finger-prints that I can find in this laboratory are from March, 1888.

been scattered almost indiscriminately among the ten fingers; yet Galton failed to solve any anthropological problem by the aid of finger-prints*.

In the matter of heredity he was more successful, he produced evidence adequate enough to demonstrate that finger-prints were hereditary, but neither he nor any one since has produced a satisfactory account of the manner in which they are inherited.

In later years † Galton formed a considerable collection of family prints of the two forefingers only. These were tabled and reduced in 1920 by Miss Ethel M. Elderton, who demonstrated the general inheritance of the ridge patterns, but noted that two finger-prints were far from adequate to determine the intensity of heredity, as although a parental peculiarity of pattern might pass to the same finger in the child, or with less probability to the homologous finger, it might also pass to any one of the remaining eight fingers; this, if it happens to any individual finger with still less probability, may occur with equal or even greater probability when we take into account the total eight of them. While the existence of ten fingers in man is a distinct advantage in the matter of personal identification—or if we like a distinct misfortune to the criminal—it is also something of a misfortune to the geneticist. At any rate Galton's work left much to be done in determining the organic correlations between prints of the different fingers in the same individual ‡ and the bearing of these organic correlations on the problem of heredity in the ridges. Thus it came about that while Galton did much pioneer work in the collection and co-ordination of material his chief contribution to the subject was in the matter of identification. He was the first to publish matter, largely due to Sir William Herschel, fully establishing the persistence of finger-print patterns; he was the first to show the nature of their variety and to classify them, and lastly he was the first to prove that it was possible to index them and rapidly to find, from a given set of prints, whether their owner was already in the index. All these problems were fundamental and must be definitely solved, if finger-prints were to be used for police purposes. None of this spade work had been achieved or at any rate published before Galton took up the subject. Before his day we have mere suggestions of the possible usefulness of these prints. Within ten years from his first study of the subject by the aid of his papers dealing with the prints from a scientific standpoint, by repeated letters to the press, by action through the British Association and by definite demonstrations in his Laboratory to the Commission appointed by Mr Asquith to consider the question of criminal identification in England, Galton had got not only bertillonage accepted in

* More recent researches, for example, those of Kubo (1918) and Collins (1915), seem to indicate that the Oriental races have a larger percentage of whorls and fewer ulnar loops than the European races. But the results are doubtful because there is a large personal equation in the matter of classification. I think we must conclude with Stockis (*Revue Anthropologique*, Année 1922, p. 92) that the results reached (thirty years after Galton) are still not adequate to admit of our asserting the existence of well-defined ethnic differences in finger-prints.

† See *Biometrika*, Vol. II, p. 365, 1903. Collection made in the years 1903 to 1905.

‡ A beginning was made in the study of the organic correlation of finger-prints by Dr H. Waite, *Biometrika*, Vol. X, p. 421 *et seq.*

England, but, what in the sequel has proved more important, the use of finger-prints. The fact that such prints are now practically adopted in the Criminal Investigation Departments of all civilised countries, is striking testimony to Galton's work and to his energy. Attempts have been made to belittle his achievement in this matter. Galton's claim is not based on his being the first to *suggest* this use of finger-prints, or on being the first actually to apply them. It lies in the fact that general police adoption of finger-prints resulted from his activities. It is easy to make suggestions, it wants an additional mental quality to get them carried out by administrative bodies, always and often justly conservative in character*.

In Galton's lecture at the Royal Institution in 1888 on "Personal Identification †," he gave an account (pp. 3-5) of Bertillon's method—bertillonage as it came to be called—the basis of which lies in recording the anthropometric measurements of criminals. Galton believed in the serviceableness of this method, but he held also that its efficiency had been overrated, because its inventor much underestimated the high correlations, which Galton surmised, and which were later demonstrated to exist between the various measurements taken. He then made his first public reference, as far as I am aware, to those "most beautiful and characteristic of all superficial marks" the

"small furrows, with the intervening ridges and their pores, that are disposed in a singularly complex yet regular order on the under surfaces of the hands and the feet. I do not now speak of the large wrinkles in which chiromantists delight, and which may be compared to the creases in an old coat, or to the deep folds in the hide of a rhinoceros, but of those fine lines of which the buttered fingers of children are apt to stamp impressions on the margins of the books they handle, that leave little to be desired on the score of distinctness."

Galton then refers to the work of Purkenje in 1823, Kollmann 1883, Sir William Herschel and Dr Faulds, etc., much in the same terms as in his *Finger Prints* of 1892 ‡. In this lecture Galton submitted on the problem of permanence :

"a most interesting piece of evidence, which thus far is unique, through the kindness of Sir Wm. Herschel. It consists of the imprints of the first two fingers of his own hand made in 1860 and in 1888 respectively, that is, at periods separated by an interval of twenty-eight years." (pp. 12-13.)

Galton analyses the *minutiae* (see our p. 178) in an adequate, but less thorough manner than he did later by the aid of sevenfold photographic enlargements and the tracing in of the ridges. It is clear that Galton was actively interested in finger-printing, and his remarks on p. 15 show that he had been experimenting in many ways on the most advantageous and

* An executive department has not only to consider the cost of installing an innovation, and afterwards of its maintenance, but likewise whether the resulting advantages will compensate for the additional expenditure.

† See our Vol. II, p. 306; also the *Journal Royal Institution*, May 25, 1888, or *Nature*, June 28, 1888.

‡ He does not refer to the paper by Nehemiah Grew in the *Phil. Trans.* of 1684 (Vol. XIV, pp. 566-67). That paper has a very good, i.e. well engraved, illustration of the ridges on the palm of the hand and on the fingers. A rather curious representation of the pores on the ridges—not referred to in the text—appears also to belong to Grew's paper. Grew emphasises that the pores are *on* the ridges, not in the furrows, and speaks of them as little fountains for the discharge of sweat. There is no statement as to permanence or as to personal identification.

cleanliest method of taking the impressions. In his *Finger Prints* of 1892 Galton says that

“My attention was first drawn to the ridges in 1888, when preparing a lecture on Personal Identification for the Royal Institution, which had for its principal object an account of the anthropometric method of Bertillon, then newly introduced into the prison administration of France. Wishing to treat of the subject generally, and having a vague knowledge of the value sometimes assigned to finger marks, I made inquiries, and was surprised to find, both how much had been done, and how much there remained to do, before establishing their theoretical value and practical utility.” (p. 2.)



Fig. 16. Finger Prints of Sir William J. Herschel at an interval of 28 years. From Galton's *Finger Prints*, Plate 15, Right Forefinger. Second method of marking *minutiae*.

I do not think that it can be asserted that Galton failed to recognise what work had been previously *published*, except in the case of Nehemiah Grew*, and from him he would indeed have learnt very little, had he known of him. That the pores were on the ridges, not in the furrows, Galton probably found out from his own observation †.

* Alix's paper of 1868 (see our p. 143 ft. †) and Klaatsch's of 1888 are referred to on p. 60 of the *Finger Prints*, but more stress possibly might have been laid on the former.

† In the *Memories*, pp. 257-8, is an amusing account of Herbert Spencer's view on the relation of ridges to pores:

“I may mention a characteristic anecdote of Herbert Spencer in connection with this. He asked me to show him my Laboratory and to take his prints, which I did. Then I spoke of the failure to discover the origin of these patterns, and how the fingers of unborn children had been dissected to ascertain their earliest stages, and so forth. Spencer remarked that this was beginning in the wrong way; that I ought to consider the purposes the ridges had to fulfil, and to work backwards. Here he said, it was obvious that the delicate mouths of the sudorific glands required the protection given to them by the ridges on either side of them and therefrom he elaborated a consistent and ingenious hypothesis at great length. I replied that his arguments were beautiful and deserved to be true, but it happened that the mouths of the ducts did not run in the valleys between the crests, but along the crests of the ridges themselves. He burst into a good-humoured and uproarious laugh and told me the famous story which I had heard from each of the other two who were present at the occurrence. Huxley was one of them. Spencer, during a pause in conversation at dinner at the Athenaeum said, ‘You would little think it, but I once wrote a tragedy.’ Huxley answered promptly, ‘I know the catastrophe.’ Spencer declared it was impossible, for he had never spoken about it before then. Huxley insisted. Spencer asked what it was. Huxley replied: ‘A beautiful theory, killed by a nasty, ugly little fact.’”

I think, however, Galton had forgotten the date at which his attention was first drawn to finger-prints. He appears to have been collecting data before his lecture in 1888. But as early as 1880 Dr Faulds wrote a letter (February 16th) from Japan to Charles Darwin mentioning that the topic might have interest for him. The letter suggested that there were *racial* differences in finger-prints and enclosed two prints of palms of hands and of the five fingers. Darwin, strangely for him, rather overlooked the possible importance of the topic; he was clearly busy and worried*. He forwarded the letter to Galton mentioning that it might have interest for anthropologists, and suggesting it had better be dealt with by the Anthropological Institute. Galton actually did present the letter to that Institute, and its officials appear to have then pigeon-holed it. Faulds' and Darwin's letters were unearthed many years later (April, 1894), after Galton had published his books, and returned by A. E. Peek to Galton. These letters I found in the *Galtoniana*.

Before this discovery I had no knowledge that Dr Faulds had written to Darwin in 1880, but it is clear that Galton sent the letter as suggested by Darwin to the Anthropological Institute. It cannot be said that any injustice was thus done either by Darwin or Galton. No busy scientist is bound to pay attention to the innumerable suggestions that may be made to him. Further, twenty years earlier, 1858, Sir William Herschel was using finger-prints for practical executive purposes in India, and lastly what is more to the point Dr Faulds sent much the same communication slightly later to *Nature* where it was printed on October 28, 1880 †, i.e. in the year of his letter to Darwin, and called forth a response from Sir William Herschel stating what he had himself achieved ‡. Galton refers to both letters not only in his Royal Institution lecture of 1888, but also in his *Finger Prints*. Before Galton issued his epoch-making papers of 1891, and his three books 1892 to 1895, no really substantial work had been published on finger-prints, since Purkenje's. A comparison of Galton's results with the two letters in *Nature* of 1880 will suffice to indicate how idle it is to attempt to belittle his claims.

* Darwin was failing in health in 1880 and correspondence with strangers had become a burden to him. See *Life and Letters*, Vol. III, p. 355 *et seq.*

† Vol. XXII, p. 605. It should be noticed that Dr Faulds states that he commenced his study of the "skin furrows of the hand" in the previous year, but he yet speaks of "the for-ever-unchangeable finger furrows of important criminals," and again in his letter to Darwin he states that photographs may grow unlike the original, but never the rugae. In other words he begs the question of permanence. At the same time he shows that he has ideas of the wide possible usefulness of the finger-print. He says that he had been studying the papillary ridges in monkeys, but appears to have overlooked the elaborate comparisons of these ridges among all kinds of primates including man in the paper by Alix: "Recherches sur la disposition des lignes papillaires de la main et du pied," *Annales des sciences naturelles (Zoologie)*, T. VIII, pp. 295-362, T. IX, pp. 5-42 and corrections T. X, p. 374. The portion in T. IX contains excellent engravings of the hands and feet ridges of primates. Alix enlarges on the great variety of the finger-prints in man, and figures "double vortex," "loop" (*Amande*), "racket," "spiral," "spiral within circle" and simple "circle." In other words he was reaching and figuring a classification to enable him to compare man with other primates.

‡ *Nature*, Nov. 25, 1880, Vol. XXIII, p. 76. Herschel recorded a twenty-two years' use of finger-prints and gives some evidence of their permanence.

A serious mis-statement more or less frequently made was that Bertillon who ultimately adopted the finger-print system of identification had initiated it. This pained Galton extremely, because he actually introduced Bertillon to the method, but the latter at the time feared practical difficulties such as the want of education in his employees. Bertillon's letter of June 15, 1891, in a reply to a letter of Galton's suggesting that he should try the system, has luckily been preserved. The essential paragraph runs as follows:

“Je vous remercie de votre nouvel envoi relativement aux *impressions digitales*. Je suis fort disposé à ajouter votre procédé au signalement anthropométrique surtout pour les enfants. Mais je redoute quelques difficultés pratiques pour le nettoyage des doigts après l'impression faite, etc. Puis mes agents si peu instruits mettront-ils le zèle nécessaire pour apprendre votre méthode? Je crois que vous traversez souvent Paris, pourriez-vous, à votre prochain voyage, me consacrer une matinée au Dépôt, pour un essayage sur la vile multitude?”

The words “votre procédé” and “votre méthode” clearly indicate that Bertillon was fully aware of the originator of this process of criminal investigation. Notwithstanding, even as late as 1896, in the English translation of Bertillon's *Instructions signalétiques*, the date of the introduction of the prints of the thumb and three fingers of the right hand into the French schedule for the criminal is given as 1884, instead of 1894, and “conveys the idea that the use of finger-prints in Paris is much older than it really is, and previous instead of subsequent, to its use in England*.” The 1893 edition of Bertillon's *Identification Anthropométrique, Instructions signalétiques* has no reference to finger-prints. It is still over-confident as to the infallibility of bertillonage†. Galton claimed neither finality nor infallibility for his methods; as to finger-print identification he found it a suggestion and he left it an art.

In 1905 M. Bertillon wrote in reply to a question of Dr Faulds:

“Les impressions digitales à Paris sont adjointes au signalement anthropométrique depuis l'année 1894. J'ajoute que nous nous en trouvons fort bien. Quoique nous n'ayons *jamais* fait d'identification erronée antièrement nous sommes encore mieux garantis, si possible, en ce qui regarde l'avenir.” (*Guide to Finger-Print Identification*, pp. 4-5.)

* See *Nature*, Vol. LIV, p. 569, where there is a review by Galton of the *Signalitic Instructions*, emphasising the superiority of the English finger-print system and direct indexing of the prints to the French anthropometric system or “bertillonage.” Galton therein prophesies what has since come to pass, that the former would ultimately supplant the latter completely.

† “L'absolu de nos affirmations dans les questions d'identité, et notamment dans les cas plus difficiles d'identification entre deux photographies, étonne encore les fonctionnaires de la police ou de l'ordre judiciaire auxquels une longue pratique n'a pas déjà enseigné ce qu'on appelle au Palais *notre infailibilité*. Nous nous devons à nous-même de démontrer que le péremptoire habituel de nos réponses ne résultait pas d'un tempérament risque-tout, mais était la conséquence raisonnée de la combinaison de divers procédés dont l'application, quand elle en a été correctement faite, ne laisse pas la moindre place à l'indécision.

“Puisse le présent volume satisfaire à ce programme et contribuer ainsi à assurer la survivance de la méthode dont nous sommes à la fois et L'INVENTEUR EXCLUSIF ET PARTOUT UN PEU L'ORGANISATEUR” (pp. x-xi). Capitals in original. Galton's view was that bertillonage could not be infallible owing to the high correlations of many of its measurements which its creator neglected.

Bertillon's letter to Galton of 1894* (see above) indicates where the inspiration originated. Galton was ever ready to acknowledge others' work in any field, and not less in finger-printing. Thus in 1891 he gave a full account of Forgeot's excellent work on blurred finger-prints†, and of the latter's methods of bringing up and photographing greasy finger marks on glass or metal. We have still in the *Galtoniana* the exhibit Galton made at the Royal Society Soirée of that year of Dr Forgeot's imprints of the entire hand.

In 1905 Dr Henry Faulds published a work entitled: *Guide to Finger-Print Identification*. It would have been in some respects a useful book had it not made exaggerated claims for the author's achievements in this field, which are accompanied by remarks belittling what Sir William Herschel had practically achieved and what Galton had carried out experimentally. Dr Faulds entirely overlooks the fact that up to 1904, beyond his original letter of 1880 in *Nature*, he had himself published nothing on the subject, which could reach men of science. That letter, if suggestive, was by no means convincing; it needed the experience that Herschel provided of the *permanence* of types, and of the *practical utility* for identification to induce a man in the first rank of science to take up the subject and study it effectively. It is noteworthy that Dr Faulds in his chronological bibliography of the subject of finger-printing, starts with his own letter in *Nature* of 1880, and proceeds nearly year by year till he comes to 1890, and then passes to 1894 omitting from his bibliography all reference to Galton's memoirs and books! The whole tone of the book was distinctly displeasing and seemed directly calculated to excite resentment in the minds of workers in the same field, who had done far more than Dr Faulds for the subject‡. In regard to the claims of Dr Faulds we must remember that his original letters to Darwin and to *Nature* were written from Japan. The letters from Kumagusu Minakata to *Nature*, Vol. LI (1894), pp. 199 and 274 prove that the use of the finger-print as a sign-manual on legal documents was familiar in Japan up to 1869; thus when a husband divorced his wife, he signed the statement of reasons with his own index-finger. The use of the finger-print as a sign-manual seems to have come

* A further letter of Bertillon's of July 3, 1896, indicates his view of finger-prints even two years later:

"Jusqu'à ce jour, en effet, les empreintes digitales n'ont été prises dans mon service qu'à titre de marques particulières, destinées à affirmer l'identité individuelle, et cela en dehors de toute classification au moins quant à présent."

† "Imprints of the Hand," by Dr Forgeot of the Laboratoire d'anthropologie criminale, Lyon, *Journal of the Anthropological Institute*, Vol. XXI, p. 282, November 10, 1891.

‡ "Of Sir William's mute, or at least inarticulate, musings over a period of some twenty years in India, I in Japan knew nothing" (p. 37). "Mr Galton who frequently acts as a graceful chorus to Sir William" (p. 36). "Mr Collins (now Inspector), who after some training by Mr F. Galton, who had recently begun the study, took charge of the Finger Print Department" [i.e. at Scotland Yard] (p. 5). It is needful to repeat that Galton began his researches early in 1888, that he had by 1895 accumulated from all quarters of the world a larger collection of finger-prints than any other living man, and had published more work about them of a high scientific order than any one previously and, I may add, *since*.

together with Japan's old laws from China*. Presumably these facts were unknown to Dr Faulds when he wrote his letters or he would have mentioned them. Fourteen years after his first letter, on the publication of the Parliamentary Blue Book in 1894, he wrote to *Nature* challenging the statement in the Blue Book that the Finger-Print system was "first suggested and to some extent practically applied by Sir William Herschel," and demanding that this claim should be "brought out a little more clearly than has yet been done, either by himself or Mr Galton" (*Nature*, Vol. L, p. 548, October 4, 1894). Herschel replied in a letter of November 7 (*Nature*, Vol. LI, p. 77, November 22, 1894), which must be convincing to any unprejudiced mind. A few extracts will suffice:

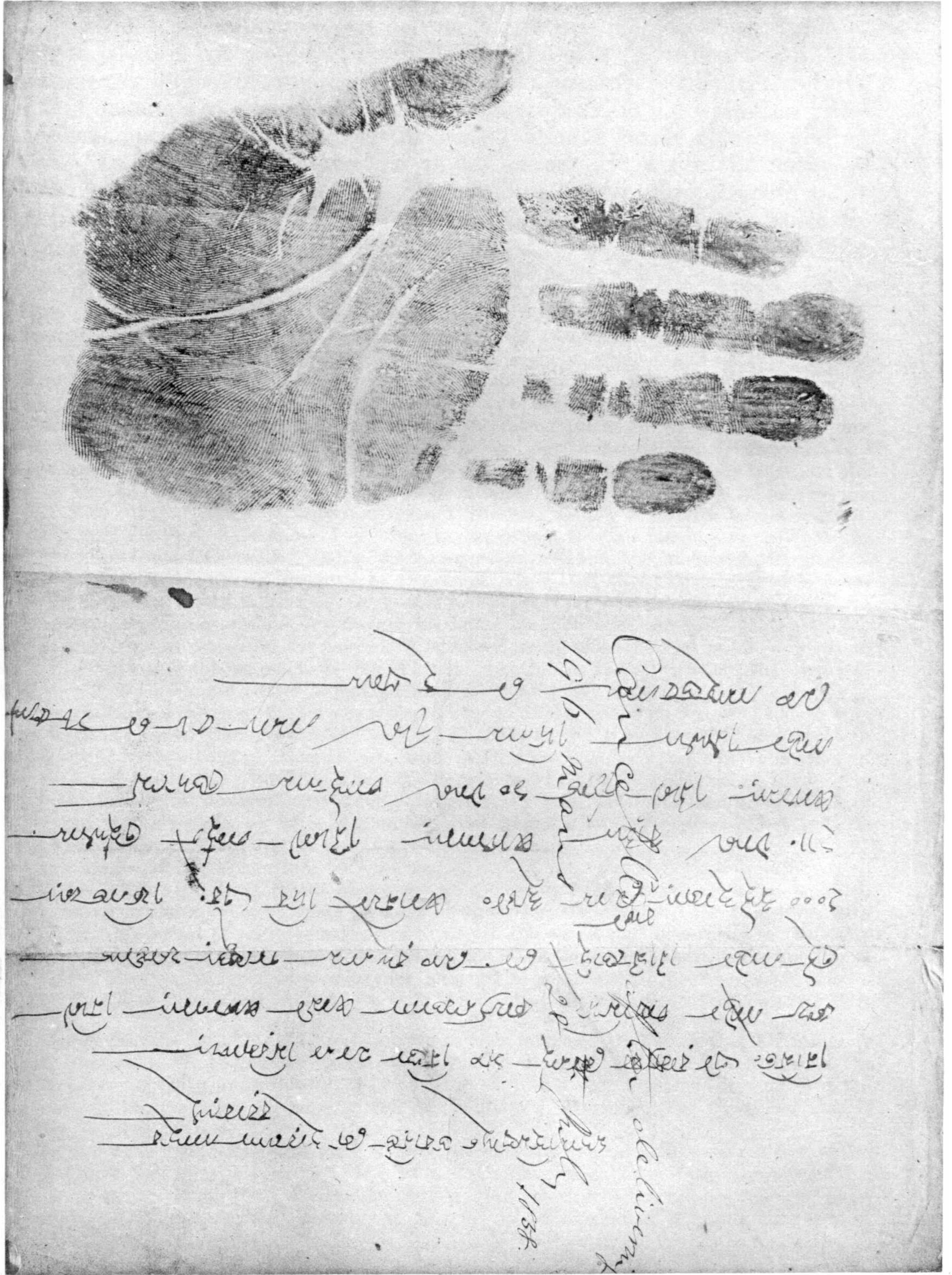
"To the best of my knowledge, Mr Faulds' letter of 1880 was, what he says it was, the first notice in the public papers, in your columns, of the value of finger-prints for the purpose of identification. His statement that he came upon it independently in 1879 (?1878) commands acceptance as a matter of course. At the same time I scarcely think that such short experience as that justified his announcing that the finger-furrows were 'for-ever-unchanging.'

"How I chanced upon the thing myself in 1858 and followed it up afterwards, has been very kindly stated on my authority by Mr Galton, at whose disposal I gladly placed all my materials on his request. Those published by him were only a part of what were available (see his *Finger Prints*, p. 27, and his *Blurred Finger Prints*). To what is there stated I need now only add, at Mr Faulds' request, a copy of the demi-official letter which I addressed in 1877 to the then Inspector-General of Jails in Bengal. That the reply I received appeared to me altogether discouraging was simply the result of my very depressed state of health at the time. *The position into which the subject has now been lifted is therefore wholly due to Mr Galton through his large development of the study, and his exquisite and costly methods of demonstrating in print the many new and important conclusions he has reached.*" [Italics in the last paragraph are the biographer's.]

There follows a copy of the demi-official letter sent to the Inspector-General of Jails in Bengal on August 15, 1877. From this letter it appears that Herschel had tested the permanence of the finger-furrows for 10 or 15 years, that it had been used for years in the Registry for Deeds at Hooghly, and that Herschel had taken thousands of finger-prints in the course of the previous twenty years, and had tried it recently both in the jail and among pensioners. He recommended it strongly for similar purposes throughout India. Herschel wrote as one official to another with whom he was on friendly terms, and so, while giving the office of his correspondent did not think it needful to mention his name.

Dr Faulds did not reply at the time and one might have hoped the matter would have been considered settled. But in 1905 he returned in his book to the fray: "The letter, or report, or book, is addressed to some mysterious personality [Sir William Herschel distinctly states that it was sent to the

* Camel drivers in Tibet sign their contracts with a thumb smeared with ink. Even at the present day, a Japanese Professor working in my laboratory informs me, a native of his country signs a document with his personal seal, but if he has not his seal with him or has mislaid it, he is allowed legally to sign with his finger-print as *a means of identification*, the latter method being a relic of a custom established for many generations. It does not seem to me that Herschel has done full justice to Japanese claims in this matter in his *Origin of Finger Printing* (see p. 40).



Rajyadhar Konai's Contract made at Hooghly, 1858, which at Sir William J. Herschel's request he signed with an imprint of his right hand as an identifiable sign-manual.

Inspector-General of Jails in Bengal], known only to literature* as 'My dear B—' and is luminously certified as 'True copy of office copy,' but by whom certified is not stated." (*Guide to Finger Print Identification*, p. 36.) It was clearly impossible to deal patiently with a controversialist of this type, who first demands to see a document and when it is exhibited waits ten years before attempting to throw discredit on it! I have rarely known Galton moved. He certainly was moved on this occasion. He wrote the notice of Faulds' book which appeared in *Nature*, Vol. LXXII, Supplement, p. iv (October 19, 1905). Anyone who has read the literature on this topic up to 1905 can only agree with what Galton states. If it is severe on Dr Faulds, the severity was warranted. I cite a portion of it:

"Dr Faulds was for some years a medical officer in Japan, and a zealous and original investigator of finger-prints. He wrote an interesting letter about them in *Nature*, October 28, 1880, dwelling upon the legal purposes to which they might be applied, and he appears to be the first person who published anything, *in print*, on this subject. However his suggestions of introducing the use of finger-prints fell flat. The reason that they did not attract attention was presumably that he supported them by no convincing proofs of three elementary propositions on which the suitability of finger-prints for legal purposes depends: It was necessary to adduce strong evidence of the, long since vaguely alleged, permanence of those ridges on the bulbs of the fingers that print their distinct lineations. It was necessary to adduce better evidence than opinions based on mere inspection of the vast variety of minute details of those markings, and finally, for purposes of criminal investigation, it was necessary to prove that a large collection could be classified with sufficient precision to enable the officials in charge of it to find out speedily whether a duplicate of any set of prints that might be submitted to them did or did not exist in the collection. Dr Faulds had no part in establishing any one of these most important preliminaries †. But though his letter of 1880 was, as above mentioned, the first *printed* communication on the subject, it appeared years after the first public and *official* use of finger-prints had been made by Sir William Herschel in India, to whom the credit of originality that Dr Faulds desires to monopolise is far more justly due....

"The question of the priority of dates is placed beyond doubt, by the reprint of the office copy of Sir William's 'demi-official' letter of August 15, 1877, to the then Inspector of Prisons in Bengal. This letter covers all that is important in Dr Faulds' subsequent communication of 1880, and goes considerably further. The method introduced by Sir Wm. Herschel, tentatively at first as a safeguard against personation, had gradually been developed and tested, both in the jail and in the registering office, during a period from ten to fifteen years before 1877 as stated in the above quoted letter to the Inspector of Prisons.

"The failure of Sir Wm. Herschel's successor, and of others at that time in authority in Bengal, to continue the development of the system so happily begun, is greatly to be deplored, but it can be explained on the same grounds as those mentioned above in connection with Dr Faulds. The writer of these remarks can testify to the occasional incredulity in the early 'nineties concerning the permanence of the ridges, for it happened to himself while staying at the house of a once distinguished physiologist, who was the writer when young of an article on the skin in a first class encyclopaedia, to hear strong objections made to that opinion. His

* The *India List* for 1876-1877 would have at once informed Dr Faulds that Mr Beverley was, in August 1877, Inspector-General of Prisons in Bengal. Herschel also wrote to the Registrar-General, Sir James Bourdillon, who later expressed regret that he had allowed the suggestion to slip through his fingers. See Sir William J. Herschel, *The Origin of Finger Printing*, Oxford, 1916, p. 25.

† Actually after his letter to *Nature* of 1880, he published no scientific contribution to the subject before Galton took it up in 1888; he wasted eight years. Then Galton published his books and papers, and only in 1905 does Dr Faulds issue a work which could be even considered a scientific contribution to the subject, and then of so acrimonious a character that it is of negligible value.

theoretical grounds were that the gland, the ducts of which pierce the ridges, would multiply with the growth of the hand, and it was not until the hands of the physiologist's own children had been examined by him through a lens, that he would be convinced that the lineations on a child's hand might be the same as when he grew up, but on a smaller scale...

"Dr Faulds in his present volume recapitulates his old grievance with no less bitterness than formerly. He overstates the value of his own work, belittles that of others, and carps at evidence recently given in criminal cases. His book is not only biased and imperfect, but unfortunately it contains nothing new that is of value, so far as the writer of these remarks can judge, and much of what Dr Faulds seems to consider new has long been forestalled. It is a pity that he did not avail himself of the opportunity of writing a book up to date, for he can write well, and the photographic illustrations which his publisher has supplied are excellent."

This is a long extract and the subject is a painful one, but it has to be definitely asserted that it was to the experience of Sir Wm. Herschel and to the laborious studies of Sir Francis Galton, and not to anything Dr Faulds wrote or said, that we owe the adoption of finger-print identification for criminal investigation at first in England and since then throughout the whole civilised world*. There has been a tendency to obscure this great achievement of Galton's not only by confusing finger-printing with bertillonage, which it ultimately killed, but owing to Dr Faulds' continual attempts to monopolise all credit for both the discovery and the practical application of finger-printing. Like all arts it has developed in practice. But even as the credit for metal bridges is not due to the man who suggested that bridges might be made of metal, nor to those who changed cast iron to wrought iron or wrought iron to steel bridges, but to the man who made the first metal bridge, and induced people to walk over it †, so the credit for finger-print identification in criminal matters is due to Herschel and Galton, or even as the former has generously said—"the position into which the subject has now been lifted is therefore wholly due to Mr Galton" (see our p. 146).

On October 21, 1893, Mr Asquith appointed a Committee ‡ consisting of Mr C. E. Troup of the Home Office, Chairman, Major Arthur Griffiths,

* My Japanese friend, referred to in the footnote on p. 146, said very definitely, that while the Japanese had resorted very early to finger-prints as personal sign-manuals, yet the Japanese criminal investigation usage did not arise from this, but was imported *de novo* from Europe.

† Thomas Paine, author of *The Rights of Man*.

‡ The origin of this Committee is fully described in a letter of Galton to the *Times*, July 7, 1893. The British Association in its Edinburgh Meeting of the previous year had listened to a paper by Manouvrier of Paris on bertillonage and another by Benedict on the modified system used in Vienna. As a result a resolution was carried by the Council in the following terms:

"Considering the need of a better system of identification than is now in use in the United Kingdom and its Dependencies, whether for detecting deserters who apply for re-enlistment, or old offenders among those accused of crime, or for the prevention of personation, more especially among the illiterate, the Council of the British Association express their opinion that the anthropometric methods in use in France and elsewhere deserve serious inquiry, as to their efficiency, the cost of their maintenance, the general utility, and the propriety of introducing them, or any modification of them, into the Criminal Department of the Home Office, into the Recruiting Departments of the Army and Navy, or into Indian or Colonial administration."

Galton was not in Edinburgh nor responsible for the resolution but he was a member of the Committee appointed in connection with it. It will be seen that the recommendation does not go beyond bertillonage. Galton, as this letter to the *Times* amply demonstrates, at once proceeded to introduce the idea of finger-printing into the proposals for a better method of identification (see also Galton's letter, *Nature*, July 6, 1893, Vol. XLVIII, p. 222), and four months later when Mr Asquith appointed his departmental committee finger-printing was *ab initio* included among the matters for examination. I know of no other reason but Galton's activities for its inclusion in Mr Asquith's programme.

Inspector of Prisons, and Mr M. L. Macnaghten, Chief Constable of the Metropolitan Police Force, 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, and to report 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 method. It will be seen that the inquiry resulted from Galton's work of 1892 and earlier, and if the evidence given be examined*, it will be found that the Committee were really considering whether *bertillonage*, or what we may call *galtonage* in contradistinction, or a combination of the two should be adopted. Galton was the *only* finger-print expert examined as a witness, and the Committee visited his laboratory, saw finger-prints being taken, and the relative ease with which Galton picked out from his cabinet the finger-prints of an individual, whose prints were provided in duplicate. It is noteworthy that Galton, with a foresight for possible difficulties, gives a very simple arrangement for a drawer into which it is impossible to place a card which does not belong to that drawer. It could be easily adapted to work for a finger-print index, but Galton actually arranged it in his illustration on the basis of five bodily measurements each grouped in three categories (see p. 81 and plate). There are two other appendices by Galton, the first (p. 79) giving directions for taking finger-prints, and the second for searching a cabinet of finger-prints indexed by a simple form of bertillonage. When the Committee came to report on the Finger-Print System (pp. 25 *et seq.*) it is of Galton and his work alone that they speak. They write:

"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....A visit to Mr Galton's laboratory is indispensable in order to appreciate the accuracy and clearness with which finger-prints 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 finger-prints of more than a hundred prisoners....The patterns and the ridges of which they [finger-prints] 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." (p. 25.)

The difficulty that arose in the minds of the Committee will be a familiar one to students of the subject, namely the large classes formed by some of the loop categories. Galton was not wholly prepared to meet this difficulty of indexing, although he was already counting the ridges of loops, and differentiating them in other ways by the nature of their cores. It was not till

* *Blue Book* (C.—1763). *Identification of Habitual Criminals Report, Minutes of Evidence and Appendices.*

1895 that he was prepared with his full ideas of indexing by finger-prints alone*. He was clearly in doubt in 1893—because his own scheme of indexing was not yet fully developed—as to whether a population of 30,000 to 50,000 could be adequately indexed solely on their finger-prints, and because the Committee shared his doubts, it is a misrepresentation to assert that they condemned his work †. In his evidence he exaggerated nothing, and placed his methods and their difficulties frankly before the Committee. It is idle to say either that Galton failed to get an independent system of finger-printing carried, or that the Committee condemned his system. Finger-printing was destined to become wholly independent of bertillonage; it very soon did become so, as the study of finger-prints advanced, but in 1893 no one had published a complete system of indexing, and Galton was the only man who was able to make even suggestions in this matter. Above all to this day the all-important problem of indexing single prints seems to be unsolved ‡. The Committee laid down the following three main conditions for deciding what system should be adopted:

“(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.”

Applying these conditions to galtonage, the Committee reported that:

“The 1st and 3rd of these conditions are met completely by Mr Galton’s finger-print method. The taking of finger-prints 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. Finger-prints are an absolute impression taken directly 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 headquarters, 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 material for conclusive proofs of identity....

“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.” (p. 29.)

* See later our account of his *Finger Print Directories*, 1895.

† Dr Faulds, *loc. cit.* p. 41, “Mr Galton’s own system, afterwards expounded in a work [i.e. his *Finger-Prints* of 1892] abounding in grave errors and set forth in a way which the Blue Book of 1894 characterises.” Cf. our pp. 145–147.

‡ Suppose a *single* print is found after a burglary and we need to ascertain whether the burglar was a known criminal, i.e. on the finger-print record. We may not even know of which finger it is a print, and yet the single print is perfectly individual and would identify the culprit were we able to index our single prints.

§ I have examined the finger-prints on many hundreds of practice sheets of prison warders, and can certify that this statement has been amply confirmed by experience.

|| Italicised by biographer. The whole essence of the Report was the abandonment of Bertillon’s “distinguishing marks,” the use of his system as merely a method of *indexing*, and the ultimate identification by the finger-prints (see p. 20).

The result of the Committee's deliberations was the recommendation that *identification* should be made by finger-prints, but that the *indexing* of the finger-prints should be by bertillonage. After recommending the appointment of a scientific adviser to the Convict Office, the Committee remark:

"Moreover, when practical experience had been obtained of the use of finger-prints, 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." (p. 35.)

It appears to me that the Committee went just as far towards replacing a tried system, bertillonage, by a new system, galtonage, as it was safe at that time to do. They even foresaw that with a really scientific adviser the latter system would entirely replace the former. In 1895 Dr Garson was appointed as scientific adviser to the Convict Office, and Inspector Collins* was sent to Galton's Laboratory to be instructed in finger-printing, and he ultimately took charge of the Finger-Print Department. Unfortunately Dr Garson, "being a skilled craniologist and writer on human measurement, was perhaps somewhat biased towards bertillonage †," and little was done towards following out the Departmental Committee's suggestion of indexing by the finger-prints themselves as experience in their use increased.

Sir E. Henry, who had adopted finger-print identification in India, with as far as I can judge only small modifications of Galton's old method ‡, became Chief Commissioner of the Metropolitan Police in 1903. Of him Galton writes§:

"When Sir E. Henry became Chief Commissioner six years ago, full of zeal for finger-prints, well experienced in their use and master of the situation, I felt satisfied that their utilisation had become firmly established, and I ceased to do more than observe its developments from

* Probably the official who has risen to fame recently in less scientific activities. His teaching of the local prison warders in finger-printing certainly produced excellent results.

† "Identification by Finger-Prints," a letter of Galton's to the *Times*, Jan. 13, 1909.

‡ I judge this chiefly from his letters filed in the *Galtoniana*, and notes of Francis Galton himself.

Thurs. Oct. 10/94:

"Mr Henry came today 10½ to 12½ to my laboratory by appointment...I showed him much about finger-prints. He had spent hours at the lab. in my absence. Agreed that my part now is to write an illustrated paper on classification. He undertakes to get me as many specimens as I want from India. I am to write to him there (he returns next week). In meantime I am to make some trials from my collection and I will talk to Macmillan." [This has reference to the proposed book, i.e. *Finger Print Directories*.]

The correspondence with regard to finger-prints continued after Mr Henry's return to India, being dated from the office of Inspector-General of Police, Calcutta. In the following year Mr Henry submitted a "Note on Finger Impressions" for the guidance of the Lieutenant-Governor. From this it appears that identification was to be by the prints and indexing by bertillonage, i.e. the system of the Report of 1893. Numerous letters, thanking Galton for communications, asking him for further information, and stating how the matter progressed in India followed in 1895, 1896 (with a further Report to the Chief Secretary in Bengal, still emphasising the doubt as to how to index the finger-prints of 20,000 persons; the letters urge the need for this indexing to replace the difficulty of exact anthropometric measurements under Indian conditions), 1899 (Henry describes his own new method of indexing) and 1900 (announcing that from April 1st the Indian Government had finally discarded anthropometry for direct finger-print indexing on Henry's system).

§ *Ibid.*

time to time. Of course all new methods require time for development and growth, and though very much has been done under Sir E. Henry's vigorous administration, I doubt whether finality has even yet been reached; for example, whether the power of lexiconising single prints has been developed to its utmost."

The letters of Herschel, Henry and Galton in the possession of the Galton Laboratory trace clearly the history of finger-printing. It was Galton, who by his books, memoirs and constant letters to the press got the matter ventilated and ultimately forced the subject on the attention of the police-authorities; he might not have been successful had not Herschel's practical experience and evidence of permanence* been at his service. It was Henry who during 1898-1900 in India reduced the indexing of finger-prints to a workable system, and ultimately abolished the laborious and in the hands of careless observers the even dangerous anthropometric system †.

But if a name is to be given to the system of finger-print identification in the same manner that bertillonage was attached to anthropometric measurement ‡, then the right term is undoubtedly galtonage.

Of course every idler, who had not taken the trouble to investigate the subject, was up in arms against reform, as all such have ever been—"It may answer well enough on the Continent, where every one submits patiently to the inevitable, but it would not do in England, and I trust that the recommendations of the Committee—opposed as they are to the sentiments and principles of Englishmen—will not meet with the approval of the Secretary of State." (*Times*, March 23, 1894, Letter signed "Observer.") How many times have we read those words, when a powerful mind has pointed the way to a beneficial reform!

Yet even as late as 1909 misrepresentations were made as to the originator of the police system for the identification of criminals by finger-prints. The *Times* in an article on the Metropolitan Police published on January 4 of that year attributed the system of identification by finger-prints to Sir Edward R. Henry! What the writer should have said was that a

* Herschel in a letter of Oct. 28, 1896 writes: "I have just compared my own mark of June 1859 with that of Oct. 1896. The identity is perfectly amazing, even to me. How nature can preserve such soft tissues for 37 years, renovating them constantly, yet preserving their delineation so precisely is not clearly intelligible to me."

† It is only fair to Bertillon to remind the reader that the anthropometric measurements were even in Bertillon's system primarily a method of indexing, and the identification depended on the record of bodily marks and characters together with the photographs. For Galton the best bodily marks were not moles, cicatrices, etc. but the finger patterns.

‡ Those who have studied all Galton wrote on the subject of Finger-Prints before 1895 and after doing so turn to Sir E. R. Henry's *Classification and Uses of Finger Prints* (1st Edition 1901, 3rd Edition 1905) may be inclined to think that the latter work does inadequate justice to Galton's labours. Henry's system of classification follows closely on Galton's and where he departs from it by the introduction of a very heterogeneous class of "Composites," it may well be doubted, if he has really succeeded in simplifying matters. His method of "ridge-tracing" for breaking up large whorl groups is essentially that of Galton's "Basis of Classification" in the 1890 *Phil. Trans.* paper (see our pp. 163-4); while "ridge-counting" was introduced originally by Galton himself to get over the large loop aggregation difficulty. Whether Henry's numerical symbolism for the various index classes gains in brevity what it loses in perspicacity can only be determined after a wide experience of the use of both full and "shorthand" formulae.

modification of Galton's method of indexing was introduced by Sir Edward Henry*. In 1895 Galton had published his *Finger Print Directories*, which contained a great improvement on his previous method of classification; this later method was in most essential points identical with that in use in 1909 at Scotland Yard. The article in the *Times* called Sir George Darwin into the field; he concluded a letter which puts forward the simple facts of the matter with the words:

"Sir Edward Henry undoubtedly deserves great credit in recognising the merits of the system and in organising its use in a practical manner in India, the Cape and England, but it would seem that the yet greater credit is due to Mr Francis Galton."

One has to remember that identification by finger-prints was in use at Scotland Yard long before Sir Edward Henry came on the scene †, but the indexing was by bertillonage. Dr Garson, the former director, was too much of an anthropologist and had a mind of too little inventive power to give up the anthropometric index. A dozen different ways of breaking up the large loop categories would occur to an inventive mind, and as soon as one of these had been tried and found successful bertillonage was bound to disappear. The fact remains that nothing was done and no progress made in abolishing bertillonage, until Sir Edward Henry succeeded Dr Garson. This absence of progress was not Galton's fault, but lay with the Government, which selected for the post of director an old-school medical anthropologist rather than a finger-print expert.

While it is absolutely impossible for one who has really studied finger-prints to confuse *A*'s prints with those of *B*, it is always possible for a clerk to make an error in extracting the dossier, which corresponds to the identified finger-prints. Such a clerical lapse occurred in a case tried at the Guildhall in 1902, and the occasion was seized upon to attack the finger-print method by certain newspapers. Galton wrote a letter on the matter to *Truth* (October 2, 1902, Vol. LII, p. 786). He pointed out that there was no doubt about the identification, but when it came to turning up the record attached to the

* In March 1897 Major-General Strahan and Sir Alexander Pedler reported on the system of identification by Finger-Prints as adopted in India. It was really a report on Henry's work and methods. In the course of the Report the three conditions laid down by Mr Asquith's Committee (see our p. 150) are cited and the following words occur:

"In the same report it is acknowledged that Mr Galton's finger-print method completely met the first and third conditions, but they disapproved of his method of classification."

This is a complete mis-statement of what the Committee did. Galton was not prepared at that date to provide a comprehensive method of indexing, accordingly it was impossible for the Committee to disapprove of his method of indexing. It was Galton himself who suggested indexing by bertillonage and this the Committee accepted, although both they and he looked upon it as a temporary stage. Galton's *Secondary Classification* was complete and published in 1895 (see our pp. 199 *et seq.*), and in the present writer's opinion there is little in Henry's book of 1901, which cannot be found, often better expressed, in Galton's of 1895 or in his earlier writings. The numerical notation is the chief novelty. We do not think the statement we have quoted above should have been allowed to appear without a qualifying note in Henry's *Classification and Uses of Finger Prints* (p. 112).

† I myself witnessed the rapid identification of criminals by their finger-prints in 1900.

impressions, a mistake had been made in the reference number and a wrong dossier was produced. Galton writes:

“I wish to point out the moral of this. In every system there must be some clerk-work and a consequent liability, however small, to clerical blunders. In the system by measurements at least five have to be made and recorded for each person, and they each require three figures to express them. The frequent occurrence of mistakes in this complicated process was the main motive for abolishing measurements altogether, first in India, and now in this country. In the finger-print system all the above clerk-work is done away with because the hand of the accused person prints its own impression. As regards the comparative trustworthiness of the two systems, there can be no reasonable doubt. I took, as you may be aware, great pains in testing them, with the result that it is inconceivable to me that an expert to whom the impressions have been submitted of two different persons, taken with the cleverness that is habitual in prisons, should ever mistake one set for the other.”

§ II. *Popularisation of Finger-Printing.*

I propose in this section to give an account of some of the minor papers and letters to newspapers by which Galton made the idea of finger-printing familiar to his countrymen. I think this plan is better than scattering them chronologically between his more solid contributions to the science of the subject, which will be dealt with in the remaining section of this chapter.

In August 1891 Galton published in the *Nineteenth Century* (Vol. xxx, pp. 303–311) an article entitled “Identification by Finger-Tips.” It contains a *résumé* of his Royal Society papers in a popular form, an account of his apparatus and a suggestion that professional photographers should take up finger-printing as part of their trade. He concludes with the prophecy:

“I look forward to a time when every convict shall have prints taken of his fingers by the prison photographer at the beginning and end of his imprisonment, and a register made of them; when recruits for either service shall go through an analogous process; when the index-number of the hands shall usually be inserted in advertisements for persons who are lost or who cannot be identified, and when every youth who is about to leave his home for a long residence abroad, shall obtain prints of his fingers at the same time that the portrait is photographed, for his friends to retain as a memento.” (p. 311.)

Another matter in connection with finger-prints which excited Galton’s attention and has very considerable scientific interest is the question of scars and wounds as influencing the ridges. On Plate VI are given illustrations of this matter which I have found in the *Galtoniana*. In Fig. (v) we have an enlarged print of a graft on the bulb of a thumb. In this case J. R. H., a solicitor in large practice, sliced off a piece of the flesh of his thumb; it was promptly picked up, replaced in what was thought to be its original position and the thumb tightly bandaged. The print taken thirty years later shows that the ridges had not been properly adjusted, the orientation of those on the graft being almost at right angles to their true position*!

In Fig. (i) *a-d* we have a good illustration of the effect of a burn, which occurred in the case of Sergeant Randle, Galton’s assistant. In Fig. (i) *b* taken immediately after the accident, the ridges have entirely disappeared, but Fig. (i) *d* indicates that if the injury has not been too

* See *Nature*, Jan. 30, 1896 (Vol. LIII, p. 295).



Fig. (i). Restoration of Ridges after a not too severe Burn.



^a
Effect of an Ulcer

^b
Tailor's Finger
Fig. (ii).

^c
Effect of a Cut



Fig. (iii). Scar in Adult, at Four Years' Interval.

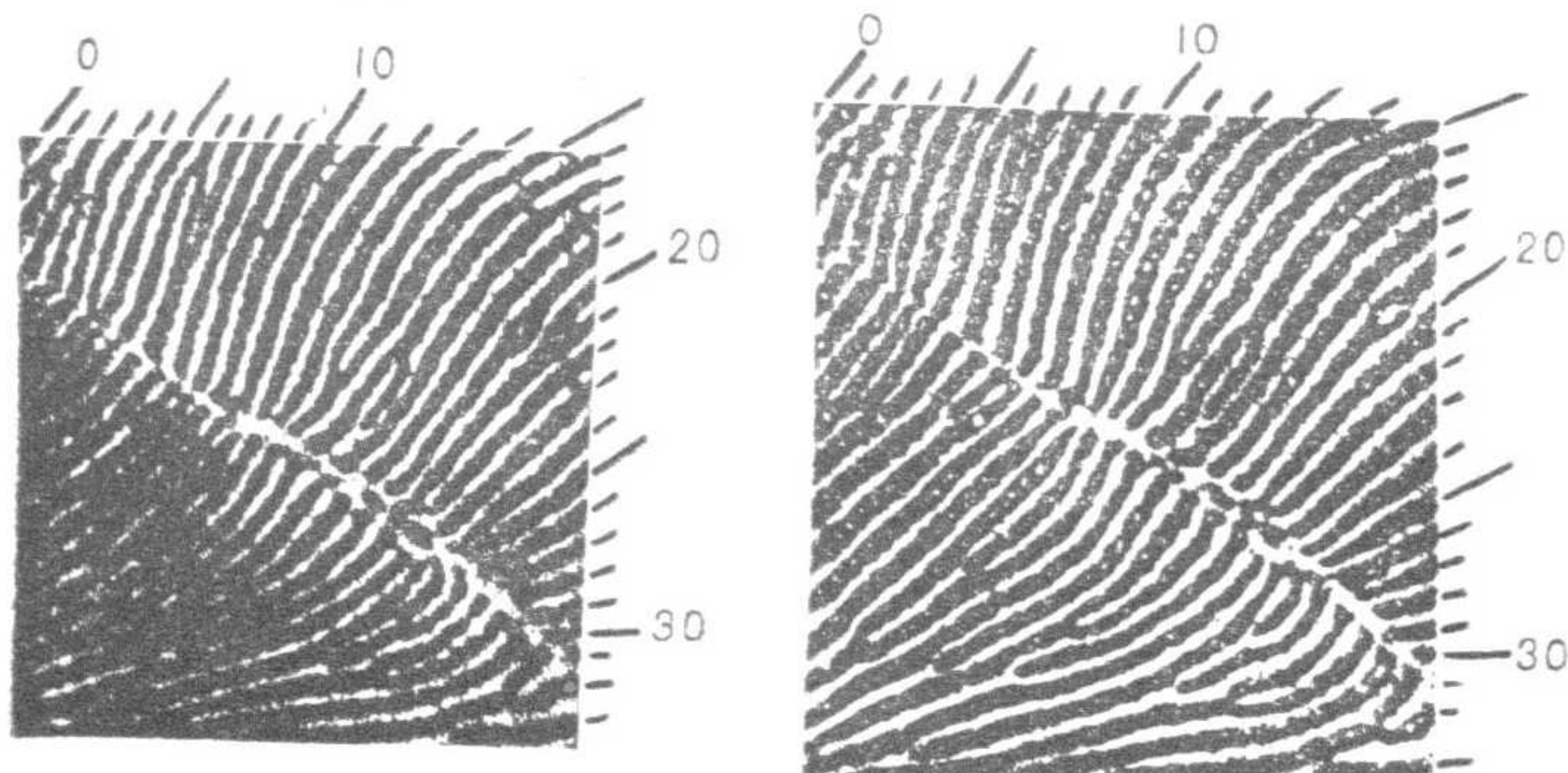


Fig. (iv). Scar in Boy, at Two Years' Interval.



Fig. (v). J.R.H., a Solicitor, sliced a piece of his thumb off; it was promptly replaced and bound up. His finger-print shows by the ridges that the slice was put on wrong way round!

Effects of various injuries on the pattern of the Finger-Print. Enough *minutiae* are, as a rule, left for identification purposes.

great, they develop again on the old sites. Figs. (ii), (iii) and (iv)* show the effect of an ulcer in destroying the ridges, the changes produced by the occupation of tailoring, and the marks left by scars and cuts. It will be recognised at once how injuries of this kind fail to destroy completely the *minutiae* of the ridges on which identification depends. Indeed if they were in existence when the earlier print was taken, they form themselves very valuable contributory factors in the recognition of identity. It is singular how little Galton left unobserved when he came to deal with a new topic; his fruitful mind seemed to envisage all possibilities that might detract from or aid the enterprise he had in hand. He collected material from all quarters, but the subject was so vast that even he left much that would still be worth gleaning. I think a wide study of finger-prints from the standpoint of occupations might still indicate interesting possibilities. The carpenter's, the metal worker's, the shoemaker's, the seamstress's, the typist's, the laundrymaid's, and even the textile worker's finger-prints may all show individual wearings of the ridges, if they were attentively studied in large numbers; and so might well replace some of the information which Bertillon drew from the shoes and trousers, etc. of his subjects.

In an article entitled "Enlarged Finger Prints" which appears in the journal *Photographic Work*, February 10, 1893, Galton emphasises the proposal that professional photographers should master the art of finger-printing and the enlargement of prints.

"It seems not unreasonable to suppose that many persons would like to possess so curious and unchanging an evidence of their own identity, and that the wish to have prints taken of the finger might become a fashion which photographers would find it lucrative to promote."

He gives two excellent enlargements to a sixfold size, in which the sweat-glands, the "islands," ridge terminals, forkings and all the *minutiae* are very distinct. We reproduce his two figures (p. 156). Fig. 17 is the print of a well-known explorer and contains at least 39 *minutiae*, Fig. 18 some 30. As Galton says every one of these *minutiae* may be expected to persist, not only during life, but after death also, until they are effaced by decay.

Galton describes his apparatus for taking prints and refers to his original and to his later enlarging cameras.

Two further letters from Galton may here be mentioned. On October 19, 1893 he wrote to *Nature* (Vol. XLVIII, p. 595) stating that finger-prints had been adopted as a means of identification for recruits in the Native Army of India (Circular, August 25, 1893). Galton points out the necessity for clear prints and also suggests for the purpose of comparing two prints the use of a mounted watchmaker's lens †, and further of four "pointers," two for each print. One pointer is used for each print to mark an origin of reference and the others to indicate the special *minutiae* which are to be compared in the prints under comparison.

* See *Finger Prints*, 1892, Plate 4, Fig. 7 a, b, c, p. 59.

† Galton's own lens neatly mounted is still in use in the Galton Laboratory: see the footnote on our p. 178.

"They are T-shaped ; their long arms are six or seven inches long, they are roughly made of wood as thick as the thumb, so that they are purposely not over light. Each pointer stands on three supports, viz. on the point of a bent pin, whose headless body has been thrust into the end of the long arm of the T, and on the ends of two nails or better on staples, one of which is driven under either end of the cross-arm. It is most easy to adjust the point of the bent pin upon any desired character in the finger-print. Both hands of the observer are thus left free to manipulate other pointers, when desired. The stationary pointers are a great help in steadying the eye while pursuing a step by step comparison between two finger-prints."

We may remark that, the pointer being raised from the paper, the bent pin scarcely obscures any part of the print.

The second letter appeared in the *Times* of December 27, 1893, and contains a suggestion which it was certainly undesirable that the authorities



Fig. 17.



Fig. 18.

Early Examples of Galton's Method of Finger-Print Enlargement.

should have entirely disregarded. It was that depositors in the post-office savings bank should have their fingers printed in their deposit books and that these should be used as a means of identification, when the depositor sought to draw money from a post-office where he was not known. This brings us indeed to a matter Galton had much at heart ; he did not think finger-prints were useful solely as a matter of criminal identification. The art of comparing finger-prints is so easily learnt that it might well be part of the training of many minor civil servants, postmasters, Public Trustee employees, War Office and Admiralty pension-officers, and many other similar officials. Two lectures and two practical classes of a few hours each would suffice to give the necessary instruction to a group of twenty or

thirty minor officials of average intelligence. It would include the taking of clear (non-blurred) prints, and the rapid identification of prints. A signature can be forged, and it changes with age and illness, or even with the nature of the pen with which it is made. The finger-print remains with all its minutiae throughout life incapable of being forged. Unless a man be a criminal there is no central office in existence even at the present day, where his finger-prints could be registered, and he could be certain of identification for legal purposes at any time during his life, and for some time after his death. For many legal purposes such a registration might be as valuable as a land-registration office, and ownership of many personal effects, securities, bonds, passports, etc. might be testified by simply finger-printing them, if the finger-prints like a trade-mark had been duly registered. It is almost a catastrophe that the process of finger-printing should have become tainted in the popular mind by a criminal atmosphere.

In 1900 Galton wrote another paper in the *Nineteenth Century* (Vol. XLVIII, pp. 118-126) under the title of "Identification Offices in India and Egypt":

"There are many Identification Offices, supported by Governments and known by various titles, in different parts of the world. Their number increases, and so does that of the purposes to which they are applied; a knowledge of them is, however, confined to a few persons. This is especially unfortunate, because a fair amount of popular interest would ensure their adequate support, and would check the common tendency of all Government institutions to slackness of management, which is particularly fatal to the efficiency of Identification Offices." (p. 118.)

He then refers to the work of Henry in India and Harvey in Egypt, where Galton had seen the working of the central office in Cairo. Speaking of Egypt he writes:

"The difficulty of identification is increased by the roaming habits of the natives, many of whom travel great distances for pilgrimages, petty commerce, or change of employment, so that witnesses may not easily be found to identify them. Again, while the natives of India and of Egypt have beautiful traits of character and some virtues in an exceptional degree, their warmest admirers would not rank veracity among them. It is not insinuated that false testimony is unknown in English courts of justice, or in England generally; indeed I find, on a rough attempt at a vocabulary (made for quite another purpose), that more than fifty English words exist which express different shades and varieties of fraud*; but if a map of the world were tinted with gradations of colour to show the percentage of false testimony in courts of law, whether in different nations or communities, England would be tinted rather lightly and both Bengal and Egypt very darkly. So, whether it be from the impossibility of identifying the mass of natives by their signatures, or from the difficulty of distinguishing them by name, or from their roving habits, or from the extraordinary prevalence of personation and false testimony among them, the need for an Identification Office has been strongly felt both in India and in Egypt."

Galton gives a list of eight ways in which finger-prints were already in use in India, namely: (1) Pensioners, civil or military; (2) Transfer of

* It may be worth while to give these words. The list is imperfect but will do: cant, cheat, chicanery, circumventing, counterfeit, chouse, connivance, cozen, crafty, cunning, deceit, defraud, delude, dishonest, dissemble, dissimulate, dodge, duplicity, fallacious, feign, flattery, fraud, furtive, hoax, humbug, hypocrisy, insinuation, intrigue, jesuitical, jobbery, knavery, lying, mendacious, peculating, perfidious, perjury, personation, rascality, roguery, scheming, scoundrel, sharper, shuffler, slanderer, slimness (a new word due to the Boers), slyness, sneaking, spying, stratagem, subterfuge, traducing, treachery, trickery, wiles [the last two added by Galton in a corrected copy of the article, which I follow. The reader will find it quite easy to add to the list, e.g. guile, imposture, fake, mislead, gerrymander, graft, etc., etc.].

property; (3) Advances by Opium Department to cultivators; (4) Receipts of employers for wages to labourers; (5) Survey of India, workers on engagement, to prevent their re-enlisting in a distant area after discharge for misbehaviour; (6) Director-General of Post-offices in similar cases; (7) Medical Department before granting certificate to examine; (8) In plague regulation and for controlling the Mussulman pilgrims to Mecca. All these cases are in addition to the matter of criminal identification. Galton suggests that finger-prints should be used in cases of life-insurance, and after registering for authenticating wills. The Indian Legislature had passed an act amending the law of evidence, by declaring relevant the testimony of those who had become proficient in deciphering finger-prints. It was clear that finger-printing had taken on in India, and most of this was due to the energy of Mr (later Sir) E. R. Henry.

Galton discusses the classification for research, alludes to the difficulty of the great preponderance of ulnar loops, which have to be distinguished mainly by lineations. Galton himself counted the number of lineations from "core" to the "V" or point of divergence of the ridges*.

"Mr Henry reckons lineations on more than one finger, with the simplification of merely noting whether their number exceeds or falls short of the average, and is thus able, as he states, to cope successfully with his far larger collection than mine. His success in this respect seems to me so surprising that I should greatly like to witness his methods tested on a really large collection, say of 100,000, in which there would probably be found no less than 6000 cases of *all-loops* of the ulnar kind, to be distinguished mainly by the method of lineations †."

Galton then speaks of the Cairo Office, of which he had seen the working. He notes several cases in which its efficiency had been proved, and this not only for criminal purposes, but for the advantage of honest men, who were given a registration and could thus demonstrate to a new employer that they were the actual men, whose merits had been testified to by former masters. Some such registration of servants would render written characters of more value than they are at present in our own country.

"Space does not permit me to go more fully into this large and interesting subject. It will be a real gain if these remarks should succeed in impressing the public with the present and future importance of Identification Offices, especially in those parts of the British Empire where for any reason the means of identification are often called for and are not infrequently absent. I think that such an institution might soon prove particularly useful at the Cape."

By such articles and frequent letters to the newspapers Galton kept the topic of finger-printing to the fore. When in 1900 he read a paper before the Khedivial Society of Geography in Cairo ‡, comparing the Egypt of 1846 with that of 1900, and spoke of the influence which D'Arnaud Bey had

* Later termed the *delta*.

† Henry was ultimately driven to count the ridges on the first two fingers of *both* hands, and to make sixteen classes of the four numbers so obtained. But even this was not sufficient, and for his indexing he counts the ridges on the little finger of the right hand with the view of arranging in the order of that count the schedules in each of the sixteen classes. Galton started the ridge counting and had already applied it to fore and middle fingers to break up the large simple loop groups.

‡ *Bulletin de la Société Khédiviale de Géographie*, V^e Série, No. 7, pp. 375-380.

had on his life, converting his conception of travel from pleasure to purpose, Galton could not refrain from discussing finger-prints. It is almost impossible to overrate the energy Galton displayed in making the general public familiar with the idea of finger-print identification. We have not only a whole series of letters to such journals as the *Times* and *Nature*, but Galton did not despise more popular organs of communication. Thus there appeared a paper in the *Sketch*, entitled: "The Wonders of a Finger-Print," with a portrait of Galton (November 20, 1895), and another in *Cassell's Saturday Journal*, March 25, 1896. The latter took the form of an interview, and perhaps a few lines of it are still worth recalling:

"There are about thirty characteristic points on an average in a finger-print," Mr Galton continued. "As I have said you will find no two pairs of fingers alike; it is like comparing the ground plans of two different cities."

"But suppose an old and hardened criminal, whose finger-print was in your possession, hacked his fingers about with a knife," I asked: "would that cause you confusion on his recapture?"

"Plenty of material for identification would still be left. He would never be able to obliterate all the ridges unless he cut off both his hands. But I don't want you to think that finger-prints are only of value for the identification of criminals. I want other people to take the finger-prints of their children for possible use in identification in after life."

"You remember what a stir there was when the rumour spread of a plot to kidnap the Duke of York's baby*. Think of all the national difficulties that would have arisen had he been lost and then professed to be found, but his identity doubted. Many people urged me at the time to propose that his finger-prints should be taken, but I hesitated to move seriously in the matter."

In the same year Galton read a paper entitled "Les empreintes digitales" at the Fourth International Congress of Criminal Anthropology†. In this paper he briefly describes the facts he had demonstrated in his *Finger Prints*, then he turns to the question of nomenclature and classification, and notes his "shorthand" method of indexing. What, however, he particularly insists upon is the need for an international concordat in the matter of nomenclature and indexing so that it would be at once feasible to telegraph the finger-print formula of a suspected person. Galton proposed:

"Qu'il soit fait des recherches dans les administrations de police des différentes nations pour déterminer la nomenclature la plus convenable et les autres détails relatifs aux empreintes digitales pour les services internationaux, c'est-à-dire pour communiquer, par lettre ou télégraphe, et en termes généralement intelligibles, le signalement par les empreintes digitales des personnes soupçonnées." (p. 37.)

The noteworthy points about this paper are:

(i) That as early as 1896 Galton had freed himself entirely from the anthropometric system; there is not a reference to bertillonage as a system of indexing, but the indexing is to depend entirely on finger-print classification.

(ii) That although the system had only been a few years at work in England and was just started in India, Galton envisages an international

* The present Prince of Wales.

† *Comptes-rendus, Session de Genève*, 1896, pp. 35-38.

system of finger-print Identification Offices with a common nomenclature, a common method of indexing and a common code.

Realising how such Identification Offices, depending wholly on finger-printing, now stretch from London to Tokyo, from Tokyo to San Francisco and thence to New York, we see how Galton recognised a widespread need, and how by his ceaseless energy he carried through a great reform. Whatever influence his idea of correlation may have exercised in the field of scientific investigation—and it has been indeed deep and far-reaching—the establishment throughout the world of finger-print identification is a no less astonishing mark of his power of achieving on the practical side.

On October 16, 1902, Galton has still another letter in *Nature* (Vol. LXVI, p. 606). It is entitled "Finger-Print Evidence." The problem he is concerned with here is to find the best manner of convincing a judge and jury that an accused person is really one whose finger-prints are already on the criminal register. Owing to the courtesy of Scotland Yard he had received two

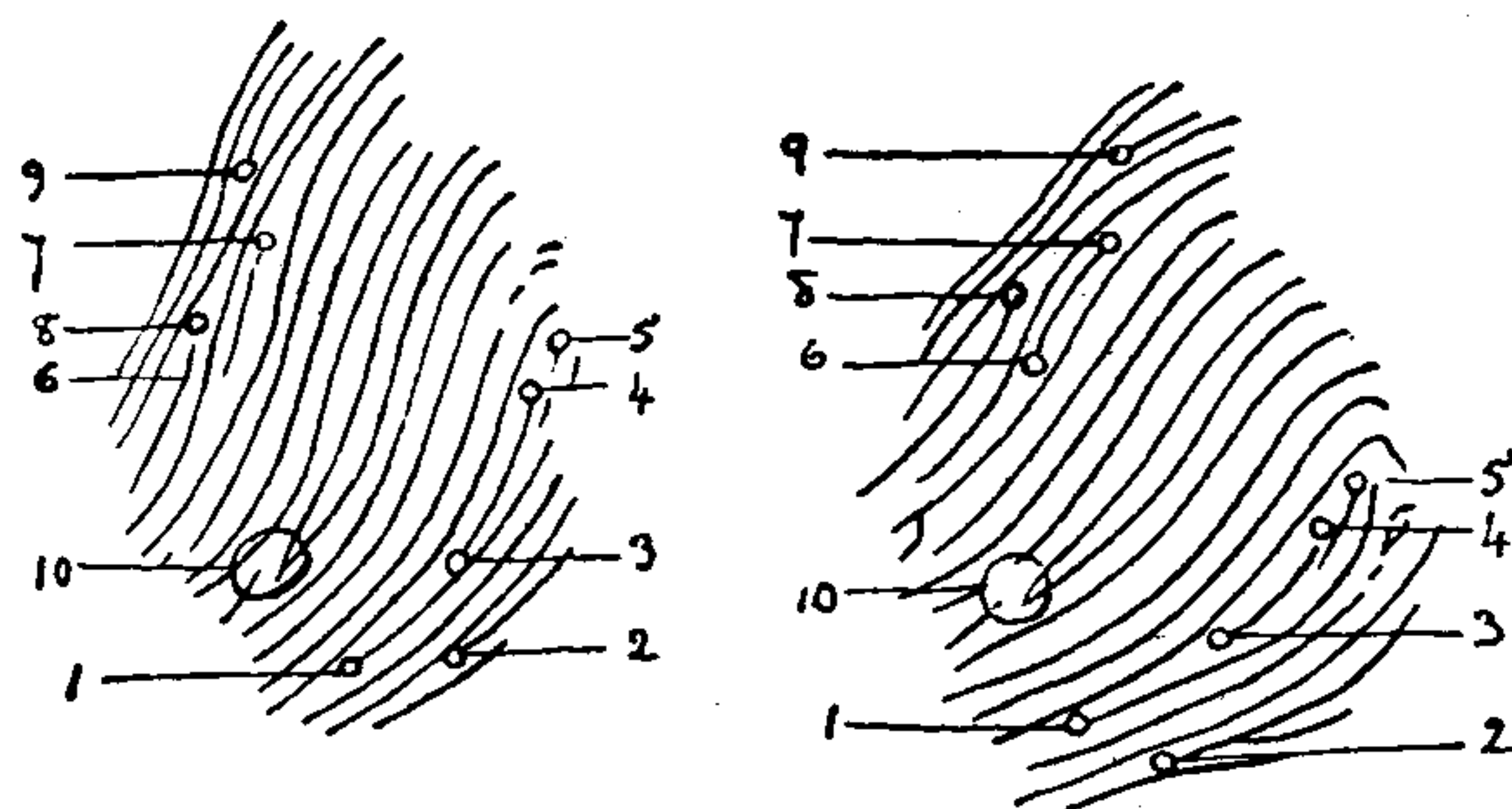


Fig. 19. Ridge-tracing Method of identifying Finger-Prints.

enlarged photographs of thumb-prints. The first is that of an impression left on the window frame of a house where a burglary had occurred, and the second that of the left thumb of a criminal who had been released and whose finger-prints were preserved and classified at Scotland Yard. Galton applies the method of his *Decipherment of Blurred Finger Prints* (see our p. 194), "believing that to be the readiest way of explaining to a judge and jury the nature of the evidence to be submitted to them....The questions of the best mode of submitting evidence and the amount of it that is reasonably required to carry conviction deserve early consideration, for we may have a great deal of it before long." In the accompanying diagrams it will be seen that Galton has selected and numbered ten *minutiae* for identification and comparison. It is scarcely conceivable that any twelve reasonably intelligent men would fail to be convinced of the identity of the two thumb-prints, although conviction would be still further strengthened were a third random thumb-print of the same type presented, which would undoubtedly lack corresponding *minutiae*.

§ III. *Scientific Papers and Books.*

A. *The Royal Society Papers.*

Galton's first important scientific paper on Finger-prints was published in 1891 in the *Philosophical Transactions**. It is entitled: "The Patterns in Thumb and Finger Marks; on their arrangement into naturally distinct classes, the permanence of the papillary ridges that make them, and the resemblance of their classes to ordinary genera." It was actually received by the Royal Society on November 3 and read November 27, 1890. It may be described as the fourth scientific contribution to the subject, the first being that of Purkenje in his *Commentatio* of 1823, the second that of Alix in his memoir of 1868, and the third the work of Kollmann in 1883 (see our pp. 141-143, and 174). While these authors endeavoured to give names to various types of finger-prints, none of them had formed a considerable collection of human prints, by aid of which it would be possible to describe anything like the variety of types and subtypes which occur, or give even the roughest measure of their relative frequencies. Galton, with his usual insight, grasped the essential point that not only a classification of types was needful, but a study of their relative frequency. He also recognised that mere assertion of their permanence must be replaced by a definite demonstration thereof†. In the present case Galton's *main* data consist of both thumb-prints of 2500 persons taken at his second Anthropometric Laboratory. I do not think Galton had fully realised at that time the amount of correlation that exists between the type of pattern and the individual finger, and that accordingly the frequencies of the thumb-prints cannot without further consideration be applied to those of finger-prints in general. Very soon after the publication of this paper Galton started to take the prints of all ten digits, and formed the large and representative collection now in the Galton Laboratory‡.

The paper first refers to Kollmann's paper (see our p. 141) for the origin of the ridges, but states that no reason has yet been given why the prominences tend to arrange themselves in continuous ridges and not to form isolated craters. Galton next describes how he takes impressions, and how it is advantageous to take duplicate impressions on tracing cloth, so that the pattern can be reversed by viewing it face downward§. (I may note that it is always an advantage to take finger-prints in duplicate, for one set can then be used for pencilling in ridges and defining the core.) If the hands be placed palms downward on the knees, so that the thumbs correspond to

* Vol. 182 B (1891), pp. 1-23.

† In the Royal Institution lecture of May 25, 1888, Galton had given, owing to the kindness of Sir W. J. Herschel, two illustrations of permanence, but even these had not been fully and adequately investigated (see our p. 142).

‡ He was taking prints of the fingers as well as the thumbs among his circle of friends in December 1890 and he began early in 1891 a more systematic collection.

§ It must be remembered that the finger-print is always a reversed impression of what one sees directly.

the great toes, it will be seen that the thumb is *inward* and the little finger *outward*. [Finger-prints taken in this order from left to right are in "natural order."] Inward and outward are respectively thumb-side and little finger-side, but these terms are awkward when we have to use them for the thumb and little finger themselves, and the same criticism applies to the anatomical terms radial and ulnar when applied to those bones themselves*.

Next Galton gives for the first time his explanation of the manner in which the "core" of a pattern originates; he held that it is due to the nail; the ridges, instead of going straight across the bulb of the finger, are distorted to cover the top of it; the space between the originally adjacent parallel ridges Galton terms the "core." This core or interspace is filled up

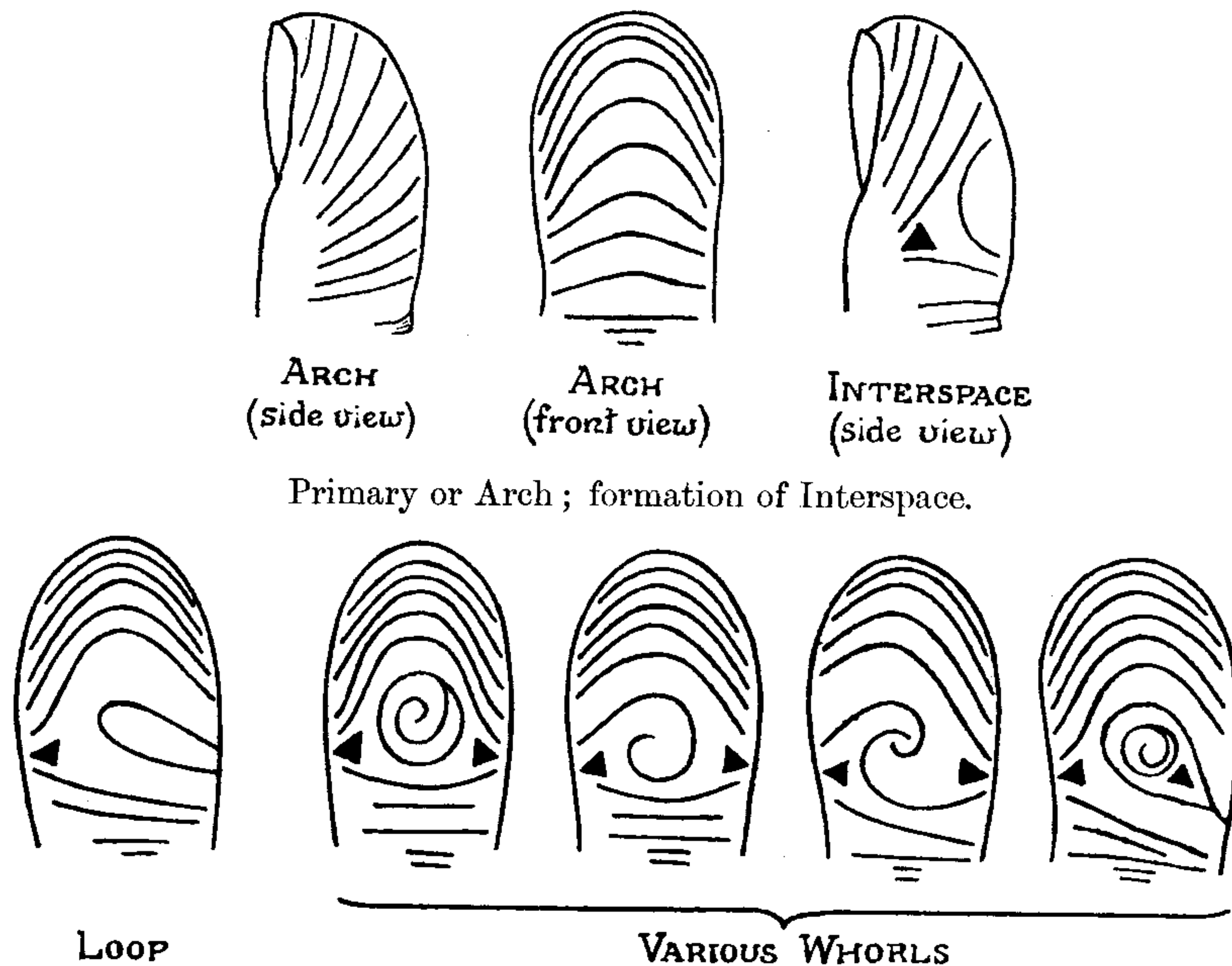


Fig. 20. Cores in Interspace, showing "deltas."

with an additional scroll work of ridges, which in themselves form the pattern on which classification depends. When the scroll work of the core consists of a series of ridges separated on the central portion of the bulb by wider intervals than at the sides of the bulb, Galton in this memoir terms it a "primary," but later he uses the term "arch." Next the "deltas" are defined. These are the small "islands" at the points where the adjacent parallel ridges begin to diverge to form the core. In a primary there are no deltas, in a loop one and in a whorl usually two are discoverable. When there are two deltas, the line joining them and its perpendicular bisector serve as axes of reference; when there is only a single delta, in a loop, Galton

* Galton unfortunately transposed "inner" and "outer" in this memoir, calling the inside of the thumb that "nearest to the rest of the hand" (p. 4). He corrected this error in his *Finger Prints* (p. 70).

takes one axis of reference to be the "axis of the loop," i.e. a line drawn to bisect the loop "at the upper end of its innermost bend," and the other axis of reference the line through the single delta perpendicular to the loop axis. This loop axis is very important, for it is the line upon which Galton first counted the number of ridges, and much depends on two observers constructing identical loop axes before proceeding to count ridges in comparing prints*. It must be remembered that the two observers may be comparing two separate prints at a distance and, owing to the termination of ridges and to the forking of ridges, a slight difference of position in the loop axis may lead to divergent results.

In Fig. 21 *W* is "outside," *V* is "inside," the print. *AH* in Fig. 21 (iii) and (iv) is the loop axis on which Galton originally counted the ridges from *A* to *H*, that at *A* counting zero. When the loop axis exactly passed through a bifurcation Galton counted the ridges as $\frac{1}{2} (1 + 2) = 1\frac{1}{2}$. He omits to tell us what happened when it exactly passed through a ridge terminal—presumably he counted it as $\frac{1}{2}$ —or what he did in the case of an island.

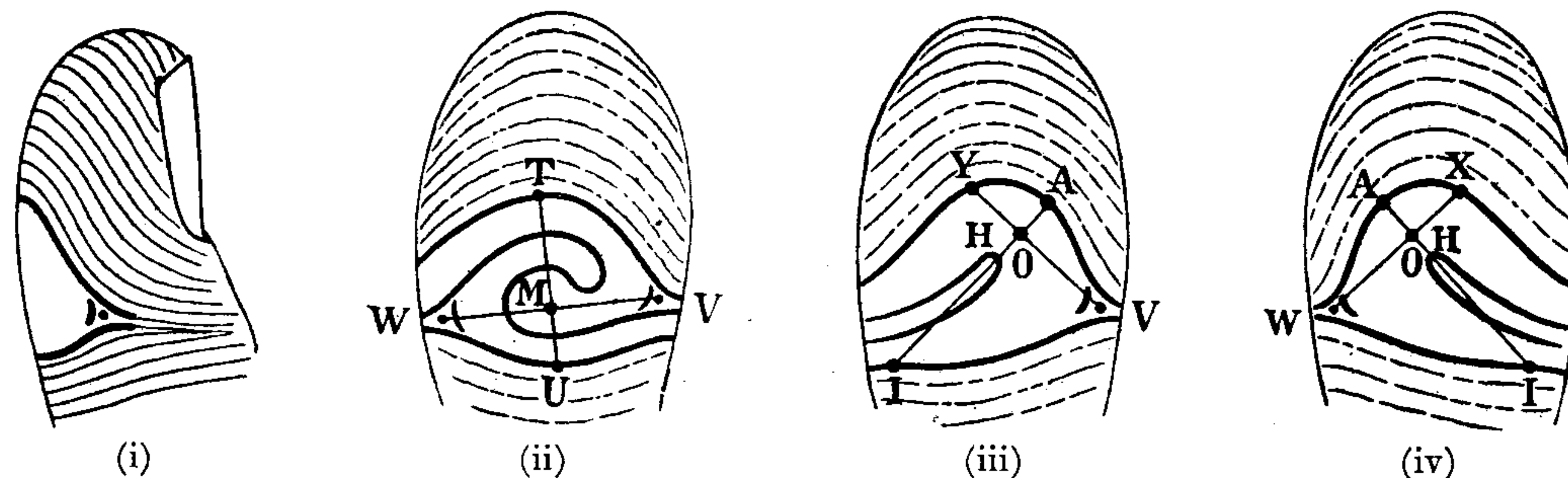


Fig. 21. Finger-print axes for measurements or counting of Ridges.

Galton next proceeds to his *first* basis of classification. It consists in paying attention solely to the deltas and the core boundaries. There may be no deltas, i.e. we have a primary or arch. If there are deltas we can trace the adjacent ridges from one or both deltas upward and downward. These ridges will either reach the other delta, or pass above or below the corresponding ridges from the other delta. There are thus three cases for the upper and three for the lower boundary of the core, or with the primary cases *ten* cases in all. Galton denotes the summit of the core on the central line of the bulb by *S*, and the bottom of the core on the same central line by *B*. Then the possible cases are

- | | | |
|------------------------------|-------------------------------|------------------------------|
| 0 = primary or arch; | 1 = <i>WSV</i> - <i>WBV</i> ; | 2 = <i>SW</i> - <i>BV</i> ; |
| 3 = <i>SV</i> - <i>BW</i> ; | 4 = <i>SV</i> - <i>BV</i> ; | 5 = <i>WSV</i> - <i>BV</i> ; |
| 6 = <i>SV</i> - <i>WBV</i> ; | 7 = <i>SW</i> - <i>BW</i> ; | 8 = <i>WSV</i> - <i>BW</i> ; |
| 9 = <i>SW</i> - <i>WBV</i> . | | |

* Galton remarks: "There is usually quite enough length in a straight line of the uppermost portion of the inner bend to indicate the direction of the required axis" (p. 9). I am less confident of this. I should be inclined to replace Galton's axes by drawing a tangent from the delta to the head of the loop, and taking this and the perpendicular to it through the point of contact as the axis of reference, defining this perpendicular as the "loop axis."

These are represented in the following diagram:

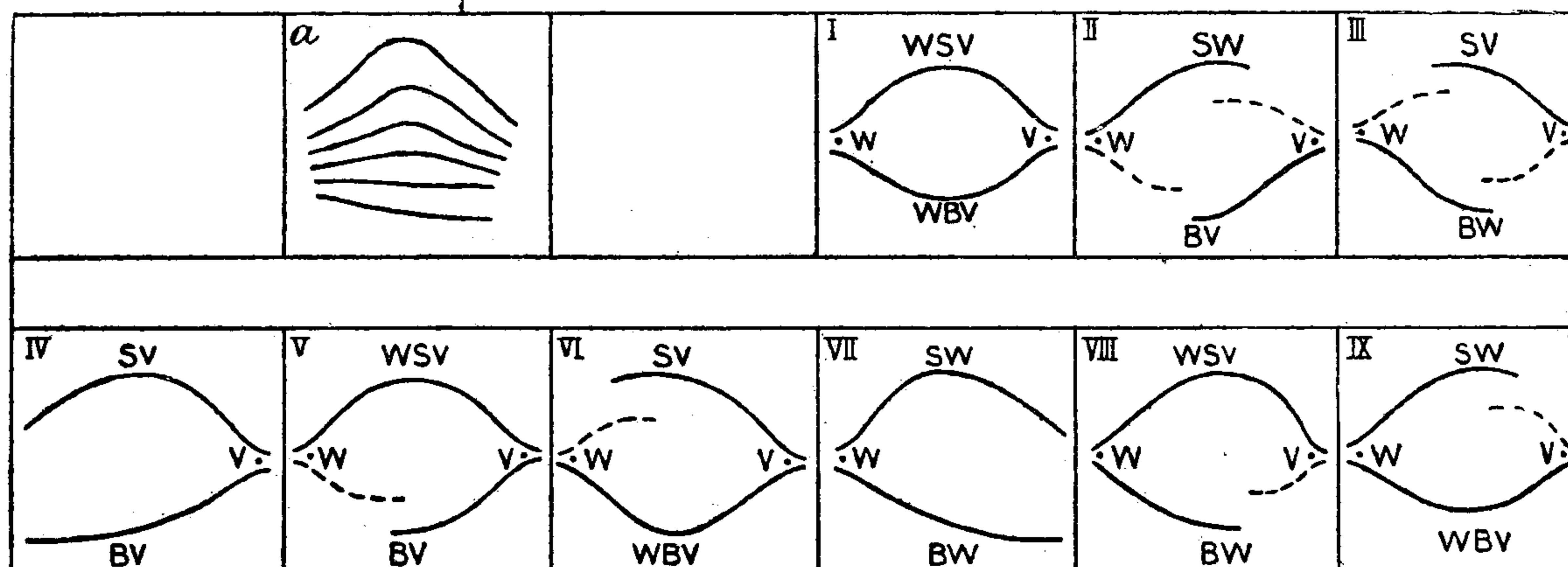


Fig. 22. Classifying by nature of Ridges from Deltas.

We can, perhaps, improve somewhat Galton's indexing in the following manner*. Consider the digits taken in order from little finger of left hand to little finger of right (as the hands are placed palms downward on the knees) to occupy the places from first to last of a ten-figure number, e.g. 32881,56490, then this would be interpreted as meaning that the little finger of the left hand was *SV* - *BW*, the ring finger *SW* - *BV*, the pointer and the forefinger *WSV* - *BW* and the thumb *WSV* - *WBV*; the thumb of the right hand would be *WSV* - *BV*, and so on down to the little finger of the right which would be an arch. Thus a thousand million variations would be possible, and every individual would have his own ten-figure index number, which could be



Fig. 23. "Outlining" a rolled pattern.

recorded in numerical order in the index. The question, however, of how many of these would be "repeats" remains to be considered. Galton shows how, after outlining the pattern, it is fairly easy to classify a great variety of patterns according to his scheme (see his Fig. 9, p. 7, which contains forty

* Galton later drops without comment his classification of prints from the contours of the cores. He nowhere states why. Probably he found it not adequately discriminative for large numbers, or perhaps he discovered the personal equation involved in drawing contours.

typical forms). Unfortunately loops occur in two of Galton's classes only, i.e. as inward and outward loops, and thus the system fails to break up the large class of plain loops which is one of the difficulties of indexing. Further, to be effective, it involves pencilling in the core. However, I feel confident that the choice of a numeral place for each digit and ten classes for each pattern, *which need not necessarily be the same for each digit*, since the relative frequency of each pattern varies from digit to digit, ought to be the basis of any sound system of finger-print indexing. Here, however, it is the difficulty of breaking up the nearly 50% of plain loops which requires ingenuity and study, and for this Galton could only suggest ridge counting. Breaking up the 25% of "whorls" is a relatively easy matter. Even if we proceed to consider the "nuclei" of the cores (Galton, p. 8) we have five belonging to the whorls, and only two



Fig. 24. "Nuclei" of cores. *a, b, c, d, e* are "nuclei" of whorls, *f* and *g* of loops.

provided by the loops. Thus, considering "inward" and "outward" loops, we have at most four loop classes, and we require greater subdivision. This problem was left unsolved by Galton in this his first memoir (1890), unless his suggestion of ridge-counting be considered adequate. Our author next proceeds to deal with the identification of patterns. He draws attention to the fact that the patterns may become distorted, either by age or decay, if the times of taking prints are at long intervals. "They may change their shape just as the pattern on different portions of the same piece of machine-made lace may become variously stretched by wear, or shrunk by wet, or even torn" (p. 9). Exactly as we might proceed to identify the lace by counting the threads of corresponding parts of the lace pattern, so we may count the ridges on corresponding parts of two finger-prints. For this purpose Galton uses the axes of reference which I have already discussed.

Besides the counting of ridges Galton also uses the *minutiae* of which he gives examples in his Fig. 11, but he is careful to warn the reader that two

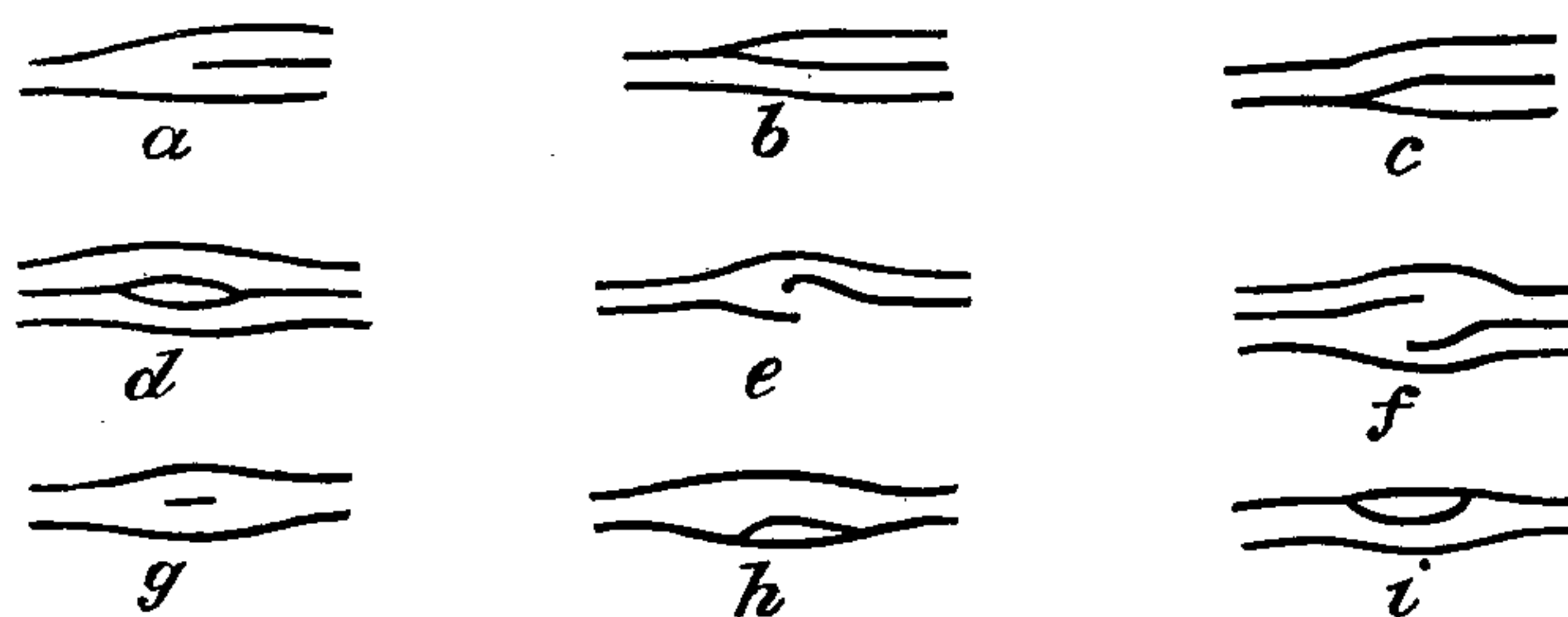


Fig. 25. Ambiguous *minutiae*.

prints of the same finger may show one a fork of ridges and the other a continuous ridge and the terminal of a new ridge, i.e. one may show *a* and the other *b* or *c* of the above figure. The reason for this is that the ridges

are not all of equal height, and occasionally will escape being inked or, even if inked, fail to be pressed on the paper. Those familiar with various types of engraving by gelatine processes will have noted like divergences when comparing pulls from the same stone under a lens. In like manner, even different copies of the same plate of Albrecht Dürer's Apocalypse woodcuts show similar variations, but no connoisseur would assert on that ground that they were not pulls from the same block. Notwithstanding this it is the *minutiae* which provide the best means of identifying two prints, and these are very numerous, if the finger be rolled.

The next section in Galton's memoir deals with the *Persistence of Patterns* (pp. 10-13) and here he had the advantage of Herschel's material. We may give a brief *résumé* of his table on p. 11:

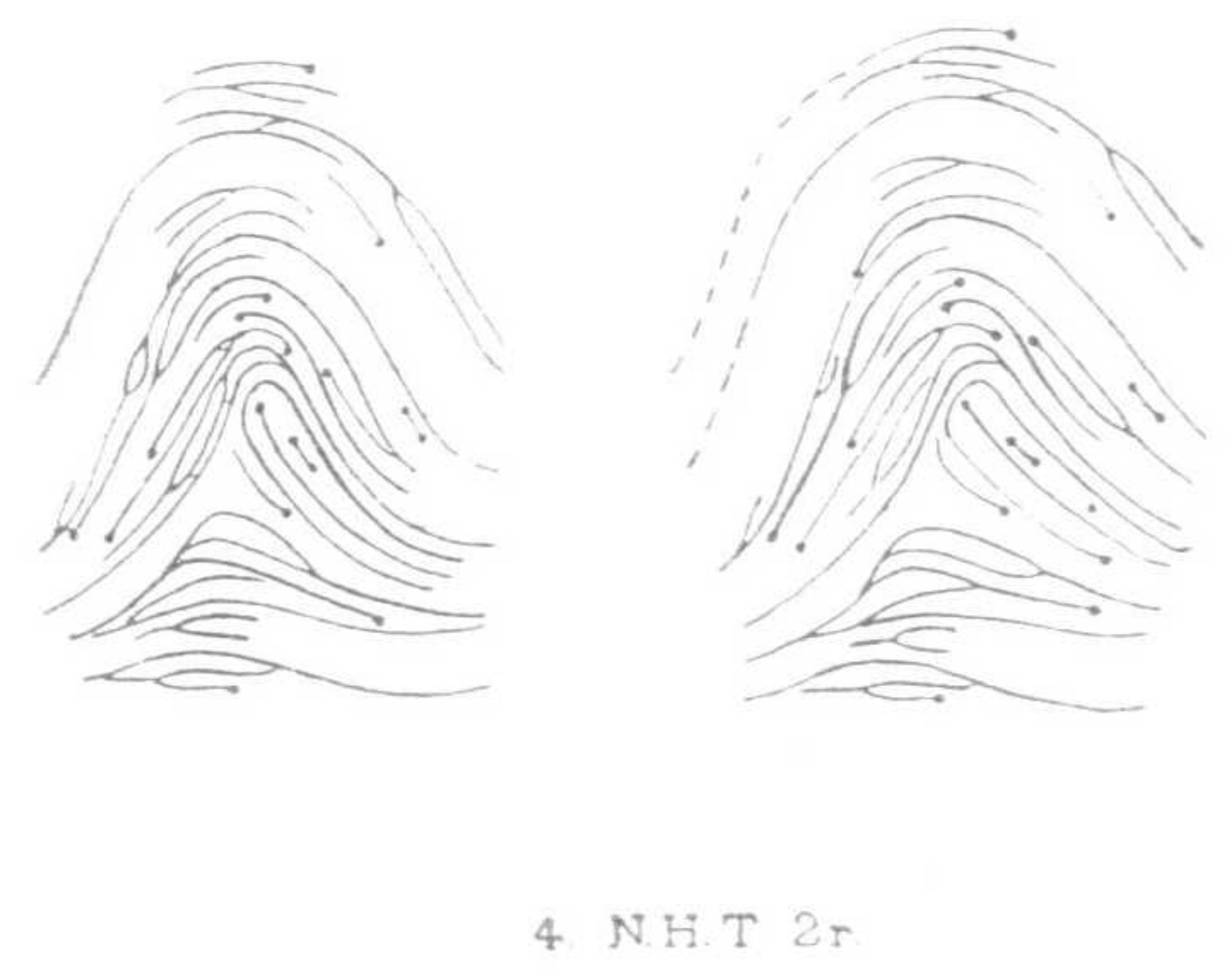
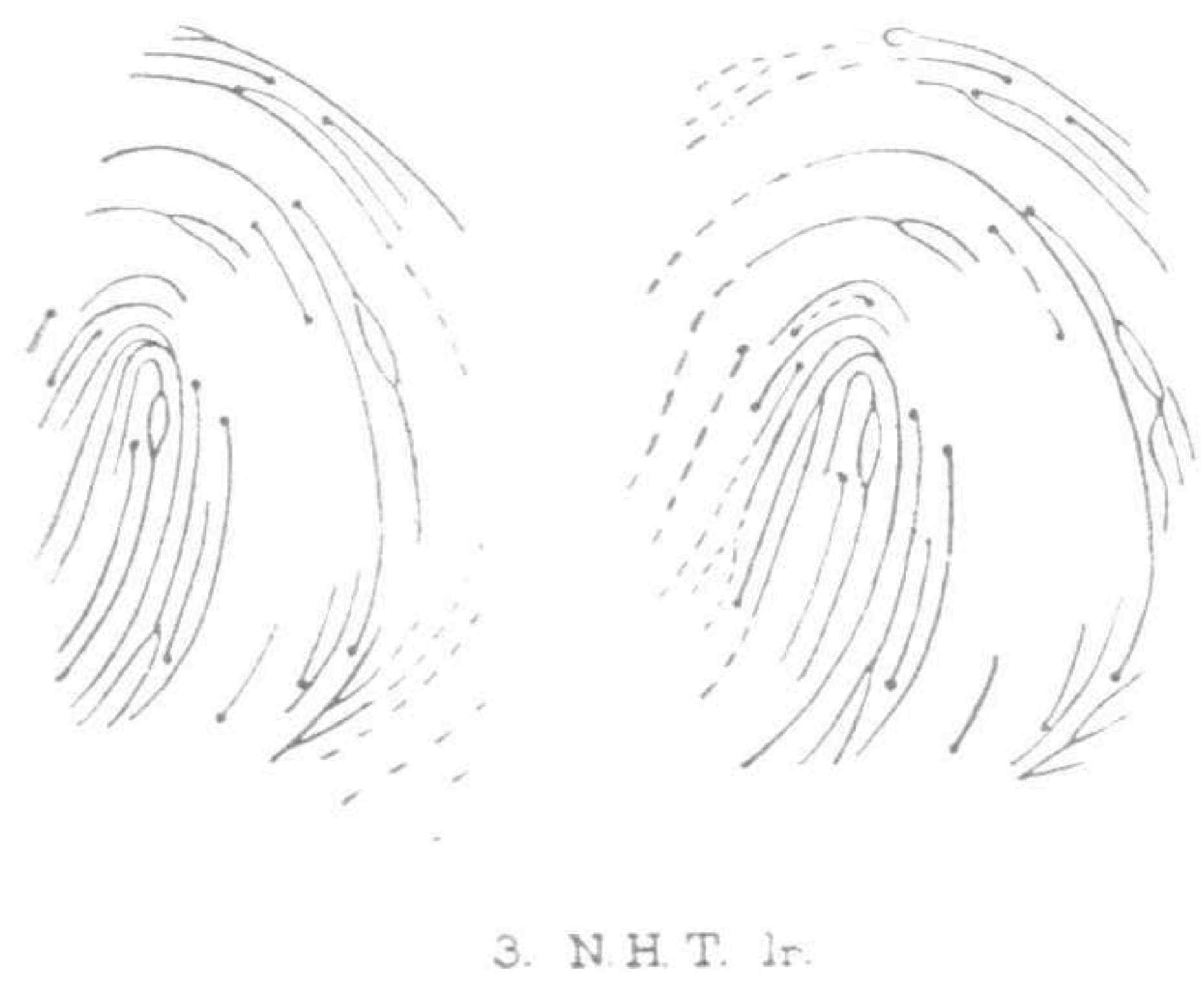
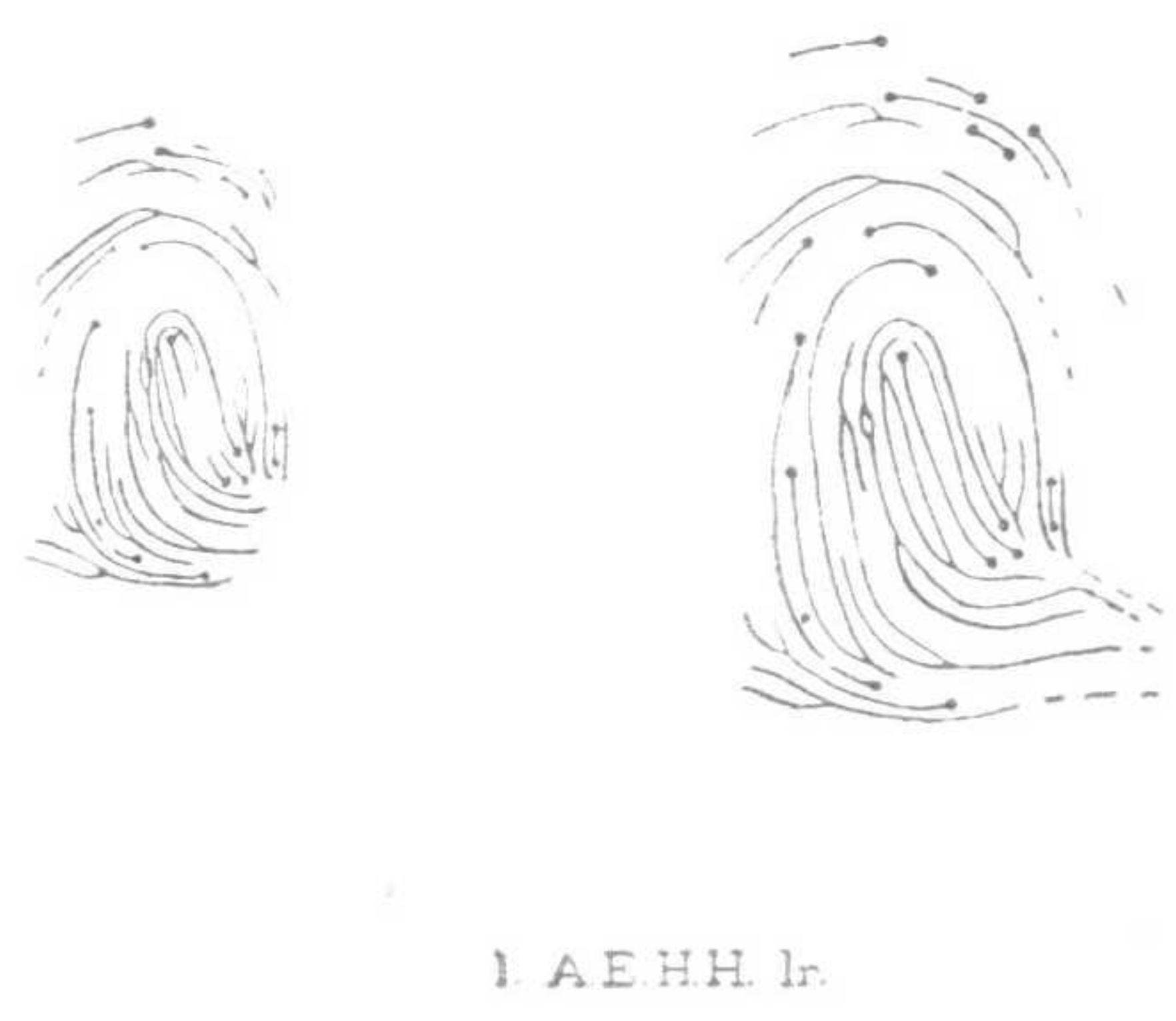
Individual and Plate number	Age at First Print	Interval in years before Second Print	Total number of <i>minutiae</i> identified
1	7½	9	33
2	7½	9	36
3	Adult	28	27
4	Adult	28	36
5	Adult	28	55
6	Adult	31	27
7	Adult	30	50
8	Adult	31	32

Thus a total of 296 *minutiae* were identified.

"The upshot of a careful step by step study is that I have found an absolute and most extraordinary coincidence between the details of each of the two impressions of the same finger of the same person. There was, as the table shows, a grand total of no less than 296 (say roundly 300) points of comparison and not a single one of them failed, though I had much trouble in deciphering the ridges, especially about the V-point [inward delta] in Case 5. There was no one case found of a difference in the number of ridges between any two specified points. Never during the lapse of all these years did a new ridge arise, or an old one disappear. The pattern in all its minute details persisted unchanged, and, *a fortiori*, it remained unchanged in its general character." (p. 12.)

Galton's method of comparing *minutiae* at this time was by outlining the ridges of the two "allochronic" prints. I have arranged Galton's persistency data, outlines next prints, on our Plates VII and VIII in a manner slightly different from that of the original plates of his memoir. This outline method has distinct advantages, if it be not here as complete as in Galton's later development of it.

Galton added a line or two to the memoir on January 28, 1891, to say that he had examined a number of other pairs of impressions in the same manner, and had found only one instance of fundamental discord, where a ridge had been partly cleft in a child, but when the child had grown to a boy the cleft had disappeared. Thus Galton, with the aid of Sir W. J. Herschel's material, satisfactorily established for the first time the permanence of fingerprints.



Persistence of *minutiae* at intervals of nine and twenty-eight years.



1862



1888

5. F.K.H. 1r



1859



1890

6. R.F.H. 2r



5. F.K.H. 1r



6. R.F.H. 2r



1860



1890

7. W.J.H. thumb, r



1859



1890

8. W.J.H. 3r



7. W.J.H. thumb, r



8. W.J.H. 3r

Persistence of *minutiae* at intervals of twenty-six, thirty and thirty-one years.

After a few remarks on scars, which consist chiefly in noting how few he had found which destroyed the patterns to any considerable extent, and how even in these cases with "rolling" generally enough is left for sound identification (see our Plate VI, p. 154), Galton turns to another matter, which needs possibly more criticism or at least an ampler treatment. He considers that there are certain main types of finger-prints, "arches," "loops," "whorls," etc. There are also, he admits, transitional forms which create difficulty in classification, but he says the result of statistical observation shows these intermediates to be relatively few. He considers therefore the finger-print types to be analogous to ordinary genera, and in order to illustrate this he takes the case of the loop, and (a) counts the number of ridges in *AH* (see our Fig. 21 (iii) and (iv), p. 163), (b) measures the index *VY/OI*, and (c) the index *AO/AH*. Using both hands, and populations numbering 140 to 176 individuals only, he forms six frequency distributions, reducing them to percentages. For example:

Percentage Number of Ridges in 166 Right Thumb Loop Prints.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	above
1	2	2	2	3	4	8	8	11	9	14	11	10	7	6	2

*Percentage Value of Index *VY/OI* in 149 Left Thumb Loop Prints.*

0.3—0.4	0.5—0.6	0.7—0.8	0.9—1.0	1.1—1.2	1.3—1.4	1.5—1.6	1.7—1.8	1.9—2.0	2.1—2.2	above
2	11	14	18	23	7	10	6	6	1	2

Galton does not apply an individual test for normality of distribution to these rather abnormal-looking distributions*, but reducing them to their medians and quartiles (see our Vol. II, pp. 385–6, 401) compounds them together to form a single average "ogive" curve (see our Plate II, p. 31). His final comparison is as follows:

Ordinates of Ogive Curve from Six Distributions and the computed Values.

Six Distributions	-231	-182	-117	-93	-73	-37	+1	+38	+77	+107	+139	+213	+260
Computed	-244	-190	-125	-100	-78	-38	0	+38	+78	+100	+125	+190	+244
Grades	5	10	20	25	30	40	50	60	70	75	80	90	95

Considering that we have 965 observations to start from, this does not appear on the face of it a very good agreement, and even Galton (p. 22) contents

* He merely places his observed values alongside the normal curve results, and says that considering the paucity of observations "there is nothing in the results that contradicts the possibility of much closer conformity when many more observations are dealt with." (p. 19.)

himself by calling it a "quasi-accordance with the theoretical law of Frequency of Error." Personally I do not see why it is needful to show accordance, quasi or otherwise, with the normal law of error. It might have served Galton's purpose to show "tailing off" in his distributions of measurements. But it does not seem to me that measurement or enumeration is really what he needs, or it must be measurement or enumeration of characters which belong alike to the various genera, not to a loop alone. The transitions from loop to whorl are qualitative rather than quantitative, and it is the frequency of these qualitative intermediates that we need to analyse. I am inclined to think that this was later recognised by Galton, for I have several times heard him say that there appeared to him nothing to be measured in finger-prints *in general*; could I not suggest a measurable character? I still know of nothing that will apply *satisfactorily* to all types, and I hold that scientific finger-print classification must be qualitative*.

As I have said, I do not see, even if Galton had proved that measurements on loop finger-prints only followed the normal law of distribution, that it would follow that types of finger-prints are genera. In order to prove this we should need to measure characters which run through the whole series of types and this is precisely what it does not appear feasible—at any rate for the present—to achieve. Undoubtedly finger-print patterns do occasionally blend, if such occasions are less frequent than the instances in which they appear to be exclusive (see our Plates XIII and XIV, p. 181). It seems therefore that the key to the matter lies in a closer study of the heredity of finger-prints than has yet been made. With this Galton certainly would have agreed. He writes (p. 21):

"There is reason to believe that the patterns are hereditary. I have no adequate amount of data, whereby to test the truth of this belief by a direct inquiry, but rest the belief partly on analogy, but more especially on the ascertained existence of a considerable tendency to symmetry. When, for instance, there is a primary pattern on one thumb, there are not far from ten chances to one in favour of its being found on the other. Again, if there is a loop in one thumb, there is a strong chance that it will be found in the other thumb also. Similarly as regards each pair of corresponding fingers. Therefore the causes of the pattern must not be looked for in purely local influences. Some of the causes why it and not another pattern is present, are common to both sides of the body and may therefore be called constitutional, and be expected to be hereditary."

Galton continuing next states that finger-prints form an "instructive instance of the effects of heredity under circumstances in which sexual selection has been neutral." He seems to think that sight could be the only sexual selective factor, for he says that finger-prints are too small to attract attention. He remarks that they appear to be uncorrelated with any desirable or repellent quality. Galton holds that they might possibly be related to sensitivity, the average breadth of a ridge-interval being possibly a measure of delicacy in the sense of touch †. But he states that this could have nothing

* I write this fully aware of the attempts made by Kristine Bonnevie (*Journal of Genetics*, Vol. xv, pp. 46-54) to give a common measurable characterisation to all types of finger-print pattern.

† Experiments on this point were soon after made for Galton by Titchener, who found no relation between ridge-interval and sensitivity.

to do with the *attractiveness* or otherwise of any particular pattern. I do not believe that Galton has quite plumbed the possible depths of the action of sexual selection in this matter. Touch is one of the least studied, and therefore the least understood of the sexual factors. The question is not that of sensitivity in the producer of a sensation, but of the feelings excited in the recipient. It is not, perhaps, probable, but it is still possible, considering how large a part touch plays in courtship, that the shades of feeling excited by it may be associated with finger-print pattern. Those who straight-away dismiss any slender possibility in this direction have hardly the true measure of our present scientific ignorance, and probably do not realise how much greater a part touch plays in the sensory life of the female than of the male.

Galton holds that there must have been complete promiscuity of matings, or as it is now called, panmixia, with regard to these patterns, and that consequently they ought to have hybridised. I cannot see that this argument is any more valid than the argument that iris-colours ought to hybridise. It is true that both iris-colours and finger-prints do blend under certain rare physiological conditions that we do not yet understand, but I can see no necessity for a universal rule which anticipates that blending must follow hybridisation. The mere fact that the individual can have finger-prints of various patterns *suggests* hybridisation, and it seems to me that the question of racial differentiation in finger-print frequencies wants renewed investigation, starting very nearly from the point where Galton left it (see our pp. 140, 193-4).

We next turn to the question of natural selection and here we read:

“As regards the influence of all other kinds of natural selection, we know that they cooperate in keeping races pure by their much more frequent destruction of the individuals who depart more widely from the typical centre. *But natural selection is wholly inoperative in respect to individual varieties of patterns and unable to exercise the slightest check upon their vagaries.* Yet, for all that, the different classes of patterns are isolated from one another, through the rarity of transitional cases, just as thoroughly, and just in the same way, as are the genera of plants and animals.” (p. 22.)

In the words I have italicised Galton seems to me to have departed from his usual cautious restraint in the matter of dogma, and some suspicion may be thrown on his conclusion from his own data. On p. 21 of the memoir are given measurements of the core and the number of ridges in loop finger-prints of the left and *right* thumbs. From this it appears that the *right* thumb exceeds the left thumb in these measurements and in the number of ridges. Is this relation reversed in left-handed persons? Nowadays we know that the finger-print types are not scattered at random among the digits, there is association between individual digit and individual type. Can it be that there is any reversal of this association in left-handed persons? We do not know; but if it should prove to be so, the first step would have been taken to show a relation between finger-print pattern and manual efficiency. It is never safe to dismiss all relationship of a character to natural selection because we cannot for the moment see any link between the character and fitness.

Galton having dismissed both sexual and natural selection from past or present influence on finger-print patterns, argues that natural selection has had no monopoly in producing genera.

“Not only is it impossible to substantiate a claim for natural selection that it is the sole agent in forming genera, but it seems, from the experience of artificial selection, that it is scarcely competent to do so by favouring mere *varieties*, in the sense in which I understand the term.

“My contention is that it acts by favouring small *sports*. Mere varieties from a common typical centre blend freely in the offspring, and the offspring of every race whose *statistical* characters are constant, necessarily tend, as I have often shown, to revert to their common typical centre*. Sports do not blend freely; they are fresh typical centres or sub-species, which suddenly arise, we do not yet know precisely through what uncommon concurrences of circumstance, and which observations show to be strongly transmissible by inheritance.

“A mere variety can never afford a sticking point in the forward course of evolution, but each new sport implies a new condition of internal equilibrium, and does afford one. A change of type is effected, as I conceive, by a succession of sports or small changes of typical centre, each being in its turn favoured and established by natural selection to the exclusion of its competitors. The distinction between a mere variety and a sport is real and fundamental. I argued this in a recent work [see our discussion pp. 58–62 above of Galton’s *Natural Inheritance*, 1889], but had then to draw my illustrations from non-physiological experiences. I could not at that time find an appropriate physiological one. The want is now excellently supplied by observations of the patterns made by the papillary ridges on the thumbs and fingers.” (pp. 22–3.)

While I am very loath to say that Galton is in error, I think that he has far from demonstrated the correctness of his views. I have cited his paper at considerable length because I want to indicate how keen a “mutationist” he was. We can claim that he was the first to assert a distinction between “mutations” (sports in his terminology) and “fluctuating variations” (varieties round a typical centre, as he would call them). If the Biometric School has been unable to follow him whole-heartedly in this path, it is because in his case the conclusion was only in a very minor degree based on observation; in the main it flowed from a misinterpretation of his own great discovery of regression †.

Finger-Print Indexing. In the year following the presentation of this memoir Galton read a second paper before the Royal Society (April 30, 1891). It was entitled: “Method of Indexing Finger-Marks,” and was published in the *Roy. Soc. Proceedings*, Vol. XLIX, pp. 540–548. Our author points out that the indexing of finger-prints is not only of importance for criminal identification, but for racial and hereditary inquiries. He especially emphasises their value in the latter case:

“The patterns are usually sharp and clear and their *minutiae* are independent of age and growth. They are necessarily trustworthy, and no reluctance is shown in permitting them to be taken, which can be founded either upon personal vanity or upon an unwillingness to communicate undesirable family peculiarities.” (p. 540.)

* [This is the old error of the misinterpretation of regression, which led Galton so often and so far astray; see our pp. 31, 48 and 83. K.P.]

† An additional point in this memoir (p. 20) may, perhaps, be just noted. Galton compares the index found from the ratio of means of two absolute variates, with the mean of all the indices found from the individual values of the variates. He shows that the two are nearly the same. We now know the proper corrective factor required to pass from one to the other.

It appears, possibly for reasons to which we have already referred (see p. 163), that Galton had by this time put aside his earlier method of indexing, and he remarks:

“Without caring to dwell on many of my earlier failures to index the finger-prints in a satisfactory way, my description shall be confined to that which has proved to be a success. It is based on a small variety of conspicuous differences of pattern in each of many digits, and not upon minute peculiarities of a single digit.” (p. 541.)

Galton had now obtained the prints of all ten digits of 289 persons, though his indexing applies only to the first hundred of these.

He here introduces for the first time the Arch-Loop-Whorl classification*, which has formed the basis of all later attempts at indexing. If a line be drawn from the tip of the forefinger to the base of the little finger, this is roughly the usual slope of the “axes” of the finger-prints if they be not symmetrical. Galton uses the odd numerals 1, 3, 5 for symmetrical forms or for sloped forms with the usual or “normal” slope, the even numerals 2, 4, 6 for the unusual or “abnormal” slopes, in the three classes, arches, loops, whorls. There is little difficulty as a rule in allotting a print to one or other of these six classes. It is only when the rarer compounds (later termed “composites”) appear that some difficulty may arise. Galton’s scheme is provided in the accompanying diagram.










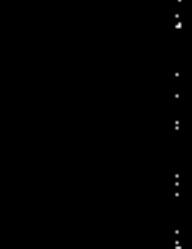










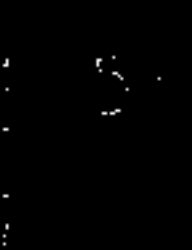
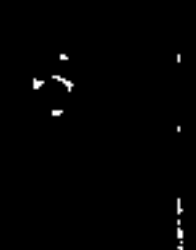
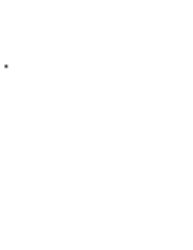
<i>Elementary divisions</i>	<i>Index number</i>	<i>Symbols of Patterns</i>				<i>Index number</i>									
		<i>symmetric</i>		<i>sloped</i>											
<i>Primary</i>	1								1-5						
<i>Whorls</i>	3								3-4						
<i>Loops</i>	5	<i>all sloped</i>													5-6

Fig. 26.

He does not arrange his numerals which denote the character of the finger-print in the natural order of the digits, i.e. from little finger left to little finger right. His reason for this is thus stated:

“The forefingers are the most variable of all the digits in respect to their patterns, their slopes being almost as frequently abnormal as not †; the third fingers rank next; the little finger ranks last, as its pattern is a loop in nine cases out of ten. I, therefore, found it convenient not to index the fingers in their natural order, but in the way that is shown at the head of the

* Galton still uses the term “primary” for arch.

† i.e. as frequently radial as ulnar.

columns of figures on the left side of Fig. 27. There, the sequence of the numerals that express the patterns on the digits is divided into two groups of three numerals and two groups of two numerals, as 355, 455, 55, 35. The first group 355 refers to the first, second and third fingers of the left hand*; the second group 455 to the first, second, and third fingers of the right hand; the

L	R	L	R	Left					Right				Index	
123	123	T4	T4	4	3	2	1	T	T	1	2	3		4
353	333	35	35	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	38 2
353	353	35	35	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	19 2
353	353	15	55	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	6 2
353	553	35	35	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	17 1
355	353	55	35	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	16 1
355	455	55	35	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	43 1
365	355	55	55	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	3 2
415	555	35	55	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	21 1

Fig. 27.

third group 55 to the thumb and fourth finger of the left hand; the fourth group 35 to the thumb and fourth finger of the right hand. The index is arranged in the numerical sequence of these sets of numbers as shown in Fig. 27 †." (pp. 542-3.)

It will be seen from Fig. 27 that Galton drew a rough symbol denoting the nature of his subclasses, the *a* to *w* of Fig. 26 in his index. The symbols with dots attached mark cases in which there may be doubt as to classification. Thus the primaries *f* and *g* may have been classed by another as loops. If there has been hesitation about them, after seeking them as loops, a second reference to the index should be made, treating them as primaries. When a whorl is "crozier" shaped, as *j*, *k*, *l*, *m*, it lies in a loop, and may when it approaches the plain eyes *t*, *u* give rise to hesitation and a dot is then added, as at *l*, *m*. Galton says that he has not found much difficulty with transitional cases, and considers it could be well surmounted if a standard collection of doubtful forms were established to ensure that different persons would abide by a common rule.

Galton (pp. 545-6) gives an index based on the ten finger-prints of 100 persons. In this index there are nine cases of duplicated numbers and three

* Galton's first finger = forefinger, second finger = middle finger, third finger = ring finger, and fourth finger = little finger. Galton's purpose is clear, but there are distinct and greater advantages in the "natural" order.

† The last column in Galton's figure, our Fig. 27, requires explanation; it is the page reference to his records where the actual finger-prints will be found. The word "Index" at the head of the column is, perhaps, not explanatory enough.

cases of triplicated numbers. In other words the index number alone would not suffice to identify an individual in about a quarter of the indexed cases. Now if the index contains 100,000 instead of 100 individuals, it is clear that these multiple cases, instead of being counted by twos and threes, would be counted by hundreds, and the number of references required to the prints themselves would become most fatiguing. The source of this evil is fairly clear if we examine Galton's Table II (p. 548). It classifies the patterns that occur in 100 prints of left forefingers. It is obvious that we have gained very

Forefinger of Left Hand.

Pattern	Classificatory Number	Number of Occurrences
Primary, plain ... } Primary nascent loop, slope normal ... } Primary nascent loop, slope abnormal	1	26
Whorl, plain ... } Whorl, with tail, slope normal ... } Whorl, with tail, slope abnormal ...	2	4
	3	23
	4	6
Loop, slope normal ... } Loop, slope abnormal ... }	5	21
	6	20
Total cases	100

little indeed in the case of primaries and whorls by taking the nature of the slope as a characteristic. The four groups of 26, 23, 21 and 20 still remain far too large. We need to break up the primaries into three nearly equal groups, not into two of 26 and 4; the same applies to the whorls, while each group of loops requires bisecting. This would give us ten classes, and fit in well with a ten-figure index number. The scheme of indexing Galton proposed in this paper could not be final, yet it was pioneer work*; no one but our author himself had so far published or even suggested a plan for indexing, and there still remained much spade-work to be done before an adequate scheme was evolved. Galton himself recognised the difficulty, thus he writes:

“The greatest difficulty in constructing a uniformly efficient catalogue lies in the troublesome frequency of plain loops, so that even the method of picture writing fails to analyse satisfactorily the numerous 555, 555, 55, 55 cases. When searching through a large number of similarly indexed prints for a particular specimen, it is a very expeditious method to fix on any well-marked characteristic of a minute kind such as an island, or enclosure, or a couple of adjacent bifurcations, that may present itself in any one of the fingers, and in making the search to use a lens or lenses of low power, fixed at the end of an arm, and to confine the attention solely to looking for that one characteristic. The cards on which the finger marks have been made may then be passed successively under the lens with great rapidity. I fear that the method of counting ridges (as the number of ridges in *AH* of my previous memoir [see our pp. 163, 167]) would be difficult to use by persons who are not experts. Anyhow, I have not yet been able to devise a plan for doing so that I can recommend.” (p. 547.)

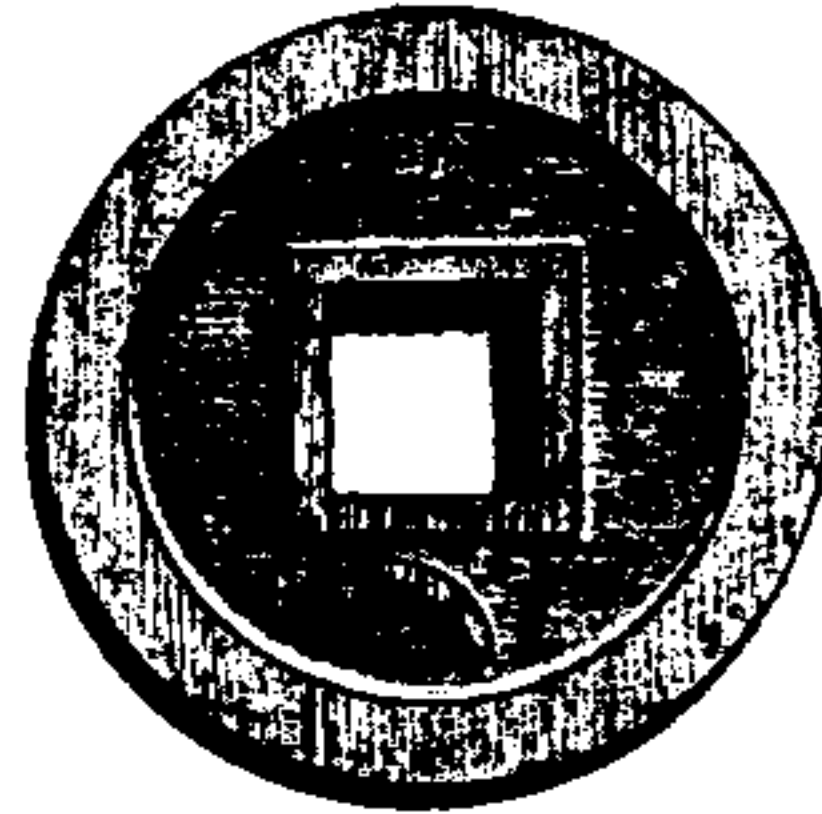
* The diagrammatic symbols used by Galton are the basis from which his fuller classification in *Finger Print Directories* starts (see our pp. 199 *et seq.*).

Another point dealt with by Galton in this memoir is the relative advantage gained in indexing by the first two fingers of the left hand, the first three fingers of the left hand, the first three fingers of both hands or by all ten digits; he finds the numbers of different patterns occurring are respectively 16, 27, 65 and 83. The ten-digit indexing is now in general use, and of course provides a greater field for identification, if the indexing be somewhat more cumbersome.

B. *Finger Prints*, 1893.

We now reach Galton's fundamental book on finger-prints, namely *Finger Prints** (Macmillan, 1893). Chapter I (pp. 1-21), entitled *Introduction*, gives a brief account of the subject referring to Purkenje and the pioneer work of Sir William Herschel; it further provides a synopsis of the contents of the entire book †.

Chapter II (pp. 22-29) deals with *Previous Use of Finger-Prints*. It recounts the use of nail-marks or finger-marks among barbarous or semi-civilised people rather as a superstitious sign of personal touch than of personal



Chinese Coin, Tang Dynasty, about 618 A. D., with nail mark of the Empress Wen-teh, figured in relief.

Fig. 28.

identity. It notes also the frequent appearance of finger-impressions upon ancient pottery. Here, as in the case of a Greek impression found by Sir Charles Walston on a steatite seal at the Argive Heraeum ‡, it is somewhat

* It is an interesting example of the futility of some reviewers, that the critic who wrote the notice of Galton's *Finger Prints* in the *Athenaeum* of Dec. 24, 1892, expressed the wish that he might devote his brilliant powers to "subjects of greater promise of practical utility"; and again: "Whether the practical results to be derived from his researches will repay the pains he has bestowed upon them we must take leave to doubt. It will be long before a British jury will consent to convict a man upon the evidence of his finger-prints; and however perfect in theory the identification may be, it will not be easy to submit it in a form that will amount to legal evidence."

† At the end of this chapter Galton thanks Mr Howard Collins for his very material aid. The correspondence between Galton and Collins during the progress of the work was considerable, and of some scientific value. In 1911 I issued a request in the *Times* and other journals for letters or copies of letters written by Galton. The response was very disappointing. During the last nine years the Galton Laboratory has had frequently to purchase letters of Galton sold by their recipients or the assigns of the latter to booksellers or autograph dealers. Among such purchases the Laboratory obtained from a Birmingham bookseller, whose catalogue the Director luckily chanced to see, Galton's numerous letters to Collins on the subject of finger-prints.

‡ *The Illustrated London News*, Feb. 7, 1925, p. 231.


doubtful if the impression was purely accidental, arising simply from touching by chance the wet clay, or was the result of moulding with the thumb the small base of an object, or was actually intended as a potter's mark. Galton next refers to Bewick's impressing his thumb-mark and a finger-mark on a



Fig. 29. Thomas Bewick, his mark.

block of wood, engraving them and afterwards using them for ornaments in his books*; this approaches the use of a finger-print for a sign-manual. Galton continues:

“Occasional instances of careful study may also be noted, such as that of Mr Faulds (*Nature*, Vol. xxii, p. 605, Oct. 28, 1880), who seems to have taken much pains, and that of Mr Tabor, the eminent photographer of San Francisco, who, noticing the lineations of a print that he had accidentally made with his own inked finger upon a blotting-paper, experimented further, and finally proposed the method of finger-prints for the registration of Chinese, whose identification has always been a difficulty, and was giving a great deal of trouble at that particular time;

August 8, 1882.
 Mr Jones, Sutter, will
 pay to Lying Bob seventy five Dollars.

 Gilbert Thompson
 U.S.G.S.

Order on a Camp Sutler, by the officer of a surveying party in New Mexico 1882.

Fig. 30.

but his proposal dropped through. Again Mr Gilbert Thompson, an American geologist, when on Government duty in 1882 in the wild parts of New Mexico, paid the members of his party

* See for example *History of Birds*, Vol. i, p. 180, edn. 1805. It is not in my edition (1807) of the *General History of Quadrupeds*. Sir William Herschel reproduces in his book, *The Origin of Finger Printing*, 1916, p. 33, a receipt of Bewick from 1818, in 1918 in the possession of Mr Quaritch. The print is a very delicate one, and has the attached words “Thomas Bewick, his mark.” Sir William thinks that these marks of Bewick, known to him as a boy, may have unwittingly led him to study such prints.

by order of [? on] the camp sutler. To guard against forgery he signed his name [? wrote the amount] across the impression made by his finger upon the order, after first pressing it on his office pad. He was good enough to send me the duplicate of one of these cheques made out in favour of a man who bore the ominous name of 'Lying Bob' [see Fig. 30 on p. 175]. The impression took the place of scroll work on an ordinary cheque; it was in violet aniline ink, and looked decidedly pretty. From time to time sporadic instances like these are met with, but none are comparable in importance to the regular and official employment made of finger-prints by Sir William Herschel, during more than a quarter of a century in Bengal. I was exceedingly obliged to him for much valuable information when first commencing this study, and have been almost wholly indebted to his kindness for the materials used in this book for proving the persistence of lineations throughout life.

"Sir William Herschel has presented me with one of the two original 'Contracts' in Bengali, dated 1858, which suggested to his mind the idea of using this method of identification*. It was so difficult to obtain credence to the signatures of the natives, that he thought he would use the signature of the hand itself, chiefly with the intention of frightening the man who made it from afterwards denying his formal act; however, the impression proved so good that Sir W. Herschel became convinced that the same method might be further utilised. He finally introduced the use of finger-prints in several departments at Hooghly in 1877, after seventeen years' experience of the value of the evidence they afforded. A too brief account of his work was given by him in *Nature* (Vol. xxiii, p. 23, Nov. 25, 1880). He mentions there that he had been taking finger marks as sign-manuals for more than twenty years, and had introduced them for practical purposes in several ways in India with marked benefit. They rendered attempts to repudiate signatures quite hopeless. Finger-prints were taken of Pensioners to prevent their personation by others after death; they were used in the office for Registration of Deeds, and at a gaol where each prisoner had to sign with his finger. By comparing the prints of persons then living, with their prints taken twenty years previously, he considered he had proved that the lapse of at least that period made no change sufficient to affect the utility of the plan. He informs me that he submitted, in 1877, a report in semi-official form to the Inspector-General of Gaols, asking to be allowed to extend the process; but no result followed. In 1881, at the request of the Governor of the gaol at Greenwich (Sydney), he sent a description of the method, but no further steps appear to have been taken there.

"If the use of finger-prints ever becomes of general importance, Sir William Herschel must be regarded as the first who devised a feasible method for regular use, and afterwards officially adopted it." (pp. 26-29.)

I have cited this long passage because I wish to give evidence that Galton did ample justice to his predecessors, more justice than has since been done to his own work†. Galton never claimed to have invented the *idea* of identification by finger-prints. What he did do was to take up the matter from the scientific standpoint to establish certain principles and the practical methods of operating them. It was his publications and his energetic demonstration of the value of finger-print identification, not occasional newspaper diatribes, which led to its adoption by the English Prison Service, and ultimately to its acceptance throughout the civilised world. Much solid

* One is reproduced on our Plate V, p. 146 and the other in Sir William Herschel's *The Origin of Finger Printing*.

† "In discussing the true natural history of the minute ridges upon the fingers Galton goes no further than did the first physiologist of note who drew attention to their presence. This was Nehemiah Grew." Louis Robinson in *North American Review*, May 15, 1905. Again: "Mr Galton distinctly says in his *Finger Prints*, p. 2: 'My attention was first drawn to the ridges in 1888,' etc. It is not a little remarkable to my mind that that date should so nearly coincide with the period when I was interesting Sir Wollaston Franks, of the British Museum, and other scientific authorities in the importance of this means of identification." *Birmingham Post*, May 16, 1905. Dr Faulds cites only the first words of Galton's paragraph on p. 2. For the full citation see our p. 142.

work had to be done before the mere idea of identification by finger-prints could be transformed into its full realisation as a practical criminal procedure. For that actual transformation we have to thank neither Nehemiah Grew nor Dr Faulds, but Francis Galton expanding and working on the experiences of Sir William Herschel.

Chapter III (pp. 30-53), entitled *Methods of Printing*, gives a very full description of methods for the permanent preservation of finger-marks.

Galton starts by indicating a way of getting very perfect finger-prints, which has been since used very largely for detective purposes. The reader can easily try it for himself; let him pass his finger over the hair at the back of his head, and then press the bulb of his finger on a window pane, that of a recently cleaned window if available; he will find a very perfect imprint of his finger lineation, and there it may remain decipherable for days—under post-war conditions of domestic service! If the finger be merely moistened the impression soon evaporates; the essential need is to oil the finger *very slightly*, and this is adequately achieved by the natural oiliness of the hair. Similar finger-prints may be obtained on polished steel—a razor blade—or on table plate. Now-a-days for the purposes of criminal investigation such accidental finger-prints can be reproduced and preserved. Galton next proceeds to give accounts of laboratory and also of pocket apparatus for finger-printing; the important factors are the persistent cleanliness needful in the apparatus, and the extreme thinness of the ink layer on the finger, if a good impression is to be obtained*. This chapter is replete with suggestions such as we have recorded of the younger Galton with his mechanical “dodges.” A thin sheet of copper which I found in one of Galton’s diaries puzzled me, till I re-read *Finger Prints*, and there noted that it was to receive soot from a candle (or even a match) to blacken fingers for their prints.

“Paste rubbed in a very thin layer over a card makes a surface that holds soot firmly, and one that will not stick to other surfaces if accidentally moistened. Glue, isinglass, size, and mucilage, are all suitable. It was my fortune as a boy to receive rudimentary lessons in drawing from a humble and rather grotesque master. He confided to me the discovery, which he claimed as his own, that pencil drawings could be fixed by licking them; and as I write these words, the image of his broad swab-like tongue performing the operation, and of his proud eyes gleaming over the drawing he was operating on, come vividly to remembrance. This reminiscence led me to try whether licking a piece of paper would give it a sufficiently adhesive surface. It did so. Nay, it led me a step further, for I took two pieces of paper and licked both. The dry side of the one was held over the candle as an equivalent to a plate for collecting soot, being saved by the moisture at the back from igniting (it had to be licked two or three times during the process), and the impression was made on the other bit of paper. An ingenious person determined to succeed in obtaining the record of a finger impression can hardly fail altogether under any ordinary circumstances.” (pp. 48-9.)

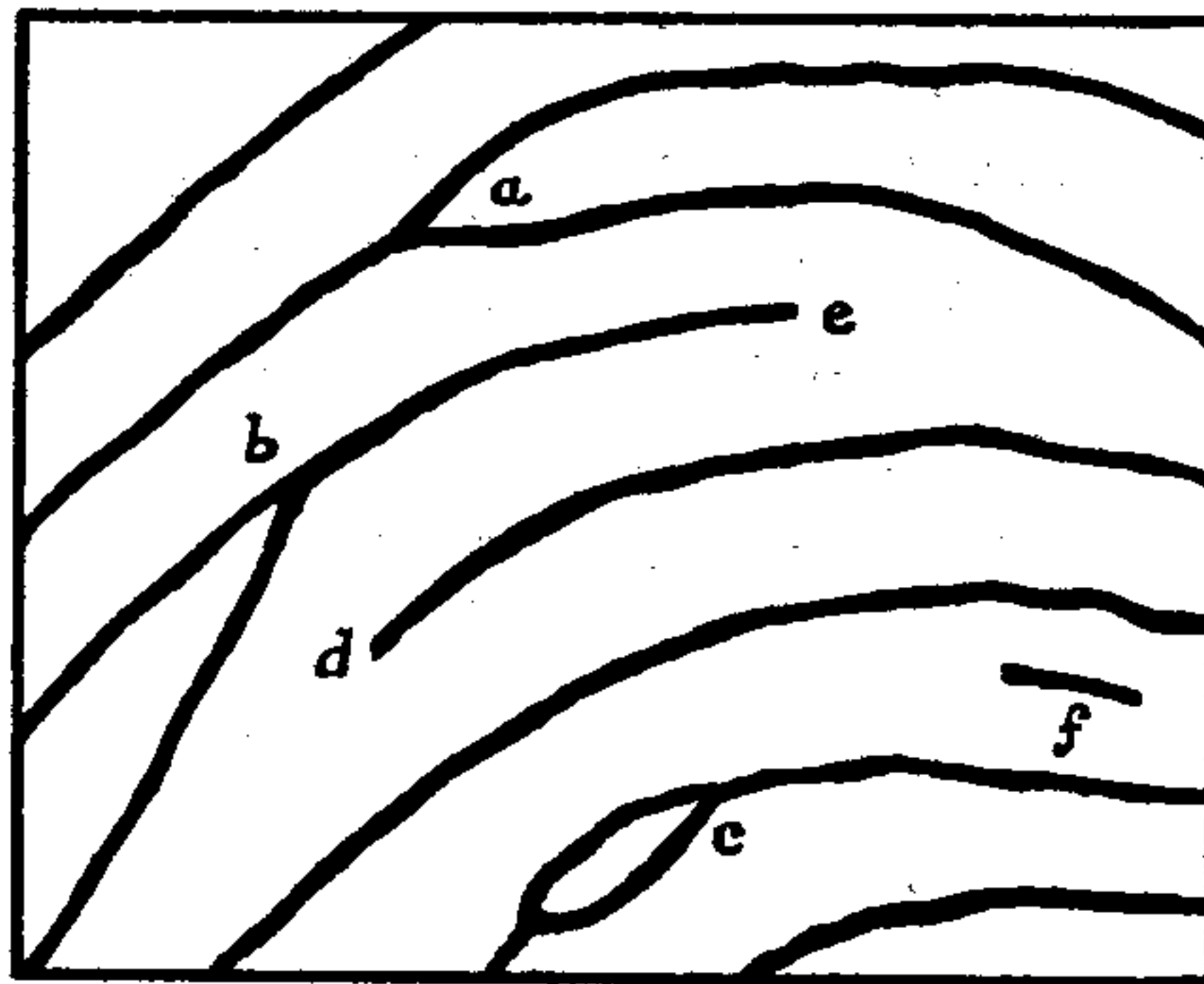
I should like to have asked Galton what he would have done had there been no *paper* †; I feel sure he would have been ready with a substitute! The chapter concludes with remarks on the photography of finger-prints and on

* The Galton Laboratory, which collects finger-prints of families, finds that an operator can be easily taught to take decipherable finger-prints with a simple pocket apparatus, which it circulates for this purpose.

† Quite good impressions can be made with bird lime and candle black, specimens in *Galtoniana*.

methods of enlarging them. In the *Galtoniana* we have still his special camera for enlarging finger-prints (see our p. 215), his much enlarged series of finger-prints used for fine classification (reproduced for this work, and to be found in a pocket at the end of this volume) and the watchmaker's glass mounted on a stand for directly examining them*.

Chapter IV (pp. 54-63) deals with *The Ridges and their Use*. Galton starts with the ridges of the palm of the hand, and indicates that they are not very closely related to the "creases," so that the latter cannot be the cause of the former. He also refers to the ridges on the soles and toes, but ultimately confines his attention to those on the fingers. Here he defines two important terms: first, *Minutiae*, which are the minute peculiarities characterising an individual ridge. A ridge may divide into two or unite with another (see Fig. 31, *a* and *b*), or it may divide and almost immediately



Characteristic Peculiarities in Ridges.
(about 8 times the natural size)

Fig. 31.

reunite, enclosing a small circular or elliptic space (*c*); at other times it may begin or end abruptly (*d* and *e*); or lastly the ridge may be so short as to form a small island (*f*). Secondly, *Patterns*: whenever an interspace is left between the boundaries of different systems of ridges, it is filled by a small system of its own which will have some characteristic shape. This shape is termed a *pattern* (see Figs. 20, 21 on our pp. 162, 163). The descriptions of *minutiae* and of patterns belonging to an individual are of special value for the purposes of identification.

On the whole there is little known of the origin and use of the ridges, beyond the fact that they carry the sweat pores. Nor is their origin or use of much importance for the purpose of identification provided we can be assured of their persistency during life. Titchener, as I have noted (p. 168), made, at the suggestion of Galton, a series of experiments with the aesthesiometer, and proved that the fineness or coarseness of the ridges in different persons had no effect whatever on the delicacy of their tactile discrimination.

* This finger-print glass appears in Furse's painting of Galton; see the Frontispiece to Vol. I. It is worth noting that Galton selected this piece of apparatus as the most characteristic of his many activities.

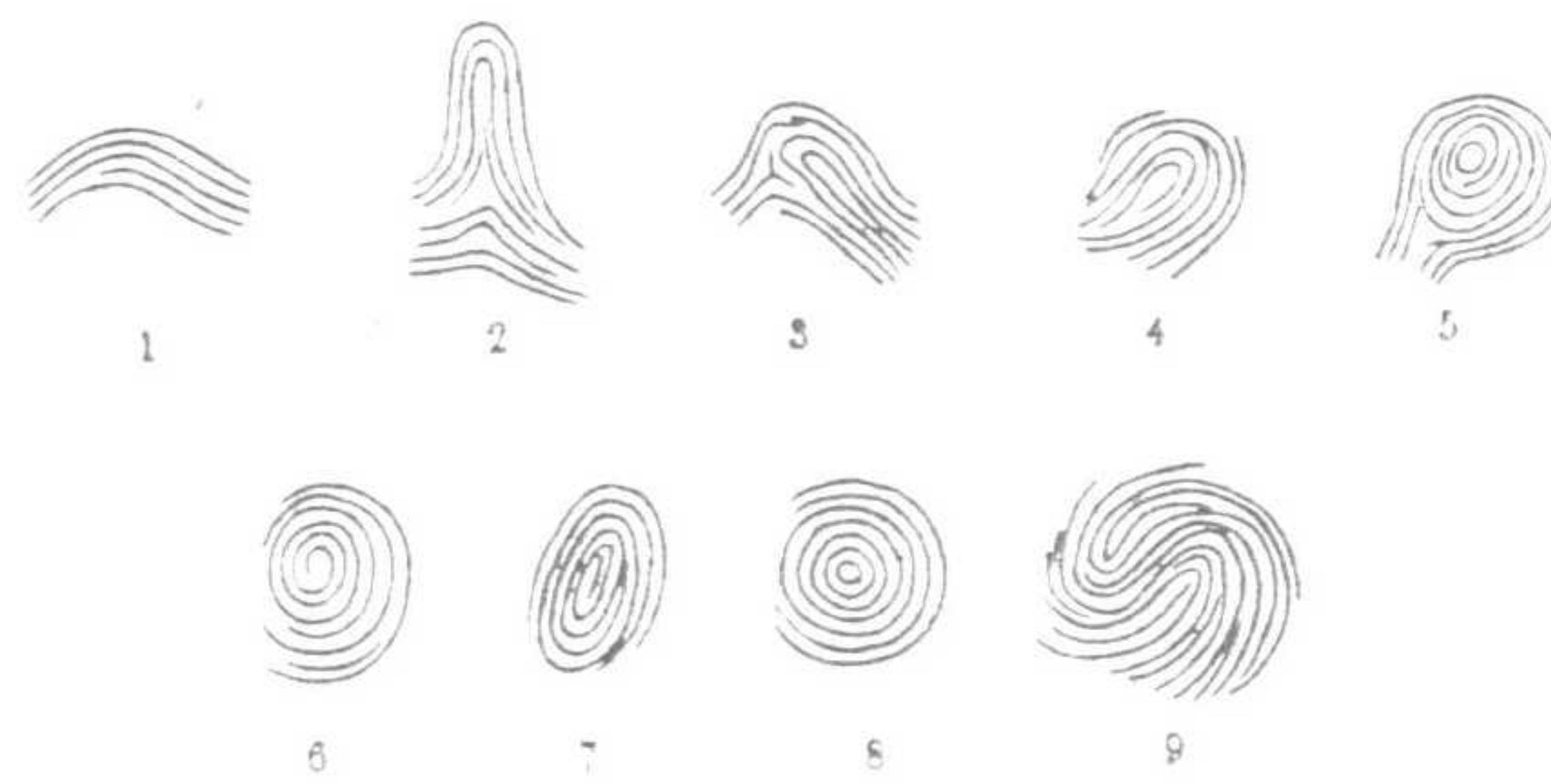
PLATE IX

THE STANDARD PATTERNS OF PURKENJE



Reproduced *de novo* from the copy of Purkenje's *Commentatio* in the Library of the Royal College of Surgeons.

THE CORES OF THE ABOVE PATTERNS.



Galton's Patterns from Purkenje's Types.

Also he found it made no difference whether one or both points of the compass rested on the ridges or in the furrows. Nor again was the width of the ridge interval any test of the relative power of discrimination of the different parts of the same hand (p. 62). Galton himself suggests that the ridges may serve the purpose of enabling us to judge the relative roughness of surfaces by touch, and so to determine their nature. If a blindfold person be asked to determine an object by touch, he will be observed to rub the surface with his finger.

"The ridges engage themselves with the roughness of the surface, and greatly help in calling forth the required sensation, which is that of a thrill; usually faint, but always to be perceived when the sensation is analysed, and which becomes very distinct when the indentations are at equal distances apart as in a file or in velvet. A thrill is analogous to a musical note, and the characteristics to the sense of touch, of different surfaces when they are rubbed by the fingers, may be compared to different qualities of sound or noise. There are, however, no pure overtones in the case of touch, as there are in nearly all sounds." (p. 63.)

I should be glad to have the experience of any of my readers on this point. I wonder if this thrill is universal; personally I am unable to associate even uniform roughness of a touched surface with anything of the nature of a thrill. Two other men were like myself. Of three women tested one had no sensation of thrill, a second failed with file and a stiff brush, but was doubtful in the case of velvet; the third felt a thrill—chill in the spine—on rubbing with the finger-tip file, velvet or brush.

Chapter V (pp. 64–88) is entitled *Patterns: their Outlines and Cores*. Galton opens this chapter by referring to Purkenje's types*, and states that he had entirely failed on trial to classify prints by mere inspection and the use of Purkenje's types. He had accordingly devised his method of "outlining" the pattern in order to classify it. He took as material for his classification 504 prints of right thumbs *enlarged* two and a half times their natural size, so

* Galton (pp. 85–88 of this chapter) provides a translation of the portion of Purkenje's *Commentatio* which deals with types, and also a plate of Purkenje's nine types, accompanied by Galton's own outlining of the cores. Purkenje's nine types are the following: (i) *Transverse Flexures* = Galton's "primaries." In the course of his description Purkenje used the word "arch." I think this must have led Galton to replace his term "primary" of 1890 by "arch" of 1892. (ii) *Central Longitudinal Stria* = Galton's "tent ed arch." (iii) *Oblique Stria* = (I think) Galton's "nascent loop." (iv) *Oblique Sinus* = Galton's "plain loop." (v) *Almond* = (I think) "circlet in loop," a sub-type of Galton's "whorl" (see his Plate 8, No. 22). (vi) *Spiral* = Galton's "whorl," sub-type "spiro-whorl" (see his Plate 8, No. 26). (vii) *Ellipse*, or *Elliptic whorl* = Galton's "whorl" (ellipses). (viii) *Circle*, or *Circular Whorl* = Galton's "whorl" (circles). (ix) *Double Whorl* = Galton's "whorl" ("duplex spiral"), see his Plate 8, No. 29. The reader who attempts to classify prints by Purkenje's nine classes will soon find, if he follows Purkenje's rather elaborate descriptions, that they exclude many frequently occurring cases. His definitions are indeed not broad enough to embrace the innumerable variations which arise. It is perhaps worth noting that Purkenje under the definition (vi) of "Spiral" introduces the word "composite" but not in its modern sense to denote a compound of two patterns, but for a spiral made up not of a single line, but of two or more lines proceeding from the single focus or pole. I imagine Galton would have called Purkenje's "composite spiral" a "whorl," sub-type "twist" (see Plate 8, No. 52 and Plate 16, Nos. 36, 37, where, however, no name is provided). Purkenje does not figure his "composite." He refers to the "small triangles," Galton's "plots," "deltas" or "islands," under his definitions (iv) and (vi). This footnote will suffice to indicate the extent to which Purkenje anticipated Galton in matters of nomenclature. See also our Plate IX.

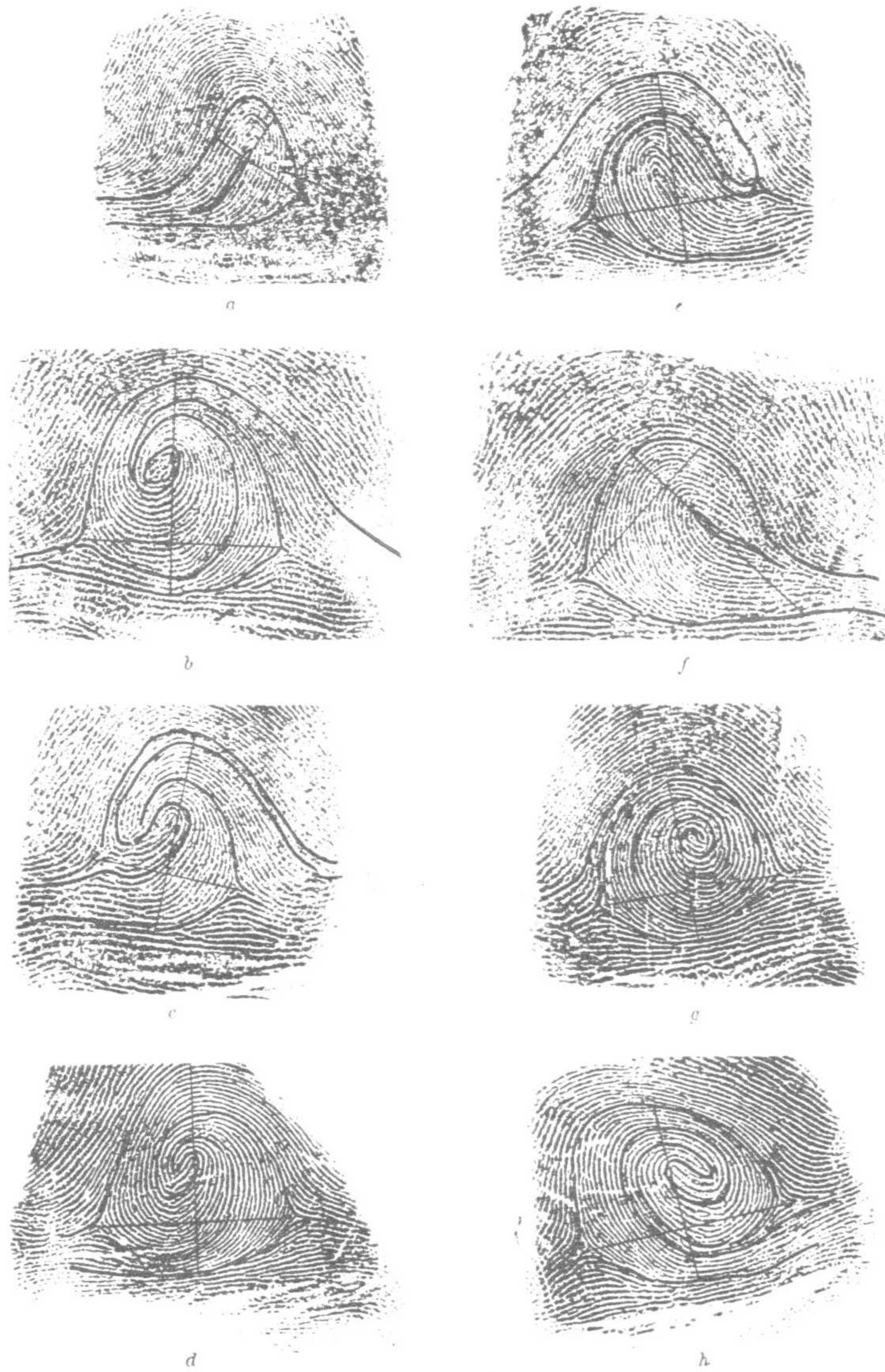
that each print was about playing card size. Galton found that on repeated trials he did not, by inspection only, deal these out into the same classes. The same failure occurred when he selected standard types and endeavoured to sort into groups by aid of these. Mere judgment by the unaided eye is liable to be influenced by the intensity of inking of some ridges; two prints will not always give the same extent of pattern. "A third cause of error is still more serious; it is that patterns, especially those of a spiral form, may be apparently similar yet fundamentally unlike, the unaided eye being frequently unable to analyse them and to discern real differences" (p. 66). Accordingly Galton introduced his system of "outlining" the pattern. To this we have already referred in discussing his *Phil. Trans.* memoir (see our p. 164). His Plate 5, here reproduced as our Plate X, shows samples of outlined patterns. Whether it is needful for an expert *always* to outline is another question, but to become an expert in classification, it is undoubtedly necessary to gain experience in grouping by outlining, even if the classification is only to be in the broadest categories. The chief reason for this is that the existing classification schemes are in truth largely artificial. There is really no generic difference between a "tented arch" and a "tented loop," or between an "eyeletted loop" and a "small spiral in loop" which Galton reckons a whorl. There are numerous such cases where the classification can only be by arbitrary standardisation. We reproduce as our Plates XI, XII and XIII Galton's Plates 7, 8 and 6 which will aid any reader desirous of learning to classify by outlines; yet even then he will undoubtedly find rare patterns, which he can only hope to thrust into a miscellaneous group of "composites." Galton's Plates 9 and 10 (see our Plates XIV and XV) give threefold enlargements of troublesome transitional patterns, the first between arches and loops and the second between loops and whorls. The beginner should attempt to classify them, and then compare his results with Galton's views on pp. 79-80.

ARCHES		RINGS		DUPLEX SPIRALS	
from both sides		from neither side		from both sides	
<i>I</i> and <i>O</i> both absent.		<i>I</i> and <i>O</i> both present		upper supply from	
				<i>I</i> side	<i>O</i> side
<i>ij</i> 	<i>ij</i> 	<i>ij</i> 	<i>io</i> 	<i>io</i> 	
I. Inner or Radial side				O. Outer or Ulnar side	
SPIRALS		LOOPS		SPIRALS	
from <i>I</i> side		from <i>I</i> side	from <i>O</i> side	from <i>O</i> side	
above	below	<i>I</i> absent	<i>O</i> absent	above	below
<i>oj</i> 	<i>jo</i> 	<i>oo</i> 	<i>ii</i> 	<i>ij</i> 	<i>ji</i>

Fig. 32. It is necessary to suppose the finger-prints are from the *right* hand.

On pp. 80-81 Galton repeats the classification of his *Phil. Trans.*

Examples of the outlining of Patterns to assist Classification.

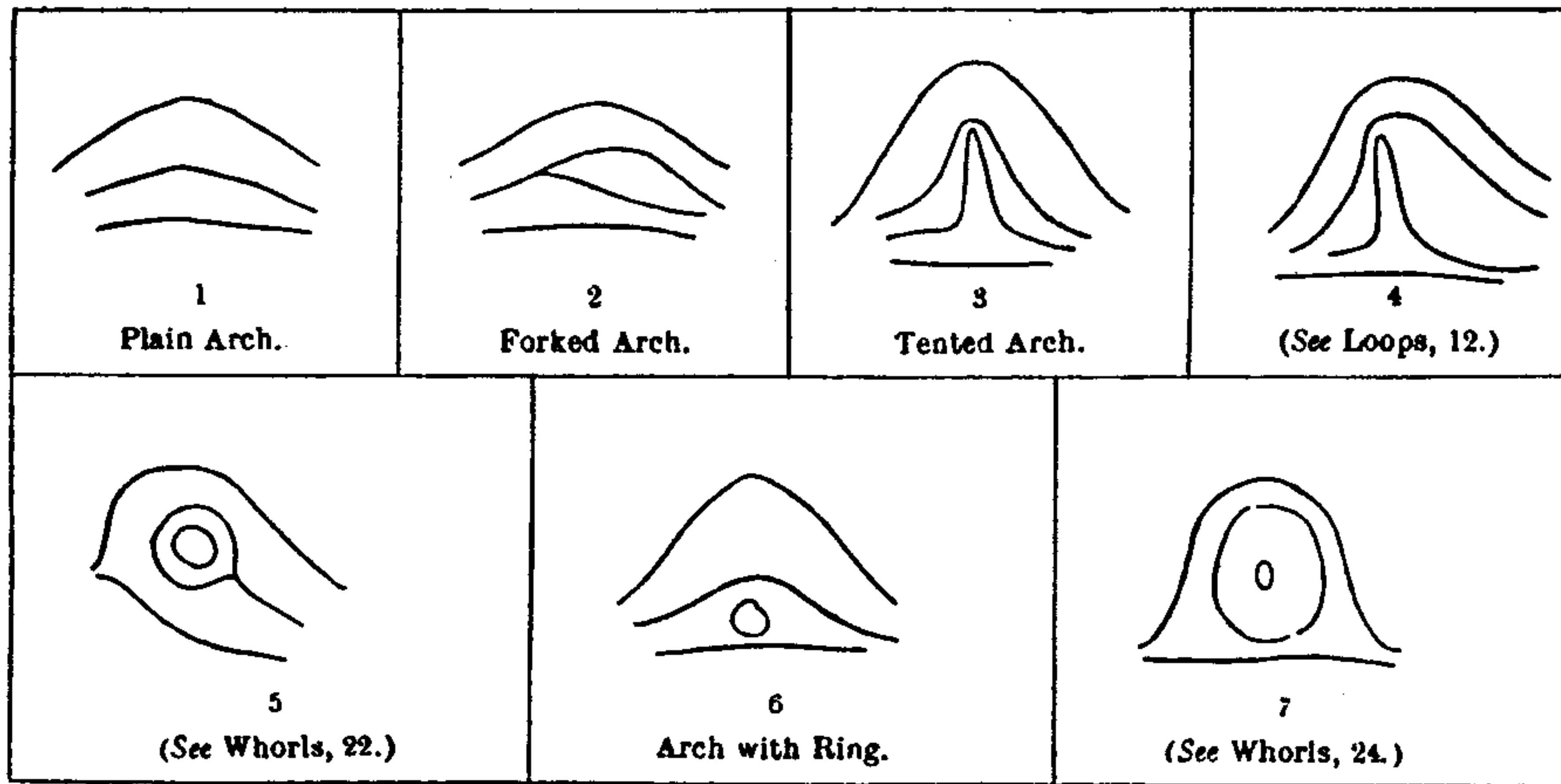


The specimens are *rolled* impressions of natural size. Galton was the first writer on the subject to introduce "rolling." All impressions are now rolled. *a* and *f* are loops; *b*, *c*, *d*, *e*, *g* and *h* are various types of whorls. *Finger Prints*, Plate 5.

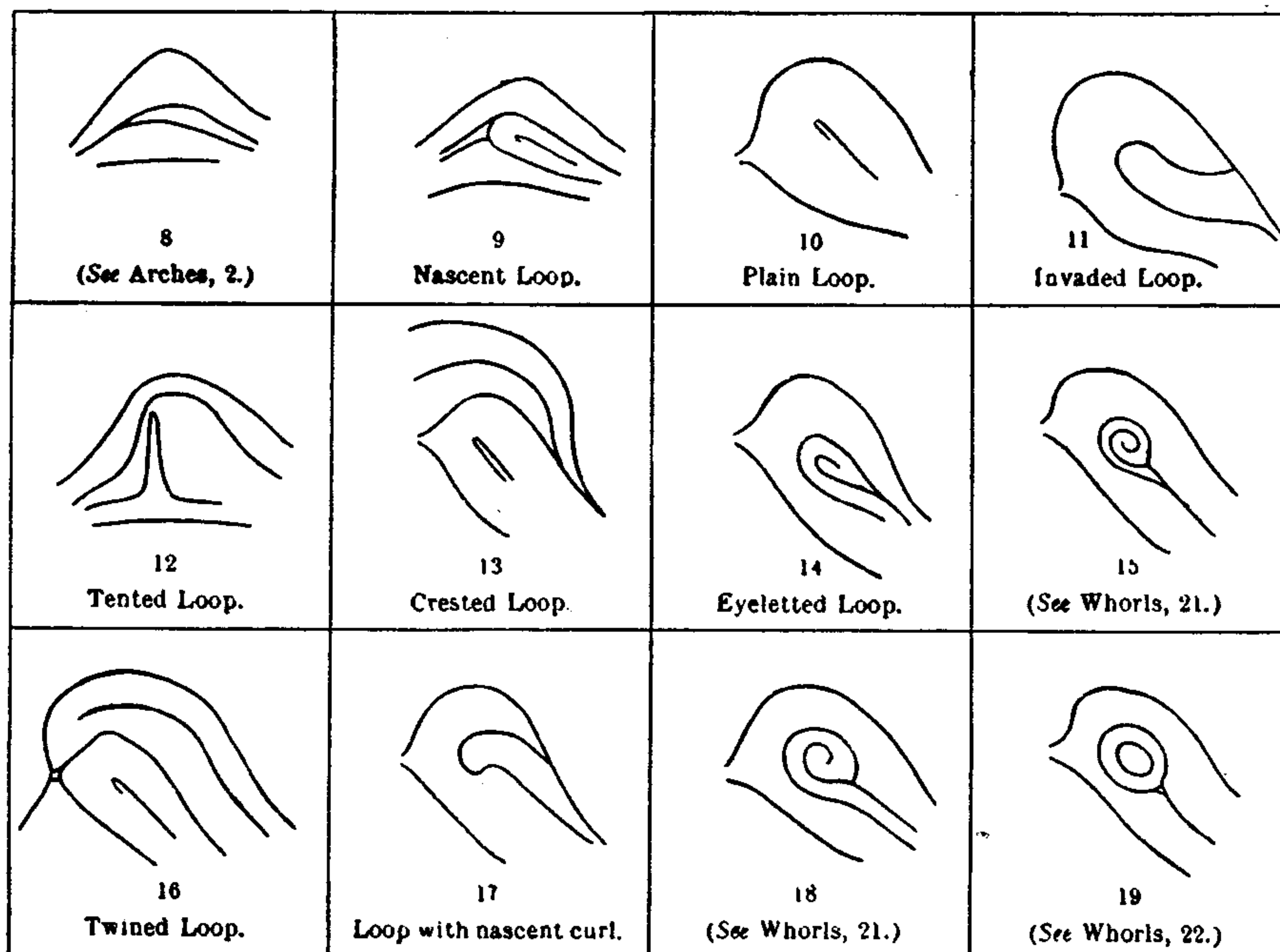
PLATE XI

Outlines of Patterns in Arches and Loops.

ARCHES.



LOOPS.



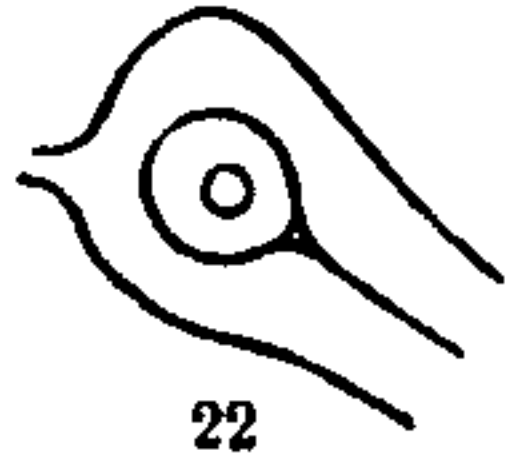

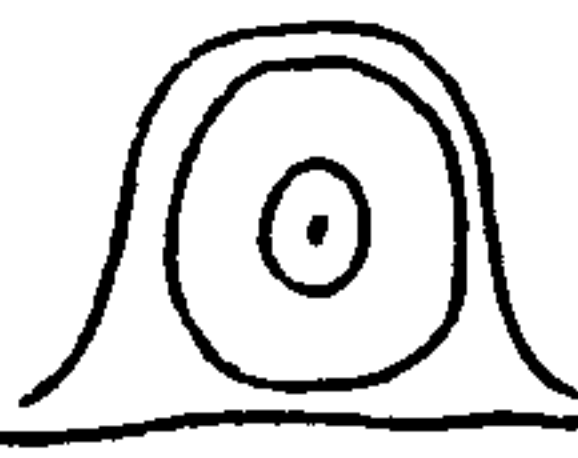





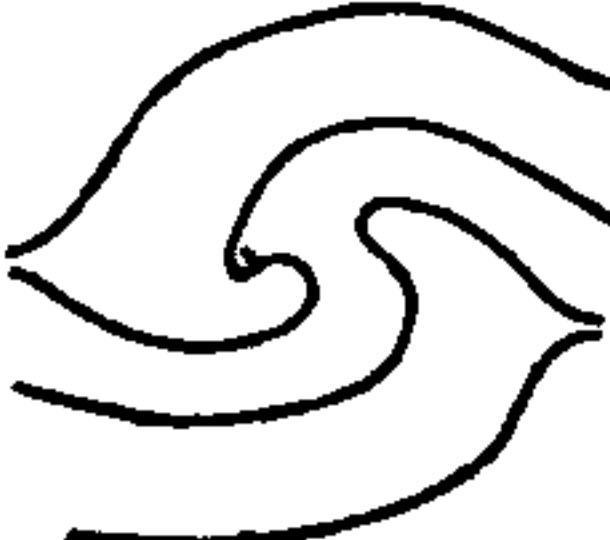


Galton's nomenclature as aids to description and classification. Arches and Loops.
From Galton's *Finger Prints*, Plate 7.

PLATE XII

Outlines to Patterns in Whorls. Types of Cores.

WHORLS.

 20 Small Spiral in Loop.	 21 Spiral in Loop.	 22 Circlet in Loop.	 23 Ring in Loop.
 24 Rings.	 25 Ellipses.	 26 Spiro-rings.	
 27 Simple Spiral.	 28 Nascent Duplex Spiral.	 29 Duplex Spiral.	 30 Banded Duplex Spiral.

CORES TO LOOPS.

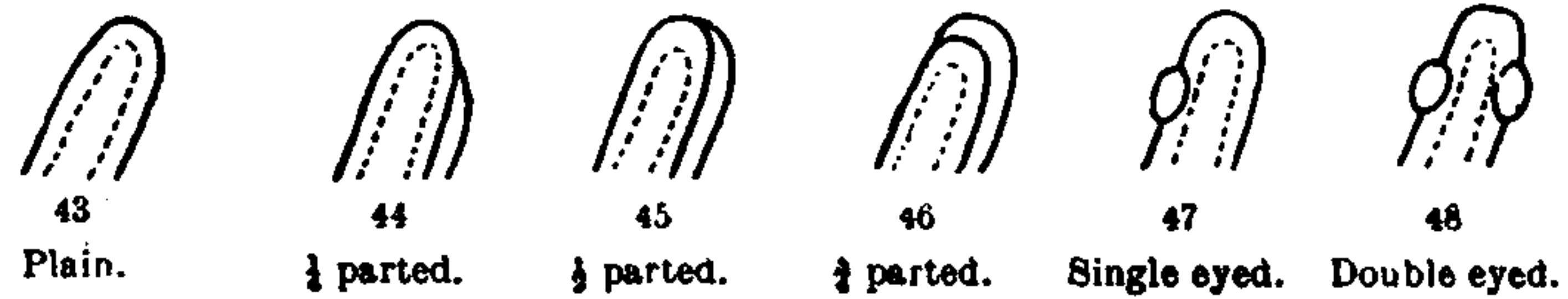
Rods:—their envelopes are indicated by dots.



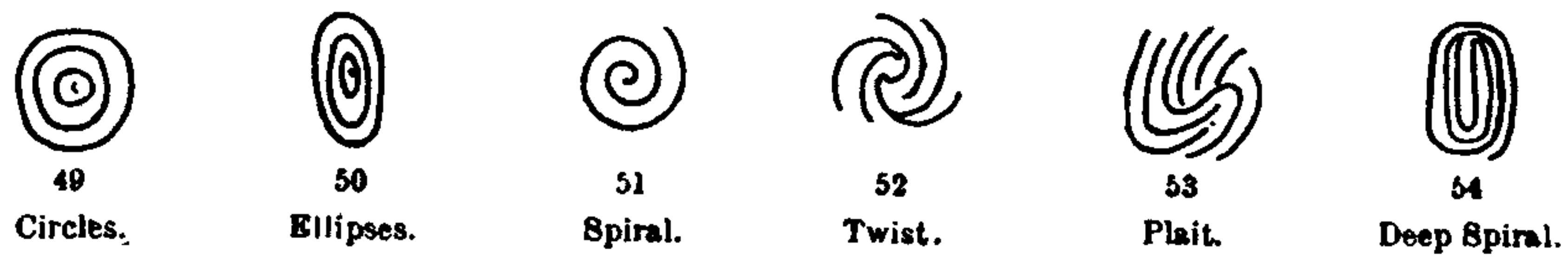
Staples:—their envelopes are indicated by dots.



Envelopes whether to Rods or Staples:—here staples only are dotted.



CORES TO WHORLS.



Galton's nomenclature as aids to description and classification.
 From Galton's *Finger Prints*, Plate 8.

OUTLINES OF THE PATTERNS OF THE DIGITS OF EIGHT PERSONS, TAKEN AT RANDOM.

Left Hand

	Little Finger.	Ring Finger.	Middle Finger.	Fore Finger.	Thumb.
1					
2					
3					
4					
5					
6					
7					
8					

Right Hand

Thumb.	Fore Finger.	Middle Finger.	Ring Finger.	Little Finger.

Ridges from inner (or radial) side have vertical hatching, from outer (or ulnar) side have horizontal hatching.

After Galton's *Finger Prints*, Plate 6.

PLATE XIV

Transitional Patterns—Arches and Loops.



(Enlarged three times)

Transitional Patterns from Galton's *Finger Prints*, Plate 9, with suggested symbols. The prints are supposed to be of left-hand fingers.

Transitional Patterns—Loops and Whorls.



(Enlarged three times)

Transitional Patterns from Galton's *Finger Prints*, Plate 10, with suggested symbols. The prints are supposed to be of left-hand fingers.

memoir (see our p. 164). Unfortunately he uses the letter *j* throughout his Plate 11 (our Fig. 32) for what he terms *u* in the text.

“The divergent ridges that bound any simple pattern admit of nine, and only nine, distinct variations in the first part of their course. The bounding ridge that has attained the summit of any such pattern must have arrived either from the Inner plot (*I*) [radial delta], the Outer plot [ulnar delta], or from both. Similarly as regards the bounding ridge that lies at the lowest point of the pattern. Any one of the three former events may occur in connection with any of the three latter events, so that they afford in all 3×3 , or nine possible combinations. It is convenient to distinguish them by easily intelligible symbols. Thus, let *i* signify a bounding line which starts from the point *I*, whether it proceeds to the summit or to the base of the pattern; let *o* be a line that similarly proceeds from *O*, and let *j* be a line that unites the two plots [deltas] *I* and *O* either by summit or by base. Again let two symbols be used, of which the first shall always refer to the summit, and the second to the base of the pattern. Then the nine possible cases are *jj*, *ji*, *jo*; *ij*, *ii*, *io*; *oj*, *oi*, *oo*. The case of the arches is peculiar, but they may be fairly classed under the symbol *jj*.” *Finger Prints*, pp. 80–81, with *j* as in figure replacing *u* of Galton’s own text.

Galton next refers to measurements on the print and states that the average ridge interval should be taken as unit of measurement for comparative

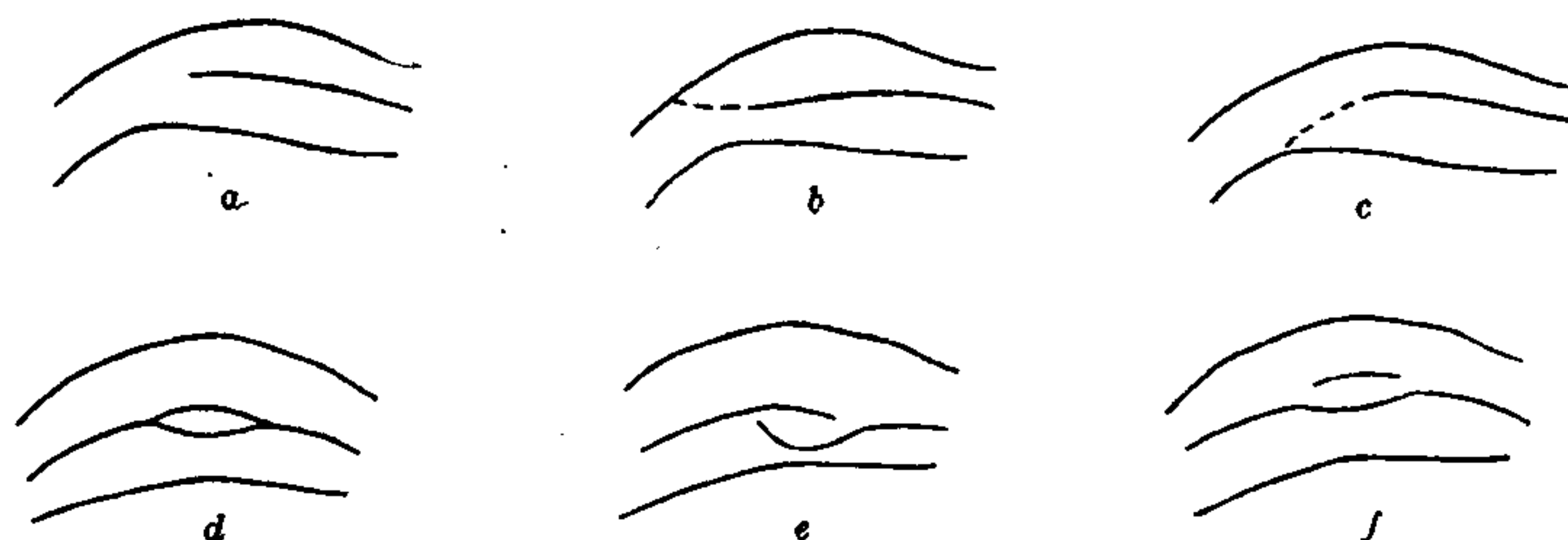


Fig. 33. Illustrations of Ambiguities in *minutiae*, *a* may appear as *b* or *c*, *d* as *e* or *f*.

purposes, especially where prints of non-adults are concerned. Plate 11 (our Fig. 33) gives illustrations of ambiguities in *minutiae* to which we have previously referred (see our p. 165).

Chapter VI (pp. 89–99) deals with *Persistence*. It is an extension of the evidence partially given in the *Phil. Trans.* memoir (see our p. 166 and Plates VII and VIII). Galton has here studied between twenty and thirty different digits and compared *minutiae* to the number of 700 (p. 96) and only found the one discrepancy to which reference has already been made (see last lines on our p. 166). We reproduce Galton’s Plates 13 and 14 (our Plates XVI and XVII) as an illustration of his methods of comparing *minutiae*, and of the periods for which persistency was demonstrated. Galton again emphasises that it is in the *minutiae*, not in the measurements of the pattern, that persistency lies (p. 98). After indicating that for the four periods of life there is no change, and that we may expect in 700 *minutiae* only one to fail us, Galton continues:

“Neither can there be any change after death, up to the time when the skin perishes through decomposition; for example, the marks on the fingers of many Egyptian mummies, and on the paws of stuffed monkeys, still remain legible. Very good evidence and careful inquiry is thus seen to justify the popular idea of the persistence of finger markings, that has hitherto been too rashly jumped at, and which wrongly ascribed the persistence to the general appearance of the pattern, rather than to the *minutiae* it contains. There appear to be no external bodily characteristics, other than deep scars and tattoo marks, comparable in their persistence to these

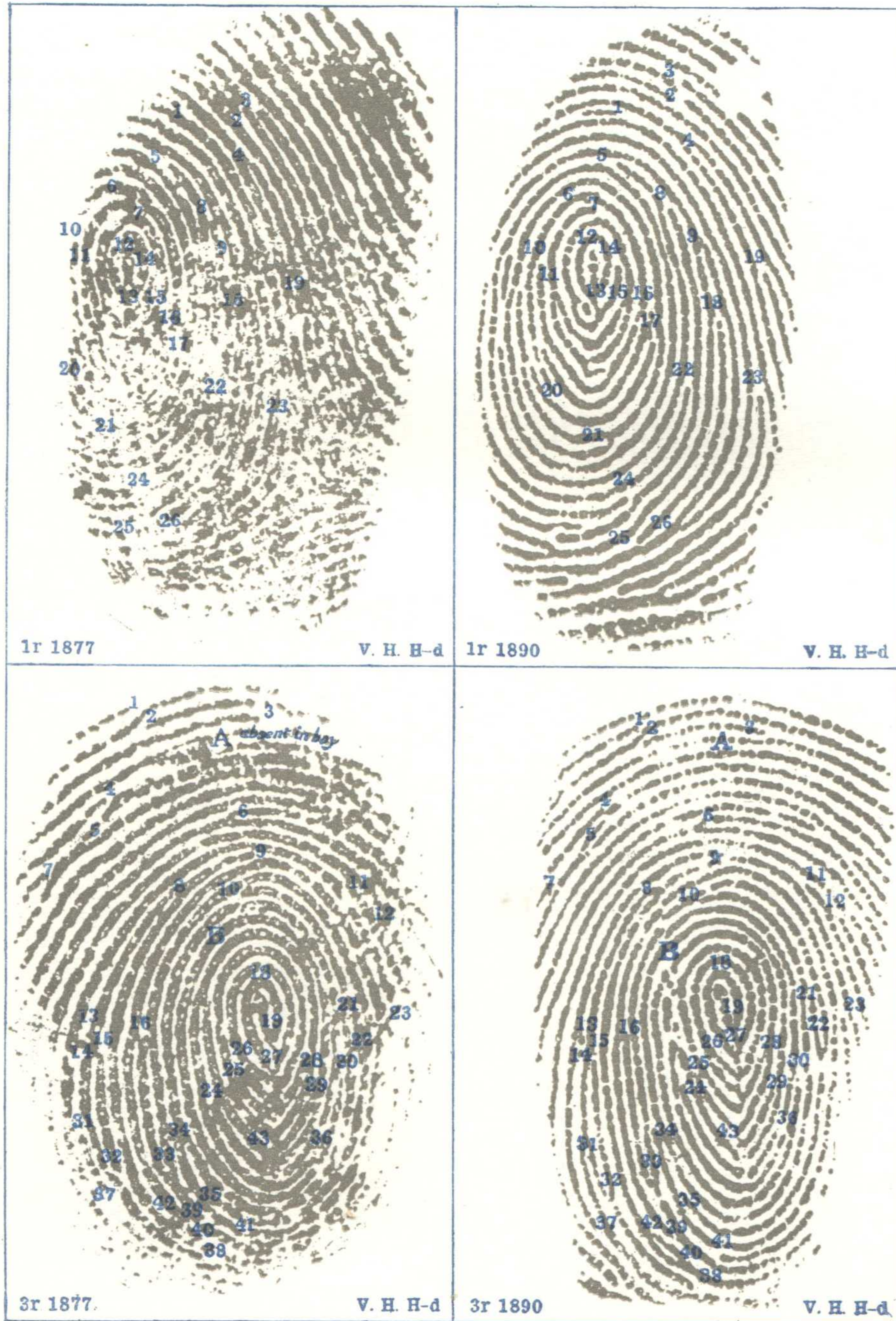
markings, whether they be on the finger, on other parts of the palmar surface of the hand, or on the sole of the foot. At the same time they are out of all proportion more numerous than any other measurable feature; about thirty-five of them are situated on the bulb of each of the ten digits, in addition to more than 100 on the ball of the thumb, which is not one-fifth of the superficies of the rest of the palmar surface. The total number of points suitable for comparison on the two hands must therefore be not less than one thousand and nearer to two; an estimate which I verified by a rough count on my own hand; similarly in respect of the feet. The dimensions of the limbs and body alter in the course of growth and decay; the colour, quantity and quality of the hair, the tint and quality of the skin, the number and set of the teeth, the expression of the features, the gestures, the handwriting, even the eye colour, change after many years. There seems no persistence in the visible parts of the body, except in these minute and hitherto too much disregarded ridges." (pp. 97-8.)

Chapter VII (pp. 100-113) is entitled *Evidential Value*. Its object is to give an approximate numerical idea of the value of finger-prints as a measure of Personal Identification. Galton's method is a somewhat elaborate one. If we take a square of one ridge interval, and place this on our finger-print, we can almost certainly draw on its surface correctly the ridge or ridges which lie behind it. When we take an opaque square of side 6-ridge intervals, and fasten this blank square to the finger-print and then reconstruct the system of ridges which lies behind it we are rather more often wrong than right in our reconstructed ridges. Galton thinks that a square of 5-ridge intervals would probably allow reconstruction as often right as wrong. He made two series of experiments of this character, with the enlargements double and sixfold. Then he made a twentyfold enlargement, and placed upon it a chequerboard arrangement of 6-ridge interval squares; he reconstructed the whole finger-print, each square from the four adjacent ones, which bordered the unseen square. There were in this case seven rightly and sixteen wrongly constructed. He now makes a rather drastic assumption "that any one of these reconstructions represents lineations that might have occurred in Nature, in association with the conditions outside the square, just as well as the lineations of the actual finger-print (p. 107). . . . It therefore seems right to look upon the squares as independent variables, in the sense that when the surrounding conditions are alone taken into account, the ridges may either run in the observed way or in a different way, the chance of these two contrasted events being taken (for safety's sake) as approximately equal." (p. 108.)

There being about 24 6-ridge interval squares in any finger-print, Galton makes $1/2^{24}$ to be the chance of the actual system of ridges appearing. He now proceeds to give a rough approximation to two other chances, which he considers to be involved: the first concerns guessing correctly the general course of the ridges adjacent to each square, and the second of guessing rightly the number of ridges that enter and issue from the square. He takes these in round numbers to be $1/2^4$ and $1/2^8$, so that the whole chance of the observed system is $1/2^{36}$. Now the total number of persons in the world has been reckoned at about 16,000,000,000 and the chance of a particular observed arrangement is of the order $1/64,000,000,000$, or the odds are very roughly 39 to 1 against the particular arrangement occurring on a single definite digit of any existing human being*.

* Galton in his own copy has a pencil note "repeat calculations" and corrects the total population of the world which in his text he has made ten times too great. I have corrected the figures in the last paragraph of his p. 110 accordingly.

V. H. H-D æt. 2½ in 1877,
and again as a boy in Nov. 1890.



To illustrate Persistence of Pattern in Finger Prints.
From Galton's *Finger Prints*, Plate 13.

Persistence of Finger-Print Patterns with corresponding *minutiae* like numbered.



Intervals of 9, 9, 26, 28, 28, 30, 31 and 31 years. Galton's illustrations from Herschel's material, *Finger Prints*, Plate 14.

While convinced that the chance of two individuals actually possessing the same finger-print in all its *minutiae* is infinitesimally small—as small as the chance that two woodcutters given the same topic would produce two blocks identical in every line and dot—yet one recognises that Galton's treatment, however ingenious, lacks the power of compelling conviction. Nature probably works more definitely to form a whole pattern than can be mimicked by Galton's 24 "independent variable" squares. He himself writes that

"it is hateful to blunder in calculations of adverse chances, by overlooking correlations between variables, and to falsely assume them to be independent, with the result that inflated estimates are made which require to be proportionately reduced. Here, however, there seems to be little room for such an error." (p. 109.)

It is the last sentence only we would call in question. After all it is the *minutiae*, rather than the pattern, by which identification is determined. Hence we might consider the problem as follows: These *minutiae* are not points, the ridges having a measurable thickness. Let us suppose a ridge-interval square to cover the area within which, if two such *minutiae* occurred in two prints under comparison, we should hold these *minutiae* to be identical in position. Galton's 6-ridge interval squares contain 36 little 1-ridge interval squares, and the chance of a given *minutiae* occurring in one of these is $\frac{1}{36}$, say $\frac{1}{2^5}$ roughly. Now Galton takes 24 such squares to a finger-print, and roughly there are 20 to 30 or even more *minutiae* in a print, say one to each 6-ridge interval square; then the probability that the *minutiae* will be placed each in its right compartment in its 6-ridge interval square is less than $\left(\frac{1}{2^5}\right)^{24}$, i.e. less than $\frac{1}{2^{120}}$. Actually it is considerably less than this because although the *minutiae* do not tend to cluster each one of them is not confined to its own 6-ridge interval square. Further all *minutiae* are not alike, e.g. ridge terminals. I think we may suppose a far more random, that is, less correlated, distribution of *minutiae*, than of parts of a pattern, and still conclude with Galton that it is very unlikely that two persons in the universe have the same print on any digit, as judged by its *minutiae*, still less on all ten digits.

Galton concludes this chapter characteristically as follows:

"We read of the dead body of Jezebel being devoured by the dogs of Jezreel, so that no man might say, 'This is Jezebel,' and that the dogs left only her skull, the palms of her hands, and the soles of her feet; but the palms of the hands and soles of the feet are the very remains by which a corpse might be most surely identified, if impressions of them during life were available." (p. 113.)

Chapter VIII (pp. 114–130) is entitled *Peculiarities of the Digits*. The data Galton uses in this chapter are the prints of the ten digits of 500 different persons. His objects are twofold: (i) to find the association of particular patterns with the individual digits, and (ii) to determine, if a particular digit has a given pattern, what is the chance that any other digit will have the same pattern. In discussion of these problems Galton uses only the triple

classification arch, loop, whorl, and states that by including forked arches and nascent loops (see our Plate XI, p. 181) as arches, he has given a more liberal interpretation to the latter category in the tables of this chapter than he has done elsewhere. His fundamental table is the following:

Percentage Frequency of Arches, Loops and Whorls on the different Digits from Observations on 5000 Digits of 500 Persons.

Digit	Right Hand				Left Hand			
	Arch	Loop	Whorl	Total	Arch	Loop	Whorl	Total
Thumb ...	3	53	44	100	5	65	30	100
Fore Finger	17	53	30	100	17	55	28	100
Middle Finger	7	78	15	100	8	76	16	100
Ring Finger	2	53	45	100	3	66	31	100
Little Finger	1	86	13	100	2	90	8	100
Total ...	30	323	147	500	35	352	113	500
Percentage (Whole Hand)	6	65	29	100	7	70	23	100

From this table the following inferences may be drawn:

The patterns are not distributed indifferently either on the hands or on the individual digits. The right hand has a redundancy of whorls and the left of loops. The Fore Finger and to a lesser extent the Middle Finger have a redundancy of arches, the Little Finger and the Middle Finger a redundancy of loops, while the Thumb, Fore Finger and Ring Finger have the highest number of whorls. When we compare the corresponding digits of the two hands, we see little differentiation of pattern in Fore Finger, Middle Finger or Little Finger, but a more marked difference between the Thumbs and Ring Fingers of the two hands. While in the first group the percentages differ in the three fingers but are the same in the two hands, in the second group they are nearly the same in the two fingers but differ in the two hands (pp. 115-118).

Dealing with the slope of the loop Galton notes that the "inner" slope is much the more rare of the two for all the fingers but the forefingers, where the proportions of inner to outer slopes are about in the ratio of 2 to 3 (39°/ and 61°/)*.

The second problem, that of the resemblance of pattern in different digits, is divided by Galton into two sections, that of the resemblance in the same digits of the two hands, and that of the resemblance of different digits either in the same or different hands. He omits the little fingers because in 86°/ to 90°/ of cases both are loops.

* Purkenje appears to consider that while the inner slope is the more rare, it is actually in the forefingers in excess of the outer.

Percentage of Cases in which the same Class of Pattern occurs in the same Digits of the two Hands (500 Persons).

Couplets of Digits	Arches	Loops	Whorls	Total
Two Thumbs ...	2	48	24	74
Two Fore Fingers ...	9	38	20	67
Two Middle Fingers	3	65	9	77
Two Ring Fingers	2	46	26	74
Mean of Total ...				72

This table as it stands is not very illuminating; take for example the middle fingers, and suppose there was no association of pattern between the same digits of the two hands. Then from the previous table the percentage probability of both being loops would be $100 \times \frac{78}{100} \times \frac{76}{100} = 59.3\%$. Similarly the percentage chances of both being arches and whorls are 0.6% and 2.4% respectively. Accordingly we must conclude that 62% of the observed 77% of coincidences would arise from mere chance, if the patterns were independent; it is the 15% balance which really marks the tendency to resemblance. Galton's second table (p. 120) is as follows:

Percentage of Cases in which the same Class of Pattern occurs in various Couplets of different Digits (500 Persons).

Couplets of Digits	Of Same Hands				Of Opposite Hands			
	Arches	Loops	Whorls	Total	Arches	Loops	Whorls	Total
Thumb and Fore Finger	2	35	16	53	2	33	15	50
Thumb and Middle Finger	1	48	9	58	1	47	8	56
Thumb and Ring Finger	1	40	20	61	1	38	18	57
Fore and Middle Fingers	5	48	12	65	5	46	11	62
Fore and Ring Fingers	2	35	17	54	2	35	17	54
Middle and Ring Fingers	2	50	13	65	2	50	12	64
Means of the Totals ...				59				57

The remarkable part of this table is that no marked change occurs in the percentage of resemblances whether the couplet of digits is from the same or opposite hands.

Of this result Galton writes:

"Though the unanimity of the results is wonderful, they are fairly arrived at, and leave no doubt that the relationship of any one particular digit, whether thumb, fore, middle, ring or little finger, to any other particular digit is the same, whether the two digits are on the same or opposite hands. It would be a most interesting subject of statistical inquiry to ascertain whether the distribution of malformations, or of the various forms of skin disease among the digits, corroborates this unexpected and remarkable result. I am sorry to have no means of undertaking it, being assured on good authority that no adequate collection of the necessary data has yet been published." (p. 122.)

Here again we have to remember that the amount of resemblance is not really measured by the numbers given; they might, as in the previous case, be merely the result of chance. Let us work out how much is due to chance in the case of the thumb and ring finger.

Percentage of Cases in which the same Class of Pattern occurs in Thumb and Ring Finger.

How found	Of Same Hands				Of Opposite Hands			
	Arches	Loops	Whorls	Total	Arches	Loops	Whorls	Total
Observed	1	40	20	61	1	38	18	57
Chance	0	36	15	51	0	35	13	48
Difference	1	4	5	10	1	3	5	9

The numbers remain very close, when we have deducted the resemblances due to chance, but perhaps do not look so impressive. Only about one-sixth of the resemblances in both cases can be attributed to the organic relationship.

Galton, on pp. 122–129, discusses a somewhat unusual method of determining the degree of association between the patterns on any two digits. To illustrate it let us take loops on the ring fingers of left and right hands. These occur in 66% and 53% of cases. Or, the chance of a loop is—if the results were independent— $100 \times \frac{66}{100} \times \frac{53}{100} = 35\%$ nearly. The maximum possible number of loops common to the two fingers is 53% and the actually observed number is 46%. We have then the three numbers 35, 46 and 53. Galton takes the first as a zero relationship and the last as a perfect relationship, which is represented by him as 100°. On the scale in which 35 represents 0° and 53, 100°, we must have $46 = \frac{46-35}{53-35} 100^\circ = \frac{11}{18} 100^\circ = 61^\circ$. He gives a table for these grades of association on p. 129 between digits of the same and of different hands. According to this table the highest relationship is between whorls on the middle and ring fingers (74°) and the lowest between loops on fore and ring fingers (13°). Galton is himself somewhat doubtful as to this method of measuring association, and I have not accordingly reproduced his full table (p. 129).

In Chapter IX (pp. 131–146) Galton deals with *Methods of Indexing*. It does not carry us far beyond the *Royal Society Proceedings* paper (see our pp. 170–174). In his main method Galton breaks up only the loops on the forefingers into “inner” and “outer.”* He represents these by *i* and *o*. Thus five symbols are used: *a* = arch, *l* = loop, *w* = whorl, and *i* = inner loop on forefinger, *o* = outer loop on forefinger. He breaks his ten-letter index into four groups†, i.e. R. hand, fore, middle and ring fingers; L. hand, fore, middle

* The reader must remember that the finger-print is *reversed*, and not be surprised at Galton labelling “inner” what appears to the reader, looking at his hand, as an “outer” slope.

† The reason for this has already been referred to (see our p. 184), namely, the greater variety in the types of forefinger prints.

and ring fingers; R. hand, thumb and little finger; and finally L. hand, thumb and little finger. Thus Galton's own index formula (see his prints on our p. 138) is *wlw, oll, wl, wl*. He indexes 100 individuals in this manner. On the basis of 500 sets of digits he gives the frequency per cent. of all index-headings which occur more often than 1%. The worst of these is *oll, oll, ll, ll*, which occurs in 4% of occurrences. Thus, if we were dealing with 100,000 cases, we might have to search among 4000 individuals with this index-heading. The rapid fall in the number of entries having only a single individual is evidenced by the following returns which Galton gives on his p. 141:

Total Number of Entries ...	100	300	500
Percentage of Entries which are the sole members of their class	63.0	49.0	39.8

When we come therefore to indices which embrace 50,000 to 100,000 individuals, it will be seen that it may be needful to go through a large number of the cards on the *o, i, a, l, w* system of indexing before we identify a given individual. Thus even with the use of inner and outer loops on the forefingers, the great frequency of loops renders this system cumbersome for large finger-print collections. I do not think that Galton in 1892, although he suggests (p. 145) counting approximately the ridges, saw his way clearly out of this difficulty of loop redundancy. Possibly he did not fully realise the difference between his small collections and those of a national index of criminals.

In this chapter Galton describes the form of card he used for printing and his manner of storing such cards (p. 145).

Chapter X is entitled *Personal Identification*. This chapter contains much of general interest, which, however, we can only afford space to summarise briefly here. After referring to the ease with which any printer could take finger-impressions Galton again emphasises the suitability of the photographer for this work (see our p. 155), as not only can he easily enlarge prints, but he keeps an index to his negatives. Galton then passes to the many purposes for which identification is not only desirable but necessary. He cites some very interesting remarks (pp. 150-152) of Major Ferris, of the Indian Staff Corps, who, ignorant of Herschel's work, had found the same series of difficulties in identification and who had seen with much appreciation the finger-print method of identification at work in Galton's Laboratory—even as Sir E. R. Henry did later.

In the next place Galton gives on the whole a favourable account of bertillonage (pp. 154-158), questioning, however, the statements made as to the *independence* of the characters measured; Bertillon had asserted without demonstrating this *independence*. Galton shows from data of a similar kind drawn from his own Anthropometric Laboratory that such variables are *not* independent. Starting with five characters, head length, head breadth, span, sitting height, and middle-finger length, he shows that 167 out of 500 persons

measured fall into classes in which there are 7 to 24 repetitions*. But even the group of 24 individuals could be separated out by taking finer divisions of the head measurements than the three classes and introducing seven eye-colour classes. I think Galton was not unnaturally critical of bertillonage, because it started by theoretically asserting the independence of measurements which he knew to be *correlated*†; it did in fact overlook one of his greatest discoveries, the quantitative measurement of the correlation of bodily measurements. Nevertheless Galton is fair to the *results* of the system:

“It would appear from these and other data, that a purely anthropometric classification, irrespective of bodily marks and photographs, would enable an expert to deal with registers of considerable size...it seems probable that with comparatively few exceptions, *at least* two thousand adults of the same sex might be individualised, merely by means of twelve careful measures, on the Bertillon system, making reasonable allowances for that small change of proportions that occurs after a lapse of a few years, and for inaccuracies of measurement. This estimate may be far below the truth, but more cannot be safely inferred from the above very limited experiment.” (p. 163.)

It may be remarked that Bertillon does not appear to have made even such a limited experiment before he started his vast collection on the basis of his “independence” dogma!

Some account is then given of an American system of identification in the case of recruits and deserters. It seems to be based on height, age (how judged?), hair and eye colours for indexing purposes and then on a careful record of the body-marks placed on outline figures. Body-marks form of course an important factor of bertillonage (pp. 164–5). Galton remarks that no system he knows of appears to take account of the teeth. If teeth are absent when a man is first examined, they will be absent when he is examined a second time. He may have lost others in addition, but the fact of his having lost certain specified teeth prevents his being mistaken for a man who still possesses them (p. 166).

M. Herbette, speaking at the International Prison Congress in Rome, remarked of bertillonage:

“In one word, to fix the human personality, to give to each human being an identity, an individuality which can be depended upon with certainty, lasting, unchangeable, always recognisable and easily adduced, this appears to be in the largest sense the aim of the new method.”

Galton fitly remarks that these perspicacious words are even more applicable to the method of finger-prints than to that of anthropometry. Bertillonage can rarely supply more than grounds for very strong suspicion, finger-prints alone are amply sufficient to produce absolute conviction of identity.

Number of Repetitions	7	8	9	10	11	14	19	24
Number of Individuals	28	8	18	20	22	28	19	24

† Some of the Bertillon measurements are indeed *highly* correlated. See Macdonell, *Biometrika*, Vol. I, pp 202, 212.

Chapter XI (pp. 170–191) discusses the subject of *Heredity* in finger-prints. This is a most difficult problem; it is not only that certain fingers favour certain classes of patterns, but that certain patterns classed in different broad groups are closely associated with each other. If we classify merely in arches, loops and whorls, we may find two kinsmen who have really kindred patterns, e.g. one having a plain arch and the other a nascent loop, classified as being as widely apart, as if the one had shown a tented arch and the other a twined loop. Again, supposing an extremely rare pattern occurs on the ring finger of one kinsman, and on the forefinger of the second, are we to dismiss this from our consideration of hereditary resemblance? It is almost inconceivable that a mere Arch-Loop-Whorl classification, especially if confined to a few fingers, can provide a true measure of inheritance although it may demonstrate that heredity is a factor of finger-print determination. Galton, in his first series of observations, confines himself to the fraternal relationship (boys and girls) of 105 pairs, dealing with right hand forefinger only and using the simple Arch-Loop-Whorl system. As we have remarked, this may show the existence of heredity, but it cannot really measure its intensity. He obtains the following table:

Observed Fraternal Couplets.

First Child

Second Child	Arch	Loop	Whorl	Total
Arch	5 (1.7) [10]	12	2	19
Loop	4	42 (37.6) [61]	15	61
Whorl	1	14	10 (6.2) [25]	25
Total	10	68	27	105

Galton then pays attention only to the numbers occurring in the diagonal column, i.e. identical prints in the fraternal couplet with the Arch-Loop-Whorl classification. The numbers in round brackets are what are to be randomly expected, the numbers in square brackets, the highest values attainable for resemblance, on the hypothesis of independence of the marginal totals. In every case the observed values lie between the random and the highest values and Galton takes this as evidence of heredity.

It will be seen that Galton is here aiming if rather ineffectually at some process like the modern method of contingency. If we apply now his method of centesimal grades we find for the degree of resemblance:

Arches: 39.8°; Loops: 18.8°; Whorls: 20.2°.

Of these the last two are probably equal within the error of random sampling. The first shows about double the relationship of the other two. I do not believe this is due to a greater intensity of the force of heredity in arches than loops, but solely to the fact that arches form a relatively rare and homogeneous group, while loops and whorls are conglomerates and the use of

these terms tends to obscure finer resemblances. This peculiarity of the loops recurs in further investigations made by Galton with the aid of Howard Collins, and the former writes:

“I am unable to account for this curious behaviour of the loops, which can hardly be due to statistical accident, in the face of so much concurrent evidence.” (p. 185.)

But I think the explanation lies in the fact that resemblance is lost when a very broad category such as “loops” is taken.

Galton, however, did see the difficulties of the Arch-Loop-Whorl classification, though not as far as I can judge of the limitation due to “corresponding finger.” He accordingly prepared a set of 53 standard patterns, of which 46 are in pairs for “inner” and “outer,” i.e. each pair is a mirror reversal. They are for the right hand, and the numbers of each pair of the last 46 must be reversed when we deal with the left hand. He calls this the “*C*-set of Standard Patterns,” as Mr Howard Collins performed most of the tabulation under the *C*-set of patterns. The data consisted of right fore, middle and ring fingers in 150 couplets of siblings*, 900 digits in all. Unluckily the “*C*-set of Standard Patterns” is in one, the most important, respect almost as defective as the Arch-Loop-Whorl classification. While in the former treatment 129 out of 210 finger-prints fell into the loop category here 291 out of 900 finger-prints fall under the pattern No. 42, which is practically the simple loop; it is clear that this standard set of 53 patterns has failed to meet the inherent difficulty of breaking up the bulk of the loops.

Our author proceeds in the same way to deal only with complete resemblances, i.e. he deals only with the diagonal of his contingency table, disregarding the possibility that a deficiency below the random value may be as important in measuring association as an excess above that value. Comparing in this way random values, observed values and maximum possible values, and applying his method of the centesimal scale, Galton obtains the following results:

Resemblance of Siblings, 150 Couplets: forefinger, 9°; middle finger, 10°; ring finger, 12°. We have no probable error given for this method of computing association, but it may be to some extent estimated by the fact that an additional 50 couplets, worked out for middle finger only, gave a value of 21°. For loops on the middle finger only, the 150 couplets gave 1.25°, and the 50 couplets 8°, indicating little if any association. In nearly all cases the random values were below the observed; in the few cases where they are not so they were only slightly in excess. I think there is enough to show that fraternal resemblance exists, but I personally hold that the classification is rather inadequate, and the statistical method of reduction is unsound.

Galton next turns (p. 185) to the degree of resemblance in twins. Here he has two series, each of 17 sets of twins for the fore, middle and ring fingers of the right hand. In the first series 19 of the 51 finger-print pairs gave the same pattern for the same fingers of both twins, 13 gave partial resemblance and 19 disagreement. Or, as he puts it, of 17 sets of three fingers, two

* Pairs of children with the same parents without regard to sex.

LEFT HAND



Dorothy

THUMB

FORE

MIDDLE

RING

LITTLE



Muriel

RIGHT HAND



Dorothy



Muriel

FINGERPRINTS OF LIKE TWINS

From the Collection in the *Galtoniana*.

sets agreed in all their three couplets of fingers; four sets in two, and five sets in one of their couplets. There are instances of partial agreement in five others, and only complete disagreement in one. Of the second series of 17 twins Galton contents himself by saying that two sets agreed in two of their couplets and five agreed in one, without giving details. He concludes that: "there cannot be the slightest doubt as to the strong tendency to resemblance in the finger patterns of twins." (p. 186.)

Unfortunately Galton gives no measure of the probability of the random occurrence of similar resemblances, and we are unable to compare what is the relative degree of resemblance of twins and ordinary siblings.

Perhaps the best appreciation the reader can rapidly form of the degree of resemblance in the finger-prints of like twins can be obtained by carefully examining our Plate XVIII which gives the finger-prints of a pair of like twins from the *Galtoniana*.

The last problem Galton touches on is that of parental heredity. Here he has only 27 pairs of parents, whom he chooses because on one of the three fingers, fore, middle, or ring, they have the same pattern. He has 4 cases of the forefinger, 14 of the middle finger and 9 of the ring finger. These 27 pairs of parents have 44 sons and 65 daughters; 22 out of the 44 sons, 37 out of the 65 daughters have the same pattern on the same finger as their parents. In 19 cases out of the 27 both parents had loops of type No 42, and in 48 cases out of their 75 children there was also a loop on the same finger; that is to say, in about 64 % of cases, while the normal percentage is about 33 %. Thus, according to Galton's method, the resemblance is about 48%. This seems to show a much greater value for filial resemblance in looping than had been found for fraternal resemblance. Yet in analysing these parental sets, Galton is rather apt to desert the method he adopted for fraternal resemblances, namely, of terming two points like or unlike according as they are of the same or not the same pattern in his C-set of 53 patterns. Thus he has 3 parental sets with No. 14 tendrilled loops; they have 17 children of whom only 3 have No. 14 pattern; he says, however, that No. 14 counts as a whorl, and that the 17 have 11 whorls and only 6 loops. Few, however, of the remaining 8 whorls bear close resemblance to No. 14. Galton gives no general measurement of parental heredity.

This raises, indeed, the broad question whether it is really the pattern which is inherited, or merely a tendency to arch, to loop, or to whorl without regard to the individual character of the pattern. Galton remarks (p. 187) that the finger-prints of twins while tending to be of the same pattern, cannot be mistaken one for the other; in other words, the number of ridges and the *minutiae* differ*. Thence he leads us to a very fertile suggestion, which neither he nor anyone else later, so far as I know, has ever worked out:

"It may be mentioned that I have an inquiry in view, which has not yet been fairly begun, owing to the want of sufficient data, namely to determine the minutest biological unit that may be hereditarily transmissible. The *minutiae* in the finger-prints of twins seem suitable objects for the purpose." (p. 187.)

* Our Plate XVIII suggests that Galton in this statement has somewhat over-emphasised the divergence between the finger-prints of twins.

The last section of this chapter is entitled the *Relative Influence of the Father and the Mother*. The fore, middle, and ring fingers of the right hand of the father and mother of 136 sons and 219 daughters were tabled under the 53 standard patterns, and I present Galton and Collins' results in the form of percentages of likenesses found in the case of the three fingers. It will be seen that for the fore and ring fingers there is no difference.

Percentages of Same Finger-prints in Parents and Offspring on the basis of 136 Sons and 219 Daughters.

Relationship	Fore Finger	Middle Finger	Ring Finger	Total Percentage of Sameness
Father and Son ...	12.5 %	25.7 %	20.6 %	58.8 % } 54.7 %
Father and Daughter	13.2 %	23.5 %	14.0 %	
Mother and Son ...	13.2 %	36.8 %	19.1 %	69.1 % } 68.4 %
Mother and Daughter	17.4 %	34.3 %	16.0 %	

I think it may be safely inferred from these percentages:

(i) that the Son has no greater degree of resemblance to the Father than the Daughter has;

(ii) that the Son has no greater degree of resemblance to the Mother than the Daughter has;

(iii) that there is no sensible degree of difference between the resemblances of Father and Mother to their offspring in the fore and ring fingers;

(iv) that there does appear to be a difference in the middle finger, and this alone causes the Mother's total of resemblances to be greater than the Father's.

Are we to assert as a result of these conclusions (*a*) that the heredity factor has greater influence in the case of the middle finger, and (*b*) that the mother has more influence than the father on the finger-prints of the offspring?

Galton does not pledge himself to (*b*), but merely throws it out as a suggestion. We must, however, note that the resemblances here given include not only the hereditary but the organic factor, and the values of the percentages given if they were corrected for random agreement might show very different results. The middle finger has a far higher percentage of loops (see the table on our p. 184) than the fore or ring fingers, hence there will be a far larger number of random coincidences to be corrected for. Until that is done we cannot accept (*a*) as true on the basis of the above table. Further, Galton has not given the digital distribution of patterns for the *two* sexes, and if these be not the same we cannot straightaway assume that (*b*) holds, or indeed that either parent has the like influence on son and daughter.

I have discussed this chapter at length, primarily because Galton was undoubtedly the first to take up the subject of the inheritance of fingerprint patterns, and it is desirable that later workers should see how he approached the problem, and so try to avoid the difficulties he encountered. Our statistical tools are better now than such tools were in 1892, but still the problem remains of transcendent difficulty. Secondly, I have done so because Galton provides as usual many suggestions for further inquiry. Here as elsewhere we come across the urgent problem of a standard set of patterns, which will subdivide plain loops into small approximately equal subclasses. Galton's set of 53 standard patterns provides at once too many and too few. There is no great advantage gained by dividing whorls into "inner" and "outer," and the division of loops into "inner" and "outer" is not division enough.

Chapter XII (pp. 192-197) deals with *Races and Classes*. Galton obtained finger-print series for the English, Pure Welsh, Hebrew, Negro and Basque races. These were dealt with in a variety of ways and he concluded that there was no *peculiar* pattern which characterises persons of the above races. Many tabulations to discover racial differentiations appear to have been made without any great success. As an illustration Galton gives the following table:

Percentages of Arches in the Right Forefinger.

Number of Persons	Race	Percentage
250	English	13·6
250	Welsh	10·8
1332	Hebrew	7·9
250	Negro	11·3

Galton considers that there may be a significant difference between the percentages of arches in the English and Hebrew races. Now the probable error of his percentage value for English is 1·5 with a slightly greater value for the Welsh and Negro. Accordingly we see that the three series of 250 are too small to show significant differences if they really exist between these three races. The difference between Hebrew and English is 3 to 4 times its probable error and may be significant. The point needs further inquiry on longer series. Although no statistical differentiation of the Negro was found, Galton remarks:

"Still, whether it be from pure fancy on my part, or from some real peculiarity, the general aspect of the Negro print strikes me as characteristic. The width of the ridges seems more uniform, their intervals more regular, and their courses more parallel than with us. In short, they give an idea of greater simplicity, due to causes that I have not yet succeeded in submitting to the test of measurement." (p. 196.)

Galton considers that this matter should be pursued further, especially "among the Hill tribes of India, Australian blacks and other diverse and so-called aboriginal races." I would venture to add the amplest study of the

Oriental Races, Japanese, Chinese, Aino and Tibetans, whose anthropological characters are so distinctive*. Further, an investigation should be made of the finger-prints of prehistoric man, especially of palaeolithic man in the caves†. Nay, we may go back further and ask what are the finger-prints of *Tarsius*, to whom some anatomists, at any rate in the matter of the hand, believe man to be more closely linked than to the anthropoids. The ancestry of man might possibly be illuminated by still further study of the primates' finger-prints. It is almost impossible to believe that the *Urmensch* had all men's present finger-print patterns scattered in a roughly promiscuous way over his digits! If he had, then it forms a huge stumbling-block in the evolution of man from a primate form.

Galton concludes his chapter by stating that he has studied the finger-prints of men of much culture and of scientific achievement, of labourers and artists and of the worst idiots.

"I have prints of eminent thinkers, and of eminent statesmen that can be matched by those of congenital idiots. No indications of temperament, character, or ability can be found in finger marks, so far as I have been able to discover." (p. 197.)

Chapter XIII (pp. 198–212), the final chapter, is entitled *Genera*, and as it is substantially a reproduction of the matter on this topic in the *Philosophical Transactions* (see our pp. 167–169), it seems unnecessary to analyse its contents or repeat the criticisms already made on it by the present writer.

Taking Galton's work as a whole we have to remember that it is the first treatise on finger-printing and none has been published since. That it is full of novel matter and teems with suggestions. That from the time of Purkenje (1823) to Alix (1868) there had been no scientific contribution to the subject, nor anything published which could provide Galton with material for study, until his own Royal Society memoirs were issued. The whole of the scientific treatment of finger-prints and the art of identification by means of them, now spread over the civilised world, arose from Galton's labours, especially those in this book. If anyone doubts this let him point to a single scientific memoir on identification by finger-prints which antedates Galton's publications, or his campaign for finger-printing as an expert art. No one can realise how insignificant were the results before Galton, who has not read his *Finger Prints*.

Decipherment of Blurred Finger Prints, 1893. In the following year Galton issued a booklet of the above title, with the subtitle *Supplementary Chapter to "Finger Prints."* Slender as is this volume (18 pp.), the important part of which consists of sixteen plates, it is again a pioneer work. It shows for the first time in numerous instances how evidence should be prepared which might convince a jury of the identity of two finger-prints, even if one or both those prints are badly impressed, or, as Galton puts it, "blurred."

* I have already indicated why I do not think the researches of Kubo or Collins conclusive as to racial differences. See the footnote p. 140 above.

† See E. Stockis, "Le dessin papillaire digital dans l'art préhistorique," *Revue Anthropologique*, année 30, 1920, p. xliii et seq.

“The registration of finger-prints of criminals, as a means of future identification, has been thought by some to be of questionable value on two grounds—first, that ordinary officials would fail to take them with sufficient sharpness to be of use; secondly, that no jury would convict on finger-print evidence. These objections deserve discussion, and would perhaps by themselves have justified a supplementary chapter to my book. It happens, however, that there are strong concurrent reasons for writing it. I have lately come into possession of the impressions of the fore and middle fingers of the right hand of eight different persons made by ordinary officials, in the first instance in the year 1878 and secondly in 1892. They not only supply a text for discussing both of the above objections, but they also afford new evidence of the persistence of the *minutiae*, that is of the forks, islands and enclosures, found in the capillary ridges.” (p. 1.)

The reader will remember (see our p. 176) that Sir W. J. Herschel in 1877 had taken finger-prints for the registration of deeds at Hooghly. Galton in his *Finger Prints* (p. 89) had suggested that it might be well worth while to hunt up such of these Hindoos as were still alive and retake their finger-prints. Through the mediation of Sir William it was possible to obtain from the magistrate and sub-registrar of Hooghly not only fresh prints of the fore and middle finger-prints of eight persons, who had impressed their finger-prints in the Register of Deeds of 1878, but also these earlier prints themselves. In all cases the range of interval was about 14 years, so that Galton got evidence of persistence roughly between the following ages: I, 51 to 65; II, 50 to 64; III, 38 to 52; IV, 28 to 42; V, 48 to 62; VI, 38 to 52; VII, 40 to 54; VIII, 32 to 46 (p. 4). But his task was not an easy one; not only were the paper* and the inking on both earlier and later prints very defective, but the prints were not *rolled* prints and in a number of cases only a portion of the bulb had been impressed. Thus some of the *minutiae* were lost on each separate print and this in itself caused a double loss on comparison. Galton contented himself with a full discussion of eight out of the sixteen finger-prints and found the following results:

Personal Number	Finger	Number of Agreements	Number of Disagreements	Patterns
I	Fore	9	0	Loop
II	Middle	5	0	Loop
III	Middle	21	0	Whorl
IV	Fore	19	0	Whorl
V	Fore	7	0	Loop
VI	Fore	19	0	Loop
VII	Middle	15	0	Loop
VIII	Fore	30	0	Whorl
Average	—	15.6	0	—

Galton discusses each finger in detail (pp. 11–15), commenting on various peculiarities and difficulties. He remarks that his evidence for correspondence

* They were on a common kind of native-made paper, worm eaten, with many holes. Several of the Hindoos were old for their race and showed signs of much manual labour wearing down the sharpness of the ridges.

is drawn from the *minutiae* and not from the general pattern ; for though no one can mistake a decided whorl for a decided loop, lesser differences are often deceptive to the untrained eye, especially when only a portion of the pattern has been impressed.

But the chief interest of Galton's present work lies not in the identification of poor impressions at fourteen years' interval by aid of their *minutiae* but in his manner of presenting the evidence. His aim is to show that rough impressions such as may be taken by ordinary officials (or left behind by the burglar) can be made to afford evidence strong enough to convince a jury that two finger-prints had been made by the same person. "It is of course supposed that the cogency of the finger-print argument will be presented to the jury in that lucid and complete form in which it is the business of barristers to state and support their case, when they are satisfied of the integrity of the evidence on which it is based" (p. 2). Galton's method is best grasped from his plates rather than from a verbal description. He first enlarges his prints $2\frac{1}{2}$ times photographically. The enlargements, eight to the page, occupy Plates I-IV. These give him a general impression of the patterns, and the particular cases and the *parts of the particular cases* he considers it desirable to study further. These selected parts of particular cases are now photographically enlarged to seven times natural size. These enlargements occupy Plates V-VIII, and are printed in black. Thus far the work, except for the choice of parts, has been largely mechanical. Now comes the labour of the expert: the outlining of the ridges on these blurred prints. In doing this tracing paper may be used by the draughtsman, but Galton thinks a better plan is to do the outlining on the back of the print placed against a pane of the window or on a photographic retouching frame.

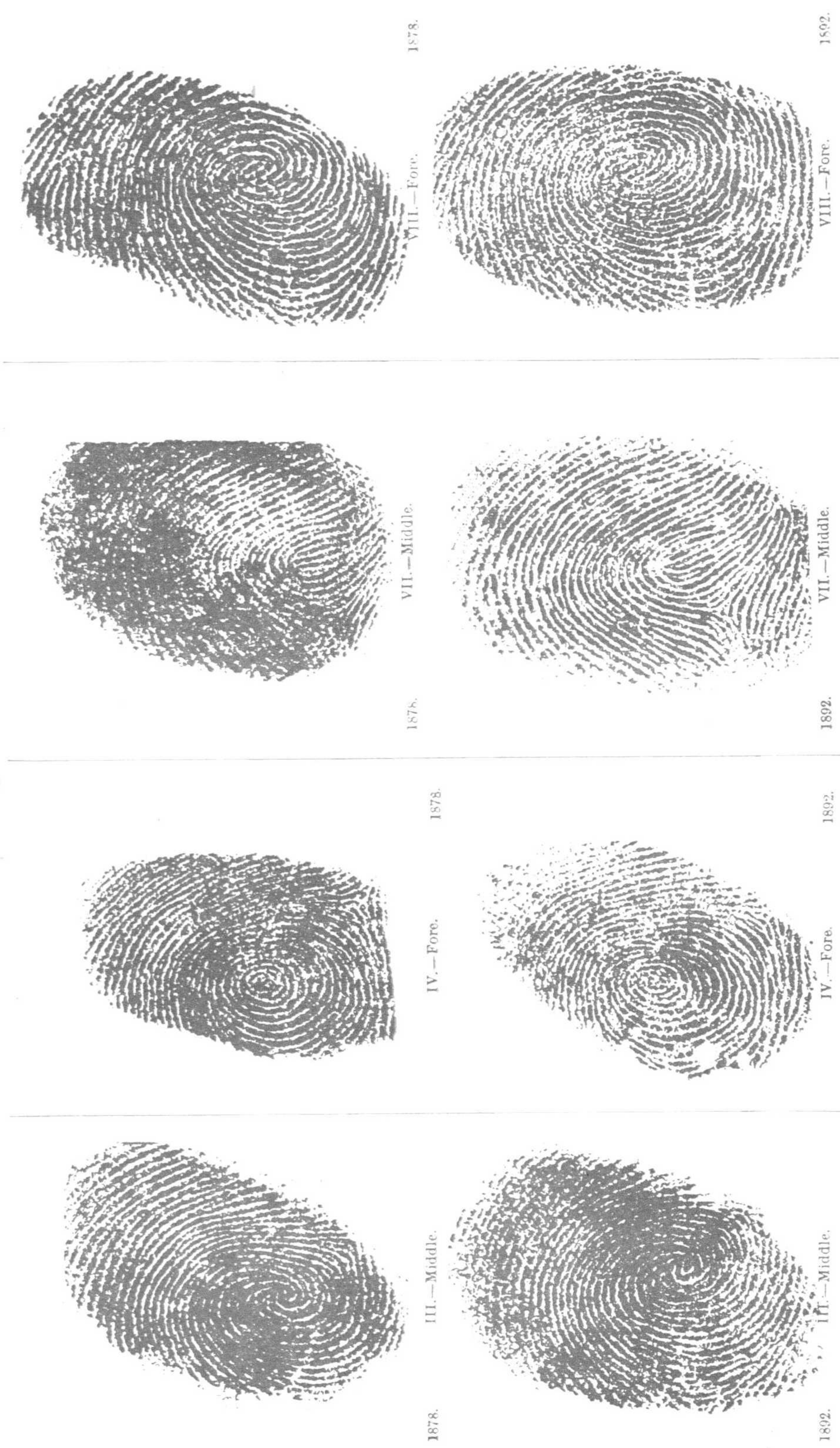
"The axes should be drawn with a finely-pointed pencil, and with care, down the middle of the ridges. Slap-dash attempts are almost sure to be failures. It is advisable to take pains to determine a common starting point, before proceeding to draw any lines at all; then to proceed from point to point in the two prints alternately, at first with wariness but afterwards much more freely. ...The continuous course of every line has to be made out from beginning to end, and the lines must nowhere be too crowded or too wide apart, and they must all flow in easy and appropriate curves; also as much regard must be paid to such blanks as are not obviously due to bad printing as to the markings. The general effect of these conditions is that a mistake in deciphering any one part of the impression nearly always introduces confusion at some other part, where the lines refuse to fit in." (pp. 10-11.)

On Plates IX-XII Galton gives his outlinings, the blurred ridges being now printed in orange with the outlining in black, still on a sevenfold scale. Tiny circles mark the ends or beginnings of ridges, but as Galton warns his readers some of these may well be forks (see his p. 8 and our pp. 165, 181).

Lastly Galton provides on the same sevenfold scale the outlinings of the ridges without the blurred ridges at all. Here in the juxtaposed prints corresponding *minutiae* are given the same small numbers, so that it is perfectly easy to refer to one after another of the correspondences. The whole series of plates forms a singularly lucid illustration of what it is possible to do even with badly printed and partial impressions. No reasonably thoughtful counsel ought with such evidence to fail to convince a jury that Dwārikā

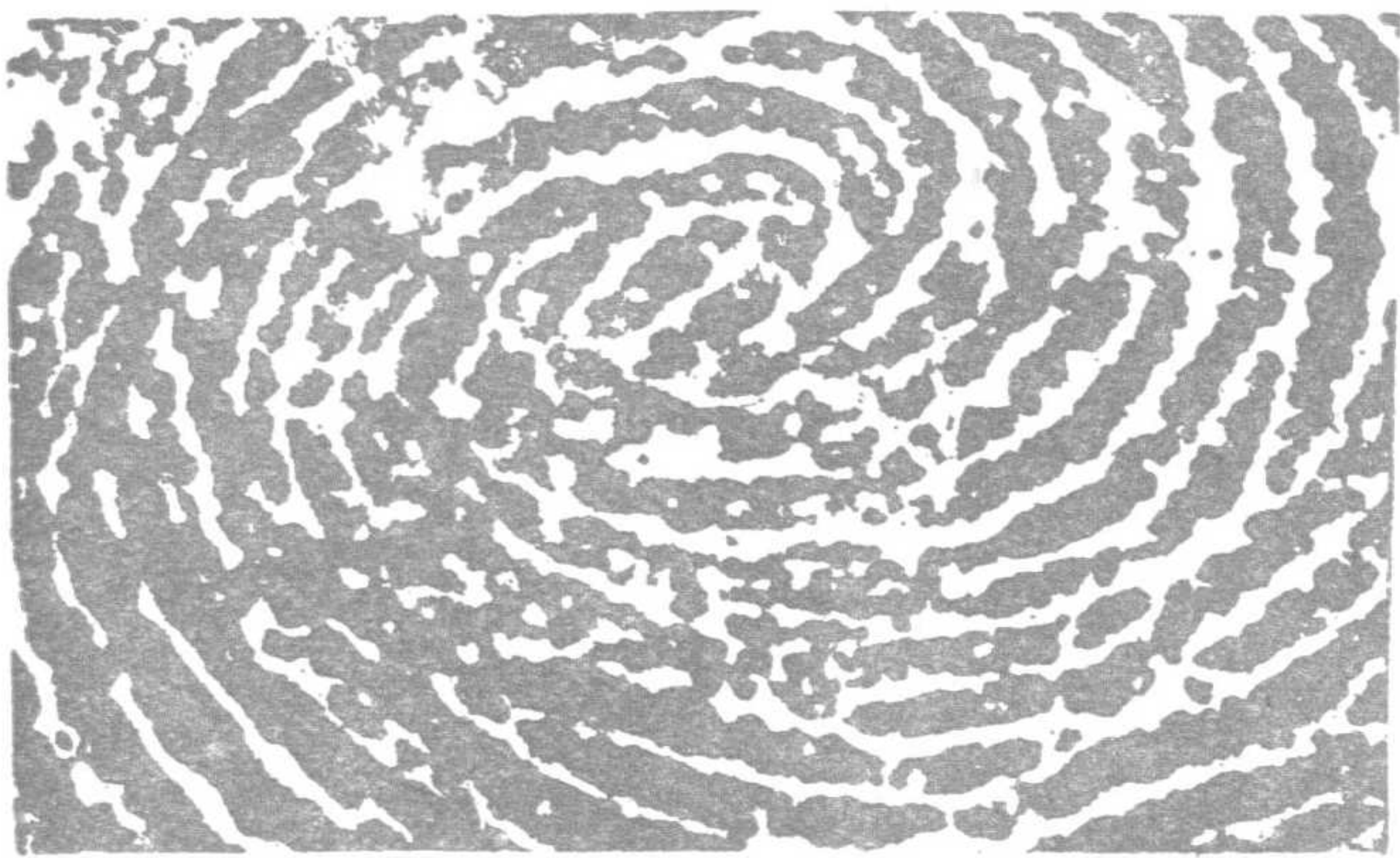
PLATE XIX

Illustrations of Galton's Treatment of Blurred Finger-Prints (Data obtained through Sir William J. Herschel).



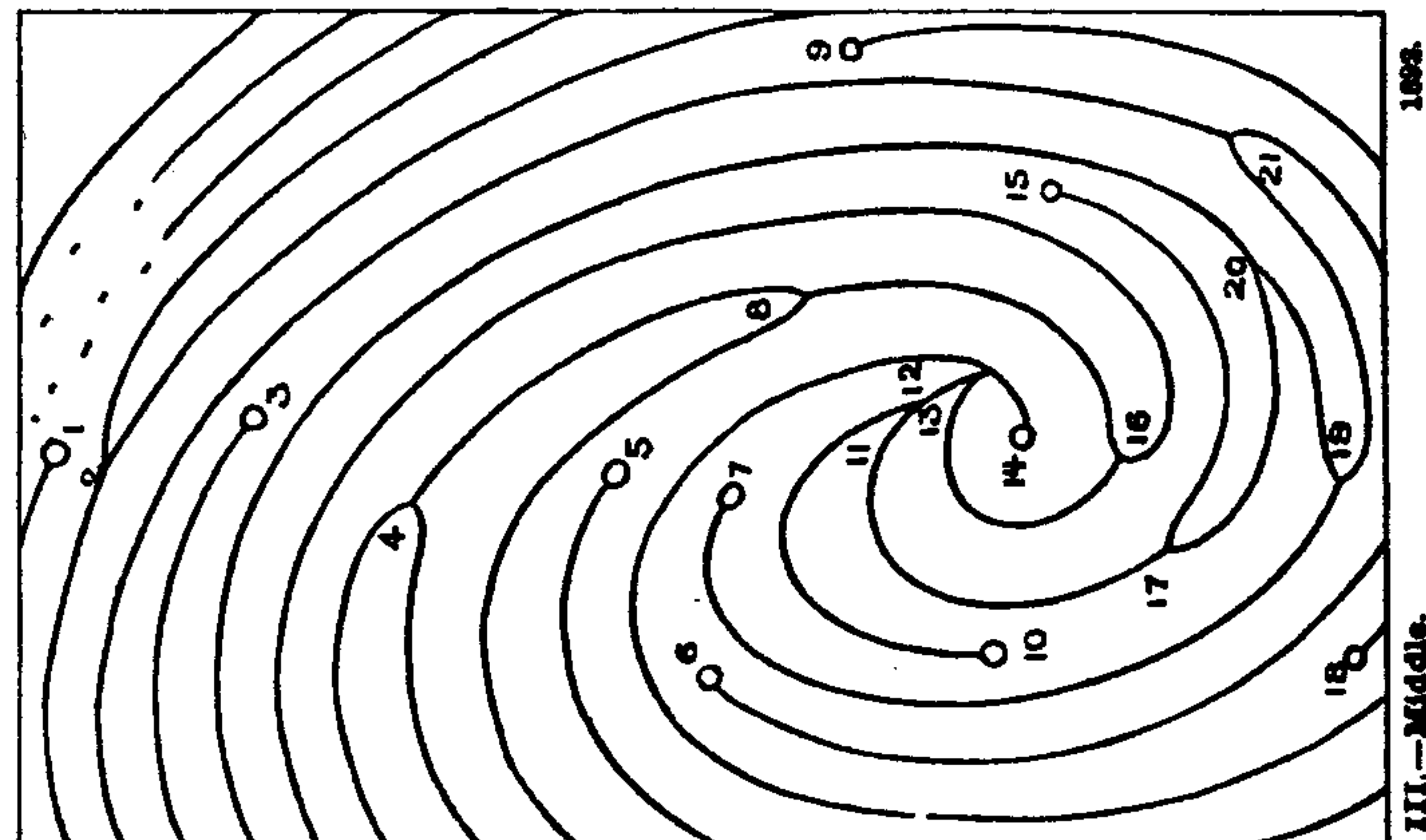
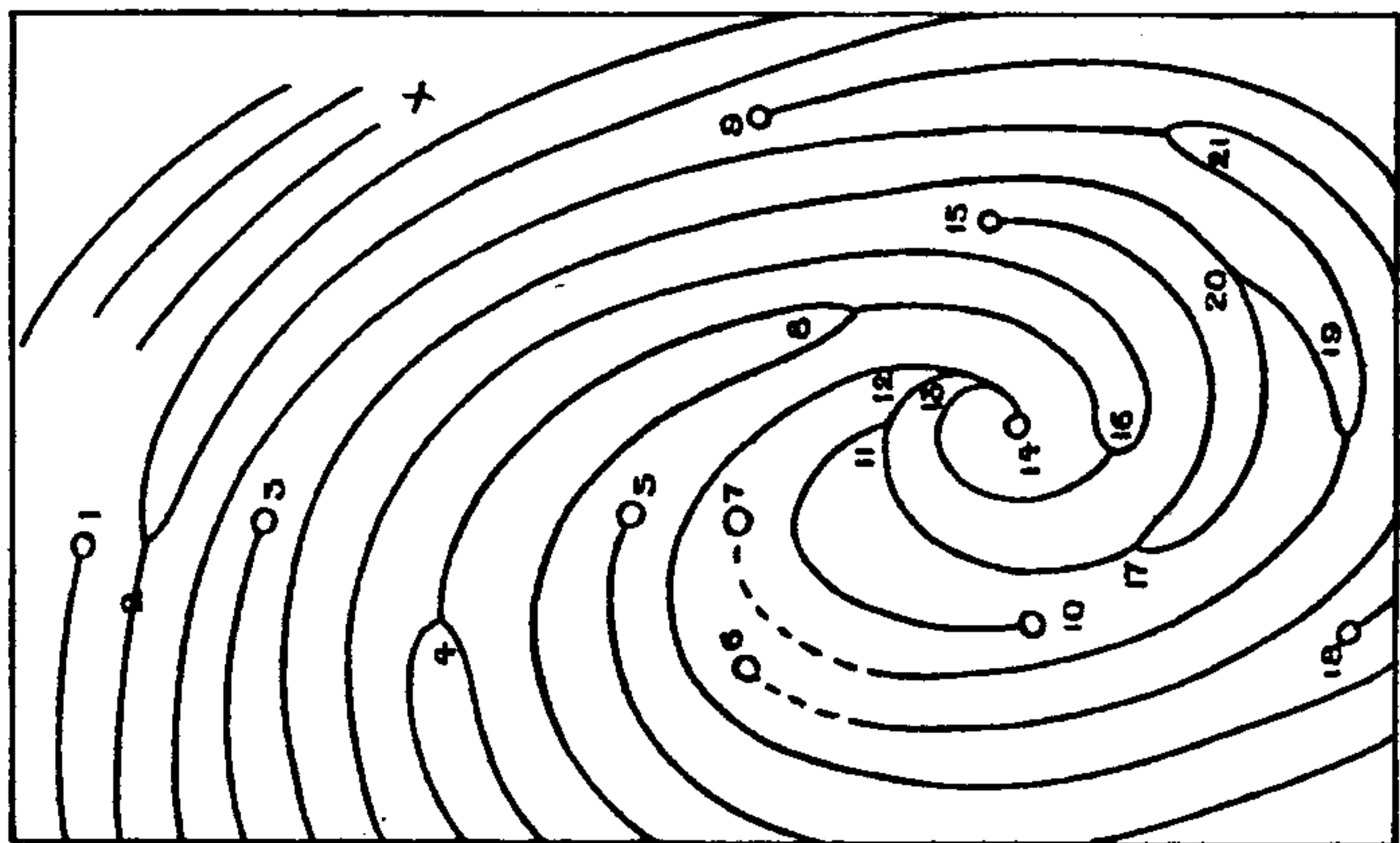
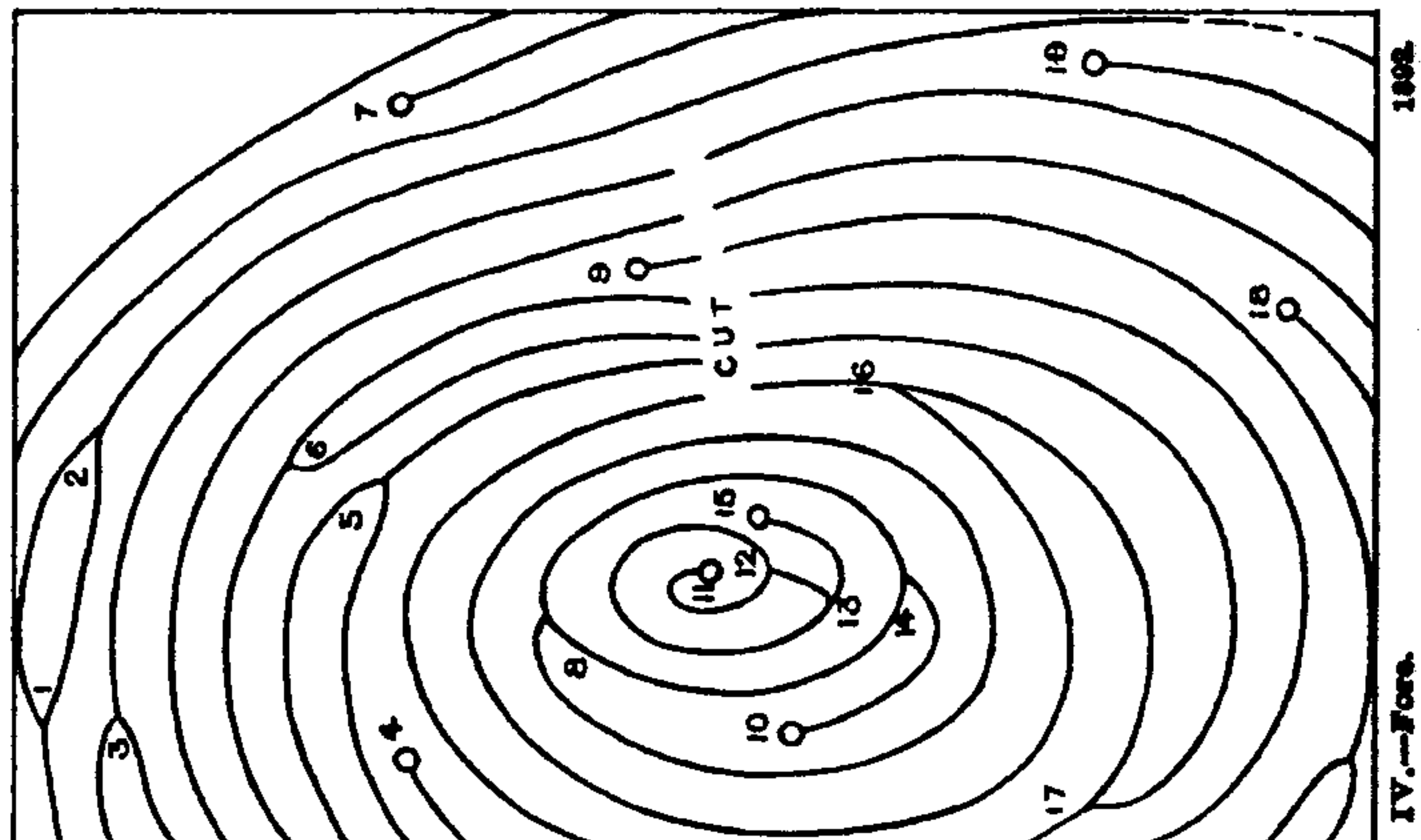
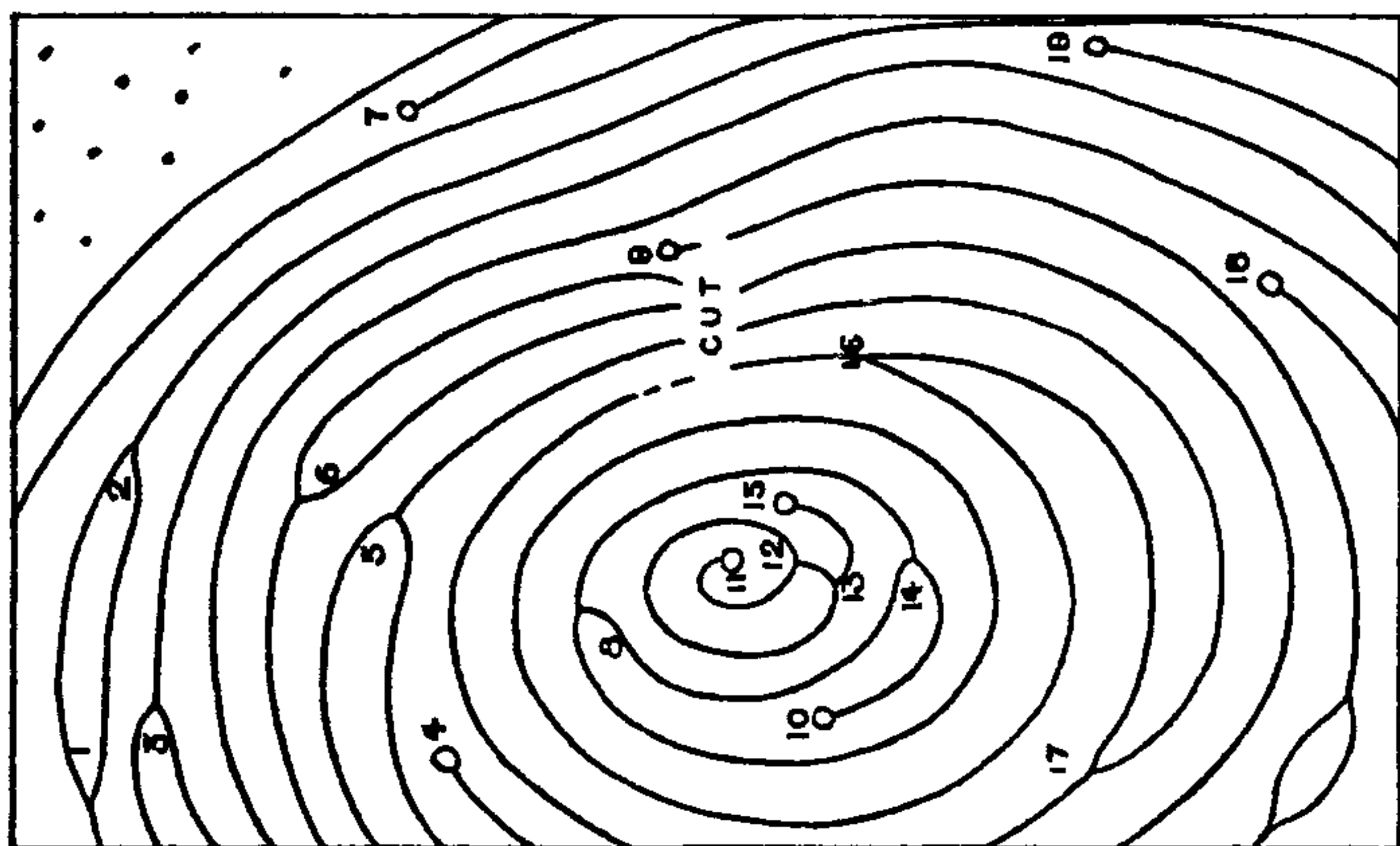
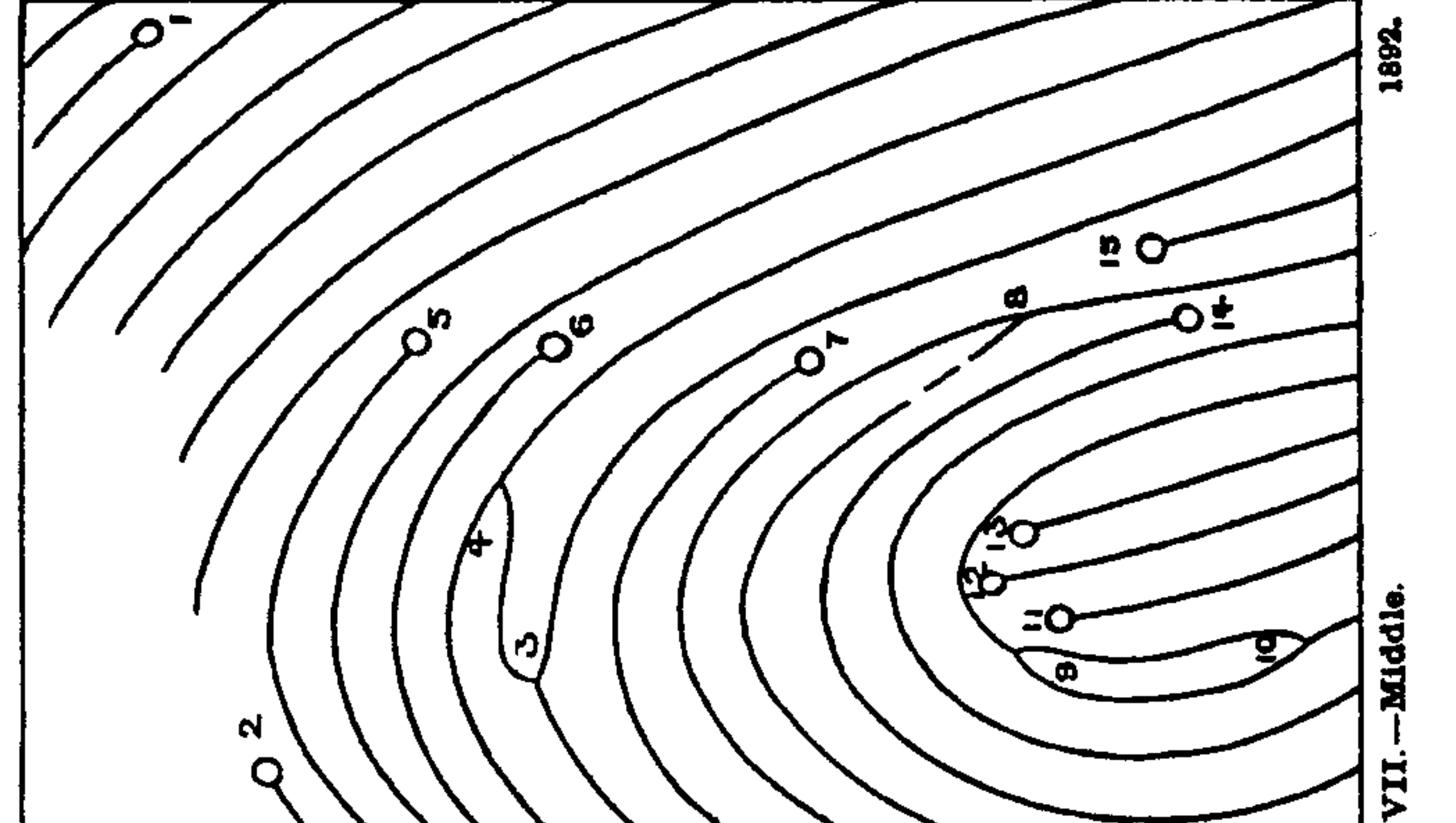
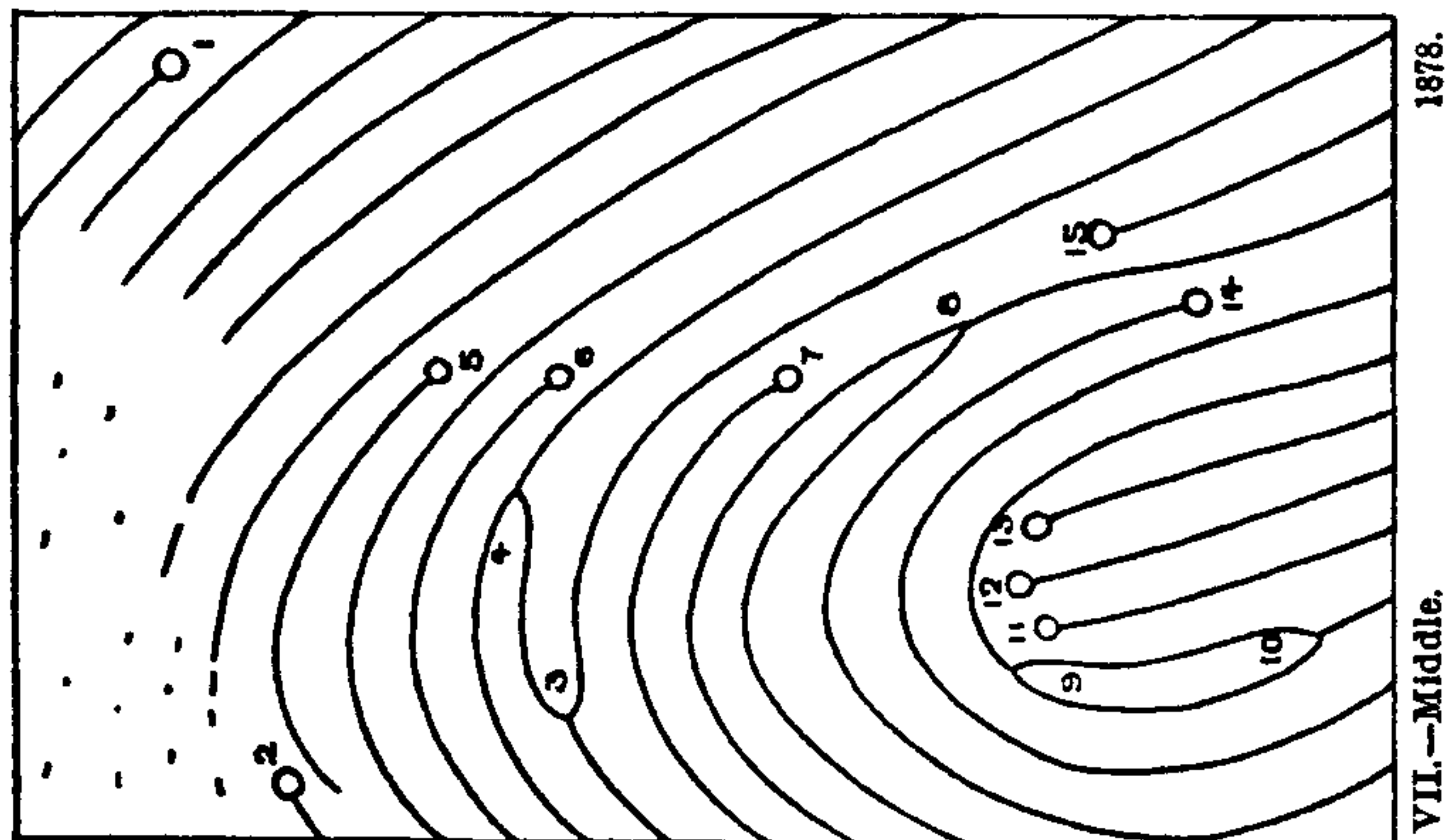
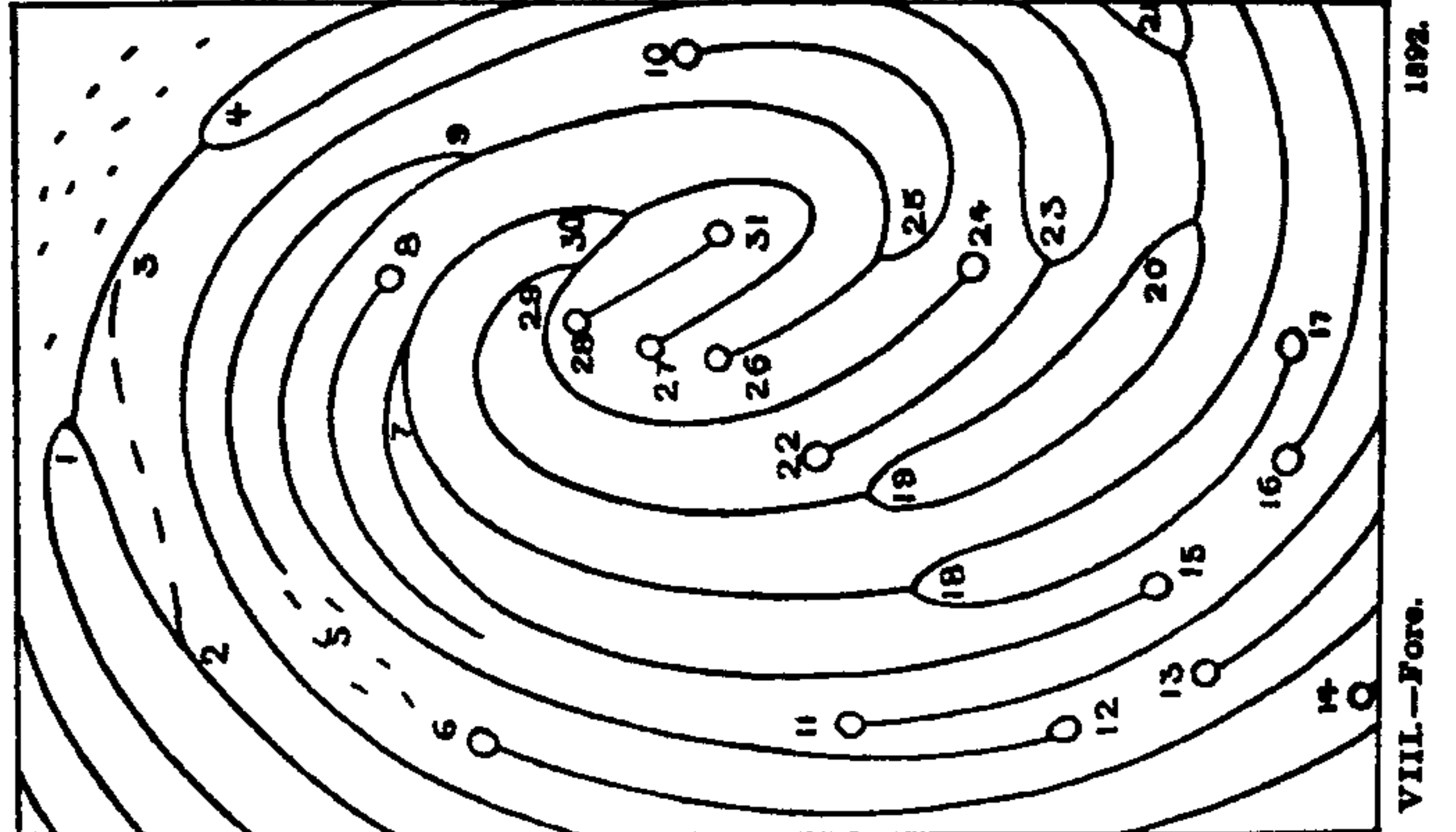
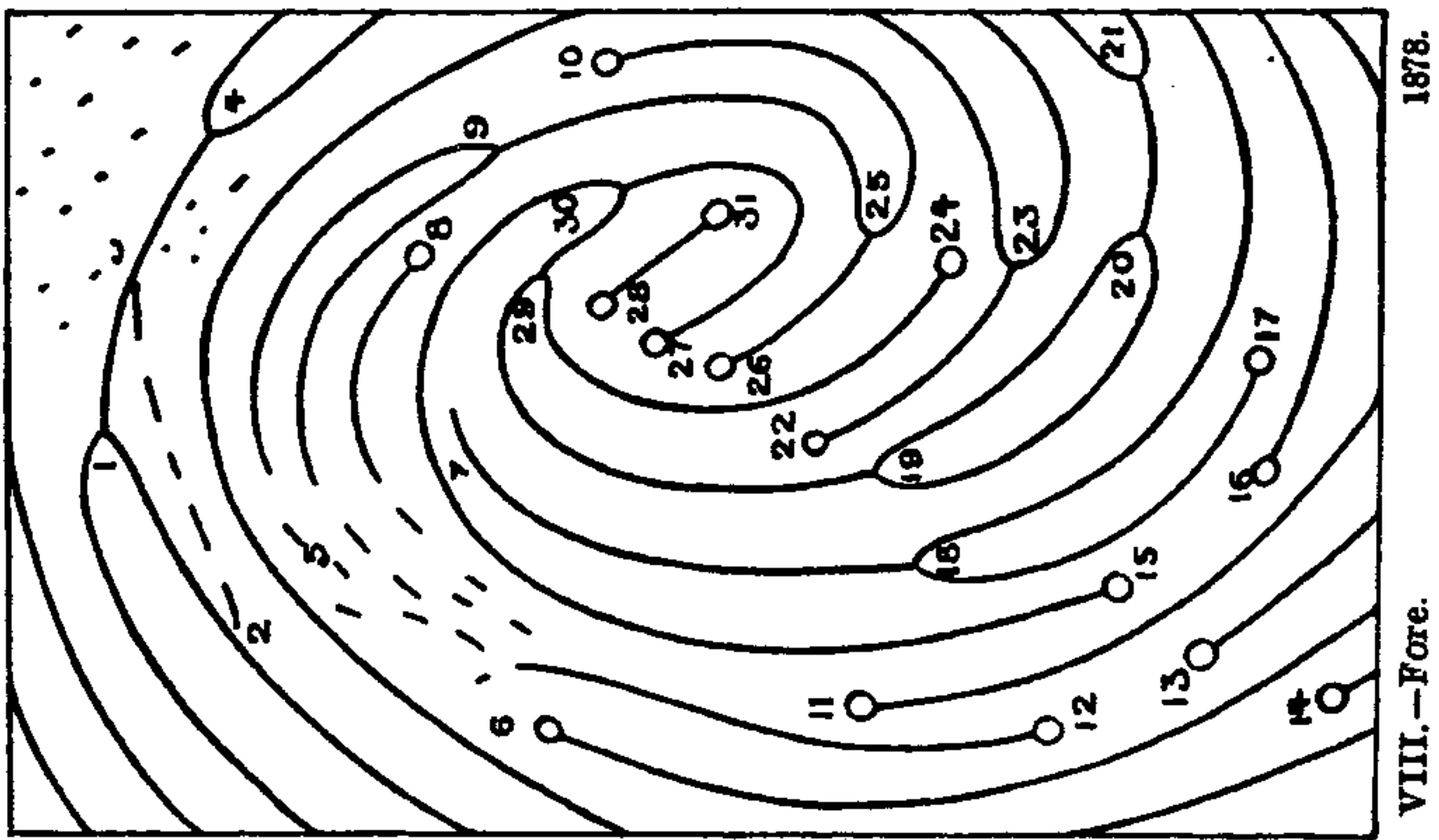
Fore and Middle Fingers of Persons at Hooghly, Bengal, taken first in 1878 and afterwards in 1892. From Plates II, III and IV of Galton's *Decipherment of Blurred Finger Prints*, 1893. Non-rolled Prints, enlarged $2\frac{1}{2}$ times.

Selected Corresponding Portions of the Hooghly Doublets (1878 and 1892) from Plate XIX.



Enlarged seven times preparatory to drawing central lines of ridges.

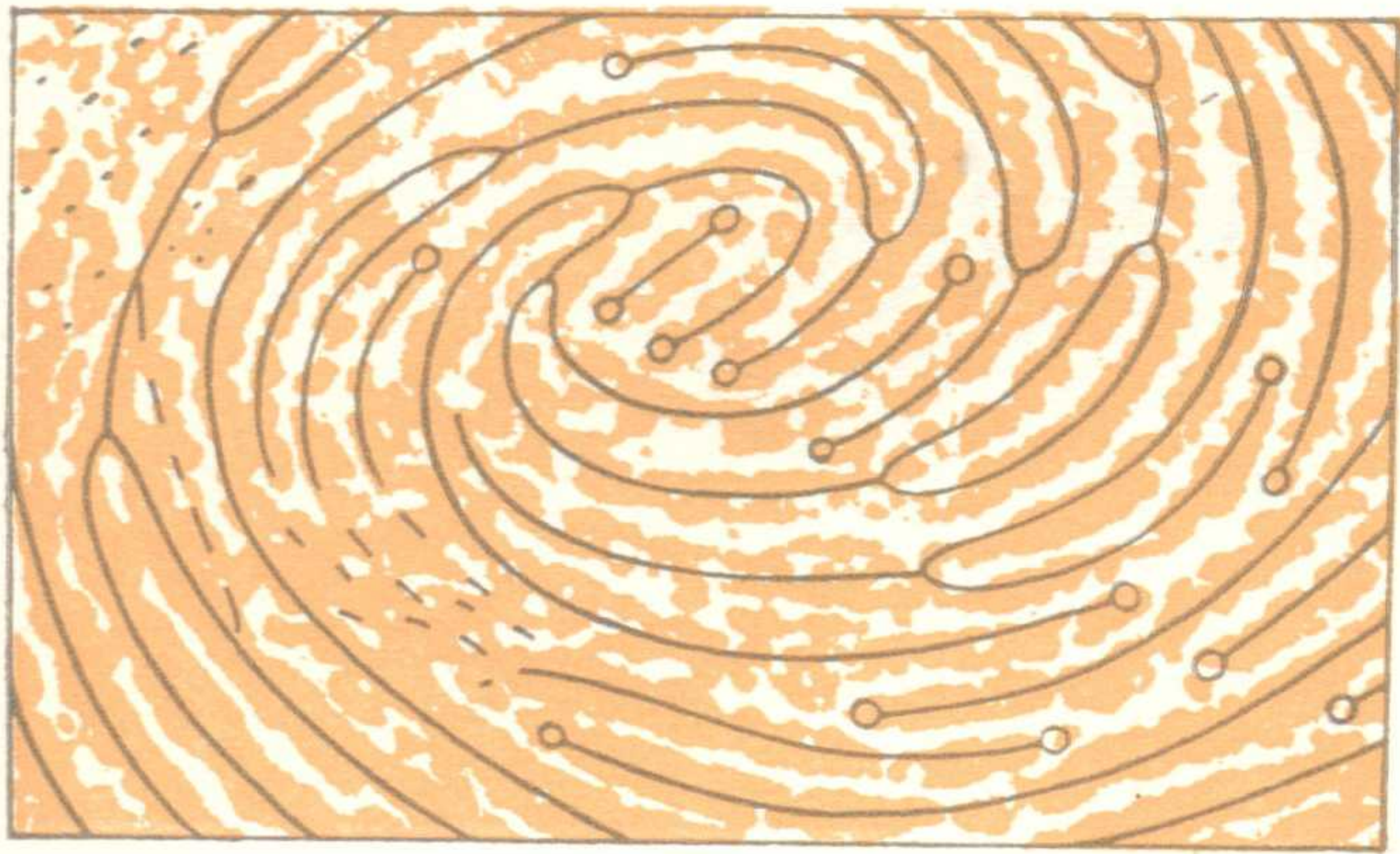
Skeleton Charts of the Central Lines of the Ridges of the Hooghly Doublets 1878 and 1892,
drawn by aid of tracing paper from the prints on Plate XX.



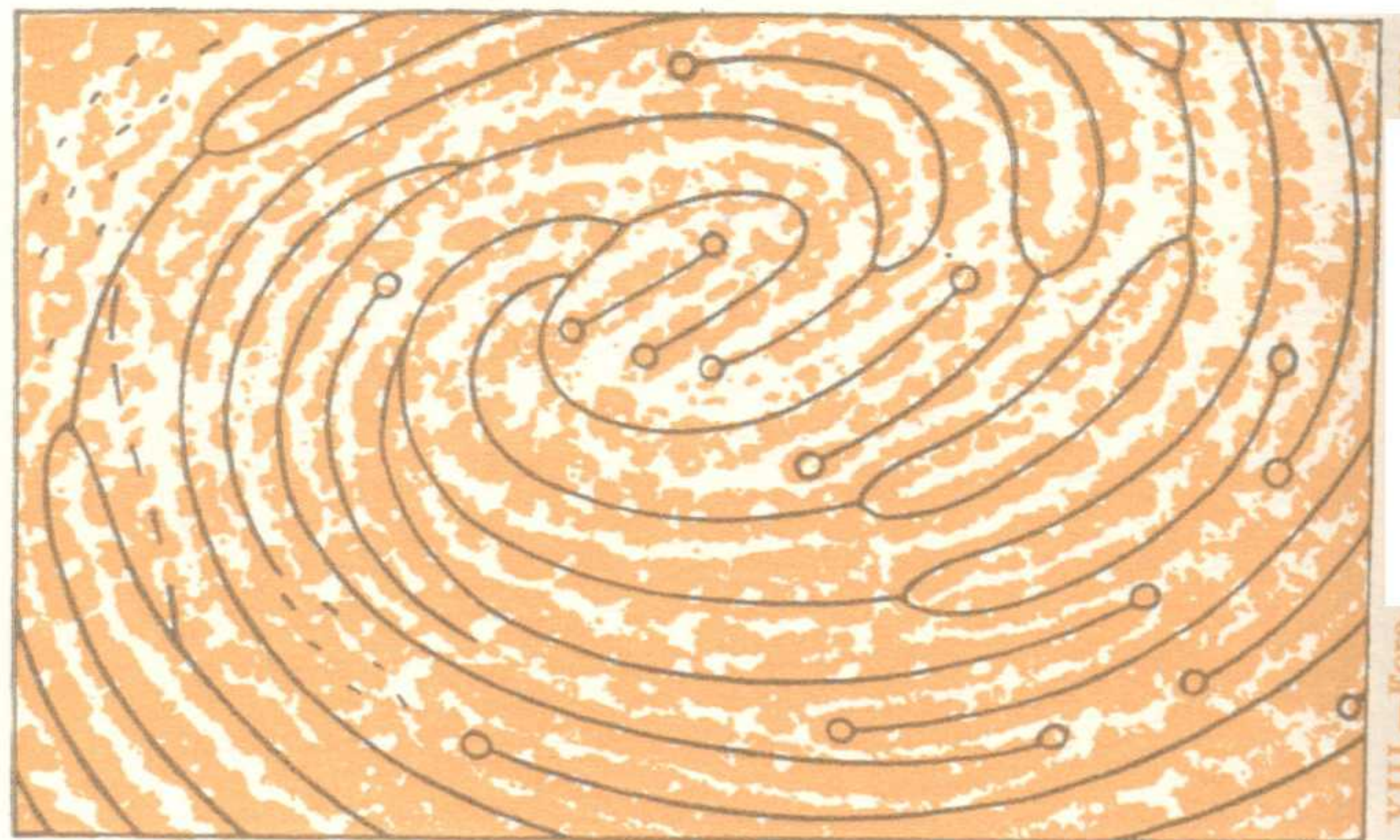
Corresponding numbers in upper and lower prints indicate persistence of *minutiae*.

PLATE XXII

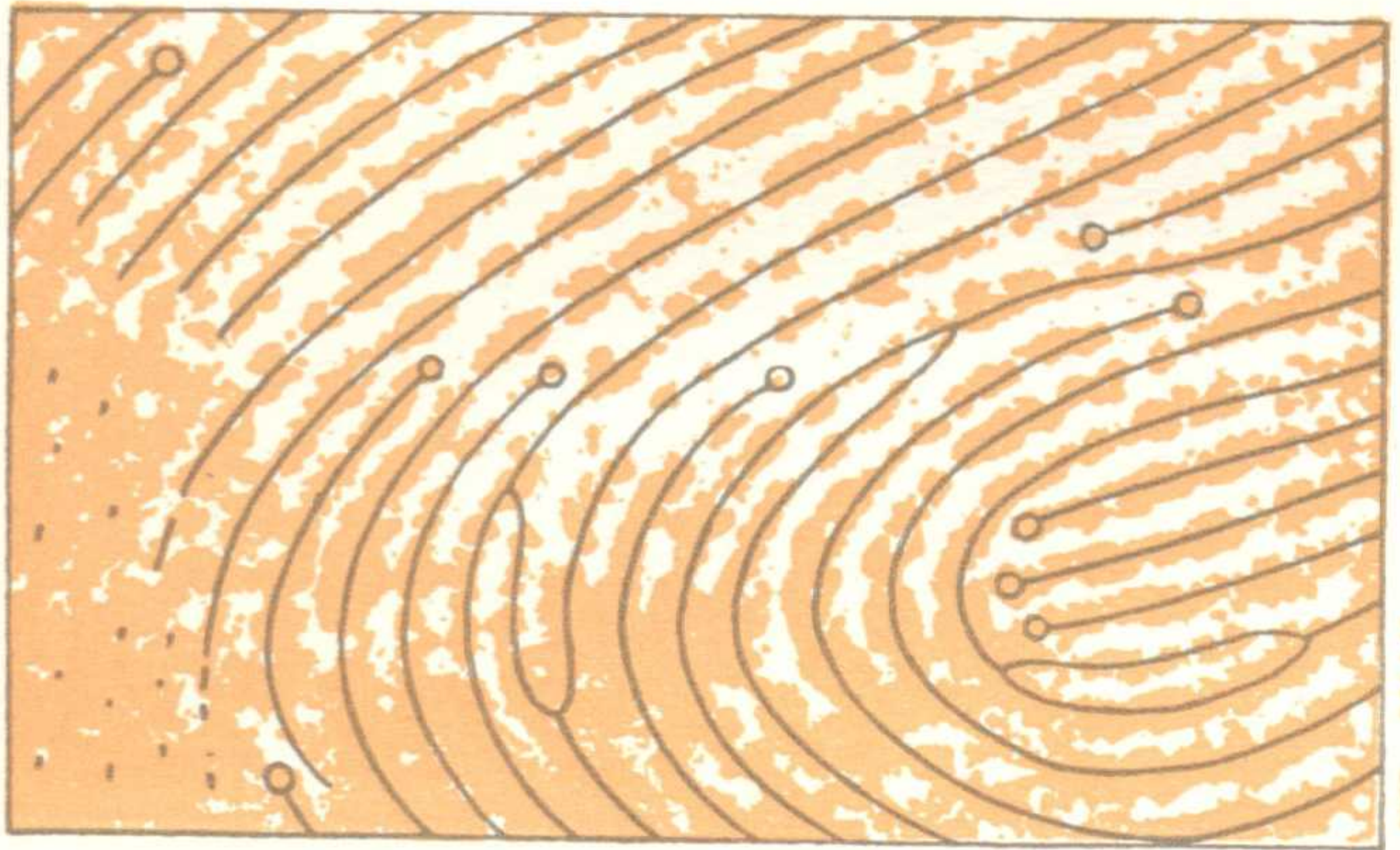
Superposition of Central Lines of Ridges on enlarged Finger-Prints, i.e. Plate XXI overprinted on Plate XX, reproduced in fainter ink.



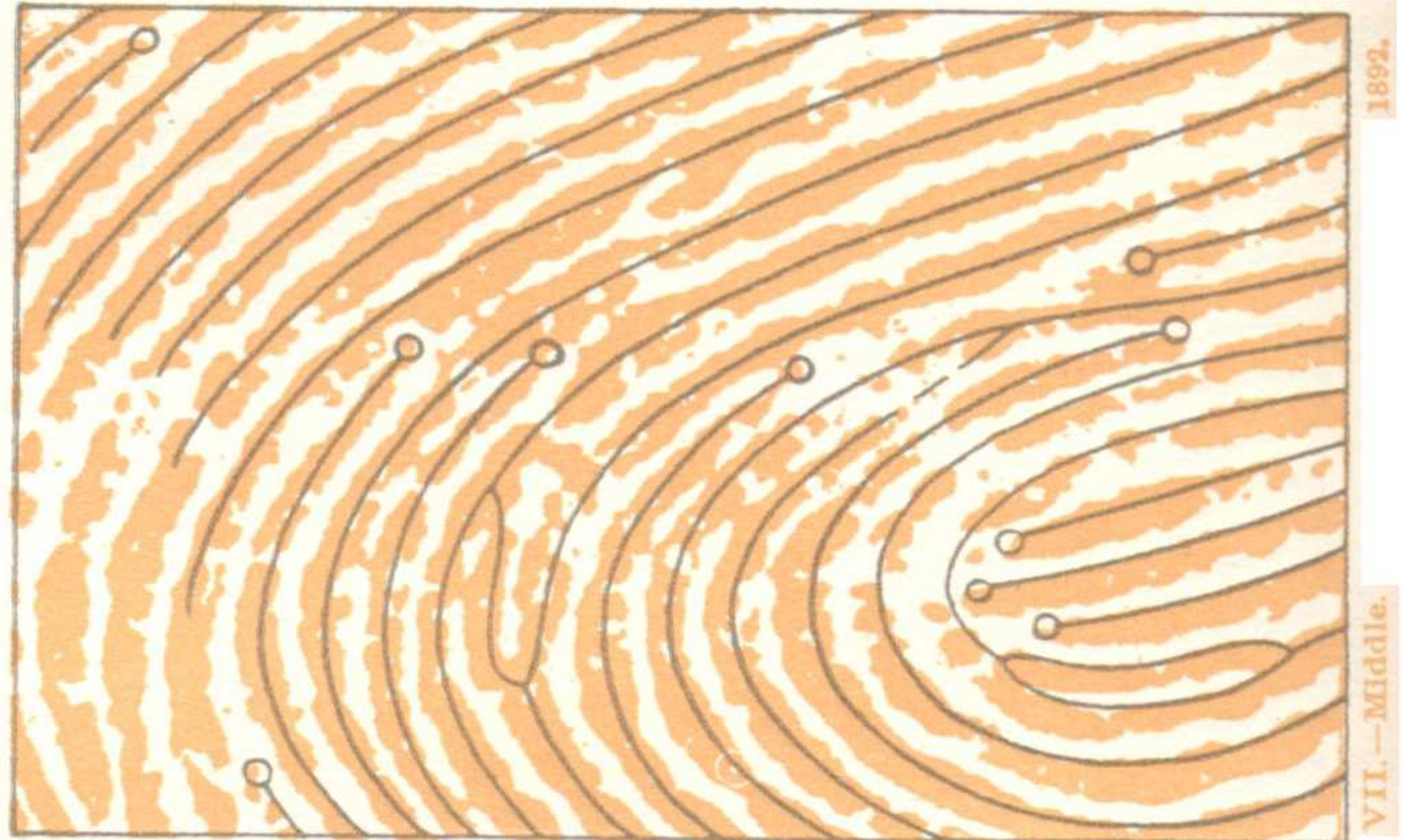
VIII.—Fore.
1878.



VIII.—Fore.
1892.



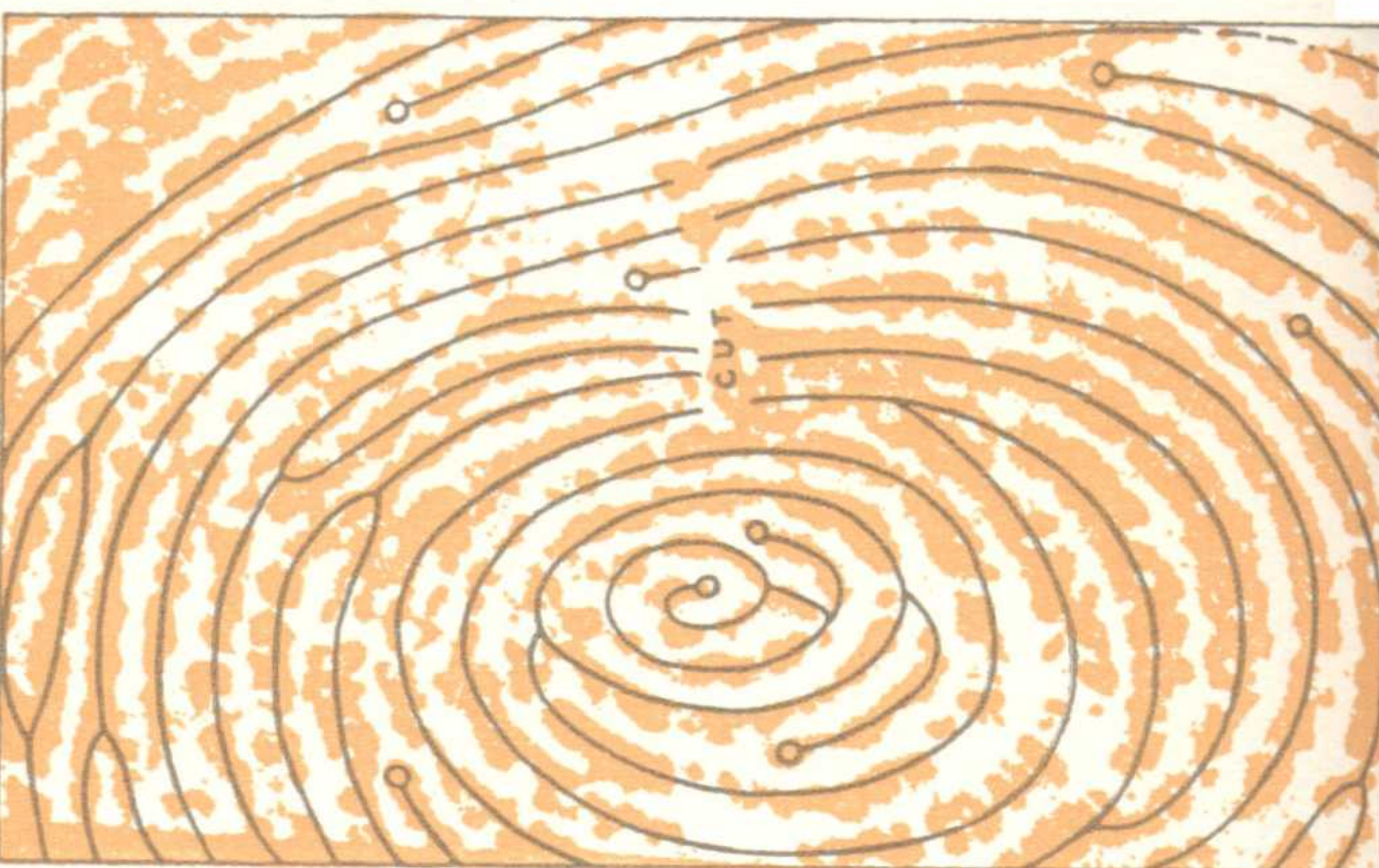
VII.—Middle.
1878.



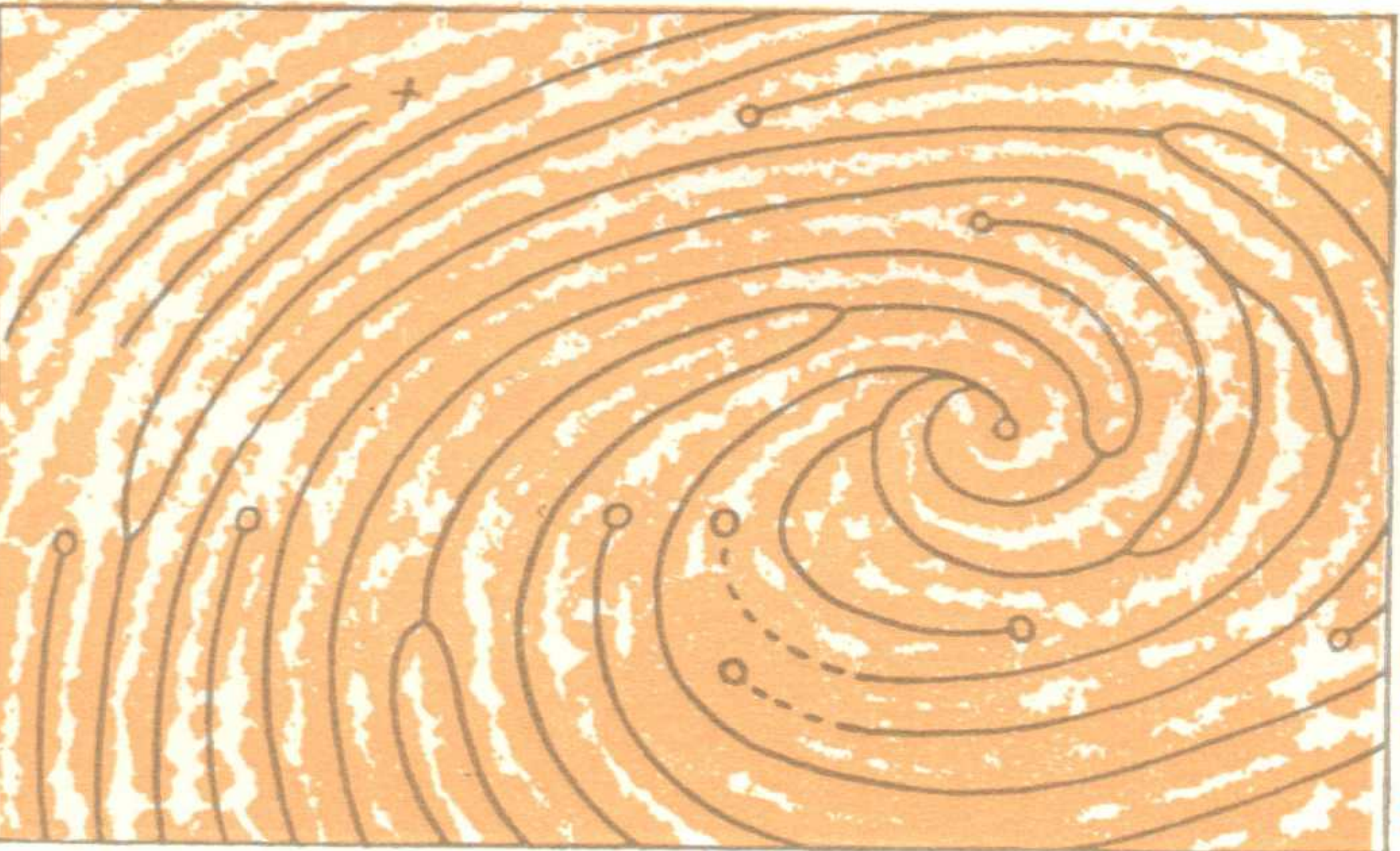
VII.—Middle.
1892.



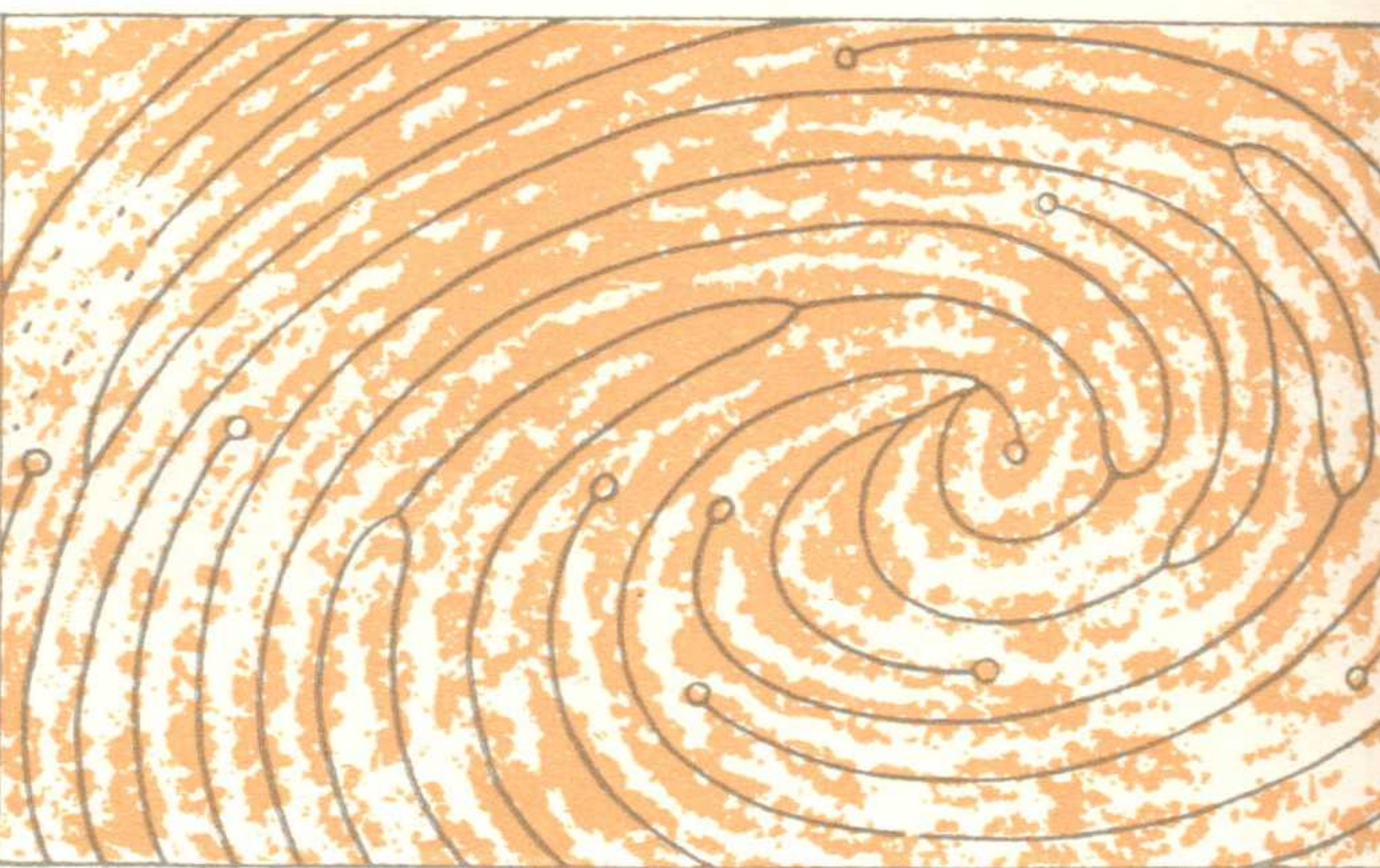
IV.—Fore.
1878.



IV.—Fore.
1892.



III.—Middle.
1878.



III.—Middle.
1892.

Nath Banerji, who had impressed his fingers in 1892 afresh, was the same man who had impressed them on Deed No. 28 in 1878!

We reproduce Galton's:

Plate II, Plate III left-hand side, Plate IV left-hand side (see our Plate XIX);

Plate VI and Plate VIII (see our Plate XX);

Plate X and Plate XII (see our Plate XXI);

Plate XIV and Plate XVI (see our Plate XXII).

These plates form the best—a graphical—illustration of Galton's methods.

On pp. 17–18, we have some useful suggestions as to enlarging finger-prints, but such work is now much more generally understood and accurately done than in 1892. Galton's two enlarging cameras are in the possession of the Galton Laboratory (see our p. 215). Our Author concludes with the following remarks:

“Photographic enlargements save a great deal of petty trouble. It is far easier to deal exhaustively with them than it is with actual impressions viewed under a magnifying glass. In the latter case, a few marked correspondences, or the reverse, can readily be picked out, and perhaps noted by the prick of a fine needle, the point of a pin being much too coarse. It is thus easy to make out whether a suspicious print deserves the trouble of photographic enlargement, but without previous enlargement a *thorough* comparison between two prints is difficult even to an expert, and no average juryman could be expected to make it.” (p. 18.)

The Second Attempt at Indexing Finger-Prints. Galton provided another Finger-Print Index to 100 persons in July 1894. It is entitled “PHYSICAL INDEX to 100 persons on their measures and finger-prints (*set up in two parts as an experiment*).” Here the two parts consist: first, of an index based primarily on five measurements as in bertillonage, and secondarily on finger-prints; and again of an index based primarily on finger-prints, and secondarily on the five measurements. I cannot find that this index was ever published although it appears to have been printed, stereotyped and circulated among Galton's friends and correspondents. It possesses in arrangement greater brevity than that of the *Finger Print Directories* of the following year, and yet gives more information since the anthropometric measurements and certain other data are included. The whole space occupied by any entry is 36×17 mm., and Galton considers that, if the entries were cut up and pasted on to cards, “a cabinet of 27 broad and shallow drawers measuring, over all, less than 12 inches in height and $4\frac{1}{2}$ feet in width, would contain more than 100,000 of these small cards arranged as a catalogue.”

Each entry or label consists of four lines (see table on p. 198). In the first line on the left is the anthropometric formula, on the right the finger-print formula. These are the bases on which the indices of Part I and Part II respectively are formed, the entries being made in order of letters and numbers in the formulae taken in consecutive order.

The second line gives the five anthropometric measurements in the order from left to right of (i) head length, (ii) head breadth, (iii) extreme breadth between cheek bones, (iv) length of left cubit, (v) length of left middle finger. To obtain the anthropometric formula, these are divided into α , l , w , which signify short, medium, long. The medium limits are for (i) 191 to 196,

(ii) 150 to 156, (iii) 129 to 136, (iv) 450 to 464, (v) 113 to 116, all inclusive. The danger of the anthropometric formula will arise when we have one or more measurements in the neighbourhood of these limits. Galton uses the five-symbol classification for his finger-print formula, namely A = arch, L = loop, W = whorl, U and R being used for ulnar and radial loops on forefingers only. He adopts the numerical abbreviations of his later work, i.e.

1 = aa or AA ,	2 = al or AL ,	3 = aw or AW ,
4 = la or LA ,	5 = ll or LL ,	6 = lw or LW ,
7 = wa or WA ,	8 = wl or WL ,	9 = ww or WW .

The third line is the secondary classification of the finger-prints, but he takes only the following six fingers in the order: fore, middle and ring fingers of the right hand, and then fore, middle and ring fingers of the left hand. In the secondary classification the symbols Galton uses are those of his *Finger Print Directories* with two additions, i.e. b = partially burnt by fire or chemicals, or so spoilt by work as to leave granulations in place of ridges, and m = the pattern is minute; so small that two specimens of the characteristic portion would occupy less space than that covered by a single dabbed print. As there is no secondary classification for thumb or little finger, the description is not so full as in the later work. Ridges are counted in the same manner as we describe on pp. 201-2; and are given for the forefingers when they are loops, and for the middle finger when it is needful to distinguish between individuals having the same primary classifications. The fourth line gives the initials of the subject, the year of birth, the year of measurement, and the registered number of the subject, so that his finger-prints may be found. The following individual cases will illustrate the compactness of the arrangement and explain its interpretation :

58a	46 R5, 88	89w	U5 R5, 55	47a	W6 W6, 88
196 153 138 454 111		203 151 137 486 121		195 148 140 446 111	
y v y — k —		6 16 — 2a — y		o v — o wv —	
G. K. 1862-94	6590	C. J. E. 1870-94	6547	G. A. 1839-94	6578

They are taken from the finger-print index. $58a = llwla$; thus G. K., whose finger-prints were registered as No. 6590 and who was born in 1862 and measured when he was 32 years old, was in the medium classes for length and breadth of head and for left cubit; he was wide in bizygomatic or cheek bone width and had a short left middle finger; the second line gives his actual measurements. His finger-print formula was ALW , RLL , WL , WL . Both his thumbs were whorls, and his little fingers loops; no further information is given. His right forefinger was an arch, there being a needle or racquet-shaped ridge therein; his right middle finger was a loop invaded by a blunt system of ridges; his right ring finger was a whorl with a racquet-shaped core. On the left hand the forefinger was a radial loop, and the ring finger a non-radial loop, the middle finger was a non-radial loop with the inner part of the

pattern more or less hooked. C. J. E. was born in 1870 and measured when 24 years old. His finger-prints will be found under register number 6547. His anthropometric formula is $89w = wlwww$, or he is of medium head breadth, but large in all his other measurements. His finger-print formula is

$$U5 R5, 55 = ULL, RLL, LL, LL,$$

or he belongs to the class of which all the ten prints are loops. We are only told that the right forefinger has an ulnar and the left a radial loop. The number of ridges on the right forefinger is 6, and on the right middle finger 16. The left forefinger with its radial loop has only two ridges and might also be called an arch (*a*); the left ring finger loop has a racquet-shaped core.

Finally G. A., born in 1839 and measured at 55 years of age, has for register number 6578. His anthropometric formula is $47a = lawaa$, or he is small in head breadth, left cubit and left middle finger, medium in head length and large in facial breadth (bizygomatic). His finger-print formula is

$$W6 W6, 88 = WLW, WLW, WL, WL.$$

Thus his thumbs are whorls and both his little fingers loops; both his forefingers are whorls with well-defined rings round the core; his right middle finger is a loop invaded by a blunt system of ridges and the same is true for the left middle finger, the print of which might, however, be mistaken for a whorl; there is no characterisation for either ring finger beyond the statement that both are whorls.

It is clear that Galton was at this date feeling his way up to a more complete secondary classification. Dropping the anthropometric data—although be it remembered they are useful when the police need to give the public some rough particulars of a criminal—there is ample space for a full 10-digit print formula in the first line, which would get much more differentiation into the uncharacterised *L*'s and *W*'s. Something of this was introduced by Galton into his *Finger Print Directories* of the following year, and we shall see that it can be easily extended. We note that for the all-loops formulae he introduces ridge counting on fore and middle fingers, and this was the method adopted by Henry from Galton, although he then proceeded for ridge frequency to follow Bertillon in using only broad categories. Galton admits that this index was only experimental, but its arrangement is suggestive especially in the cases where anthropometric measurements are also desirable. It has the advantage that as the frequency under any formula increases, it is always feasible to add more detailed secondary classification in the third line. For example, it would be at once feasible in the last illustration to break up the six whorls into those fed radially, ulnarly or from both sides, and again into right-handed and left-handed screw classes.

The Final Work on Indexing Finger-Prints. Galton's third volume on the subject of finger prints appeared in 1895; it is entitled *Finger Print Directories*, and is gracefully dedicated to Sir William J. Herschel*. The main purpose

* "I do myself the pleasure of dedicating this book to you, in recognition of your initiative in employing finger-prints in official signatures, nearly forty years ago, and in grateful remembrance of the invaluable help you freely gave me when I began to study them." Here, as elsewhere, Galton very fully acknowledges his indebtedness to Herschel's aid.

of the book is to provide a method of indexing 200,000 to 300,000 individuals. Galton assumes that five anthropometric characters will each be divided into three classes as in bertillonage, and accordingly, if this provides for $3^5 = 243$ classes, we need only to secure some method of finger-print indexing which will leave very few multiple entries in 1000 cases. This is the problem Galton sets himself; it will be seen that in 1895 he still thought it desirable to use a small dose of bertillonage to aid his index, if it was to provide rapid references to more than 1000 to 3000 individuals.

Galton here starts from the old Arch-Loop-Whorl classification with the addition of the inner and outer slope of loops on the forefinger, only now, I think unfortunately, he changes many of his symbols and some of his previous terminology. Having preferred in his earlier works "inner" for the thumb side and "outer" for the little finger side, he now adopts radial and ulnar formerly rejected; thus the symbols *i* and *o* are replaced by *r* and *u*. He still works in this index with the 10 digits arranged thus*: Right, fore, middle, ring fingers; Left, ditto. Right, thumb, little finger; Left, ditto—which in his old treatment gave 10 letters. He reduces them, however, to eight, by noting that *a*, *l*, *w* can only occur pair by pair in nine ways, and he gives the first nine figures to these, so that it is possible to represent thumb and little finger prints by a single figure. Thus far it is difficult to see that much has been gained on his earlier classification. Indeed with slight changes of notation Galton's present *Primary Classification* is his old *a*, *l* (*i*, *o*), *w* system. Now the defects of this as the sole classification are well exhibited in the following table which he gives (p. 77):

Formulae with Frequencies 10 and over in 1000 Tests.

Order of Frequency	Formula	Frequency of Occurrence
1	<i>ull, ull, ll, ll</i>	59
2	<i>rll, rll, ll, ll</i>	35
3	<i>ull, rll, ll, ll</i>	24
4	<i>www, www, ww, ww</i>	19
5	<i>rll, ull, ll, ll</i>	17
6	<i>ulw, ull, ll, ll</i>	14
7	<i>ulw, ulw, ll, ll</i>	12
8	<i>www, www, wl, wl</i>	11
9	<i>wll, ull, ll, ll</i>	10
10	<i>ull, ull, ll, ll</i>	10
		Total 211

* He states, however (pp. 72 and 111), that he has modified this view for the purpose of indexing and now prefers to take his finger-prints in order from left little finger to right little finger. There is little doubt that the latter, the "natural" order, and also the one in which the impressions are collectively dabbed and usually rolled, is less liable to errors of reading. At the same time as it starts with the little finger it gives far less variety to the *initial* letters of the index.

In other words, between a fifth and a quarter of the sets fall into groups which are far too unwieldy for rapid index searching. It is clear that the loops and whorls are the chief source of this trouble (see our pp. 149, 165 and 173) and Galton proceeds to break them up by what he terms a *Secondary Classification*, or a system of adding subscripts to the letters of his primary classification. The subscripts or suffixes as Galton calls them are very numerous, although some can only be attached to certain patterns. For example, what would have appeared in his old (his present primary) classification as

$oww, oll, ww, ll,$

now becomes

$uw_yw, ul^\dagger l_{vy}, w_{lvy}w, ll_v,$

where subscript y means that the core of the corresponding whorl is pear- or racquet-shaped; \dagger denotes that there was a scar on the middle finger of the left hand; l_{vy} denotes a loop with invasion of ridges from the side and with a racquet core; w_{lvy} means a whorl which might be mistaken for a loop, has an invasion of ridges from the side and a racquet core, and l_v denotes a loop with a like invasion only. Thus 18 symbols are used to index the set. Galton defines and discusses 28 letters and symbols which may be used as suffixes. Obviously the above system of subscripts is one liable to error either in writing or printing, and Galton, although he suggests its use, does not actually adopt it in the *Directory* he publishes of 300 sets of prints of the 10 digits. Here he gives the primary classification symbols on the left of his page, and then on the right in 10 columns the suffixes to be attached to each of these symbols. For example, the above formula appears as

| Uww | ull | 9, 5 || - , y , - | - , \dagger , vy | lvy , - | - , v |,

where the last 10 columns correspond to the digits in order of the primary formula ($9 = ww$, $5 = ll$, the thumb and little finger formulae of right and left hands: see our p. 198).

Besides the 28 symbols which are chiefly devoted to breaking up the large loop and whorl groups, Galton introduces for the troublesome all-loops group the counting of the ridges on the forefingers. This counting he now does in a different manner from that of his earlier papers, and one which seems less liable to misinterpretation. He first determines a better line for counting the ridges on (see his pp. 78-80) than he had previously selected (see our pp. 163 and 165). The following are his rules (see Fig. 34, p. 202):

"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, a^1 and a^2 ; then the top of the central ridge is the inner terminus*.

* I think there is a risk of confusion here to which Galton does not refer. The ridge or ridges within the "staple" may or may not meet the latter. In Figs. a^1 and a^2 the inner ridges are made to meet the staple, and the inner terminus is not put at the top of the

“(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. b).

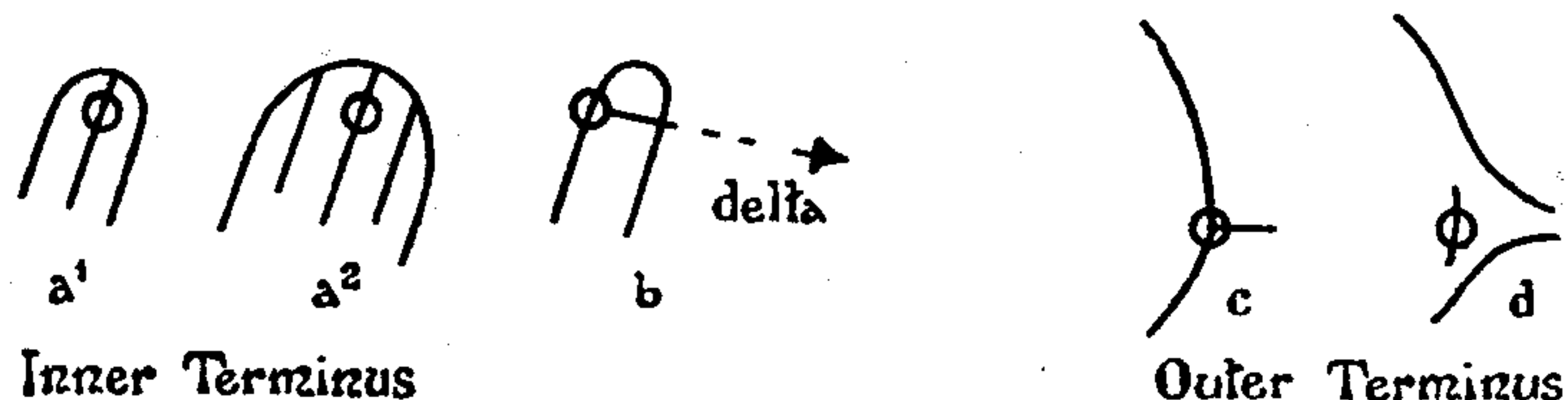


Fig. 34. Inner and Outer Termini for Ridge Counting.

“*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 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 (Fig. c).

“(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.”

Galton tells us that the 156 (*ull, ull, ll, ll*)’s of his collection of 2632 sets showed, counting as above, all numbers of ridges from 3 to 16 with fairly equal frequency. He had also a few “under 3” and eight cases above 16; roughly these 15 groups would reduce the 156 to groups of about 10 sets. But Galton considers we must search not only the observed count-number, but two count-numbers on either side of it, or practically (having regard to

central ridge. If it had been, then, I think, it is clear that with the delta in relatively the same position as in Fig. b one less ridge would be counted in Fig. a¹ and two less in Fig. a². It is possible that the engraver erred in carrying the ridges quite up to the staple. Or, it may be, remembering what Galton has said about *cols*, i.e. that we cannot be certain whether a ridge terminates or forks, we ought always to put the inner terminal, as in Figs. a¹ and a² above, not where the central ridge meets the staple, but at about a ridge interval from the meet.

* The term “shoulder” is somewhat vague; the ridge-counts might well differ according to the choice of “shoulder.” If the word means where the sides of the staple become parallel, then the engraver of Fig. b has hardly hit this off. I believe it would be preferable to define the shoulder as about a ridge interval below the summit. Galton’s Plate 4 (our Plate XXVI), entitled “Counting Ridges,” hardly seems to meet my difficulties in this and in the previous footnote. If Fig. 82 be a case of Fig. a¹, then Galton does not appear to put the inner terminus at the top of the central ridge; had he done so, I think the ridges would be 12 instead of 13.

† Galton’s illustrations of ridge-counting are given on our Plate XXVI and would have been more helpful with a finer counting line. A thick line runs into the stem and occasionally obscures the finer parts of the delta.

terminal groups) about a group containing $4\frac{1}{2}$ ridges on the average. Each of these groups would contain 40 to 50 individuals of the 156, or less than $\frac{1}{3}$ and more than $\frac{1}{4}$ of the whole. Hence to count ridges in the first finger presenting a loop would reduce to less than a frequency of 10 all the groups of large frequencies except those under the formulae *ull*, *ull*, *ll*, *ll* and *www*, *www*, *ww*, *ww* (see the table on our p. 200). For the former group Galton suggests in addition counting ridges on the middle finger, and is thus able to break up his material into groups of less than 10 sets*. Here he introduces an interesting point; he gives a partial table (p. 82) for the number of ridges which occur in right middle and ring fingers for certain values of the count on the right forefinger. If the means of the former be found we have:

Number of Ridges in Fore Finger	Mean number of Ridges in	
	Middle Finger	Ring Finger
4	9.8	14.4
8	10.4	14.9
12	11.8	14.2
16	13.7	15.3

This suggests that there is correlation between the number of ridges at any rate in the fore and middle fingers of the same hand, and indicates a possible line of inquiry for the inheritance of ridge-numbers, when loops are available in both relatives.

We have next to consider how Galton meets the difficulty of the *www*, *www*, *ww*, *ww* class of pattern and others with numerous whorls. The main idea he uses is that if the tail of a whorl or the ridges which form it come from the radial side, the subscript or suffix *r* is used. If they come from the ulnar side the suffix *u* might be used, but Galton says this is so frequent that he does not use it. Hence *w* standing alone might mean fed from both sides, from neither side, or from the ulnar side. The suffix *s* is, however, used for whorls fed from both sides, but this may occur in three different ways:

(i) The ridges from either side may double back upon themselves, so that the contributory portions have blunt ends = *sb*.

(ii) The ridges from the two sides may be twisted together almost to a point = *sq*.

(iii) One set of contributory ridges may spring normally from one side of the finger, the other from one side of the tail of a tailed whorl = *sv*.

There are other symbols used by Galton in relation to whorls, namely *g*,

* The reader must remember that these numbers are based on a standard of 1000 sets. For 100,000 sets some of the groups might still be too large.

when the whorl has a great core, *o*, when there is at least one complete and detached ring in the whorl*.

EIGHT FORMS OF WHORL (two deltas)

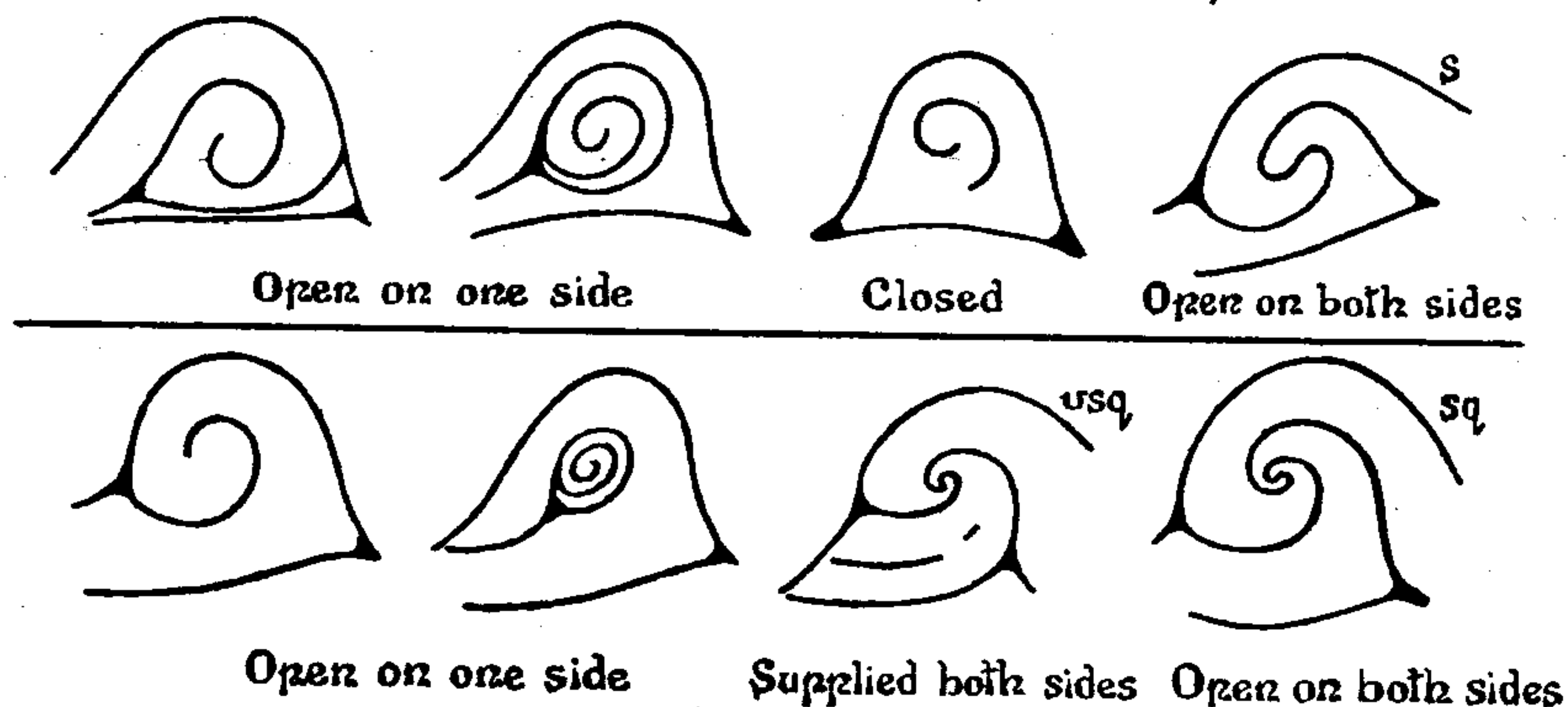


Fig. 35. Types of whorls from Galton's *Finger Print Directories*.

Galton remarks that it is best to leave a whorl ambiguous rather than attach a *v* or a *q* to it which it does not clearly and distinctly demand. "The omission of a suffix is of little harm; the insertion of a wrong one is. Cases should be dealt with merely 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" (p. 94). It is, however, on the *r* and *s* sub-classification that Galton chiefly depends for breaking up the all or many whorl groups. Thus he writes:

"It is mainly through the help of the *r* and *s* suffixes that it is possible to discriminate between the all-whorls which occur 19 times in every 1000 cases [see our p. 200]. The whorls

* According to Galton's nomenclature, when in tracing any part of a pattern the direction changes so as to have pointed to all parts of the compass, that pattern is to be called a whorl.

PARTIAL AND COMPLETE CIRCUITS

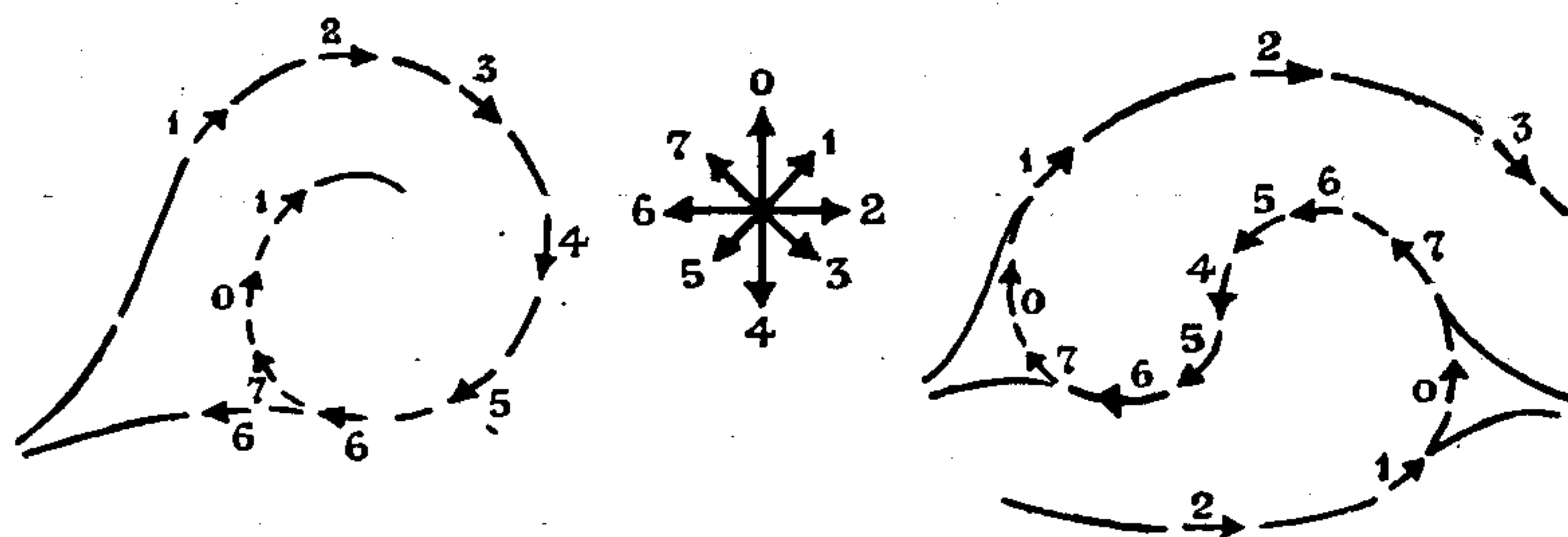


Fig. 36 a.

Fig. 36 b.

Illustration of complete circuits needed to classify a pattern as a whorl.

Hence arches with elliptic or circular rings between their arched ridges are classed as whorls. See Plates 7 and 8 of *Finger Prints* (our Plates XI and XII) and the accompanying cut, Figs. 36 a and 36 b, where, however, a print like Fig. 36 b, for which the compass point 4 might easily be non-existent, is still counted a whorl.

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 be pressed into the service of sub-classification, the sets admitting of being arranged in the order of the number of *r*'s that they severally contain, irrespective of the fingers on which those *r*'s appear." (pp. 95-6.)

A point which I think would be of value, but has not, I think, been noted by Galton, is the character of the whorl or spiral. Starting from the pole of the spiral does it correspond to a right or left-handed screw motion, i.e. is the rotation clockwise or counter-clockwise? It appears to me that these two types occur in not such unequal numbers, and at once divide whorls into two classes. Of course a clockwise or right-handed screw whorl on the actual finger is reversed on the imprint, but we may confine our classification to the imprints.

A further classification which might also be made in the case of simple spirals—and which easily admits of four classes—is the direction of the whorl or spiral at its pole or terminal. Is this direction generally upwards or downwards, generally radial or ulnar? There would be some doubt as to the 45° slopes, but as a rule the general polar slope is fairly obvious. I think there is thus actually small difficulty in breaking up the whorls for the purposes of indexing.

Galton makes only one division of arches in his Primary Classification, namely into Plain and Tented Arches (see our Fig. 37). The symbols *k*, *r*, *u*, or *v* may, however, be attached in the Secondary Classification.

We have already seen that Galton uses counting of ridges on the fore-finger and if necessary on the middle finger in order to break up the loop groups. But he admits that this is scarcely adequate in itself to deal with an index of 3000 sets or persons. Accordingly he uses other suffixes to differentiate loops by their cores. He considers the following three types will suffice:

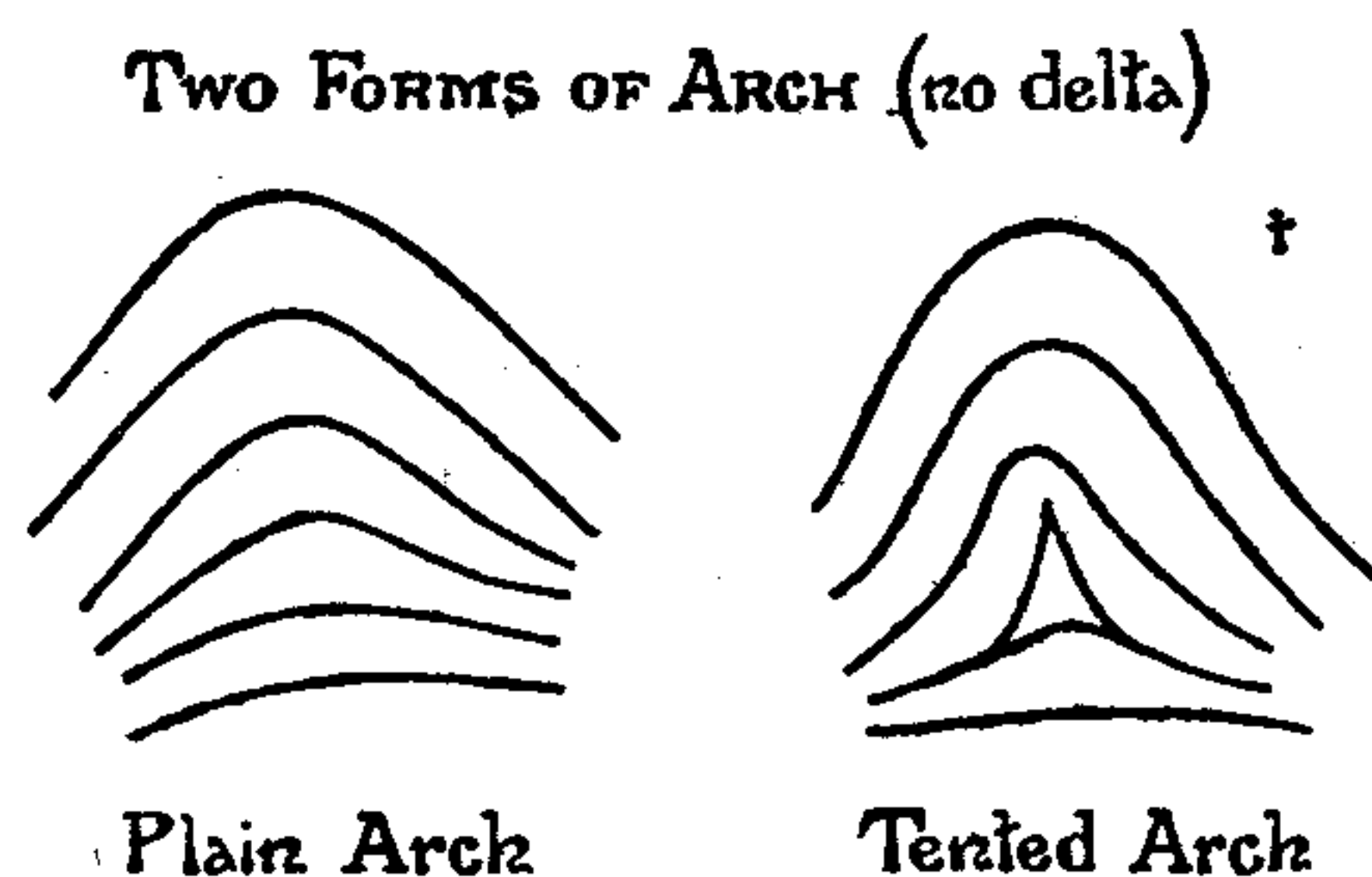


Fig. 37.

THREE FORMS OF LOOP

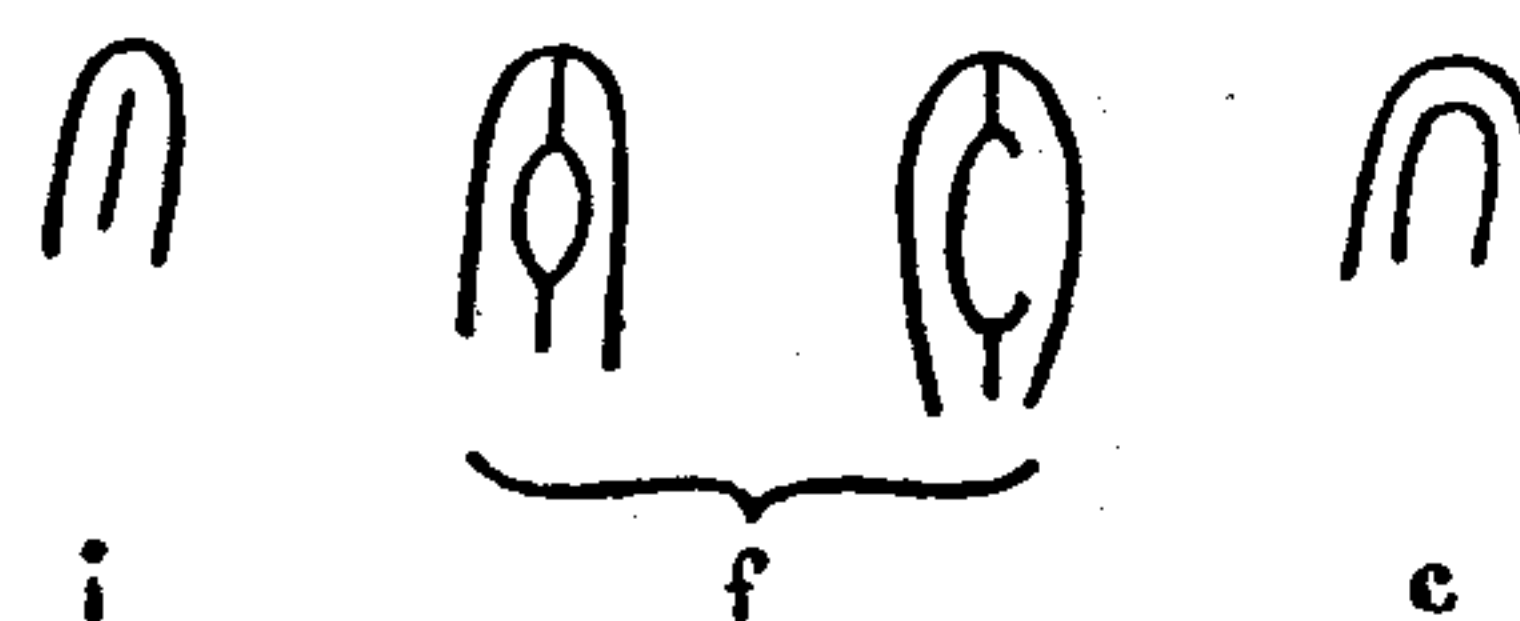


Fig. 38. Classification of Cores of Loops.

i is a central rod, whose head stands quite distinct and separate from the ridge curving round it. Galton says there is no need to fear a *col*, if there be the distance of a furrow between central rod and staple. *f* covers the cases in which the central rod forks whether it reaches the staple or not; it may

reunite forming the eye of a needle, or there may be an imperfect eye. The main point is that the core is not a simple rod; the several conditions do not need symbolising severally, they are all expressed by *f*.

c represents the case when the core within the loop is a second staple wholly detached from the outer staple which curves round it.

Galton uses still further symbols in his secondary classification—*k*, *v*, *x*, *y*, and three others to denote conditions of the print itself, namely: *d*, † and *. *d* marks a damaged print, either owing to the condition of the finger, or to the printing. If the print be wholly unreadable, then *d* is inserted in its proper place in the primary 10 symbols; if the print be only partially damaged, then *d* is to be used as a suffix. † denotes the scar of a cut, and should be used, however small the scar may be, as it is a valuable means of identification. * denotes that a portion of the finger has been more or less smashed, and should be combined with *d*.

Of the other four symbols *x* denotes that there is something very peculiar or questionable about the pattern.

v indicates what Galton terms an invaded loop. Usually the ridges enter through the open mouths of the loop, curve round and take their exits



Fig. 39. Secondary Classification of Loops, Galton's *y* and *v*.

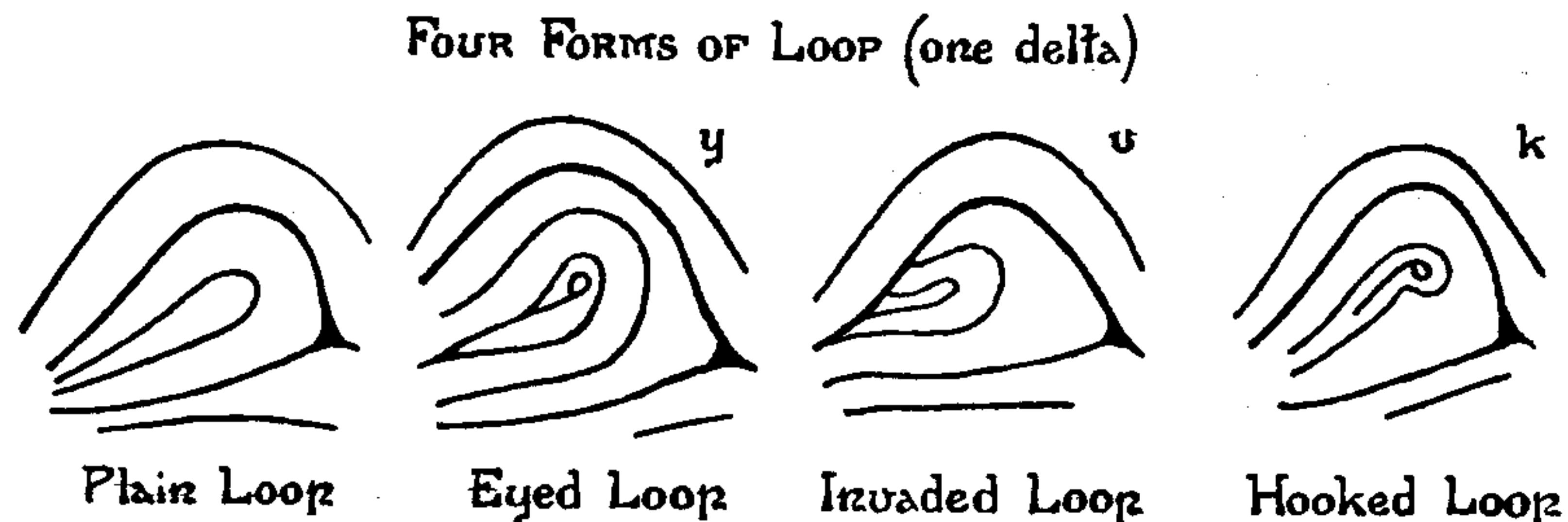


Fig. 40. Secondary Classification of Loops, Galton's *y*, *v* and *k*.

parallel to their entrances. Sometimes, however, a system of ridges instead of entering from the mouth, springs out from one of the sides and destroys the symmetry of the pattern. Such a loop is an "invaded loop" and symbolised by *v*. Galton holds *y* to be one of the most generally useful of suffixes; it is the formation in the inner part of the loop of an eyed form. In the ordinary loop the ridges after turning back run parallel; in the eyed loop they reunite after recurving and enclose a minute plot. *y* must be distinguished from *f*, which latter is an island or approximate island in a central rod.

Finally *k* denotes a curvature sometimes affecting the whole of a loop, turning it into more or less of a solid hook, i.e. not a hook formed by a single

damaged (\bar{c}) = Galton's d . A short quantity over a letter (\check{e}) denotes a questionable pattern = Galton's x . A single dot (sign of fluxion), as \dot{m} , denotes the scar of a cut = Galton's \dagger ; two dots (second fluxion or "Umlaut"), as \ddot{c} , denotes a smashed finger = Galton's $*$. Thus we replace these four subscripts by symbols already familiar to the printer. We then propose to adopt the Greek alphabet to represent arches, small italic letters to represent loops, and capitals to represent whorls. It is thus at once feasible to disregard all individual letters and write down the common Arch-Loop-Whorl formula by regarding alphabets only. The individual subspecies are represented by the individual letters. But we soon find that if we are to have only as many subspecies as Galton deals with, we shall need more letters than exist in any of the three alphabets! We are thus driven back to suffixes, but here we find it easier to write numerical powers than to use subscript letters. Further, as we only want 10 characteristics, the 10 numerals will suffice. They are as follows:

- 0 = Galton's o , or the core of the whorl has a detached ring.
- 1 = Galton's b , or the end of a single spiral or the two ends of a double spiral are blunted.
- 2 = Galton's q , or the core of the spiral is made of ridges twisted up into a point.
- 3 = Galton's g , or the core of the whorl is very large.
- 4 = Galton's k , or the body of the loop or whorl is curved like a hook, or some of the inner ridges are hooked.
- 5 = Galton's v , or there is an invasion of ridges from the side of loop or whorl.
- 6 = Galton's y , or the core of a loop or whorl, or even sometimes of an arch, has an eye shaped like a pear or racquet.
- 7 = Galton's c , or the upper part or innermost core of the loop is shaped like a staple detached from the enveloping ridge.
- 8 = Galton's f , or the innermost core of the loop forks like a tuning fork; it may afterwards reunite, enclosing a space like the eye of a needle (or like a broken eye).
- 9 = Galton's i , or the innermost core of the loop is a rod whose head is separate from the enveloping ridge. Multiple rods may also be included under 9.

It will be seen that the first four numerals (0, 1, 2, 3) apply only to whorls; the last three (7, 8, 9) only to loops; the remaining three (4, 5, 6) to any species of print. A little practice soon causes one to remember the significance of these numerals as easily as Galton's letters. Any combination of these numerals may appear as a power. Thus k^{54} we shall see denotes a radial loop with some resemblance to an arch, with an invasion of ridges from the side, and one or more hooked ridges; again A^{40} denotes a simple right-handed screw radial whorl with a completed circle and a ridge hooked round. Galton would represent this as $w(r, ko)$, where w denotes the whorl, r that it is radial, and ko that there is a coil of ridges enclosed in a complete or nearly complete ring. So much for the power suffixes.

It should be noted that the order of the numerals in the power is indifferent. We may now turn to the subspecies of the main species indicated by different letters of their special alphabets.

Arches:

- α = simple arch; β = tented arch; γ = arch with a central dot or very small circle;
- κ = arch approaching radial loop;
- λ = arch approaching ulnar loop;
- μ = arch which might equally well be classed as a radial loop;
- ν = arch which might equally well be classed as an ulnar loop;
- π = arch approaching a radial whorl;
- ρ = arch approaching an ulnar whorl;
- σ = arch which might equally well be classed as a radial whorl;
- τ = arch which might equally well be classed as an ulnar whorl;
- ζ = tented arch which might be confused with a loop fed from both sides.

It will be seen that κ , λ are nascent loops, π , ρ nascent whorls, and μ , ν , σ , τ quite ambiguous forms, which it may be needful to look out under other headings when searching the index.

Loops:

- a = radial loop; b = ulnar loop; c = loop fed from both sides;
- d = loop which cannot be clearly classed under a , b or c ;
- e = double adjacent loops; f = double superimposed loops;
- g = loop resembling a tented arch;
- h = loop which somewhat exceeds the limit at which it could be classed as an arch (or nascent loop);
- k = radial loop which has some likeness to an arch;
- l = ulnar loop which has some likeness to an arch;
- m = radial loop which might equally well be classed as an arch;
- n = ulnar loop which might equally well be classed as an arch;
- u = radial loop which has some likeness to a whorl;
- v = ulnar loop which has some likeness to a whorl;
- x = radial loop which might equally well be classed as a whorl;
- y = ulnar loop which might equally well be classed as a whorl;
- z = loop fed from both sides which might be classed as a tented arch.

As before it will be seen that m , n and z are ambiguous cases interchangeable with μ , ν and ζ ; k and l ought not to be, but may sometimes be confused with κ and λ .

Whorls:

Thus far our symbolism has only been an attempt to abbreviate Galton's. In the case of whorls we think it desirable to introduce certain additional broad classes, besides Galton's radial (r), ulnar (u) and fed from both sides (s). In the first place we distinguish between a simple spiral and a compound spiral with several whorling ridges linked at the pole. In the next place we

distinguish starting from the pole between clockwise and counter-clockwise, or right handed and left-handed screw motion. We have thus twelve primary classes:

- A* = simple radial right-handed screw whorl;
B = „ ulnar „ „ „
C = „ fed from both sides right-handed screw whorl;
D = compound radial right-handed screw whorl;
E = „ ulnar „ „ „
F = „ fed from both sides right-handed screw whorl;
G = simple radial left-handed screw whorl;
H = „ ulnar „ „ „
I = „ fed from both sides left-handed screw whorl;
J = compound radial left-handed screw whorl;
K = „ ulnar „ „ „
L = „ fed from both sides left-handed screw whorl.

For the resembling and the ambiguous cases we have:

- P* = radial whorl approaching arch;
R = ulnar whorl approaching arch;
S = radial whorl which might equally well be classed as arch;
T = ulnar whorl which might equally well be classed as arch;
U = radial whorl approaching loop;
V = ulnar whorl approaching loop;
X = radial whorl which might equally well be classed as loop;
Y = ulnar whorl which might equally well be classed as loop.

Clearly *X*, *Y* are interchangeable with *x* and *y*, and if the index shows no *U* or *V*, then *u* or *v* should be sought for.

Unfortunately Galton's index does not record directly whether his whorls were simple or compound, or whether they were right or left-handed screws. Accordingly, in writing down his symbolism and that above for a few cases, we shall assume, where there is nothing to guide us, that his whorls were simple spirals and right-handed screws. I have chosen ten cases nearly at random from Galton's index of 300 sets of prints, only taking care that the selected individuals had very ample secondary classifications.

The table below gives the two notations.

In the condensed system, the indexing should be by order of letters, but for the same letter the Greek should stand before the small italic letter and the small italic before the capital, e.g. β before *b* and *b* before *B*.

It will be seen that it is possible to put an even finer classification based on Galton's into a very concentrated form. Therein alphabets indicate the genera, or primary classification, letters the species or subclasses, and powers the individual peculiarities. In this way many thousand finger-print sets may be indexed without reference to anthropometric characters. But we have always to remember that to avoid multiple entries more and more symbols must inevitably be used. A very little practice, however, teaches anyone the meaning of the symbols employed. It does not seem possible to adopt

any system in which the symbols will be self-explanatory, and neither in Galton's original, nor in the present condensed system has this been attempted. The problem of the Identification Bureau is to balance the time lost in writing down and in reading a complicated system, against the time lost in examining the multiple entries of a more simple classification.

Table illustrating how Galton's System of Finger-Print indexing may be condensed and at the same time further developed.

Directory														
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		Number in Register
F.M.R.	F.M.R.			F.	M.	R.	F.	M.	R.	Th.	L.	Th.	L.	
<i>Aal</i>	<i>all</i>	5	5	—	<i>l</i>	—	—	—	<i>yw</i>	<i>v</i>	—	<i>vw</i>	—	3550
<i>Rll</i>	<i>rll</i>	5	5	12	—	<i>vy</i>	—	<i>ky</i>	<i>y</i>	<i>v</i>	—	—	—	3531
<i>Rll</i>	<i>rww</i>	8	8	<i>k</i>	—	<i>v</i>	<i>vk</i>	<i>sb</i>	<i>sb</i>	—	—	<i>sb</i>	—	2351
<i>Rlw</i>	<i>ull</i>	5	5	<i>kw</i>	<i>r</i>	<i>by</i>	<i>3ay</i>	—	—	<i>v</i>	—	—	—	3660
<i>Rlw</i>	<i>www</i>	9	5	† <i>k</i>	—	—	<i>rko</i>	<i>s</i>	<i>s</i>	<i>sb</i>	—	—	—	1985
<i>Ull</i>	<i>ull</i>	5	5	10 <i>c</i>	—	<i>vyc</i>	<i>i</i>	<i>c</i>	—	—	—	—	—	3617
<i>Ull</i>	<i>www</i>	5	8	<i>v</i>	<i>v</i>	<i>v</i>	<i>r</i>	<i>ko</i>	—	<i>vw</i>	—	<i>sq</i>	—	3560
<i>Ulw</i>	<i>rlw</i>	8	8	—	—	—	<i>avk</i>	—	<i>ryl</i>	†	—	<i>s</i>	—	3498
<i>Wll</i>	<i>rll</i>	8	8	<i>kw</i>	—	—	2	†	—	<i>g</i>	—	<i>gs</i>	—	3554
<i>Wlw</i>	<i>www</i>	8	8	<i>r†</i>	—	—	<i>ly</i>	—	†	<i>o</i>	<i>v</i>	<i>vs</i>	—	738

The following are the values on our present condensed system:

<i>b</i>	<i>u</i> ⁶	<i>b</i>	<i>a</i>	<i>u</i> ⁵	<i>b</i> ⁵	<i>a</i>	<i>κ</i>	<i>b</i>	<i>b</i>	3550
<i>b</i>	<i>b</i> ⁶	<i>b</i> ⁴⁶	<i>a</i>	<i>b</i>	<i>b</i> ⁵	<i>a</i>	<i>b</i>	<i>b</i> ⁵⁶	<i>b</i> {xii}	3531
<i>b</i>	<i>C</i> ¹	<i>C</i> ¹	<i>a</i> ⁵⁴	<i>C</i> ¹	<i>B</i>	<i>a</i> ⁴	<i>b</i>	<i>b</i> ⁵	<i>b</i>	2351
{3}	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i> ⁵	<i>u</i> ⁴⁵	<i>a</i>	<i>B</i> ¹⁶	<i>b</i>	3660
<i>b</i>	<i>C</i>	<i>C</i>	<i>A</i> ⁴⁰	<i>b</i>	<i>C</i> ¹	<i>a</i> ⁴	<i>b</i>	<i>B</i>	<i>B</i>	1985
<i>b</i>	<i>b</i>	<i>b</i> ⁷	<i>b</i> ⁹	<i>b</i>	<i>b</i>	<i>b</i> ⁷	<i>b</i>	<i>b</i> ⁵⁶⁷	<i>b</i> {x}	3617
<i>b</i>	<i>B</i>	<i>B</i> ⁴⁰	<i>A</i>	<i>C</i> ²	<i>v</i> ⁵	<i>b</i> ⁵	<i>b</i> ⁵	<i>b</i> ⁵	<i>b</i>	3560
<i>b</i>	<i>U</i> ⁶	<i>b</i>	<i>k</i> ⁵⁴	<i>C</i>	<i>B</i>	<i>b</i>	<i>b</i>	<i>B</i>	<i>b</i>	3498
{2}	<i>b</i>	<i>b</i>	<i>b</i>	<i>a</i>	<i>C</i> ³	<i>B</i> ³	<i>A</i> ⁴⁵	<i>b</i>	<i>b</i>	3554
<i>b</i>	<i>B</i>	<i>B</i>	<i>V</i> ⁶	<i>C</i> ⁵	<i>B</i> ⁰	<i>A</i>	<i>b</i>	<i>B</i>	<i>b</i> ⁵	738

With Galton: Th. = Thumb; F. = Forefinger; M. = Middle finger; R. = Ring finger; L. = Little finger. In the condensed system, the fingers are in "natural order from left little to right little finger." The vertical is placed between the two thumbs.

We have now to consider briefly the remainder of this last finger-print work of Francis Galton.

In the *Introductory Chapter* Galton clearly defines his aim. Scotland Yard was beginning to form a vast collection of finger-prints, but these were to be primarily classified by four or five anthropometric measurements, so that the number of finger-prints in a group would not amount to more than a few hundreds or at most to, perhaps, 3000. It was the large groups in these subindices which Galton desired to break up. He was not describing how to deal with indices of 100,000 to 200,000 sets; that is a more modern problem.

* See our p. 198.

Yet, I believe, the extension I have given above of Galton's classification would readily admit of dealing with far larger numbers than he was considering. The important feature of Galton's present work is that he does not give merely definitions of his symbols for secondary classification, but he provides also illustrations of the various finger-print anomalies and characteristics he has symbolised. It is a misfortune that of the nine plates of finger-prints which accompany the memoir, all but two have the impressions natural size, and very often, to detect Galton's point, it is needful to use a magnifying glass. As the work has been long out of print and as there is, so far as I am aware, no published series of typical prints available, these plates are reproduced here on an enlarged scale to indicate Galton's ideas*. He is very modest about what he has achieved. The work, I think, shows some signs of haste, not in the studies on which it is based, but in the manner in which it is put together as if to supply some pressing need. He writes:

"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 finger-prints 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 [see our pp. 148 and 174]. ... Having studied and during the last few months having re-studied many thousands of sets of finger-prints, 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 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 (pp. 7-47) largely reproduces the *Report of the Departmental Committee*. With this I have dealt very fully on our pp. 148-151. Chapter III (pp. 48-59) contains *Conditions and Requirements* which to the reader of our present chapter will be already familiar; they concern the breaking up of the larger groups which arise in the *ALW (+ UR)* primary classification. On pp. 58-9 are some interesting observations on the amount of work which would be needful in order to register the 35,000 annual recruits to the British Army by their finger-prints, and so to stop desertion followed by re-enlistment.

Chapter IV (pp. 60-77) *Primary Classification*, and Chapter V (pp. 78-107) *Secondary Classification*, we have already summarised (see our pp. 203-205 above). Together with the plates (our Plates XXIII-XXX), they form by far the best account a novice in finger-printing can study even to-day. Chapter VI, a brief one of only three pages, deals with *Ambiguous Patterns*. This is a most valuable chapter as indicating how we must treat intermediate

* Some further understanding of his classificatory system may be obtained from the much reduced set of standard types, which will be found in the pocket at the end of this volume. The originals in three large frames are in the Anthropometric Laboratory at University College, London.



1



7



13



19 Nascent Loop (a_l)



2



8



14



20 Nascent Loop (a_l)



3



9



15



21 Nascent Loop (a_l)



4



10 Nascent Loop (a_l)



16



22 Tented Arch



5



11



17



23 Tented Arch



6



12



18 (a_l or l_a)



24

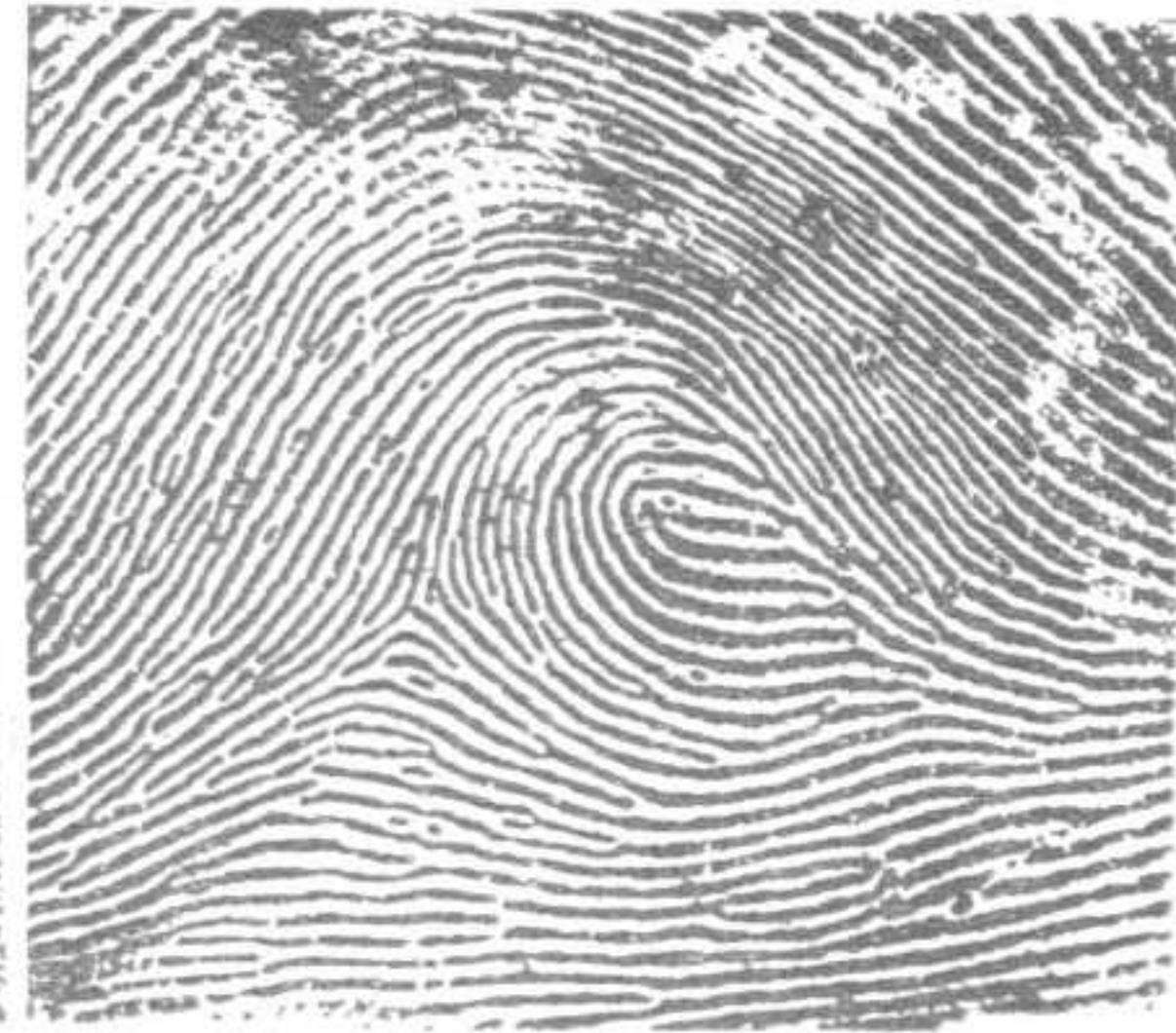
Types treated by Galton as Loops.



25



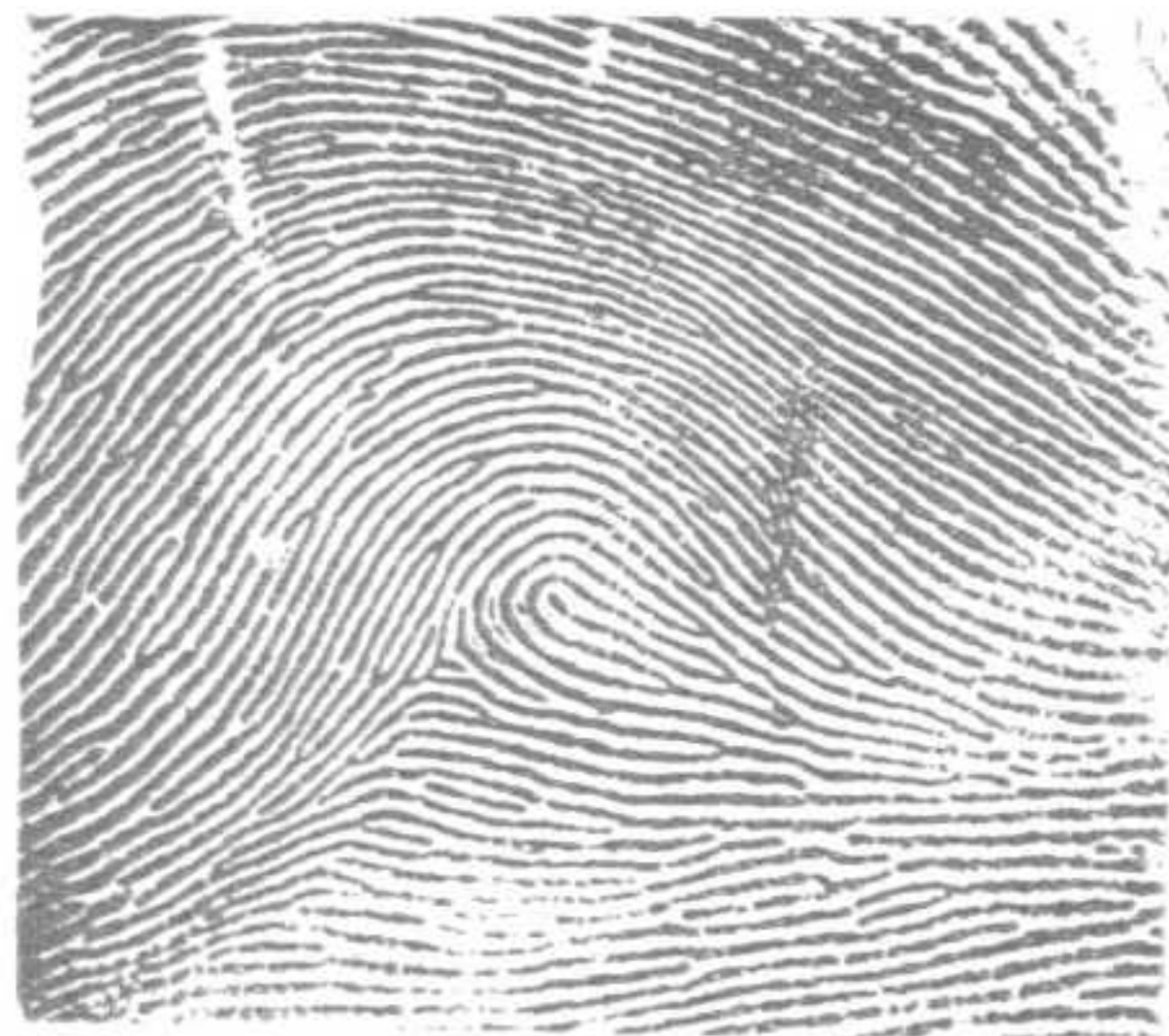
31



37 Loop (r)



43 Loop (l)



26



32



38 Loop (r)



44 Loop (l)



27



33



39 Loop (r)



45 Loop (l)



28



34



40



46 Loop (r)



29



35



41



47 Loop (l)



30



36



42 ? Arch (lr)



48 Loop (k)

Types treated by Galton as Whorls.



49



55 Whorl (*o*)



61 Whorl (*esq*)



67 Whorl (*bs*)



50 Whorl (*o*)



56



62



68 Whorl (*bs*)



51



57



63



69 Whorl (*bs*)



52 Whorl (*o*)



58



64 Whorl (*sq*)



70 Whorl (*bs*)



53 Whorl (*o*)



59 Whorl (*o*)



65 Whorl (*sb*)



71 Whorl (*bs*)



54 Whorl (*y*)



60

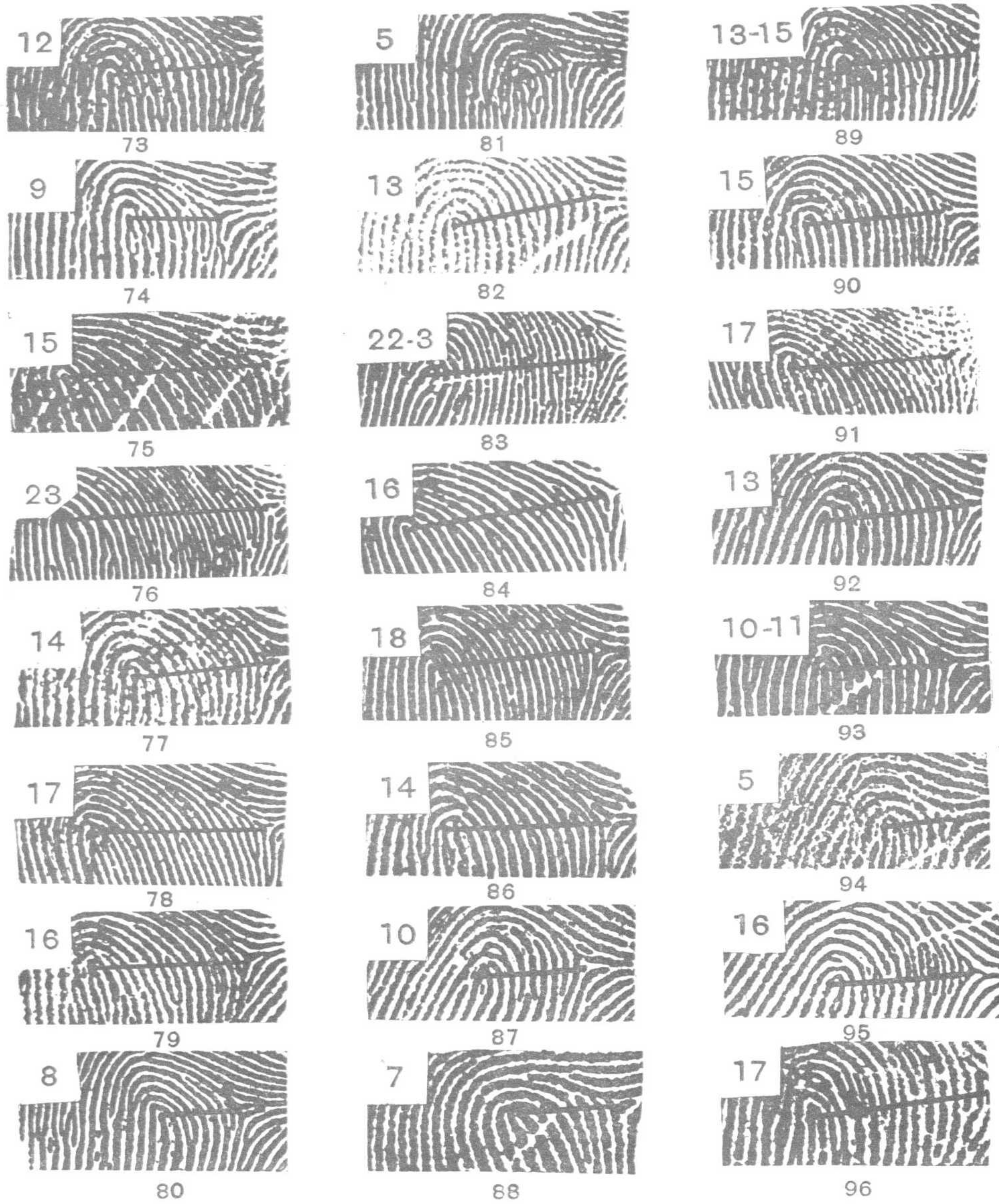


66 Whorl (*y*)



72 Whorl (*bs*)

PLATE XXVI

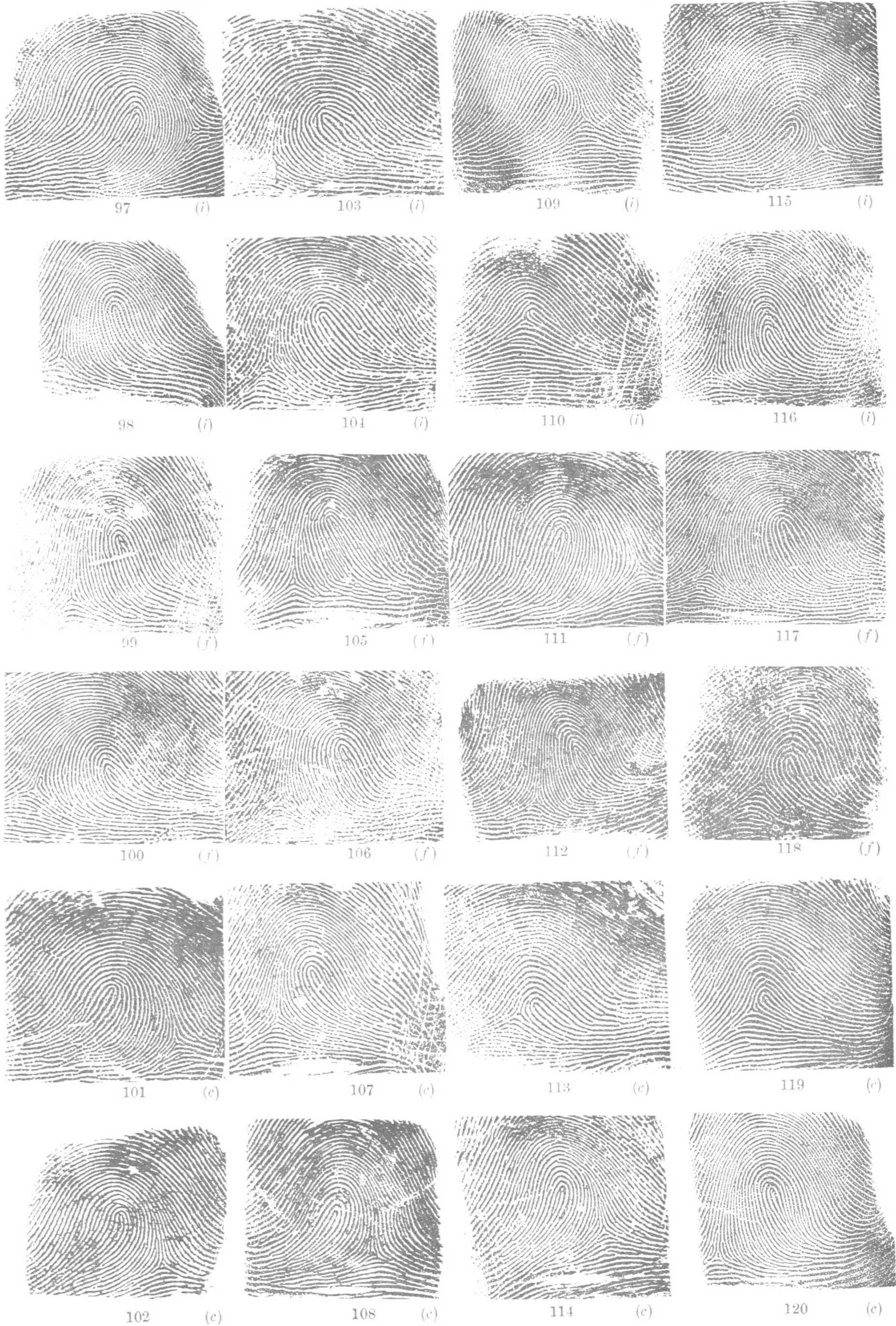


Galton's method of counting the Ridges in Loops. The number of ridges as determined by him are given in the left-hand top corner of each print: see our pp. 201-202.



A dabbed and a rolled print of the same finger to indicate how the former may lead one to classify as a loop, what the latter shows to be really a whorl: see our p. 213.

Illustrations of Galton's Symbols *i*, *f* and *c*. (See our p. 205.)



Illustrations of Galton's Symbols *y*, *v*, *vy*. (See our p. 206.)



121 (y)



127 (y)



133 (y)



139 (y)



122 (y)



128 (y)



134 (y)



140 (y)



123 (v)



129 (v)



135 (v)



141 (v)



124 (v)



130 (v)



136 (v)



142 (v)



125 (vy)



131 (vy)



137 (vy)



143 (vy)



126 (vy)



132 (vy)



138 (vy)



144 (vy)

PLATE XXIX

Galton's Symbols applied to Noteworthy Peculiarities. (See our p. 208.)



145



151



157

(sb)



163

(sb)



146

(o)



152

(o)



158



164

(sq)



147

(o)



153

(sq)



159

(g)



165

(g)



148



154



160

(k)



166

(k)



149



155



161

(k)



167

(k)



150

(+)



156

(+)



162

(+)



168

(+)

PLATE XXX

Various Prints with Galton's Classifications.



169
Loop (a)



170
Loop (a)



171
Loop (a)



172
Loop (a)



173
Imperfect Forms of Tented Arch



174



175
Whorl (ky)



176
Loop (s)



177
Loop (s)



178
Whorl (sb)



179
Whorl (sb)



180
Loop (y)



181
Loop (y)



182
Whorl (y)



183
Whorl (y)

To illustrate the Symbols of Galton's Secondary Classification.

patterns. I transcribe two-thirds of it for the benefit of those who can no longer obtain Galton's original work*.

"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* [i.e. Arch to Loop]. 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 should 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).

"2. When it consists of two or even three imperfect bends (Figs. 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.

"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 unite the suffix *l* to this." (pp. 108-9.)

Clearly since Arches form a relatively small group, it would be to the advantage of the indexer, if frontier cases were allotted as far as possible to Arches.

"*A* to *W* [i.e. Arch to Whorl]. Between *A* and *W* a very small, or else an imperfect circle, or 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 *Wky*.

"*L* to *W* [i.e. Loop to Whorl]. Between *L* and *W* a large class of transitional cases have been sufficiently discussed in speaking of complete and incomplete circuits†. See Figs. 180-183.

"The specimens Figs. 176 to 179 show the relationships between whorls to which the suffix *sb* 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." (pp. 109-10.) [See our p. 206.]

Lastly Galton refers to the case in which a real whorl may be mistaken for a loop because enough of the finger ridges have not been imprinted by rolling. This is especially a danger with "dabbed" prints. See our Plate XXVI.

Chapter VII (pp. 111-115) is entitled *Suggested Improvements*. Here, as I have said, Galton gives up his special finger arrangement in favour of the

* I have retained Galton's figure numbers, and the figures to which he refers will be found on our Plates XXIII-XXX.

† See our p. 204 footnote.

“natural order” (see our p. 200). We have seen that in the earlier publications Galton used *o* and *i*, “outer” and “inner,” to mark his directions; in this work, to begin with, he uses “ulnar” and “radial” and the symbols *U* and *R* (or *u* and *r*) instead of *o* and *i*. He now appears to discard *U* and *R*, writing as follows:

“As regards the *U* and *R* notation, I am now decidedly in favour of the plan tentatively suggested in my answer to Question 207 [*Departmental Committee Report (Evidence)*], 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*.” (p. 112.)

Galton next suggests a symbolic notation for the arch, whorl and two kinds of loops, i.e.



Arch *Loop* *Loop* *Whorl*

He says that the relief to eye and brain by this simple notation is very great. 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 (p. 112). Galton does not, however, suggest how with such symbols the secondary classification is to be worked out.

This chapter concludes with an account of Galton's finger-print enlarging camera, which will magnify up to sixfold. We have already referred to this instrument (see our p. 197). Chapter VIII (pp. 116–123) contains the *Specimen Directory of 300 Sets*. At first the variety of symbols in the Secondary Classification is somewhat trying, but after a little becomes easily interpretable. Besides the numerals which are provided for the forefinger in the case of the ridge-counts in the formula *lll, ll, ll*, other numerals occur in the index; they never exceed 4, and they may stand alone or be associated with *a* or *l*. They are in the *Secondary Classification*, and I cannot find that Galton has anywhere explained their meaning. This I am unable to supply. As I have said, I think the secondary classification needs condensation. It is also desirable that the method should be applied to several thousand sets of prints to ascertain, by an actual statistical experience, where the grading is still too coarse, or where it is over fine. If a student of finger-prints should, however, question me as to where he could learn how to index several thousand sets of finger-prints, I still could not refer him to anything better than Galton's *Finger Print Directories* of more than thirty years ago!

* Galton does not say how he proposes to symbolise the particular slope. As far as I can see, the result would be that two radial whorls on homologous fingers, say, which might be practically identical instead of being represented by the same symbol, would be represented by different symbols, which for any scientific purpose (e.g. inheritance) would be disastrous. If the finger-prints are taken in natural order, I see no difficulty in inscribing the letter *U* outside both little fingers and the letter *R* in the middle of the set of prints, between the adjacent thumbs. They might even be printed in these positions on the blanks which serve for the finger impressions. If the slope is then *downwards* from forefinger towards the little finger it is ulnar, otherwise radial.

The reader who has had the courage to follow Galton's biographer through the intricacies of this chapter will, I am sure, be convinced not only of the labour Galton devoted to his finger-print studies but also of the amazing energy he exhibited in acquainting not only administrative bodies but the public at large with the possibilities which then lay hidden in finger-printing, and this not solely for scientific but also for practical purposes. If the reader can find anyone who before 1895 had published a title of what Galton had

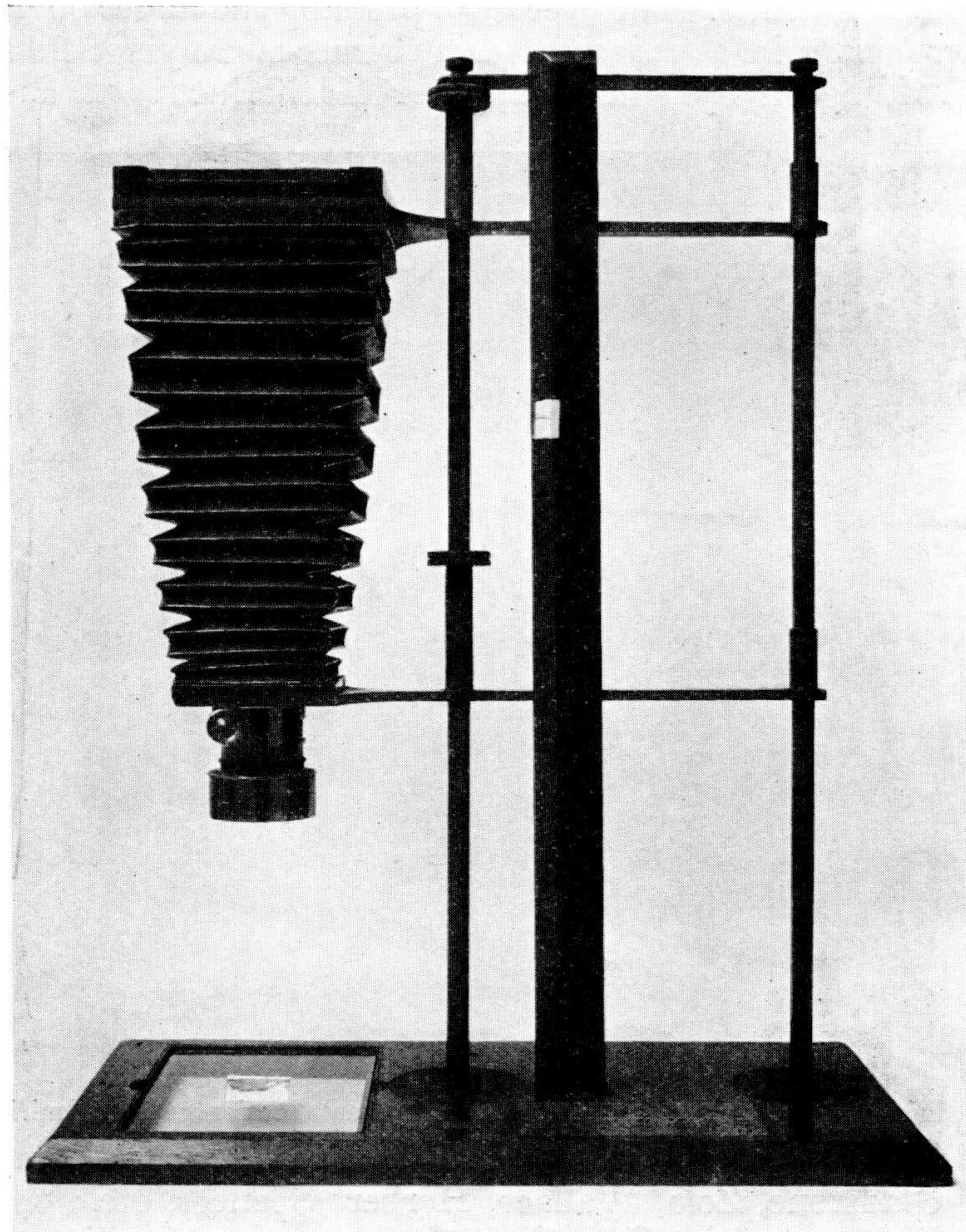


Fig. 41. Galton's Finger-Print Enlarging Camera.

issued on this topic, then I will admit him also to be a pioneer; if he can find anyone who has since 1895 done more than amplify in minor, often in very minor points Galton's work, then I will admit him a worthy successor to Galton.

Finger-printing as a science and finger-printing as an art are both alike the product of Galton's insight, ingenuity and tireless activity; the attempts to belittle the credit due to him can only spring from those who for their own purposes choose to ignore the literature of the subject.

Note to Chapter XV.

Finger-Prints as Reminiscences. As some collect autographs and others photographs, so we may collect finger-prints as mementoes of friends or of great men. Such a collection was formed by Francis Galton, and, the circumstances not always being favourable for a printer's ink impression, he not infrequently fell back on sealing-wax. In the *Galtoniana* are many sealing-wax impressions of Galton's friends. Thus we have Herbert Spencer's and quite a number of Sir W. R. Grove's* prints. The process of pressing the finger on hot wax was not always without pain, as is indicated in the accompanying 1893 Christmas greeting of Addington Symonds' daughter Katherine to Francis Galton.

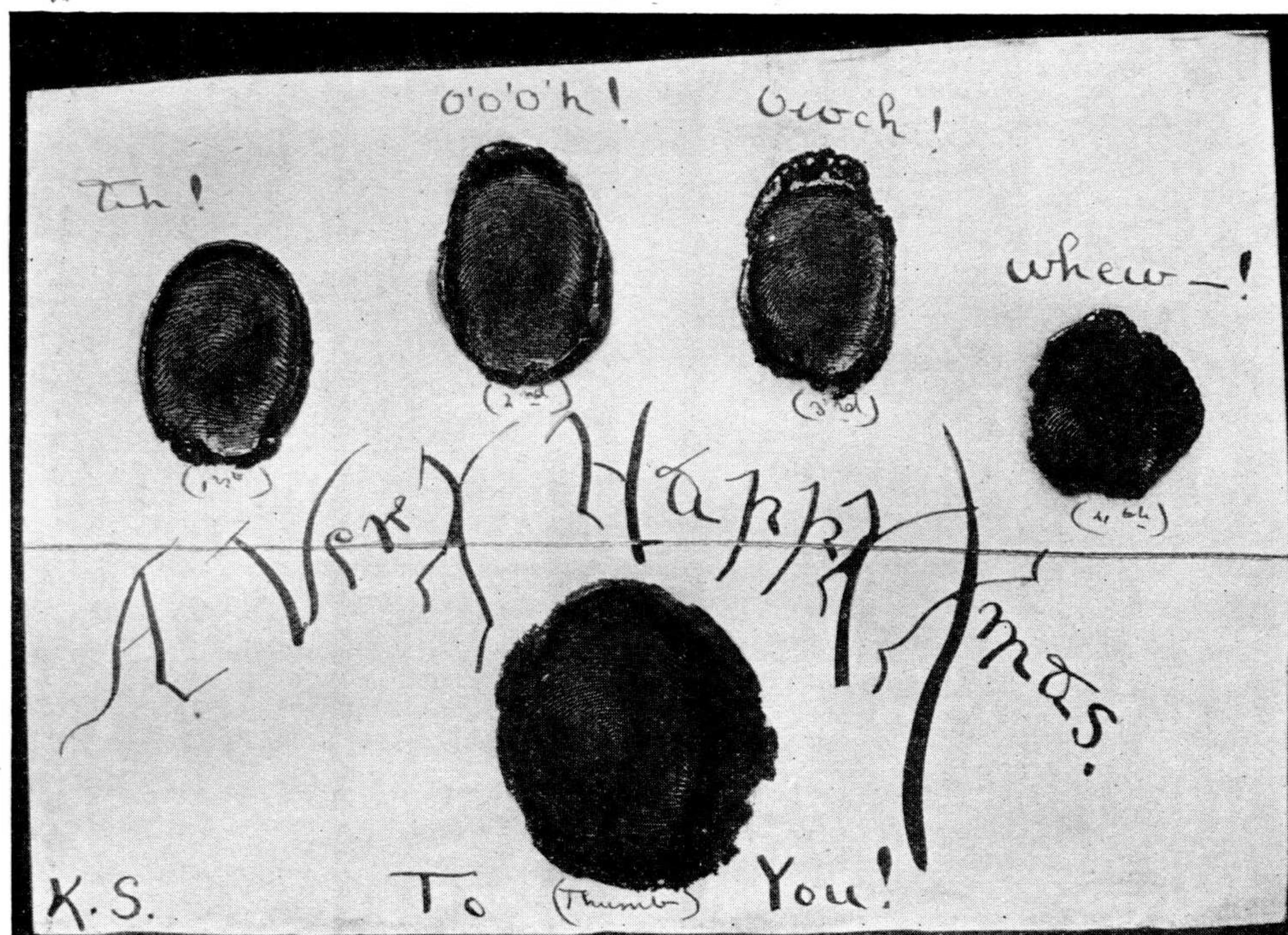
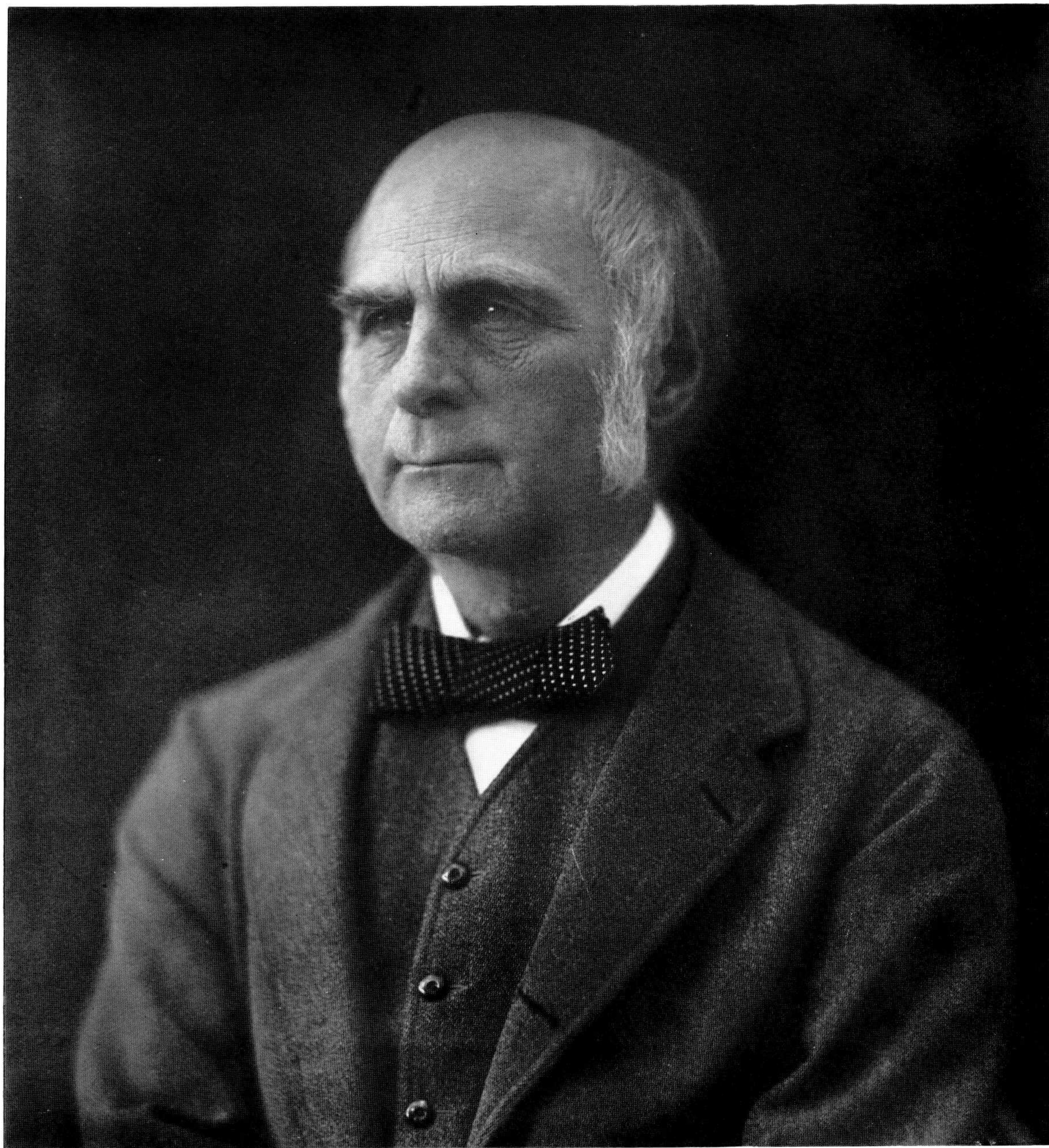


Fig. 42. A Christmas Greeting to Francis Galton "from an affectionate and admiring friend."

Among the prints of famous men to be found in Galton's Album of Prints are those of Gladstone, Zola, Wallace, Herbert Spencer, etc.; the Darwins, the Vernon Harcourts, the Garrods and many other families also appear. Galton himself had a seal cut from his right ring finger print, and this is still used on the name cards at the Annual Galton Laboratory Dinner. There are many other relics of Galton's early finger-print collecting days, e.g. prints of idiots, of farm labourers, of the Herschels at different ages, and occasionally foot and hand prints, as well as some finger-prints of apes. For some years Galton must have always had a finger-printing apparatus in his pocket, and possibly, like all men with a dominating hobby, have been somewhat of a trial to his acquaintances.

* Of combined legal and scientific fame!



Francis Galton, the Founder of the Science of Eugenics, from a photograph of 1902,
by the late Mr Dew-Smith. (By kind permission of Mrs Dew-Smith.)