T I T L E.

A ROUTE BY WHICH THE ELECTRIC IMPULSE IS FACILITATED IN ITS PASSAGE THROUGH THE HUMAN EPIDERMIS:

A THESIS BY

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P R E F A C E.

All the work of this research was undertaken at The Institute of Physiology, University of Glasgow, where every facility was most willingly afforded for its conduct. The late Professor D.Noel Paton took unstinted interest in the work which was most materially advanced under the enthusiastic and sympathetic encouragement of my chief, Professor E.P.Cathcart, towards both of whom I experience an everlasting debt of appreciative gratitude. Dr.George Dalziel has my warm thanks for kindly consenting to remove - without anaesthetic - the necessary pieces of skin from my forearm and to Mr.Bell and Mr.Gairns of the Institute of Physiology I convey my grateful acknowledgment for their assistance in preparing the photographs of the tissues. I am indebted to Mr.A.Smellie who was instrumental in noting the meter readings and finally though the major part of the observations were made on myself, to the several medical students who so willingly subjected themselves to these

these painful experiments, I extend my thanks.

I N D E X.

D I A G R A M S.

It has been observed by many writers, Lewis Jones (1) Browne (2) that the electrical impulse applied in the usual way by moist electrodes passes through the skin by ionisation in and polarisation of the tissues and tissue fluids with the result that one is obviously not dealing with normal skin if the study under these conditions of the passage of the electric stimulus be made. A considerable amount of work was done by the candidate to enquire into the relation between these polarisation and ionisation phenomena and the measurement of Rheobase and Chronaxie in man based on the findings of Lapicque (3) and Bourguignon (4) the work forming the basis of another paper to be published.

It happened incidentally that during observations on the time element of production of polarisation in skin a small "pore" moist electrode (active electrode) was used to explore the skin while a large indifferent electrode was strapped to the leg, a peculiar phenomenon was noted while

while going over the skin of the left forearm with the active electrode. An applied voltage of 60 volts was used, and to find a "motor point" the active electrode was dabbed over the flexor aspect of the forearm. Over the major area of the skin no electrical sensation whatever was experienced provided the application of the stimulus was momentary (half a second), but at some few spots not necessarily motor points, sudden sharp shocks were felt. The possibility of rapid polarisation and of electrolysis of the skin and tissue fluids at these areas due to the high applied voltage and to the [illegible] electrodes was considered, and to obviate this "dry point" electrodes were used as the active electrodes. The dry skin of the forearm was thoroughly explored with the dry point electrode in the same way as is employed in the determination of "tactile" sensation (Starling (5)). The electrode was not permitted to be in contact with the skin longer than half a second, because then the epidermis is is rapidly destroyed forming the well-known electric burn as described by Browne (Reference (2), with the usual characteristic sequelae; the appearance of a tiny blister which soon breaks and leaves a small brownish point with a depressed surface circumscribed by a red linear engorgement. In addition it was observed that when the applied voltage was high (70 volt) and a milliammeter placed in series with the electrode circuit, the skin explored in the way described is insensitive to the electrical stimulus, no sensation of shock is felt over the skin generally and no movement is observed in the milliammeter on account of the exceptionally high resistance of the epidermis. However, at a few minute points there is obtained a very sudden and painful shock with a rapid deflection of the meter whenever these special points are touched.

For convenience these points have been called "electric points" and will be referred to as such in the

the course of this paper.

The present thesis is an enquiry into the nature of these points and resolves itself into an attempt to study the route by which the electrical stimulus of short duration may traverse the skin when the stimulus acts for a short interval of time and is applied without the possibility of polarisation and electrolysis occurring.

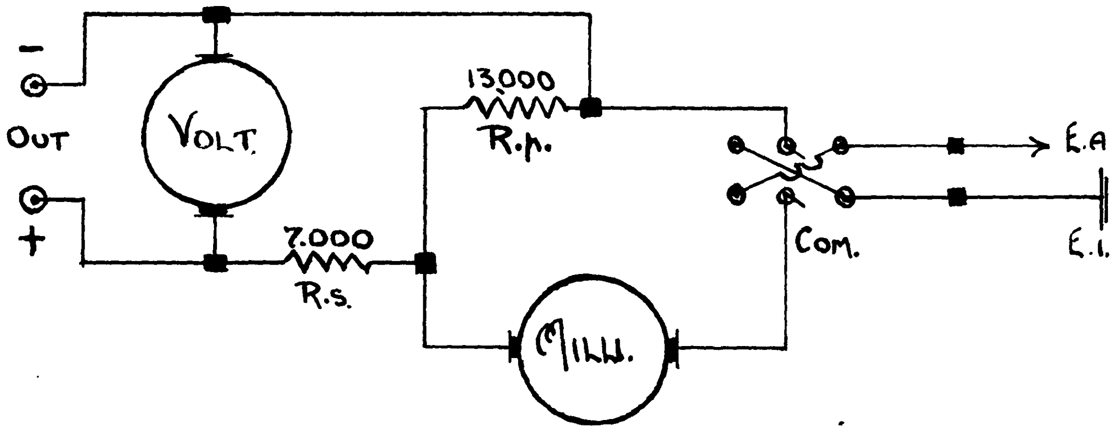
No reference to any previous work along these lines could be found.

THE APPARATUS.

The apparatus used is a modification of that described by Lapicque (6) Bourguignon (4) and Fulton (7). A current of constant intensity is taken from a battery of 100 two volt Hart Enduro accumulators which are grouped in sets of ten giving twenty volts per group. Tappings are taken to a voltage selector from each group and also from each cell in one group so that any voltage from zero to two hundred (0 - 200) may be rapidly obtained by steps of two volts. The voltage selector supplies the current to the main circuit of a Lapicque Box (6) which virtually is a potentiometer so constructed that changing a switch from "rheobase" to "chronaxie" automatically doubles the output current both in pressure and in intensity. Since this Box is built to accommodate a pressure of twenty volts having a resistance of seventy-two ohms each in the rheobase and chronaxie circuits so that the current in the main input circuit is

(Fig I)

Diagram of ELECTRODE CIRCUIT.



"OUT" --- Output from LAPICQUE BOX.

"VOLT" -- Voltmeter across MAIN ELECTRODE CIRCUIT.

"R.p."--- Parallel Resistance -- I3000 ohm.

"R.s."--- Series Resistance ---- 7000 ohm.

"MILLI"-- Milliammeter in series with ELECTRODES.

"COM"---- Commutator.

"E.a."--- Active Electrode.

"E.i."--- Inactive Electrode.

is constant at 0.27 ampere, when the input voltage from the voltage selector is greater than 20 volts compensating resistances - non-inductively wound - of 72 ohms each are added to the rheobase and chronaxie circuits for each additional 20 volts so that the current in the input circuit is maintained constant at 0.27 amp. In the experiments to be described the chronaxie condenser system is not used and the current from the Lapicque Box is passed directly to the "electrode circuit".

THE ELECTRODE CIRCUIT. (Fig.1).

To measure the pressure in this circuit a high resistance voltmeter is placed across the input terminals, rather than across the electrodes where it would form a shunt of considerable magnitude and give unreliable readings of the intensity at the electrodes. In the circuit are the compensating resistances recommended by Lapicque and Fulton (7) and by Bourguignon (8). In the main circuit there is a a resistance of 7,000 ohms in series with the electrodes which have in parallel a resistance of 13,000 ohms and also in series an accurate "dead-beat" milliammeter. To reverse the polarity of the electrodes a commutator is placed in their circuit.

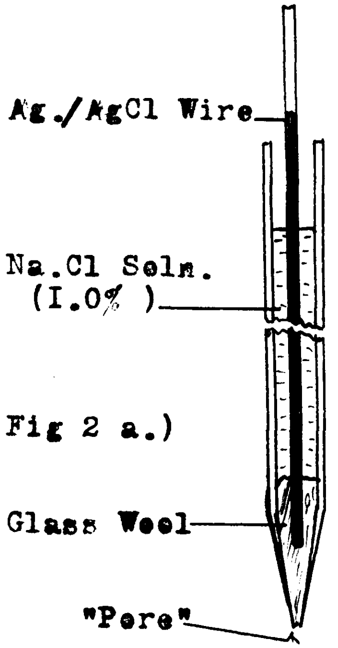
THE ELECTRODES.

The inactive electrode to be strapped to the calf is to the pattern suggested by Bourguignon (9). It is a sheet of silver foil (20 x 10 cm.) coated with silver chloride covered with lint, soaked with 1.0% sodium chloride (aqueous) solution, with a retaining cover of cheese cloth.

The active electrodes were specially designed for the research.

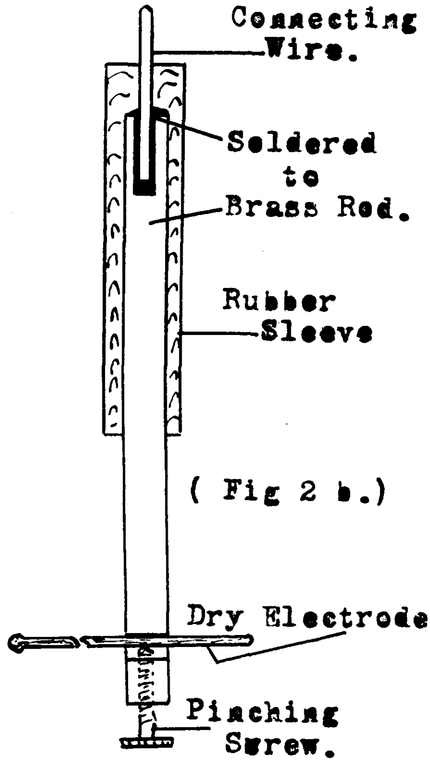
(A) At the outset of the work a "pore" wet silver/silver chloride electrode was used consisting of a long glass tube (4 mm.bore) drawn to a pore point with a cross-sectional area of about 1 sq.mm. The pore was partially occluded by glass

(Fig 2)



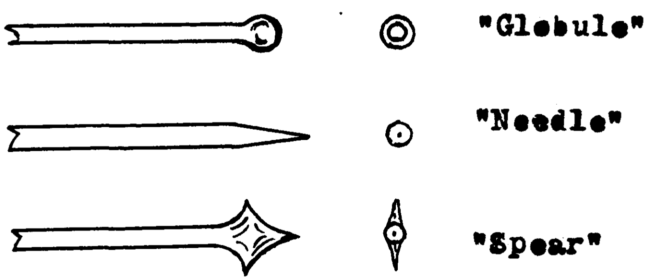
(Fig 2 a.)

Moist "PORE" Electrode.



(Fig 2 b.)

Dry Point Electrode Holder.



Types of "DRY POINT" Electrodes.

(Fig 2 c.)

glass wool and the tube filled with 1.0% sodium chloride solution into which dipped a silver wire (18 s.w.g.) coated with silver chloride forming a non-polarisable electrode (Fig.2a)

(B) The dry point electrode upon which most of the research depends takes the form of a round brass rod 4 inches long, $\frac{3}{8}$" thick, drilled at one end to accommodate the "wire" electrodes which are held rigid by a pinching-screw. Flexible copper wire is soldered into the opposite end of this handle which is covered by rubber tubing for insulation purposes (Fig.2b). The wire electrodes are made from hard drawn brass wire (28 s.w.g.) having different shaped points of application, some needle pointed, spear pointed and others with small globules of brass fused to the end of the wire (Fig.2c) The points are kept clean and polished for the experiments.

TECHNIQUE.

The large indifferent electrode is strapped to the left leg over the gastrocnemius; the Lapicque Box is adjusted

adjusted to give a definite voltage to the electrode system; the area of skin selected for examination is gone over either with the "pore" or with the "dry point" electrode, the duration of contact being about one-tenth second - a mere dab - care being taken not to puncture the skin and readings are made of any deflection in the milliammeter while any accompanying sensations are noted. In the subsequent work unless otherwise stated, the small "globule" electrode was used with an applied voltage of 70 volts.

Some attention was paid to the inactive pole to find if it were allowing the maximum current to pass for the applied voltage. The left leg and foot were placed in salt solution with a large zinc plate (250 x 200 cm.) as the indifferent electrode. Using the same applied voltage (70 volts) the dry point was applied to an insensitive part of the skin till the milliammeter showed a constant deflection. This was 3.65 ma. and was due to the production of an electric

electric burn. It was considered, therefore, that the indifferent electrode with the area of 200 sq.cm. was suitable for the experiments because obviously the peak current was passing through the electrode system.

AREA OF THE ELECTRODE POINT.

A study of the area of the electrode points was made on the flexor aspect of the left forearm. This was done by marking the position of the point by a small spot of ink. The skin was then carefully explored around the spot with a needle pointed dry electrode, note being made when any deflection of the milliammeter occurred or sensation of pain was experienced. The circumscribed area thus delimited was never greater than 1 sq.mm. and the "electric points" were always found to occupy equally small areas. This observation possibly explains the difficulty of finding the "electric points", but once they are found there is no denying the maximum deflection of the milliammeter accompanied equally

equally suddenly by the sharp stinging pain of the electric shock.

It was chiefly this observation following the experience with the wet "pore" electrode which initiated the enquiry.

Questions arose. What are these "points"? Are they distributed widely and uniformly? Are they associated with any of the well-known "spots" - touch, pain, thermal? Are they aweat ducts or hair follicles? Do they vary in position or are they constant and if so of what duration? Have they a well defined structure?

DISTRIBUTION.

The electric points are found with comparitive difficulty as has been demonstrated. They are present chiefly on the forearm, flexor and extensor aspects of arm, leg and thigh and on back and chest. No uniformity of distribution could be detected and symmetrical disposition was NOT at all seen.

On one subject the distribution for one week was found to be as in Fig.3.

(Fig 3)

Table showing Distribution of <u>ELECTRIC POINTS.</u>

POSITION.	No. of Points.
Forearm (left) flexor aspect.- - - - - - - - - -	4
Forearm (left) extensor aspect. - - - - - - - -	I
Forearm (right) flexor aspect.- - - - - - - -	2
Forearm (right) extensor aspect.- - - - - - -	5
Arm (left) - - - - - - - - - - - - - - - - -	2
Arm (right).- - - - - - - - - - - - - - - - -	3
Chest.- - - - - - - - - - - - - - - - - - - -	I
Back. -	5
Thigh (left) inner aspect.- - - - - - - - - - -	2
Thigh (right) inner aspect. - - - - - - - - - -	0
Legs and Feet (left and right) - - - - - - -	0
Hands (left and right).- - - - - - - - - - - -	0
Face and Head. - - - - - - - - - - - - - - - -	0

No points were found on the hands, face or scalp, nor were they observed on the scalps of bald-headed subjects. Scar tissue (appendix wounds of long standing) do not show any "points".

The great variation in distribution is obviously apparent and although it may be argued that in all probability more could be found were it not for the minute area in which they lie these "points" are comparatively rare.

Once a "point" was determined it was found that it is absolutely constant in position for several days till it finally disappears. The period elapsing was on an average five days between the time of discovery and loss of the "point". Later, however, a method is described whereby the complete duration - life history - of an "electric point" may be determined.

RELATION TO SWEAT DUCTS.

The skin of both hands (palmar and dorsal aspects) was most carefully explored, but no "electric points" were found. Sweat ducts and areas in which these ducts are abundant in the hand gave entirely negative results. This was contrary to the idea that sweat ducts and glands afforded the path for the electric stimulus. Even when the sweat glands of the hand were active the same negative results were obtained.

RELATION TO HAIR FOLLICLES.

Areas of the forearms were shaved, care being taken not to damage or cut the skin. To the hair follicles exposed the dry point electrode was applied but no deflection was obtained. Similar negative results were obtained over the shaved upper lip and on the scalp both in bald and hirsute individuals. It was concluded therefore that the "electric points" are neither hair follicles nor sebaceous or sweat ducts.

RELATION TO TACTILE, PAIN AND THERMAL SENSATION AND TO NERVE TISSUE.

Using Von Frey bristles the tactile points were carefully delimited over large areas in the forearm. These points were then immediately subjected to the dry "pin point" electrode with an applied voltage of 70 volts. In no case was any sensation of shock experienced.

Pain "spots" marked by the sensation recorded subsequent to pricking with a needle gave negative results to the "electric point" technique, except in one position where the skin had been inadvertently punctured.

Thermal "spots" also gave consistently negative results when explored by the dry point electrode.

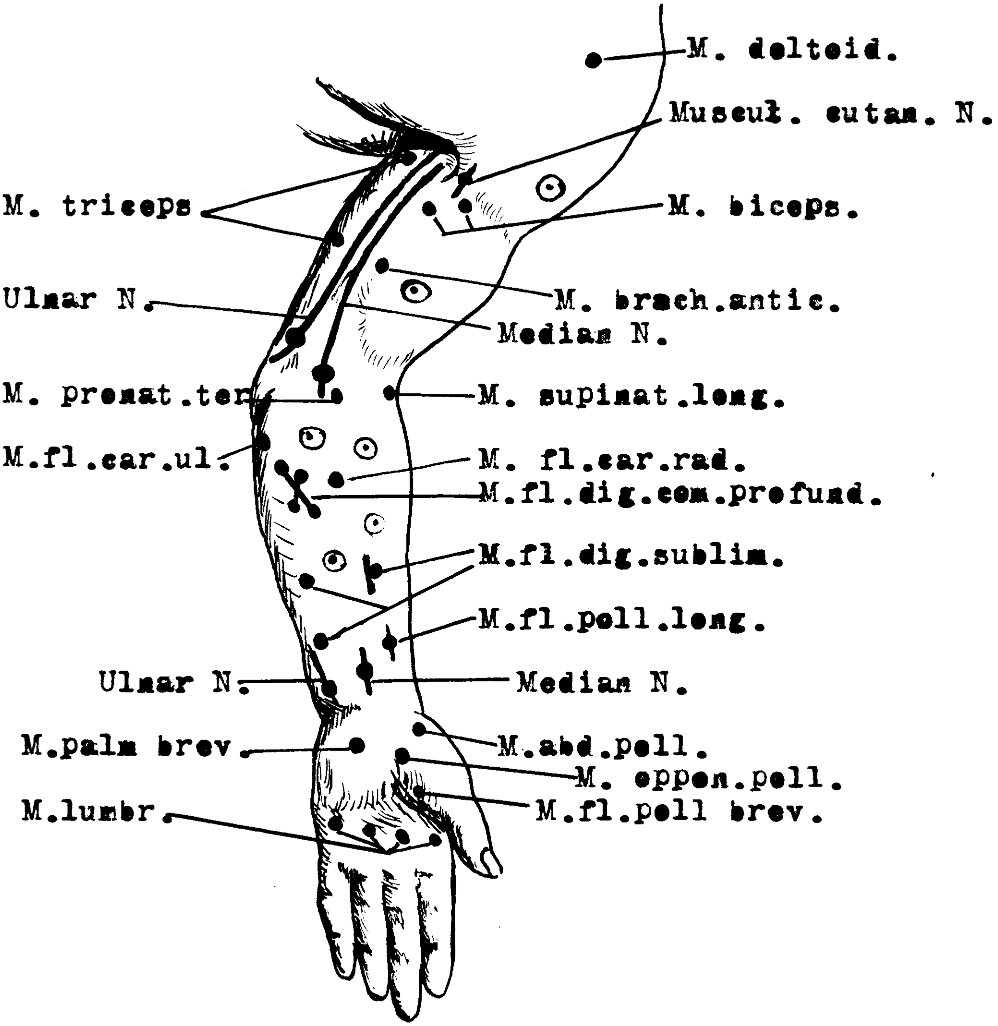
Over areas richly supplied by cutaneous nerves (nose and finger tips) completely negative results were obtained.

Apart therefore from the sensation of touch by the electrode, no shock was experienced at any tactile pain or

(Fig 4.)

Distribution of Motor Points (black) Electric Points (red)

in Left Arm, flexor aspect.



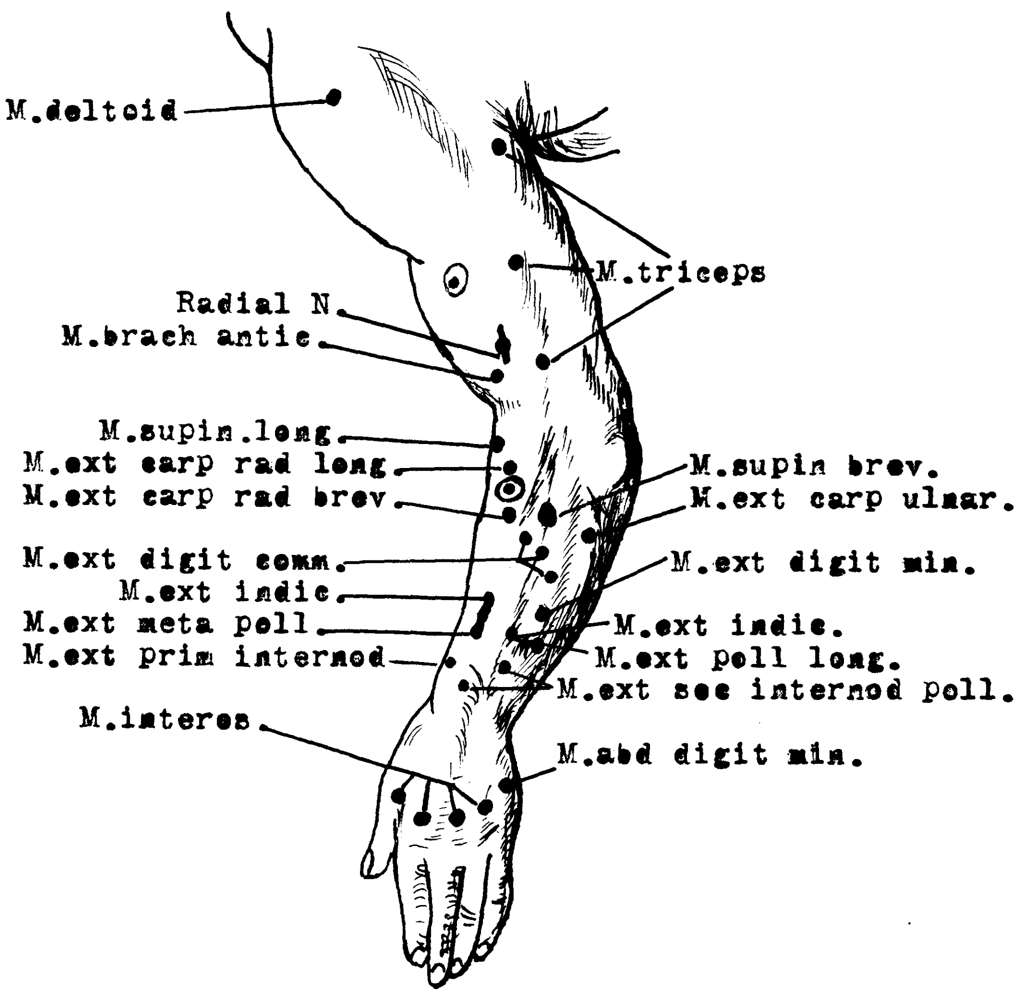
or thermal point, and the conclusion was drawn that the electric points have no relation to the other well-known "spots" and that therefore the conduction of the electric stimulus through the skin is not associated primarily with the nerve tissues subserving these sensations, although this tissue may be affected secondarily by the products of the electrical stimulus (free hydrogen ions, polarisation substances, electrolytic changes and alterations of surface charges on cell interfaces). Some confirmation of this conclusion lies in the observation that no "electric points" were found in "scar" tissue no matter how thoroughly it was explored.

RELATION TO MOTOR POINTS. (Figs. 4 and 5).

The various "motor" points of the forearm muscles were carefully marked out and localised by indelible ink. After some hours of drying and of resting of these parts the "dry point" electrode was applied to the motor points.

(Fig 5.)

Distribution of Motor Points (black) Electric Points (red) in Left Arm, extensor aspect.



Not one gave any suspicion of shock and no deflection of the milliammeter was obtained. This was repeatedly performed and in various areas of the body but all with constantly negative result. It was concluded therefore that the electric points have no relation to the muscle motor points of stimulation.

RELATION TO TYPE OF ELECTRODE AND TO VARIATION IN APPLIED VOLTAGE.

The entire flexor aspect of the right forearm was carefully and systematically explored with the "globule electrode" and four points were found and marked, each giving a deflection of 3.6 ma. when touched with the electrode. The area was investigated immediately afterwards in the same way using the same applied voltage (70) but with a "needle" electrode. No additional "electric points" were found although the original four were again observed. Thus the "points" do not depend for their localisation to any great extent on the shape of the electrode point.

In the same way with the voltage altered increasing by 10 volts from 30 to 100 volts the forearm was explored but no change in position or in number of "points" could be detected.

On the other hand with a voltage of 200 although similar results were obtained in that a most violent shock was experienced at the "electric point", the skin generally became slightly sensitive to the electric strain and shocks were felt all over the forearm. This is probably due to a rapid reduction of "electric burn" under the high applied voltage and not to sensation derived from the special "electric points", as will be shown when a comparison is made between these points and electric burns.

It was concluded, therefore, that the "electric points" do not vary with the type of electrodes used (provided they are fine enough) nor with the applied voltage up to a certain value.

CONNECTION BETWEEN ELECTRIC POINTS AND FLUID CONDUCTORS.

That fluid conductors have a decided influence on the phenomena was considered probable, because bleeding points gave the same results as the "electric points". In areas in which no "electric points" were found a pin prick was made in the skin. The bleeding point was permitted to dry but its position was carefully marked. On applying the "dry point" electrode in the usual way no sensation was experienced until contact was made with the injured spot; this was followed instantly by a sharp pain and a deflection of the milliammeter to the same amount as when an "electric point" was touched, i.e. 3.6 ma. at 70 volts. The injured point on the skin, of course, forms a direct path as a fluid conductor through the highly resisting skin to the fluid tissues beneath and the "electric points" were considered in the same light:- namely fluid conductors from the surface to the moist subcutaneous tissues.

This is the reason why in exploring the forearm in relation to the hair follicles, the skin has to be shaved carefully so as to avoid injury lest adventitious conducting paths be established.

RELATION BETWEEN ELECTRIC POINTS AND CONGESTION (Heat, Cold, Massage, Liniments, Sinapism).

If the skin be gorged with blood it would be thought naturally to offer a less resistance and to present more of these "electric points", an idea suggested by Waller (10) in his reference to the changes in skin resistance.

Heating the skin by immersion in hot water is clearly out of count because this results in changing the state of the epidermis and making it sodden resembling in short the conditions produced under the large moist electrode. Under these circumstances the skin all over is equally sensitive to the "dry point" electrode although generally the resistance is higher than over the "electric points", there being less current passed through the sodden skin (1.7 ma.) than through

through the "electric point" (3.6 ma.)

It is probable that immersion in water causes the surface epidermis - the stratum corneum - to become swollen by inter- and intra- cellular occluded salts imbibing water, swelling and in obliterating the layers of air between the cells of the stratum corneum thus to lower the resistance of the epidermis by removing the insulating layer of air. This would account for the passage of a small quota of current generally through the sodden skin but not for the sudden "peak" amount though the "electric point". On the other hand the phenomenon would lend support to the idea of "electric points" being fluid conductors of electricity.

Radiant heat avoids any moistening of the skin and was used as a means of engorging the epidermis. The forearm was subjected to heat from an electric radiator till the skin was red and "angry". Exploration with the "dry point" electrode was performed but no additional "points" were found,

found, apart from those already marked. In addition no change was produced in the "electric points", whose conductivity remained unaltered when the skin was engorged with blood.

This is contrary to the findings of Aveling and McDowall (11), who state that there is a lower resistance in the skin following engorgement, but in their case observations were made using "moist" electrodes in which polarisation is known to occur. Lewis Jones (1) maintains that vascularity has no influence on resistance. Results were equally negative when the skin was engorged by massage (effleurage) by turpentine and by a mustard sinapism applied for 20 minutes. The influence of intense cold is also without effect on the production of additional "electric points"

INFLUENCE OF ULTRA VIOLET RADIATION.

Two diverse results accrue from theeffects of ultra violet radiation depending upon whether the skin is destroyed or not.

(A) SIMPLE ERYTHEMA.

Erythema produced by ultra violet radiation from a quartz mercury vapour atmospheric burner (D.C. 250 volts) gives results identical with heat erythema i.e. no increase in the number of "points" and no change in the existing "points".

(B) VESICATION AND DESQUAMATION.

The entirely different results obtained by ultra violet radiation with subsequent vesication and desquamation shed considerable light on the subject.

The radiation was played over a large area of skin of the right forearm where four "electric points" only were previously noted. Vesication followed in two days and the entire area of the vesicle was sensitive to the dry electrode with this difference that whereas a reading of 3.6 ma. was obtained over the previous marked "electric points", generally there was a deflection 1.8 ma. over the blistered area, whose covering epidermis was tense with the subdermal exuded serum.

Desquamation followed in 5 days from application of the ultra violet radiation leaving a new moist red epidermis for exploration. This was found to be a most valuable method for producing a new skin whose age definitely could be estimated.

Immediately the superficial i.e. the old skin is peeled off a moist red epidermis is revealed which is equally sensitive all over to the "dry point" electrode. There are no variations in the readings which are all constant at 3.6 ma. for 70 volt input. This there is a difference from the case in which the skin is sodden and moist following immersion in hot water. With the water two sets of readings are obtained (1.7 ma. for sodden skin and 3.6 ma. for the "electric points") but with the new skin following ultra violet radiation all the readings are 3.6 ma. even after the skin has been washed and dried.

In a day the new skin becomes dry and presents an ideal surface upon which to study the various sensitive "points"

"points", not only in distribution but in time of onset and duration.

In this new skin is present a large number of "electric points" which are definitely localised and are not associated with the sensitive points (pain, tactile, thermal). They do not bear any obvious relation to superficial blood vessels (veins) or to any definite structure (tendon and bone). The current intensity passing through them is constant (3.6 m.a. at 70 volt input) and remains constant at this value for about 10 days after which there is a falling off in intensity with corresponding increased resistance at the "electric points" till in 17 days' time the skin over the desquamated area has the same resistance as the rest of the body skin, in other words, no sensation of shock, no deflection and no "electric points" apparent since no current now passes.

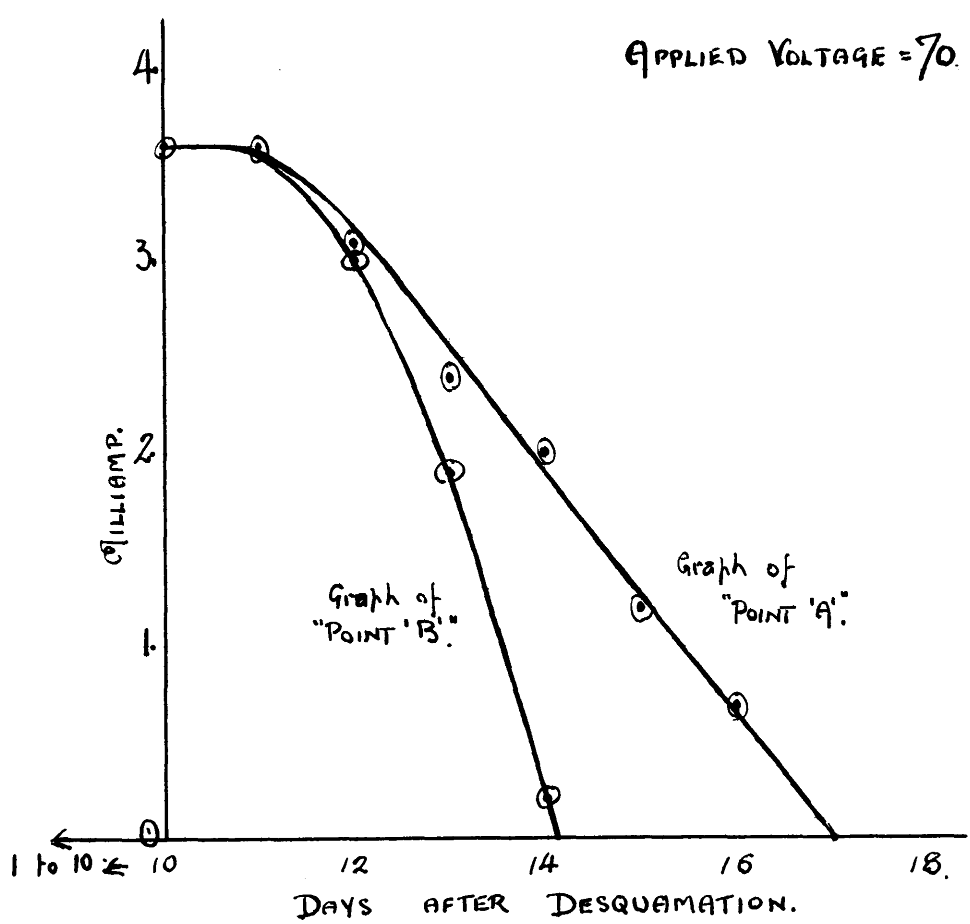
The changes in these "electric points" are two-fold. There is an irregular disappearance numerically starting after

(Fig 6.)

Table showing "time-atrophy" of new ELECTRIC POINTS after Vesication by Ultra Violet Radiation, with observations on the change of "current intensity" of two "points".

Days after Desquamation.		E.Points noted.		Current Intensity (milliamp.) Point "A"	--	Point "B".
I to IO	--	numerous -	(IOth day)	3.6	---	3.6
IO	---	" "	--- "	3.6	---	3.6
II	---	43	-------	3.6	---	3.6
I2	---	29	-------	3.I	---	3.0
I3	---	I7	-------	2.4	---	I.9
I4	---	I6	-------	2.0	---	0.2
I5	---	I2	-------	I.2	---	0.0
I6	---	4	-------	0.7	---	--
I7	---	2	-------	0.0	---	--
I8	---	0	-------	--	---	--

(Fig.7.)



Graph showing the changes in "Current-intensity"of two points "A" and "B"after desquamation by U.V.Radiation. The changes are apparently due to drying of the moist new epidermis.

after 11 days, with an irregular increase in the resistance of such "points" as remain, some "points" showing increased resistance, others being unaltered, making observation difficult and unreliable. A few "points" seem to disappear suddenly in one day, others pass slowly away with increasing resistance to the electric current. A Table (Fig.6) and a Graph (Fig.7) show the observations made on this phenomena and record the changes in resistance - measured as current passed - in two such "points". They give some idea of the irregular rate of change in the skin.

These changes must be due to some structural alteration in the skin, possibly atrophy and drying of some fluid conducting paths in the new epidermis, and probably due in short to the atrophy of capillary loops which have become budded into the epidermal papillae. This idea is borne out in section work to be described below.

(Fig. 8.)

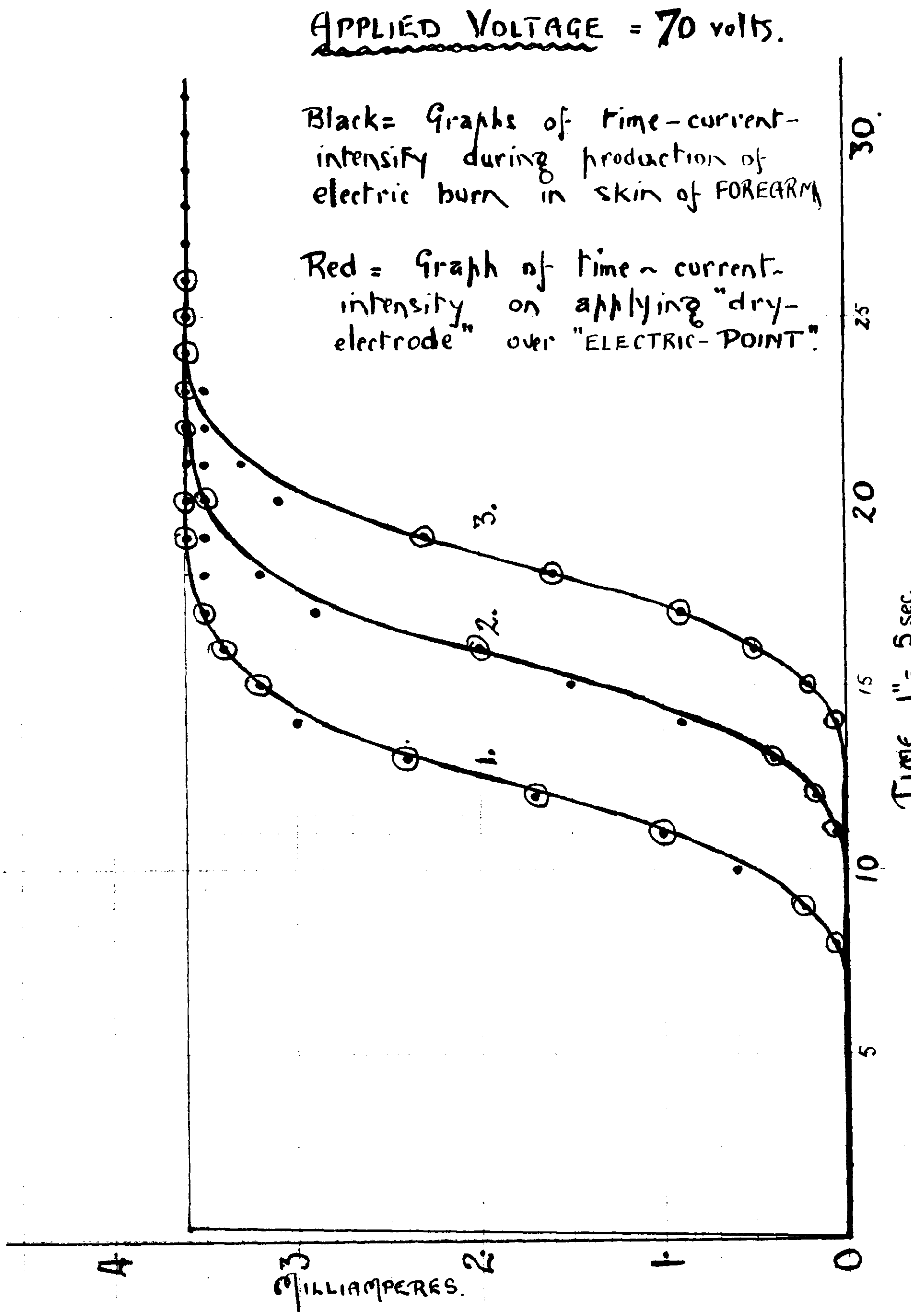
Table of Time to establish CONSTANT MAXIMUM INTENSITY with "globule" electrode on Left Forearm (flexor aspect)

Applied Voltage --- 70 volts.

Time to reach max.(3.6 m.a.) by ELECTRIC POINT --Instantly.

Polar. Time. (sec.)		Current Intensity. (ma.)		
	Point No.	I	II	III
0	--	0	0	0
I	--	0	0	0
2	--	0	0	0
3	--	0	0	0
4	--	0	0	0
5	--	0	0	0
6	--	0	0	0
7	--	0	0	0
8	--	0	0.05	0
9	--	0	0.22	0
I0	--	0	0.6	0
II	--	0	I.	0.05
I2	--	0	I.7	0.I8
I3	--	0	2.4	0.4
I4	--	0.05	3.0	0.9
I5	--	0.2	3.2	I.5
I6	--	0.5	3.4	2.0
I7	--	0.9	3.5	2.9
I8	--	I.6	3.5	3.2
I9	--	2.3	3.6	3.5
20	--	3.I	3.6	3.5
2I	--	3.3	3.6	3.5
22	--	3.5	3.6	3.6
23	--	3.5	3.6	3.6
24	--	3.6	--	--
25	--	3.6	--	--
26	--	3.6	--	--
27	--	3.6	--	--

(Fig 9.)



Graph showing the "time-interval" of electrolysis of skin

with Intensity Curves for "Dry Electrodes"

at applied voltage of 70 volts.

COMPARISON BETWEEN ELECTRIC POINTS AND ELECTRIC BURNS.

Earlier (Page 3) it is stated that if the electrode is allowed to remain in contact with the skin for any considerable time, the epidermis is destroyed leaving a depressed open wound due, according to Leduc (12) to the caustic action of ions generated at the electrodes. Records were made on several occasions concerning the time taken to produce these destructive changes and the current intensity flowing through the electrode system while the destruction was in progress was measured. These results are tabulated for three observations (Fig.8) and graphed (Fig 9) in conjunction with the record of an "electric point". They show a definite but variable interval must elapse before the skin resistance is broken, probably by ionisation; there is a gradual break down of the resistance for the first few seconds, then a rapid rise in intensity, followed by a tapering off of intensity to the same maximum as is found at the "electric point". The tapering off in the

the time - intensity curve may be due to polarisation changes in the destroyed tissue offering a back electro-motive force to the current. The Electric Burn thus produced behaves like an "electric point" for many days afterwards as it is slowly healed and replaced by scar tissue.

EFFECT OF REVERSAL OF CURRENT ON ELECTRIC POINT.

Generally the reversal of the direction of current in a unidirectional system has a marked effect on the current intensity flowing in the system. While the current is flowing polarisation is set up at the chemical interfaces producing a back electro-motive force with increased resistance in the circuit. On reversal of the current this back e.m.f. momentarily acts with the new e.m.f. and lowering the resistance permits more current to flow in the system till a new polarisation is set up and the current drops to its original constant value.

Provided the "dry point" electrode is not kept

kept indefinitely at an "electric point" reversal of the system causes no change in current intensity passed. With 70 volt of applied pressure the intensity is constant at 3.6 ma. whether reversal occurs or not, indicating that the "electric point" is not an artefact due to localised polarisation of the tissues.

REMOVAL AND SECTION OF ELECTRIC POINTS.

Continuing the observations on these "electric points", from the extensor aspect of my left forearm (Fig.5) three pieces of skin containing one "electric point" each were removed, the skin being cut without any anaesthetic (local or general) lest the structure be altered. The epidermis was cut to the underlying deep areolar tissue. These pieces each half an inch square were fixed in formalin embedded in paraffin, cut and stained by haemalum and eosin.

Where the "electric point" had been marked the section showed a small tubular structure passing tortuously

(Fig IO a.)

Section of Human Skin. (x 250.)

"C"-- Conducting Channel from Surface to Papilla.

tortuously in a papilla from the deep dermal tissues to the surface stratum corneum where the end became frayed out and covered by desquamated cells. The tube appeared to be lined with endothelium and it does not terminate in any glandular structure as revealed by serial sections. It passes imperceptibly into the subdermal tissue apparently as a capillary loop which has become atrophied. The structure is neither a hair follicle nor a sweat duct and it does not show the structure of nerve tissue (Figs.10 a b c).

Wax models to scale (X 400) were made of the individual papillae containing these structures. The tubular tunnel in the papilla is continuous from the surface but ends in the deepest part of the papilla after a sinuous course which may be branched once down through the papilla.

It is suggested that these structures furnish paths as fluid or moist conductors - probably containing a saline solution from evaporating body fluids - for the passage of

(Fig IO b.)

Section of Human Skin. (x 250.)

"C"-- Conducting Channel from Surface to Papilla.

of the electrical stimulus through the highly resistant skin when "dry point" electrodes are used. Being tubular, were their contents moist or fluid, a path of low resistance is offered towards the moist subcutaneous tissues and it is suggested that they are the "electric points" above investigated, probably atrophied capillary loops, which have grown into the developing epidermal papillae - a suggestion confirmed by the observation that following ultra violet radiation the new epidermis contains many "electric points" which fade and disappear as the skin becomes dry and hard.

SUMMARY.

This thesis seeks to present evidence for the presence of special conducting paths for the electrical stimulus through the skin when the stimulus is applied by a pointed dry electrode; in order to avoid polarisation of the system application being made momentarily.

Normally these points - called "electric points" -

(Fig IO e.)

Section of Human Skin. (x 250.)

"C"-- Conducting Channel from Surface to Papilla.

are scattered over the body surface unsymmetrically and irregularly. They facilitate the passage of the electric current by presenting a path of exceptionally low resistance.

They are circumscribed in a small area having no relation to sweat ducts, hair follicles or to points of tactile or thermal sensation or to "motor points".

They permit the passage of a uniform current intensity suddenly with no lag and at peak value, the passage being associated with sharp stinging pains.

They are unaffected by capillary dilatation (heat, massage, sinapism and rubefacients) but are generated by vesication and desquamation following ultra violet radiation.

They endure on an average for 17 days.

They are akin to wounds as regards electrical resistance and offer an easy path through the resistant epidermis.

Section shows them to have a tubular structure

structure lined with endothelium passing from the apex of a dermal papilla in a tortuous manner to end under the stratum corneum as a patent tube unrelated to sweat glands, hair follicles or nerves.

In conclusion, in considering these conducting paths to the subdermal tissues, it is interesting to speculate if they have any relation to diseases of the skin and subjacent tissues, e.g. "ideopathic" pustules and abscesses. Do they afford in addition to channels for electric currents potential and patent routes of entry for pathogenic organisms?

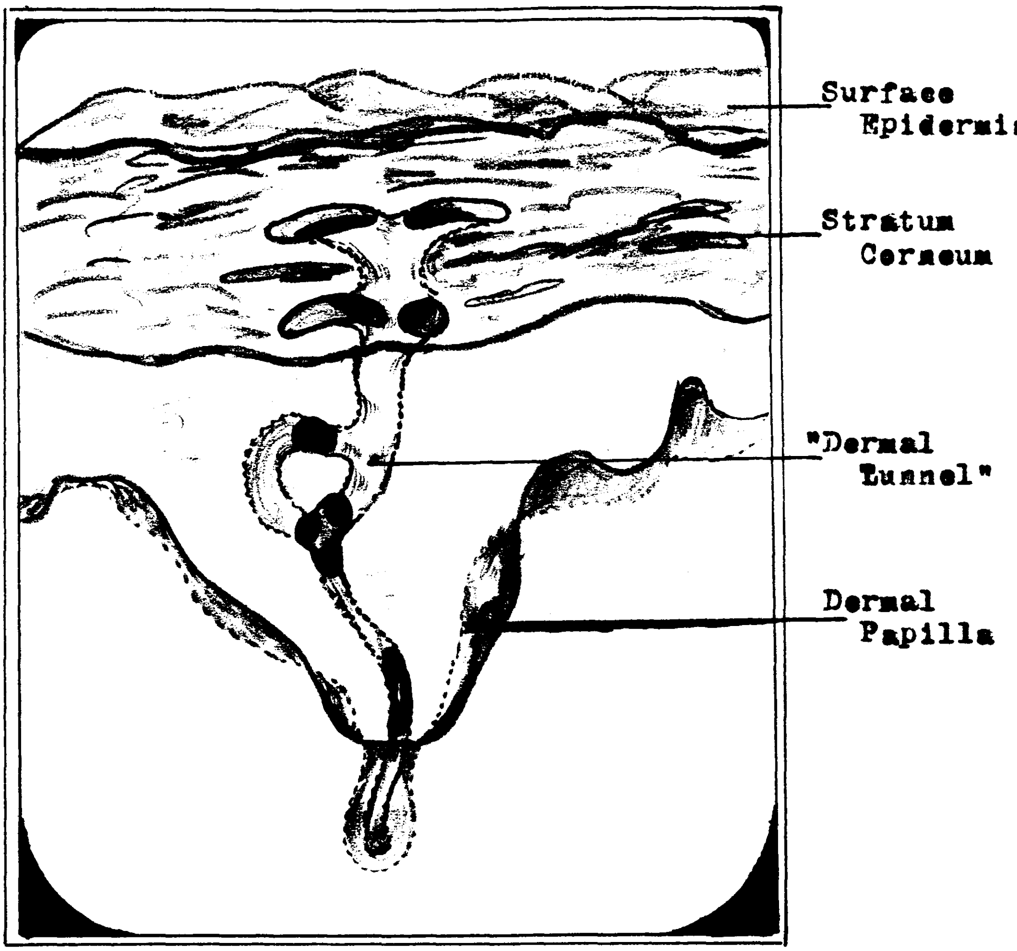
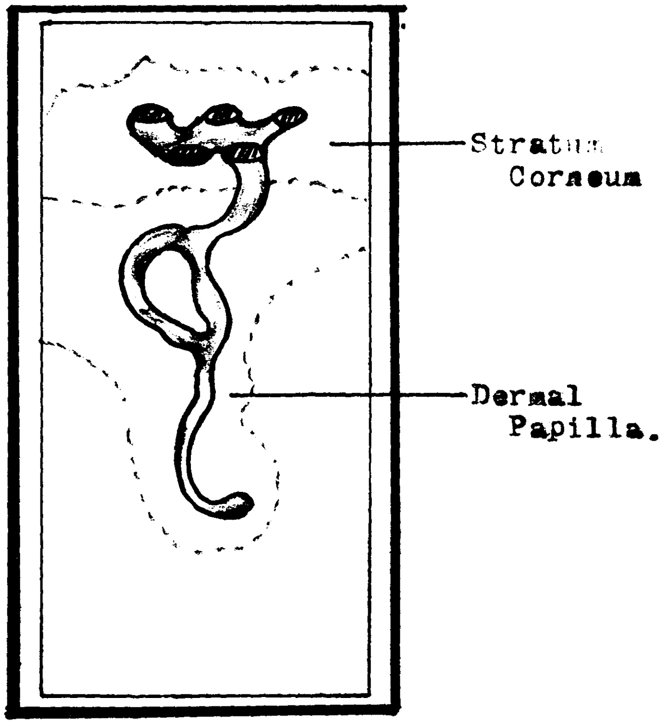


Diagram-- "Dermal Tunnel"in Dermal Papilla.



CAST of "DERMAL TUNNEL".

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