Clin Exam passed June 1924.
M.B. Ch.B. 1922.

The Mount,
Montrose,
Angus.

Thesis received 7/1/30.

THE MECHANICS OF INTERNAL ROTATION OF THE FOETUS.

by

JOHN CHASSAR MOIR, M.B., Ch.B., F.R.C.S.E

Thesis Presented

for the Degree of M.D.

THE MECHANICS OF INTERNAL ROTATION OF THE FOETUS.

SECTION I.

INTRODUCTION.

The subject of the Mechanics of Labour has been made by succeeding generations of obstetricians a battlefield on which almost interminable wars have been fought. A study of the rival causes which have been championed shows that the forces which play and interplay, act and react, to bring about parturition are unexpectedly complicated. The subject is, therefore, one of considerable interest, the more so because some of the generally accepted theories to explain these forces, ring untrue when judged from a mechanical standpoint.

Smellie has said in a paper describing the uses of his forceps[1], "I endeavour to reduce the art of Midwifery to the principles of mechanism, ascertain the make, shape and situation of the pelvis together with the form and dimension of the child's head, and explain the method of extracting from the rules of moving bodies in different directions."

It is certain that those early workers whose names are sacred in the history of midwifery, owed much of their success to a clearer knowledge of the mechanism/

mechanism of labour than their contemporaries possessed. With such knowledge the obstetrician can cooperate with nature's forces: without it, cooperation is replaced by interference. This subject is, therefore, of more than academic importance.

Of all the movements which take place in parturition none is more surprising, none is more difficult of explanation, and none has provoked more discussion than the Rotation of the Foetus; and it is with the object of examining anew this vexed subject that this thesis has been prepared.

DEFINITION OF ROTATION. Internal Rotation is a turning movement of the foetus with relation to the birth-canal. This action is distinct from, but normally superimposed on the movement of descent. The axis about which a given part of the foetus rotates, roughly corresponds to a line marking the direction of advance of that part. It follows, therefore, that the rotation which occurs in the head as it emerges from the birth canal, is taking place about an axis which is nearly at right angles to that about which the trunk is free to rotate.
It is possible that internal rotation does not normally/

normally cause the foetus to rotate as a whole: clinical observation and X-ray examinations show that the shoulders usually - but not invariably - undergo rotation at a later stage than the head.

By internal rotation one usually pictures a movement of the occiput towards the symphysis in normal cases, or towards the sacrum in abnormal cases. It is necessary, however, to include under the heading of Rotation the similar movements of other denominators which take place in abnormal presentations. Thus, the rotational movement of the child's pelvis in a breech delivery, and the similar movements of the after-coming head must also be included, although it must not be assumed that these movements are necessarily caused by the same forces which determine rotation in a vertex presentation. Again, the movement of external rotation of the head is in reality an internal rotation of the trunk, and must be included with the other forms of rotation.

On the necessity of internal rotation all are agreed: unless the passenger is very small in proportion to the passages, the absence of rotation will cause an impaction.

Buchanan[2] has demonstrated the necessity for rotation in a novel manner, and his model, although of doubtful accuracy, is nevertheless amusing, instructive, /

instructive, and convincing. (See Figs. 1 & 2, page 53.) That such an important process must demand constant and powerful forces to bring it about is obvious, yet the origin and nature of these forces is one of the most obscure of all problems of midwifery mechanics.

A theory to be valid must explain the occurrence of rotation in both normal and abnormal presentations. It must also explain why on rare occasions the mechanism breaks down and rotation does not occur at all, or if it does, is in the wrong direction. Two other facts it must explain. These are the much quoted experiments of Dubois[3] and of Edgar[4].

Dubois found that rotation occurred from the occipito-posterior position when a dead foetus was pushed through the birth canal of a woman who had recently died in child-bed. This experiment succeeded three times, but failed on the fourth. A larger foetus was then substituted, and the experiment succeeded on two further occasions.

Edgar's experiment was on similar lines. He screwed a swivel into a foetal head 1". behind the small fontanelle and by means of a cord dragged the head through the pelvis. Internal rotation occurred.

A theory to be adequate must explain all these facts. Some of the older text-books give many explanations, none of which is satisfying, and some of which are contradictory; and it is significant that/

that in some more recently published works little attempt is made to explain the mechanics of the process, and the subject is condensed into a few lines. Surely such a remarkable and important feature of parturition is worthy of more detailed consideration.

SECTION II.

A CONSIDERATION OF THE SHAPE OF THE PARTURIENT CANAL.

From a study of the literature on the mechanics of labour it is seen that most of the early workers looked for an explanation of rotation in the peculiar construction of the pelvis. The shape of the channel at various levels; the slope of the "planes of the ischium"; the long sloped posterior wall, and the short anterior wall; the scoop-like construction of the sacrum and distended pelvic floor, - all these facts were used to explain the phenomenon.

Such theories based on some peculiarity of shape of the bony pelvis are difficult to visualise, and when an attempt is made to demonstrate the action with actual specimens, they become - from a mechanical standpoint - incomprehensible. Short internal rotation they can explain, but long internal rotation they would hinder rather than help. Why should the hollow of the sacrum attract the sinciput while it spurns the occiput? And why under certain circumstances should it transfer its attraction to the previously despised occiput? Obviously there are some missing factors which must be found to make the explanation complete.

Internal rotation takes place in a pelvis which is padded with soft tissues and traversed by a distensible/

distensible elastic and muscular canal. It is improbable, therefore, that trifling differences in measurements of cross-sections of the bony canal - differences deviating from the average by less than 5% - can have such a potent influence as to cause internal rotation. In point of fact, the distended birth canal as seen in frozen sections, and museum specimens, is remarkable for its even contour and calibre. The one and only peculiarity to be seen is that the canal at its lower end is sharply bent on itself. This bend is of nearly 90°, and is familiar under the name of the "Curve of Carus".

There can be little doubt that this curve is one of the essential factors in bringing about rotation, for it is when the head begins to negotiate the curve that rotation begins. It is interesting to recall that Dubois's experiment failed when the pelvic floor was stretched. It can be readily understood that the stretching obliterated the curve at its sharpest portion, thereby removing one of the essential factors in the cause of internal rotation.

SECTION III.

CONSIDERATION OF THE SHAPE AND ATTITUDE OF THE FOETAL HEAD.

On the shape of the foetal head, and on the attitude which it assumes in its descent depends the phenomenon of Internal Rotation.

Accurately to measure, model, and reconstruct such a body would seem to be an easy matter; nevertheless, actual examination of the head before, and immediately following delivery, shows that this subject is one of some complexity; and clinical observations have given results which are in some respects essentially different from orthodox descriptions.

It is customary to describe certain diameters and measurements of a foetal skull, and to demonstrate the mechanism of labour by means of a dried and preserved specimen severed from the trunk. Theories of mechanics based on such observations, and mind-pictures of the progress of labour built on such demonstrations, are necessarily prone to fallacy. The skull is often not that of a normal full-time foetus, but that of one which has died because of some abnormality in birth. Moreover, the moulding which it at first possessed has largely disappeared in/

in the preparation of the specimen. Of still greater importance is the fact that it is wrong to consider the head without reference to the body. From a mechanical point of view the head is an appendage of the trunk, and the two must be considered as a whole. If this is done, and a newly born child is held in position in a preserved pelvis, the mechanical impossibility of some of the statements often made with regard to the process of labour is at once apparent. These statements will be later discussed in detail.

To describe Internal Rotation it is necessary to consider the structures as they exist at the time when that movement takes place. Internal Rotation occurs when the birth passages are well canalised, when the foetal head is well flexed and moulded, and when the head is beginning to encounter the bend in the canal, or in other words, to impinge on the pelvic floor.

On the general importance of moulding of the foetal head all writers on Midwifery are agreed, and some obstetricians such as Edgar[5] have carefully investigated this subject and have given detailed accounts of it. It is remarkable, therefore, that in spite of the fact that it is this moulded head which undergoes rotation, there appears to be no description of this movement in which the changes due to/

to moulding are taken into account. Theories to explain the phenomenon are almost all based on a consideration of a dried and unmoulded specimen, and the controlling action of the remainder of the foetal body is ignored.

The effect of moulding in altering the shape of the soft foetal head must impress everyone who examines a newly born child. Indeed, the effect in some cases is so marked that the long occipito-frontal diameter is virtually obliterated, and, owing to the flattened landmarks, measurement may be so difficult that any figures arrived at are of little interest. In effect, the anterior and posterior projections of the elliptical head are withdrawn. The previous excess of the occipito-frontal diameter has been deducted and added to the longest diameter of the head. Before moulding this was the occipito-mental diameter: it is now a vertico-mental diameter.

The new shape of the head is well shown in the accompanying diagrams and photographs. On the full appreciation of this change rests the acceptance of the later theories in this thesis. (See Figs. 3, 4 and 5, page 54)

To study the moulded head three methods were used - photography, direct tracings of the head, and frozen sections (See Figs. 6 and 7, page 55)

The tracings were made by holding the head over a/

a sheet of paper, and, with a fine pencil carefully held in a vertical position, marking the outline on the paper below. Interesting results have been obtained by this method, and examples are shown of the many cases collected. (See Figs. 8, 9, and 10, pages 56 and 57)

Another point of much importance is seen from these photographs and tracings. When the head is fully flexed it will be found that with the exception of the face, there is little or no projection of the outline on one side of the middle line which is not present on the other. The occiput and sinciput cease to be recognisable as projections, and the moulded foetal head is now nearly symmetrical about its long axis. As will be seen from the tracings it is best described as an elongated bluntly pointed cylinder, the base of which is cut off obliquely. This base is attached to a similar cylinder - the trunk - which also ends obliquely. These cylinders are so articulated that their oblique extremities lie parallel and adjacent to each other. This accounts for the apparent asymmetry caused by the projection of the face and mandible. In reality, these parts are merely the extremity of the oblique base of the cylinder.

The question now arises, what is the position of the articulation between the two cylinders? Or,/

Or, expressed differently, at what point in the neck does bending occur? It is sometimes assumed that this point lies near the posterior part of the neck, and there are theories of mechanism based on this assumption. Thus, Buchanan,[6] shows in diagram and model, how the "pivot-point" lies close to the surface of the nape of the neck. In point of fact, this assumption is nearly correct, but not for the reasons usually implied. It was felt that this subject could only be studied by the aid of suitable sections. An opportunity arose in obtaining the body of a two days' old child. The body was below average size, but presumably showed a similar anatomy to a full-sized foetus. Following Barbour's technic[7] frozen sections were made (1) through the suboccipito-bregmatic diameter, (2) through the suboccipito-frontal diameter, (3) through the suboccipito-mental diameter, (4) through the neck close to the base of the skull. From the photographs and tracings of the last two, it will be seen that the centre of the body of the second cervical vertebra lies $\frac{7}{8}$" from the front, and $1\frac{1}{8}$" from the back of the neck. The transverse processes lie $\frac{1}{4}$" behind this point, and are, therefore, practically in the centre of the section. (See Figs 11 and 12, page 58) Flexion thus takes place in the middle of the neck. When, however, the foetus is in the birth canal, its configuration and attitude, as/

Barbour

as seen in frozen sections, is such that the anterior part of the neck does not reach the wall of the canal. The vertebral column is, therefore, no longer central with regard to passage through which the body is driven. (See Fig. 13, page 59)

If the child's head is looked at from the side as in Fig. 9, page 57 , the position at which flexion occurs in indicated by the mid-point of a line spanning the neck at the level of the occipital protuberance behind, and the lower border of the mandible in front. From the point thus obtained a line may be drawn to the centre of the dome of the vertex. This represents the line along which the driving force is directed when the head is fully flexed. (This omits from present consideration any force which may be transmitted from the sternum to the mandible.)

It will now be still more evident that there is good reason for regarding the foetal head as a cylindrical structure obliquely cut off at its lower end. Further, it will be seen that when the head is fully flexed, the long axis is very nearly parallel to, and continuous with the long axis of the body.

THE ATTITUDE OF THE FOETAL HEAD.

Much has been made of the question of Flexion of the Foetal Head. All text-books stress its importance, and deal at length with its degree during the various stages/

stages of descent. The reasons for its occurrence and for its disappearance by extension (or "deflexion" as Hart termed it), have caused much discussion, and an unnecessary air of mystery seems to hang around process. It has been shown that the foetal head must be regarded as a cylindrical structure, and Dr James Young gives the simplest explanation when he says,[8] "Extension means simply another way by which the long axis of the head becomes tilted parallel to the axis of the cylinder."

Why flexion should occur at the beginning of labour (or before it, as Barbour[9] believed) it is not the object of this paper to discuss. That it is present, all are agreed, and the study of Frozen Sections[10] and of the X-rays of Warnekross[11] shows how well marked it is in the second stage.

THE SHAPE OF THE HEAD ON CROSS SECTION.

If a newly born child with a well moulded head is held in position in a pelvis, and if the head is flexed as it is in labour, it will be seen that not only is the presenting part (which canalises the structures) circular, but every successive segment which passes through the canal is either circular on cross section, or is slightly elliptical. It is never asymmetrical. Actual measurements taken of the/

the newly born head show that the suboccipito-bregmatic and bi-parietal diameters are nearly equal, the latter often being less by $\frac{1}{8}$" (or 4%). It therefore follows that a cross section at this level is very nearly circular. To demonstrate this fact more fully, a method was found of using a loop of easily moulded lead. This loop pressed around the head records the shape which can later be traced on paper. Such tracings are shown. (See Figs. 14 and 15, pages 60 & 61) Further evidence was obtained from the frozen sections made in the suboccipito-bregmatic and suboccipito-frontal diameters. These investigations clearly show that at the "girdle of contact" the foetal head is practically circular.

Because the advancing part of the moulded head is a rounded dome, and because the head is virtually circular in cross section at this point, and because the head is a tight fit in the birth canal, it follows that the part of the pelvic floor which it first touches and depresses, is situated in the mid-line, and, as descent continues, both levator-ani muscles are equally distended.

CONCLUSIONS ARRIVED AT FROM THESE INVESTIGATIONS.

1. That moulding profoundly alters the shape of the foetal head.
2. That the head becomes a bluntly pointed cylindrical structure.

3. That when the moulded head is fully flexed, the long axis is very nearly parallel to, and con_ tinuous with the long axis of the body.

4. That the moulded and flexed foetal head must be regarded as being very nearly symmetrical about its long axis.

SECTION IV.

CRITICISM OF THEORIES TO EXPLAIN INTERNAL ROTATION.

One of the most comprehensive and instructive papers on internal rotation is that of Paramore published in 1909.[12] He first deals with the historical aspect, then discusses, criticises, and assesses the theories hitherto brought forward by Sir Fielding Ould, Smellie, Saxtorph Soleyres and Berger, Schmitt, Naegele, Leishmann, Veit, Varnier, Whitridge Williams, Olshausen (Schroeder), Bumm, Sellheim and West. Lastly he describes in great detail his own views, and gives his own theory. This paper is so complete that it would be idle repetition to attempt to cover the same ground. Nevertheless there is much in it which demands attention.

Veit, and Whitridge Williams in his earlier writings, believed that there is much importance in the shape of the various planes of the birth canal. The plane at the lower end of the bony canal is roughly circular, while that at the outlet of the soft parts, elliptical, with the conjugate in the antro-posterior dimensions. This, they believed, guided the head in descent from an oblique into an antro-posterior position. Paramore criticises this theory/

theory by pointing out that with a flexed head the soft parts are distended by a structure which is only 0.5 cm. greater in one diameter than the other. He further shows that the conjugate of the outlet is not necessarily in the antro-posterior dimension, because while the lower end of the birth canal is free behind, it is attached to the pelvic arch in front; and because this arch is wide and the span between the tuberosities is ample, there would be no difficulty in the canal being distended transversely. It would be easier, Paramore states, to separate the lateral margins by a small amount than to cause the posterior border to recede by twice that distance. Of the truth of this statement there is some doubt; nevertheless it expresses a fact which is sometimes forgotten. There can be no exact dimensions for the distended outlet; these depend on the size and the shape of the body distending it. A sack of coal shows irregularities on the surface, but it would be absurd to say that the elevations and depressions were put there to accommodate the individual lumps of coal. A further criticism of this theory is that it is difficult to believe that such an important process as internal rotation could depend on the purchase obtained on the head by differences in calibre of the canal which scarcely exceed 5%. Lastly, this theory by itself cannot explain anterior-rotation of a posterior occiput - indeed it would hinder this from happening.

OLSHAUSEN'S THEORY. Olshausen in Schroeder's text-book gives a theory which has been supported and amplified by Bumm. According to this reasoning, rotation of the head even in occipito-posterior positions is initiated by rotation of the trunk. This fact they claim to have established clinically, and they further state that the position of the trunk is governed by a flattening of the uterus which occurs with the onset of labour. Frozen sections, they claim, demonstrate this fact, and even when the body is frozen in the erect posture as Barbour did in one of his cases, a flattening is said to be seen. Paramore gives good reasons for doubting the truth of these observations. With regard to the frozen sections Barbour himself warns against drawing conclusions from one or two specimens as to the conditions obtaining during life.[13] One feels that other objections could be raised to this theory. Even after rupture of the membranes a considerable amount of liquor amnii generally surrounds the body. How then can a flattening of the uterus grip the body? Moreover, this theory assumes that the trunk is a flattened structure. But with flexed arms and legs included, this is not necessarily true, as Edgar's diagrams/

diagrams show.[14] (See Fig. 16, page 62) Lastly, it has been claimed that the X-ray work done in Bumm's clinic shows the rotation of the trunk. A study of the album of skiagrams by Warnekross[11] of the Anatomy of Labour, forces one to believe that it is a matter of very great difficulty to draw any conclusion as to the relative positions of the head and trunk with regard to rotation of the one on the other.

SELLHEIM'S THEORY. Sellheim[15] in 1906 published the results of a most exhaustive inquiry into the mechanism of labour with special reference to internal rotation. His work on this subject differs from that of all other investigators in that he regarded the foetal head and trunk as a whole; he showed that the foetal axis is normally angled on itself, and can be bent with unequal ease in different directions, and he demonstrated that such a body when forced through a curved canal would rotate in response to physical laws, so that the part most easily bent coincided with the knee of the canal. To prove his theories he devised many elaborate experiments, not all of which, however, can be claimed to represent in a truthful manner the forces which exist in the second stage of labour. Paramore, in his paper, discusses Sellheim's/

Sellheim's work, and severely criticises his views. (1) He rightly makes objection to Sellheim's phantom birth canal, which, because of its elastic sides, allows the birth object to bulge markedly during its descent, which is brought about by compressed air from above. (2) He criticises (with less reason) the assumption that the head bends least easily in the direction of increased flexion, by stating that this must be an intermittent muscular action.
(3) He says that Sellheim's theory does not explain the occasional failure of internal rotation in those cases where the head is small in relation to the pelvis. (4) He states that the theory cannot account for the success of Dubois's experiment with a dead foetus, where muscular activity was absent.
(5) He states that Sellheim does not explain, or even refer to the persistent occipito-posterior case.
(6) His main criticism to which he devotes much space can be summarised thus:- The downward thrust imparted to the foetus causing the head to be driven against the pelvic floor, is so great that any lateral force exerted by the child's head on the closely investing soft parts must by comparison be negligible. Before this last mentioned force could become operative, it would have to exceed the force which causes a recession of the pelvic floor posteriorly and laterally before the advancing head.

With/

With Paramore's criticism one must agree on some points but differ on others. His main criticism does not appear to be sound. If because of the shape and structure of the foetus and the shape of the canal through which it is driven, there arises in the foetus a force which tends to make it rotate, then it must, ipso facto, rotate, unless prevented by some new factor, and Paramore mentions no new force which can do this. The relative greatness of the driving force imparted to the foetus, and of the rotational force arising in the foetus does not influence rotation, provided that time is ample and lubrication efficient. The alternate advance and recession of the head over a period of hours satisfies the first condition, and the nature of the vernix caseosa ensures the second.

In assessing the value of Sellheim's theory one is, therefore, forced to believe that in spite of the severe criticism with which it has been faced, there lies within it an unassailable truth.

PARAMORE'S THEORY. Paramore ends his paper by a lengthy and somewhat complicated description of his own views on the subject. These are briefly as follows:-

In the fully flexed occipito-posterior position various forces tend to cause a jamming of the forehead against the/

the symphysis. The only action possible is a rotation, because the pelvis at this level is ¼" wider transversely, and the longer diameter of the head consequently passes into this larger dimension. The movement having been initiated, a new force arises.
A reproduction of a diagram prepared by Paramore of the foetal skull (See Fig. 17, page 63) shows that the distance CD is greater than the distance FE, and, therefore, taking AB as the axis of rotation, there is a greater leverage exerted by D than by F, hence the brow is pushed into the hollow of the sacrum, while the driving force from above causes the vertex to advance under the pelvic arch. In other words, an impaction of the head is overcome by rotation being superimposed on descent. A screw-like motion is thus set up, and the brow is pushed backwards by the remainder of the head advancing more rapidly.

Paramore finally shows how all these movements are altered by an incompletely flexed head, which in consequence does not rotate.

A weak point in this theory is the fact that it is based on a consideration of a head which is not moulded. The shape and dimensions of the skull as shown in his diagram must be modified in the head which is actually undergoing rotation. Moreover, it is obvious that a mistake is being made in assuming that the line of the driving force applied to the head is/

is the same as the axis of rotation. It suits Paramore to do so, because by regarding this axis as a fulcrum he can show that there is a greater leverage exerted on it by the sinciput than by the occiput. A moment's consideration will show that the line marking the axis of rotation is not an attribute of the head, but an attribute of the canal through which it passes. If the moving body fills the canal, obviously it can only rotate about a point which marks the centre of the canal at the level of the "girdle of contact". There cannot, therefore, be an unequal leverage about this axis, because the levers are equal on both sides, and, secondly, because the fulcrum is not a fixed point. Paramore's theory thus rests on assumptions which reasoning shows are unsound.

YOUNG'S THEORY. Dr James Young in 1913 brought forward a theory of the cause of rotation.[16] His paper on the subject is stimulating reading because of the novel manner in which he approaches the problem, and the unusual ways in which he describes the different processes. His views on the subject are in many ways similar to those of Paramore, and the criticisms of Paramore's theory also apply to Young's theory. There is, however, an additional importance in Dr Young's/

Young's work: he produced a working model which demonstrated the occurrence of rotation. (See Fig. 18, page 64) It cannot be agreed that this model, ingenious as it is, accurately represents the foetal head during parturition. That it will rotate there is no doubt: rotate it must, because it introduces the principle of caster action. The construction is such that with the swivel rod screwed into the head nearer the occiput than the sinciput, the head will, when negotiating a curved canal, only pass with the sinciput dragged behind it. It is possible that this action may play a secondary rôle in causing rotation of the head. The second of the models to be later described makes use of this action to a small extent; nevertheless it is firmly believed that the essential cause of rotation is to be found elsewhere.

HART'S THEORY. Dr Berry Hart's name will always be honoured because of his extensive original work on the physics of parturition. He wrote in a convincing manner on internal rotation, and his views have gained wide acceptance largely due to the fact that he formulated on his theory a valuable working principle: "Whatever part of the foetus first meets with the resistance of one lateral/

lateral half of the posterior segment of the pelvic floor, will be rotated to the front."[17]

He regarded the pelvic floor as consisting of a small anterior, and a large posterior segment. In labour the posterior segment is deeply depressed to allow the head to emerge. He states that internal rotation starts when the head passes the narrow plane of the pelvis, and that the prime factor in bringing about the movement is the pressure of one lateral half of the sacral segment in excess on the deep presenting and lateral part. He also states that the shape of the anterior pelvic wall gives the path.

From his writings it is clear that when he speaks of the "pressure of one lateral half of the sacral segment in excess on the deep presenting and lateral part", he believed that in a vertex presentation the occiput impinges on the sacral segment in advance of the vertex, and further, that this presenting part is eccentric in position.

As has already been shown, a study of the newly born child's head makes it impossible to understand how the occiput can by itself be the first part to come into relation with the sacral segment, and the evidence of frozen sections confirms this opinion. (See Fig. 19, page 65). Only when the sacral segment is well depressed, does the occiput come into relation with/

with it; but by that time the vertex and sinciput are also embraced. The dome-shaped leading part of the head which first encounters the sacral segment is the posterior part of the vertex. (See Fig. 7, page 55) A pressing forward of this part will result in a tilting of the head - a movement of flexion, extension, or asynclitism, according to the original position. It can never cause rotation, because the part pressed forward does not occupy an eccentric position.

This eccentric position is an essential factor in Hart's theory, and without it there can be no possibility of rotation. Were this not so, a boy's hoop held in an upright position would start to revolve because of the upward pressure of the ground, and perpetual motion would be established. This is obviously absurd, and revolution could only momentarily occur if the hoop were other than circular in outline. The hoop would then revolve until its centre of gravity reached the lowest possible point. So with the foetal head. If the axis of rotation were eccentric, then it would move towards the sacral segment as the latter pushes the main mass of the head forwards. In other words, rotation could occur if the axis of rotation were farther from the occiput than the axis of the centre of the head-mass. Hart, however, does not appear to have made reference to this essential condition. In point of fact, one believes/

believes that the two axes referred to either coincide, or so nearly do so that it is impossible to believe that the small purchase obtained could be the cause of internal rotation. Moreover, it has already been shown that the axis of rotation must occupy a median position. (Page 24)

A legitimate attack might be made on these last statements by saying that while the presenting part may not occupy an eccentric position anatomically, yet, by reason of the tendency for the foetal head to extend, it may press unevenly on the two sides of the pelvis giving in effect the equivalent of the required eccentricity. This question will be considered later. It is however, not Hart's theory, and need not now be discussed. Inasmuch as the head is well flexed, and inasmuch as the part which depresses the pelvic floor is dome-shaped and practically circular in cross-section, and inasmuch as the head is a tight fit in the pelvis, so must the sacral segment be equally distended on both sides; and it follows that there is no excess of sacral segment to press on one side of the head, and still less is there a deep presenting lateral part for it to press on.

From a consideration of these facts one is forced to believe that Hart's theory has even less to commend it than those other theories already considered. Its general acceptance is probably due to

the/

the apparent truth of the well known rule evolved from it, but this does not necessarily prove the accuracy of the theory.

THE GUTTER-SHAPED PELVIC FLOOR. This theory is best described by Eden.[18] He says:

"The essential cause of this movement (internal rotation) is the influence of the sloping pelvic floor. As we have seen, the soft parts forming the pelvic floor slope from behind forwards and downwards, and from the sides, forwards, downwards, and inwards - towards the middle line. Therefore, a body coming in contact with any part of the pelvic floor will be directed by it forwards and downwards and under the pelvic arch. When the head is flexed, the posterior part of the vertex reaches the pelvic floor in advance of the anterior, and is accordingly directed forwards by its slope; in other words, the occiput rotates under the pelvic arch. This will occur whether the occiput lies in an anterior or posterior position."

This is a combination of Hart's teaching with the older theories of rotation based on the shape of the pelvis. The criticisms already made of these views can be repeated. In particular, the influence of/

of the pelvic floor can only be to _tilt_ the head. Rotation demands an eccentric pressure which this theory does not provide.

SECTION V.

DESCRIPTION OF MODELS ILLUSTRATING THE MECHANISM OF ROTATION.

From what has been said in the preceding sections, certain facts stand out clearly:-

1. The passenger is propelled through the passage by a driving force acting from above.

2. The passage is practically circular in cross section at every point, and it has at its lower end a very marked bend - a bend of almost a right angle.

3. The foetus is a double cylinder, the head forms one-half of the cylinder, and is joined by means of a flexible neck to the trunk which forms the second half of the cylinder.

4. The cylinders of which the foetus is built are so articulated that one can be bent on the other with different facility in different directions.

Are these data sufficient to explain rotation? One believes they are: the forces which are brought into play when such a body is driven through such a canal must inevitably cause rotation. To demonstrate this one has sought the use of models.

The/

The first model is in two portions. The first part represents the birth canal, and is made of rigid material so constructed that it is perfectly circular in cross section at every point. (See Fig. 20, page 66) It is modelled on the reproduction of Braun's frozen section in Barbour's "Anatomy of Labour"; and reference to Fig. 21, page 66) shows that it is a fairly accurate representation of the parturient passage.

The second part consists of two wooden cylindrical blocks jointed in a special manner. When at rest the long axes of the two cylinders are continuous with each other. (See Fig. 22, page 67)

Each cylindrical block will by itself easily pass through the hollow cylinder, but if they are articulated, jamming tends to occur. The reason for this is that when the leading cylinder has negotiated the curve, its point of articulation will lie in the centre of the lumen of the cylinder. The second cylinder will, however, still be at right angles to the first, and its point of articulation will nearly touch the wall of the canal at the point of the greatest convexity of the curve. Hence, the two points of articulation will be pulled asunder. This tendency can be overcome by causing flexion to take place at more than one point; in other words by introducing an artificial vertebral column. This problem/

problem presented a considerable difficulty, but was satisfactorily solved by the use of flexible metal gas-piping. This piping allows of flexion in every direction, but is yet rigid enough to convey the propulsive force to the leading cylinder.

The ease of flexing one block on the other is controlled by springs or elastic bands, and the design is such that it is possible to carry out experiments to show the effect of altering the flexibility of the two segments. For simplicity in description, the elastic bands will be termed the anterior, the posterior, and the lateral bands, in accordance with the similar forces which they represent in the foetus.

The driving force is imparted to the artificial foetus by means of a rod attached through a swivel joint to the rear cylinder. It is thus only possible to exert a driving action on the foetus; no rotational force can be conveyed through the rod. It is also possible to withdraw the body from the cylinder, and thus an up and down movement can be obtained, similar to that which the foetus undergoes in labour.

Interesting results confirming theory have rewarded the construction and study of this model. Three experiments will be described.-

1./

1. If the anterior band is weak and the other three are of greater and equal strength, then rotation will occur from an L.O.A. or R.O.A. to an O.A. position, but will not occur from an R.O.P. or L.O.P. position.

2. If the anterior and two lateral bands are weak, but equal to each other, and the posterior band is strong, rotation will take place from an R.O.P. or L.O.P position to a transverse position but no further.

3. If these experiments are combined and the anterior band made weak, the two lateral bands equal and of medium strength, and the posterior band strong, then anterior rotation of the occiput will always take place no matter in which position the artificial foetus is made to enter the canal. (See Figs. 23 and 24, page 68)

That this model foetus undergoes internal rotation is very evident; yet to give satisfaction to the mind of the observer, the reasons why the movement takes place must be explained.

The subject may be approached from several aspects, but in each case the expressing in words of what is essentially a mind-picture of interplay of forces, becomes a task so formidable and involved that/

that there is risk of the points at issue being still further complicated and obscured. Probably the simplest explanation, and one which at least re-presents the nature of the forces, is as follows:-

Consider the forces which act on each end of the stretched elastic bands when the model is bent on negotiating the curve of the canal (See Fig. 25, page 69).

Suppose the "foetus" to be in an R.O.P. position, then the strong posterior band AE is under tension. The point E is therefore pulled towards A.

By the rule of the Parallelogram of Forces it is legitimate to regard AE as the resultant of two component forces of equal magnitude, ER and ES.

The force ES acts by retarding the advance of the "foetus". It can play little part in rotation and may therefore be ignored.

Consider now the force ER.

In a section at right angles to the last, this force is again shown (See Fig. 26, page 69).

Again split this force into two components ET and EU.

EU passes through the centre of rotation, and therefore cannot influence rotation. It can be ignored.

The force ET is a tangential force and is active in the matter of rotation.

All/

All that has been said can be repeated for the forces acting on the point H, which marks the point of attachment of the lateral elastic band. But, because this band is weaker, the forces which it evokes will all be of smaller magnitude. Hence the force HV is overcome by the force ET. Rotation will therefore occur in the direction of ET as far as the transverse position. Short internal rotation is thus explained.

When the band AE passes the transverse position the action is transferred to the lateral band which in turn overcomes the weaker forces of the anterior band, and the movement of rotation is therefore continued until the weakest band coincides with the position which demands the greatest stretching.

When the different bands reach the transverse position there is for an instant a "dead point". This is of interest theoretically, but does not influence rotation in practice.

The forces have so far been considered with regard to the leading cylinder (the head). Similar forces can be shown to be acting on the trunk where the other ends of the elastic bands are attached.

In the actual foetus there are not four definite and independent bands as in the model, but an infinite number of bands which collectively make for an unequal flexibility of the neck. Similar forces to/

to those just described are called forth, and when the foetus is pushed through a curved canal, rotation inevitably occurs.

The ease with which the model foetus undergoes both short and long internal rotation is remarkable, and the successful accomplishment, in spite of the absence of a lubricant to correspond to the vernix caseosa, emphasises the powerful nature of the forces at work. Indeed, if this model can be shown to represent in an accurate manner the essential facts of parturition, then the problem of Internal Rotation is solved.

Reasons have already been given for believing that the shape of the birth canal and the structure of the foetus are truthfully reproduced. These reasons must now be amplified.

FLEXIBILITY OF THE FOETAL HEAD ON THE TRUNK.

Study of the model shows that an essential factor in bringing about rotation is the unequal degree of ease with which the head can be bent on the trunk in different directions. This fact has already been mentioned, and its truth assumed. Is the foetal head in reality articulated to the body in this very special manner?

This can be determined by laying a newly-born child/

child on a table, attaching a band around the head, and pulling through a spring balance on the band until the head is deflected a given distance in each direction. Figures vary in different cases, but in all there is a marked agreement with the conditions found necessary in the experimental foetus.

Thus:-

Bending in direction of increased flexion	5 lbs.
" " lateral direction . .	2 lbs.
" " direction of extension - (a negative figure) . .	-3 lbs.

Sellheim has apparently arrived at similar conclusions by use of a tightly fitting skull cap, through which the child's head could be deflected by means of a spring.

In estimating the force required to bend the head on the trunk in different directions, it has been shown that the force required to cause extension was a negative figure. This is another way of stating that the attitude of the foetus was not the position of rest. When at rest, the head is slightly extended on the body, causing the foetal axis to be angulated. (See Fig. 27, page 70). In the case in which the measurements were taken, a force equal to the pull of 3 lbs. was required to bring the axis of the head into line with that of the trunk, as it is when rotation begins.

The/

The effect of this force is to augment the tendency for rotation to take place. This statement can be easily verified by suitably altering the model already described.

To demonstrate these facts still more clearly, a second model was made. (See Fig. 28, page 71). This model shows the angulation of the head on the trunk. It is also fashioned to represent more accurately the foetal structure. The head and trunk are obliquely cut off at the adjoining ends, and the apparent asymmetry due to the face and mandible is thus reproduced. The vertebral column has received special attention, and more elaborate provision is made for bending over a large portion of the foetal length. Lastly, the position of the vertebral column has been accurately fixed in accordance with the findings in the frozen sections of the foetus already described.

Compared with the first, this second model is of more accurate construction, and consequently reproduces more truthfully the forces at work during parturition. In actual test, it demonstrates the movement of rotation in a still more convincing manner.

A CRITICISM ANSWERED.

A criticism has been made of these models because the "foetus" rotates as a whole. By clinical observation it is known that this does not always happen; in particular, the extent of the movement of restitution after a long internal rotation of the head, shows that there are occasions when the movement of the trunk lags far behind that of the head.

The fact that the head may be twisted so that the chin points over the shoulder only goes to show how powerful the rotational force may become. The nature of the force remains the same, because the unequal flexibility of the head on the trunk is maintained, or even increased by this strained attitude. To some extent, the state of affairs can be reproduced in the second model by artificially restraining the movement of the rear cylinder. This criticism is, therefore, one of mere detail directed towards technicalities in the construction of the model: it in no way invalidates the theory already set forth.

SECTION VI.

APPLICATIONS OF THE THEORY.

The theory already given amply accounts for internal rotation of the foetal head in a vertex presentation. It equally readily explains the movement in its less usual forms.

INTERNAL ROTATION IN A FACE PRESENTATION.

The forward rotation of the chin in a face presentation can be shown to depend on the same laws. The head is again transformed into a cylinder, as is shown in the accompanying diagram. (See Fig. 29, page 72). The head, being already extended, can only with difficulty be forced into further extension: it can, however, be easily flexed, hence internal rotation takes place.

ROTATION OF THE AFTERCOMING HEAD.

In a breech delivery, the aftercoming head tends to rotate into the most favourable position, with the occiput directed towards the mother's abdomen. The reasons for this have been difficult to explain. The most generally accepted theories of internal rotation could not be applied, and it has been necessary to assume that the forces which are active in the case of a vertex presentation are replaced by different/

different forces when the trunk precedes the head. There is some justification for this belief, because there are undoubtedly new reasons for rotation of the head which are not present in the more usual forms of delivery.

Chief amongst these is the fact that the obstetrician intentionally manipulates the head into the correct position.

Another important point sometimes overlooked is the fact that the chin projects further from the basilar condyles than does the posterior surface of the neck. The point of attachment of the vertebral column to the skull is thus eccentric in position. In consequence of this, any traction of the child's body after its delivery will tend to bring the basi-occiput to the front, leaving the chin and face to rotate into the hollow of the sacrum. (Fig 30, p. 73)

(It is interesting at this point to recall Edgar's experiment with a foetal head. With a swivel screwed into the head behind the posterior fontanelle, he pulled by means of a cord, and found that the head emerged with the occiput in the anterior position. Obviously, the part pulled on is bound to come to the front: such a reversal of midwifery mechanics cannot justly be used to illustrate the problems of parturition.)

While believing that these facts help the rotation/

rotation of the aftercoming head, there is still more reason to believe that in the main the movement is governed by the same forces which are active when the head is the presenting part. Every point already given in the explanation of rotation can be repeated for the aftercoming head. It matters not which end of the double cylinder leads, rotation is inevitable. The models previously described can be used to demonstrate this fact.

ROTATION OF THE FOETAL TRUNK.

Rotation of the trunk is seen in two forms: in a cephalic presentation by the rotation of the shoulders into the antro-posterior dimension of the outlet, and, in the case of a pelvic presentation, by the similar movement of the trochanters.

At first thought it seems that an obvious explanation of the trunk movements is to be found in the pure accommodation theory - the greatest foetal diameter being forced into the longest maternal dimension. There are, however, objections to this. The greatest foetal diameter may in one case be the shoulders, but can it be said with equal certainty that in a breech presentation with flexed legs, the pelvic mass of the child is definitely greater in one dimension than another? (See Fig. 16, page 62). Another objection is found in the fact that the dimensions/

dimensions of the outlet are not so unequal as is usually believed: they depend chiefly on the shape of the distending body. (Paramore.[12]) This explanation is, therefore, sufficiently uncertain to make it desirable to look for an alternative.

The thought at once occurs that the forces which so adequately account for rotation of the head may also be active in the case of the trunk. Two of the factors are the same. The trunk is a cylindrical body capable of being bent on itself. The channel through which it passes is the same curved canal which activates the latent forces in the head and causes them to bring about rotation. The third essential factor must now be looked for. This is an unequal flexibility of the cylinder in different directions.

Sellheim in his original article dealt with this point, and showed X-Ray pictures of a preserved foetal vertebral column bent in various directions. He demonstrated that the range of lateral flexion exceeds that of anterior or posterior flexion.

The examination of an anatomical specimen is not completely convincing. It was therefore decided to repeat this experiment with a living and unanaesthetised newly born child. The experiment is an undertaking of considerable difficulty owing to the struggles of the child when held in unusual positions/

positions below an X-Ray tube. The results of these investigations are shown, and it will be seen that for a given force (roughly estimated) lateral flexion of the trunk can be more fully produced than flexion in any other direction. (See Figs. 31, 32, 33, and 34, page 74)

A corroborative method is the use of a spring balance as described in connection with flexion of the head. A band was applied round the root of the neck of a newly born child. The lower half of the child's trunk was held firmly, and a measure was then taken of the pull required to cause the shoulders to deviate given distance in each direction. The experiment was then repeated with the breech. Such investigations are also made exceedingly difficult owing to the opposition of the child. Accurate readings are thus impossible; nevertheless, the relationship of one force to the other may be fairly readily obtained.

The following are the actual figures arrived at:-

Cephalic end of the Trunk.

Force required to cause Extension	-	6 lbs.
" " " Flexion	-	5½ "
" " " Lateral Flexion	-	3½ "

Pelvic end of Trunk.

Force required to cause Extension	-	5½ lbs.
" " " Flexion	-	4½ "
" " " Lateral Flexion		3 "

Even more convincing is the simple experiment of grasping the child with one hand applied to the shoulder girdle, and the other to the pelvic girdle. It will then be found that it is appreciably easier to bend the trunk in a lateral direction than in any other.

Every factor is thus present to enable the trunk to evoke the same forces which cause rotation of the head. Internal rotation therefore occurs - but with one difference. In the case of the head there are three unequal flexibilities which allow long internal rotation to take place as well as short rotation. In the case of the trunk there are only two flexibilities in which the difference is well marked (lateral flexion, and flexion in other directions) hence, it is only possible for short rotation to occur.

FAILURE OF INTERNAL ROTATION.

No theory would be complete which did not account for the persistent occipito-posterior, and persistent mento-posterior cases. The very occasional failure of rotation can be explained in ~~three~~ four ways:-

1. The head may be small in proportion to the birth canal. In consequence, the usual flexion and moulding are absent, and the unequal flexibilities are not brought into action. Hence, rotation does not take place.

2./

2. The head may be large in proportion to the birth canal. A definite obstruction may occur, or, failing that, the frictional forces may be so great that they overcome the rotational tendency of the head.

From what has been said it will be realised that this tendency is (theoretically) at a zero level when the occiput is pointing directly posteriorly, and quickly increases as the latter moves to one or other side. For this reason, if the frictional forces succeed in arresting rotation, they do so when the rotational tendency is at its lowest. Thus it is, that in the persistent occipito_posterior case, the head is usually lying in the antro_posterior diameter of the pelvis. It is misleading to say of such cases that the occiput has passed into the hollow of the sacrum. If on rare occasions this appears to happen, the "reverse rotation" has taken place before the head has been influenced by the bend of the birth canal. There is no special significance in the "hollow of the sacrum", except for the part it plays in forming the curved birth_canal, and it is misleading to speak of it as if it were an obstetrical Lorelei ever ready to lure the navigator to his doom.

3./

3. The all-important curve of the birth-canal may be lessened or even abolished. This may be brought about in various ways.

The pelvis may be distorted by rickets. Besides the primary effect of narrowing the inlet, there is often a secondary flattening of the sacral curve, and an opening up of the pelvic outlet. The birth canal is thus straightened, and rotation of the foetus is less likely to take place. To this must be added the fact that in these cases the attitude of the foetal head is also abnormal (Michaelis' Obliquity). This further militates against rotation, as will be shown under heading 4.

A Funnel-shaped pelvis (Whitridge Williams) has a narrow pubic arch approximating to the male type. The narrowness of this arch may be such that the foetal head is unable to find accommodation within its span. The head is therefore driven backwards and causes an excessive distension or tearing of the sacral segment of the pelvic floor. The result of this is that the birth canal again becomes straighter/

straighter than usual and loses its power to activate the forces which make the foetus rotate."

The same conditions can be reproduced by an abnormally lax pelvic floor resulting from previous obstetrical injuries, and it is interesting to recall that spontaneous face-to-pubis deliveries are usually associated with multiparity on the part of the mother. These cases are to be regarded as clinical corroboration of Dubois's experimental findings (page 4).

4. When allowances are made for all the preceding possibilities there remains a group of cases in which rotation does not occur in spite of apparent normality of mother and child. The study of the mechanics of rotation makes these cases specially interesting.

The foetal head is found to be incompletely flexed (in a vertex presentation), or incompletely extended (in a face/

face presentation). It is well known that in practice these positions are of bad omen, and strongly predispose to a failure of rotation. (See Figs. 35 and 36, page 75) In such cases the head can be almost as easily bent in the direction of flexion as in extension. The essential factor of the unequal flexibilities is absent, and rotation consequently fails.

From the foregoing it will be realised that an amply satisfying explanation of internal rotation of the foetus has been given. Rotation of the head in its normal and abnormal positions, rotation of the shoulders and of the breech, even rotation of the aftercoming head, can all be adequately accounted for. It would be surprising if internal rotation of one part of the body were brought about by methods different from those by which another part is caused to rotate: such an assumption is now unnecessary. The movement is governed by mechanical laws which are remarkably constant, and are responsible for each of the varied manifestations of internal rotation.

It is said that the exception proves the rule. In this connection, the occasional persistent occipito-posterior, and persistent mento-posterior cases are the apparent exceptions which indeed both test the rule and demonstrate its truth.

In/

In conclusion, the following statement in abstract terms can be made of the facts of rotation. Part of the driving force exerted on the foetus in causing it to pass through a curved canal, is absorbed, and, owing to the peculiar construction of the foetus, is converted into certain unequal lateral forces. These pressures, reacting on the foetus, bring into play tangential forces which, in turn, are the cause of rotation.

CONCLUSIONS.

1. Internal Rotation is a movement of the foetus which is of supreme importance for the easy accomplishment of parturition.

2. This movement assumes many different forms according to the attitude of the foetus, and the stage of delivery.

3. The usual theories to explain rotation are inadequate, and (with the exception of Sellheim's theory) they all contain grave inaccuracies.

4. Special investigations have shown that the shape of the head when it undergoes rotation, is altered in essential respects. Because of the attitude of flexion, and because of moulding, it becomes a bluntly pointed cylinder.

5. There is an unequal flexibility of the head on the trunk in different directions.

6. With these facts it is possible to construct a model which demonstrates internal rotation.

7. It is possible to give a mathematical explanation of the reasons for rotation.

8. Internal rotation of the head in a vertex or face presentation, rotation of the shoulders, rotation/

rotation of the pelvis in a breech presentation, and rotation of the aftercoming head, can all be adequately accounted for.

9. The persistent occipito-posterior and persistent mento-posterior cases present points of especial interest which confirm the accuracy of the theory.

REFERENCES.

1. Smellie: Collection of Cases and Observations, Vol.II, p. 354.

2. Buchanan: Midwifery Mechanics.

3. Dubois: Quoted by Lusk, Science and Art of Midwifery, 3rd Edition, p. 180.

4. Edgar: Practice of Obstetrics. 4th Edition, p.424

5. Edgar: Practice of Obstetrics. " " p.433

6. Buchanan: Midwifery Mechanics.

7. Barbour: The Anatomy of Labour as studied in Frozen Sections, 2nd Edition, p.10.

8. Young: Proceedings of the Royal Society of Medicine, Feb. 6th. 1913.

9. Barbour: The Anatomy of Labour, 2nd Edition, p.190

10. Barbour: Atlas of the Anatomy of Labour as exhibited in Frozen Sections.

11. Warnekross: Schwangerschaft und Geburt im Roentgenbilde.

12. Paramore: Journal of Obstetrics and Gynaecology of the British Empire, Oct.1909, p.213.

13. Barbour: The Anatomy of Labour, Chap.II.

14. Edgar: Practice of Obstetrics. 4th Edition, p.401.

15. Sellheim: Die Beziehungen des Geburtskanales und des Geburtsobjektes zur Geburtsmechanik. (Beiträge zur Geburtshilfe und Gyn.1906)

16. Young: Proceedings of the Royal Society of Medicine, Feby. 6th, 1913.

17. Hart: Guide to Midwifery, p.176.

18. Eden and Holland: Manual of Midwifery, p.263.

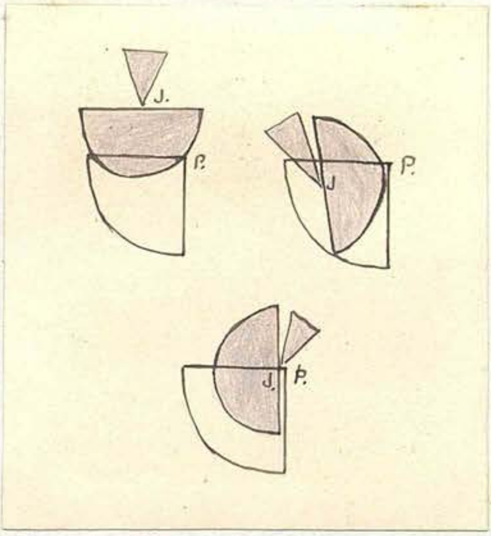


Fig. 1. Buchanan's Diagram.

Only when the "pivot-point" of the head (J) is in apposition to the "pivot-point" of the pelvis (P.) can the head escape. This it does by "revolving" under the symphysis.

(From "Midwifery Mechanics.")

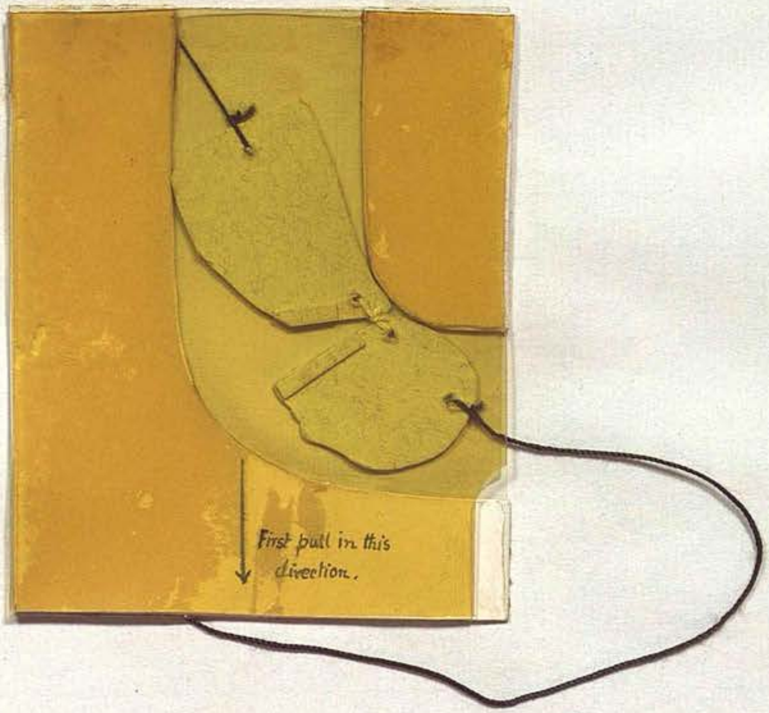


Fig. 2. Modification of Buchanan's Model.

The "foetus" can be drawn through the canal only when the occiput is placed anteriorly.

(When withdrawing "foetus" from an impacted posterior position, please keep both ends of thread taut.)

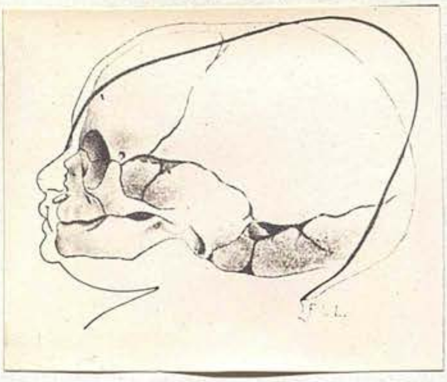


Fig. 3. Moulding of Foetal Head

(Photographed from Williams's "Obstetrics".)

Fig. 4. Marked Moulding of Head.

Fig. 5. Excessive Moulding.

(Figs. 4 and 5 photographed from Edgar's "Practice of Obstetrics".)

Fig. 6. Photograph of a Newly Born Child, showing Moulding of the Head.

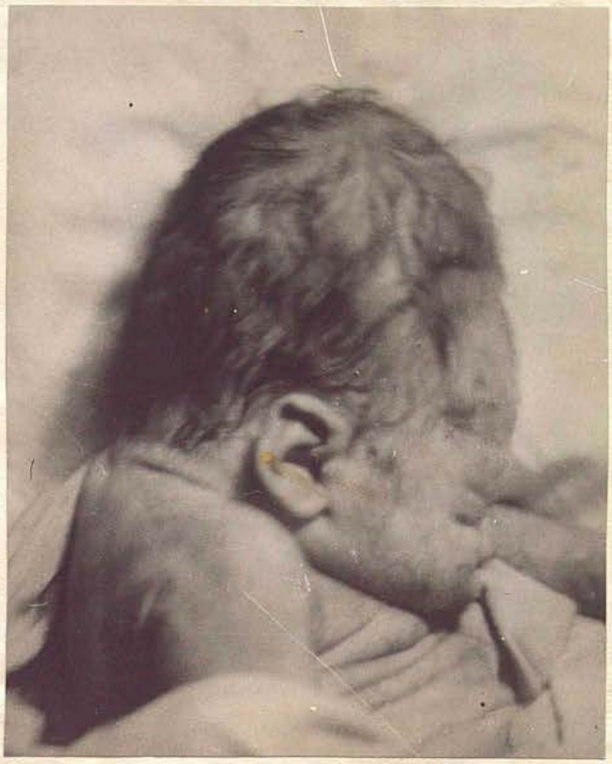


Fig. 7. The same case as above, but with the Head in the Attitude which it assumes when undergoing Rotation.

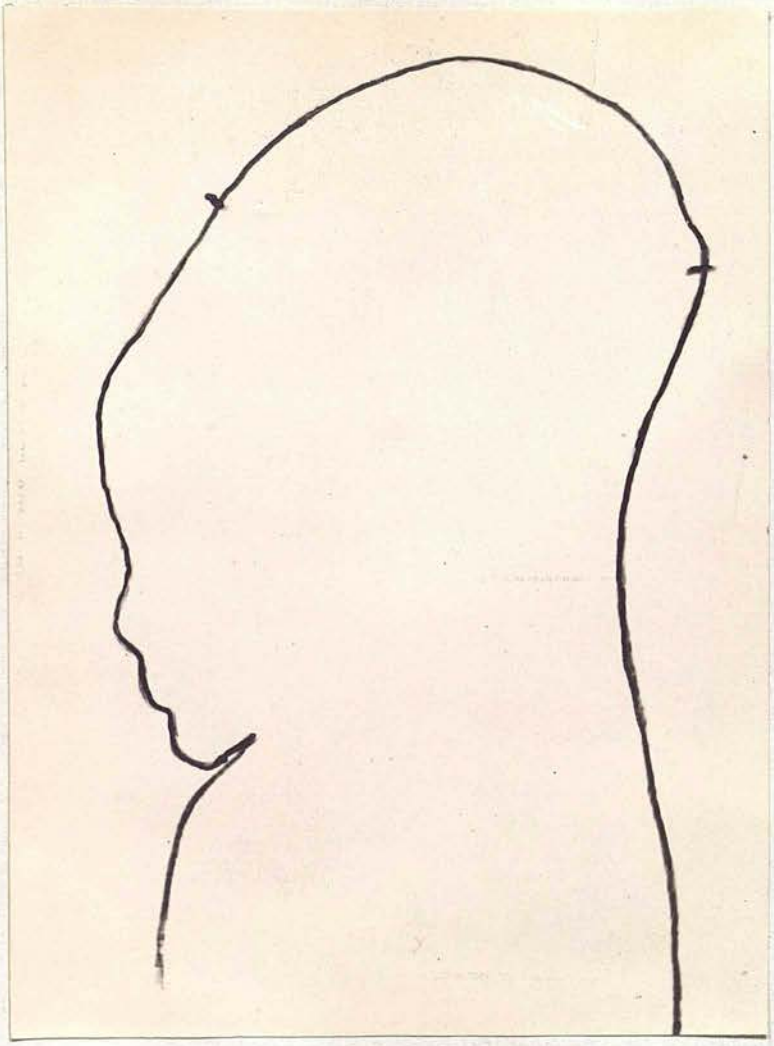


Fig. 8. Child's Head, showing Moulding.

(Direct Tracing, photographically reduced.)

The Positions of the Fontanelles are shown.

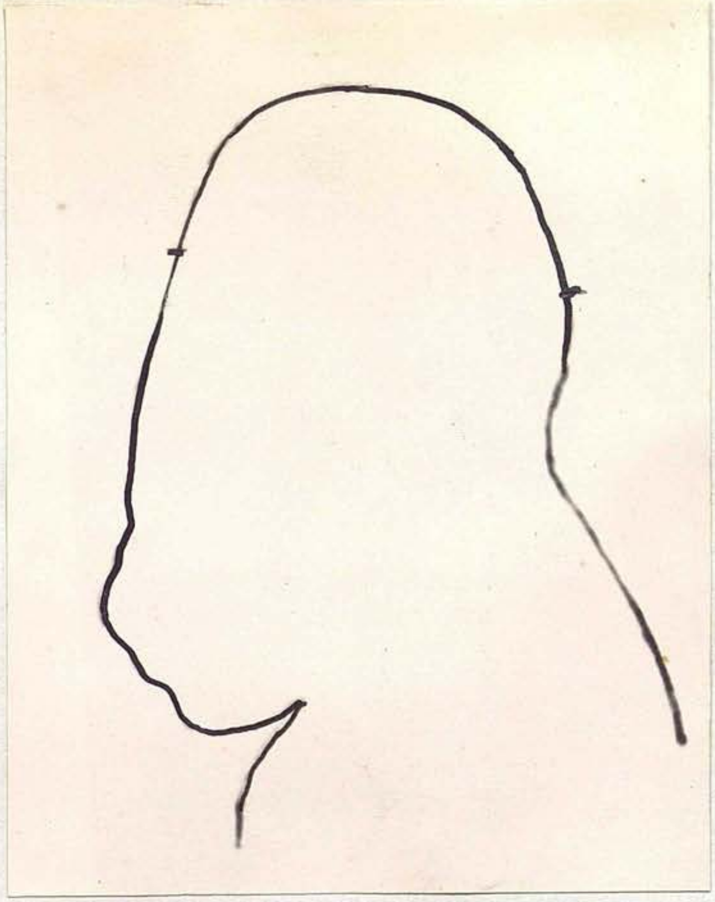
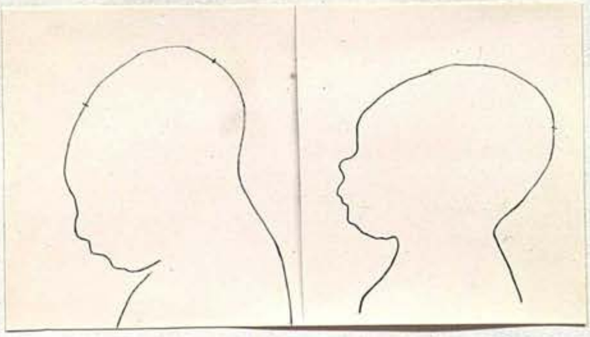


Fig. 9. Tracing of Head showing great Moulding.

Note, the Occiput and Sinciput cease to form projections, and the head is now a cylindrical structure.



a. b.

Fig. 10. Tracings of Head where Moulding was almost absent.

a. Flexed. b. Deflexed.

Note that flexion causes the shape to approximate to that shown in Fig. 9.

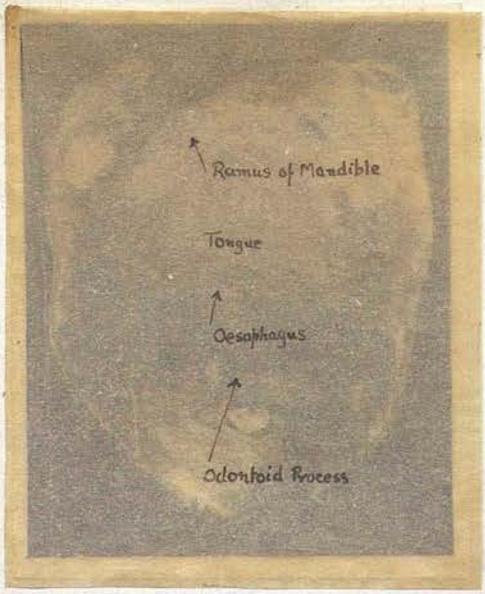


Fig. 11. Frozen Section made through the Sub-occipito-mental Diameter.

Fig. 12. Frozen Section made through the Neck close to the Base of the Skull.

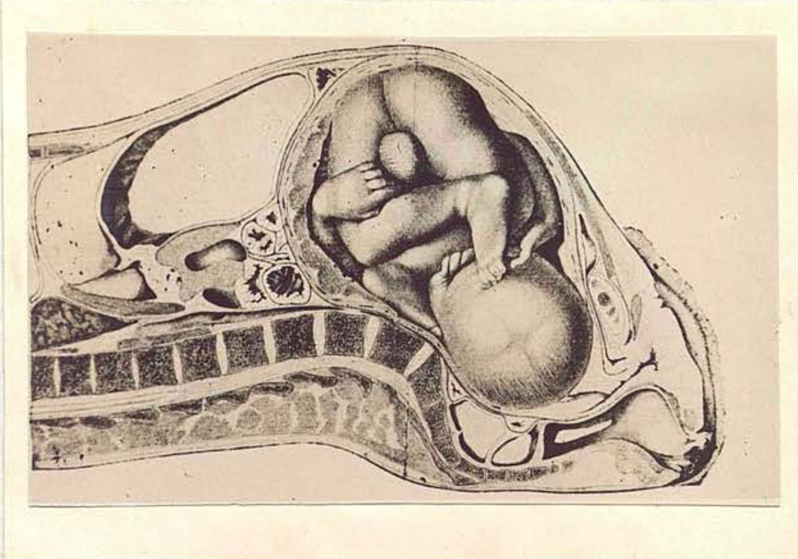


Fig. 13. Frozen Section at End of Pregnancy (Zweifel.).

(Photographed from Whitridge Williams's "Obstetrics".)

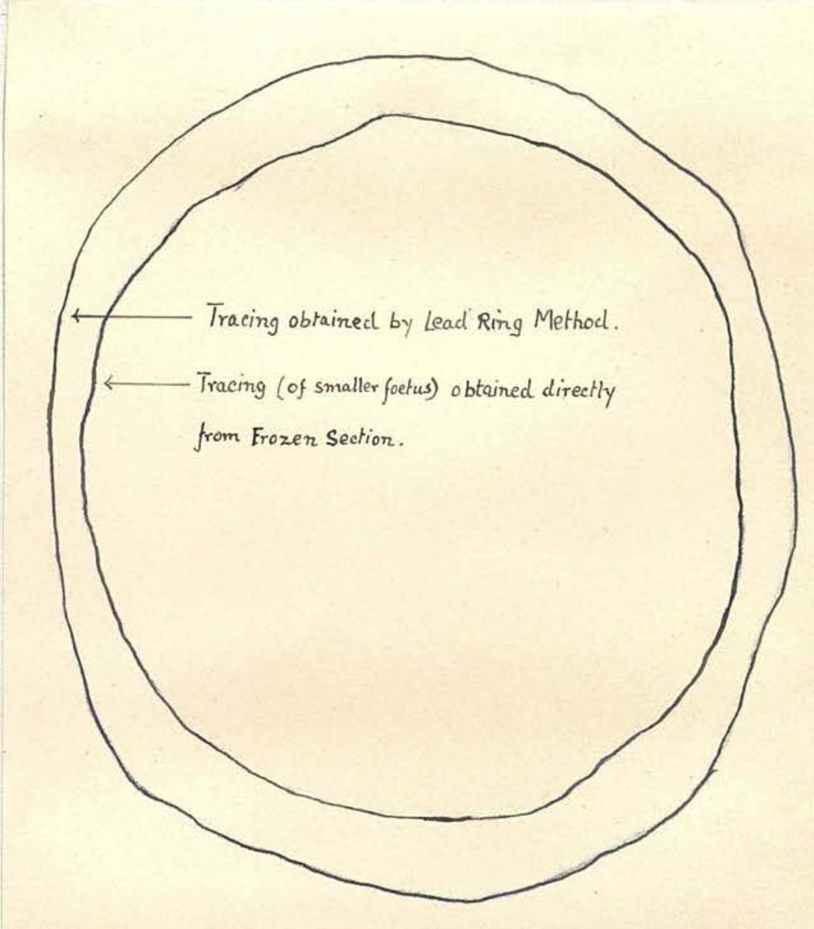


Fig. 14. The Shape of the Head on Section at the level of the Sub-occipito Bregmatic Plane.

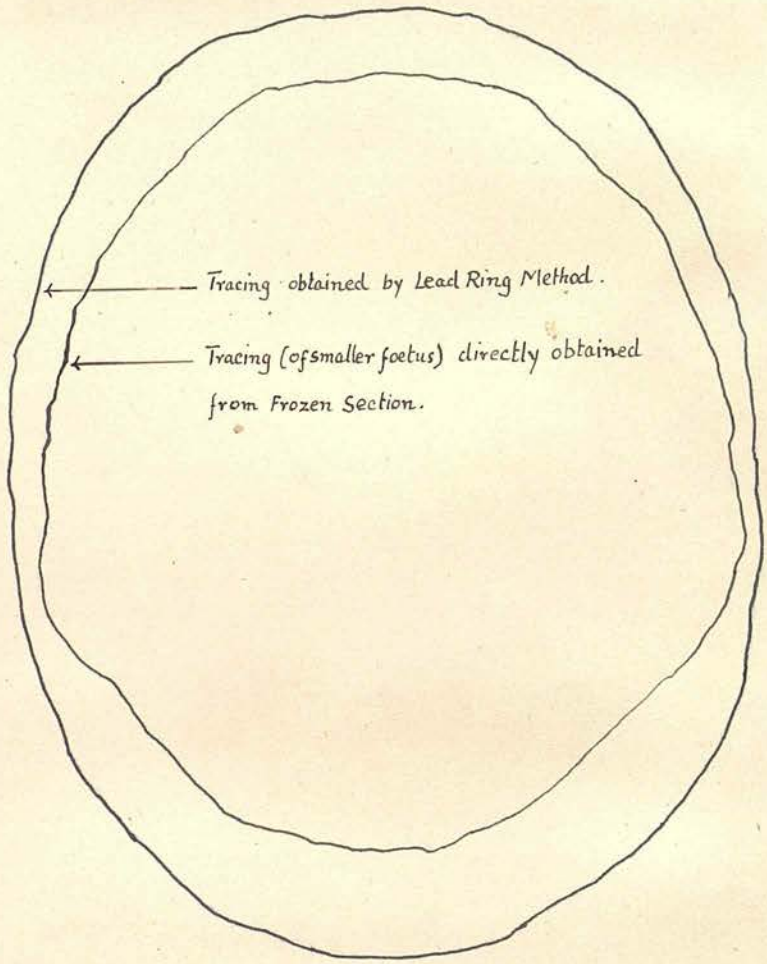


Fig. 15. Shape of Head on Section at the level of the Occipito Frontal Plane.

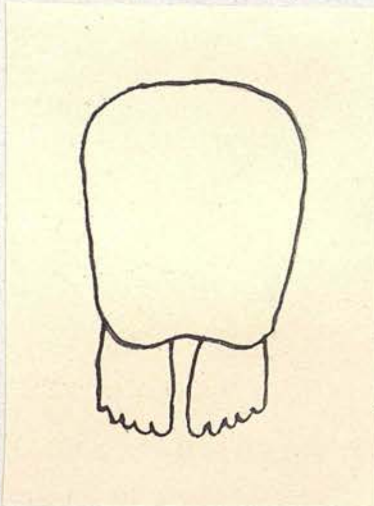


Fig. 16. Mid-Plane of Foetal Ellipse.

(Redrawn from Edgar's "Practice of Obstetrics.")

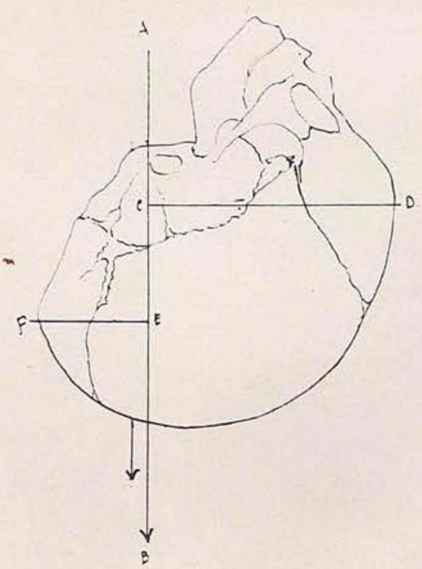


Fig. 5. Showing how the forehead is placed eccentrically to the cranial axial line. A B the cranial axial line, about which internal rotation takes place when flexion is good. When the vertex (B) is fixed by the force from above (acting along A B), the point D, coming into relation with the pelvic wall, acts as the flange of a screw.

Fig. 17. Reproduction of Paramore's Diagram illustrating his Theory of the Cause of Rotation.

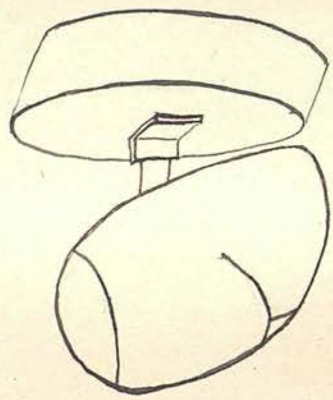


Fig. 18. Dr. James Young's Model of a Foetal Head.

(Redrawn from the Proceedings of the Royal Society of Medicine.)

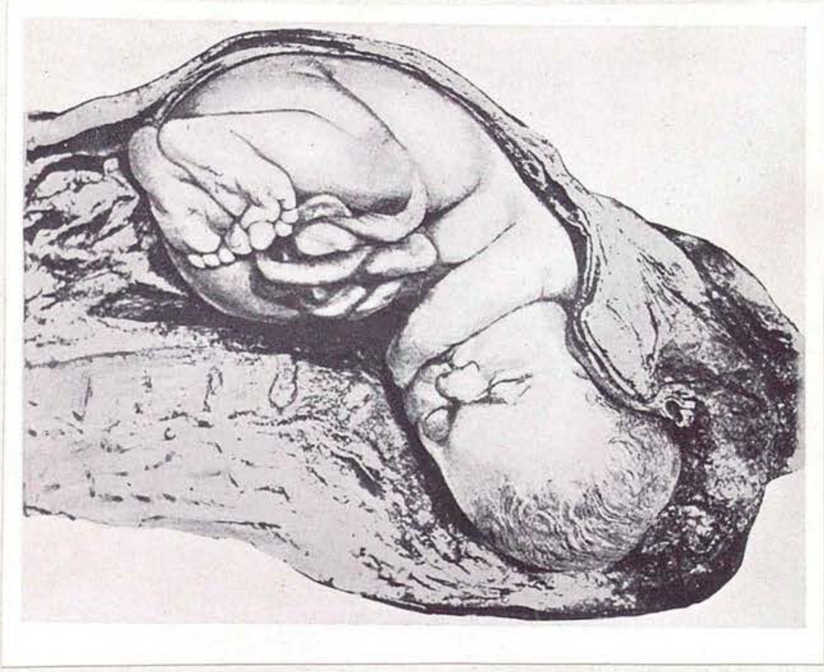


Fig. 19. Studdiford's Frozen Section.

(Photographed from Edgar's "Practice of Obstetrics.")

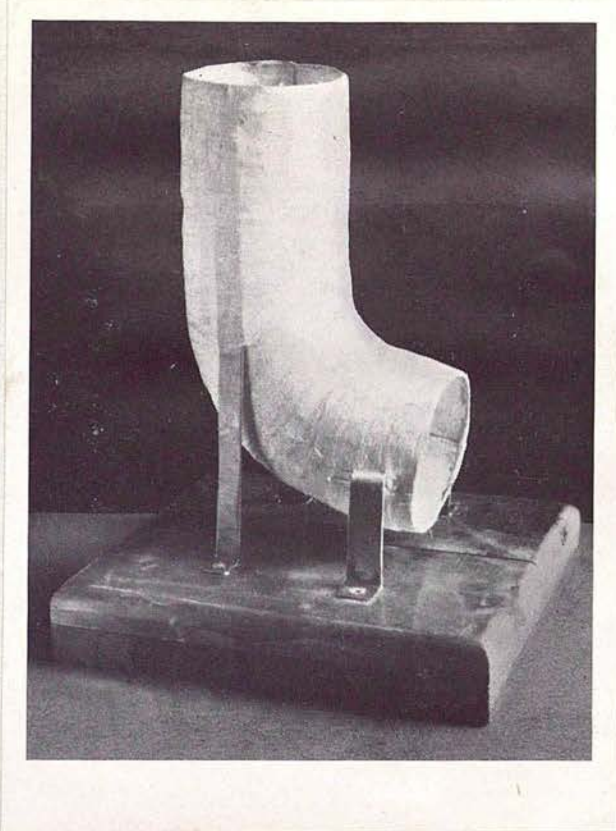


Fig. 20. Model of the Parturient Canal.

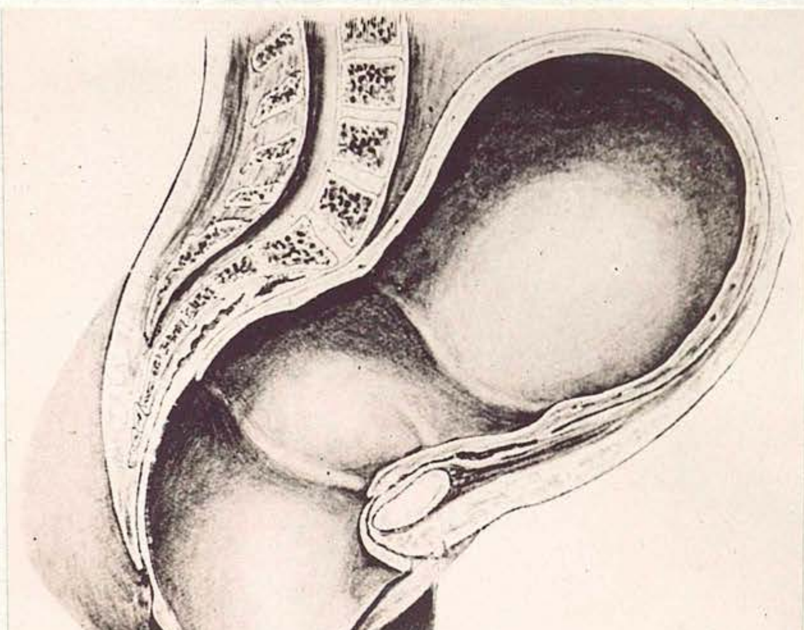


Fig. 21. The fully dilated Parturient Canal

(Reproduced from Galabin and Blacker's Text Book.)

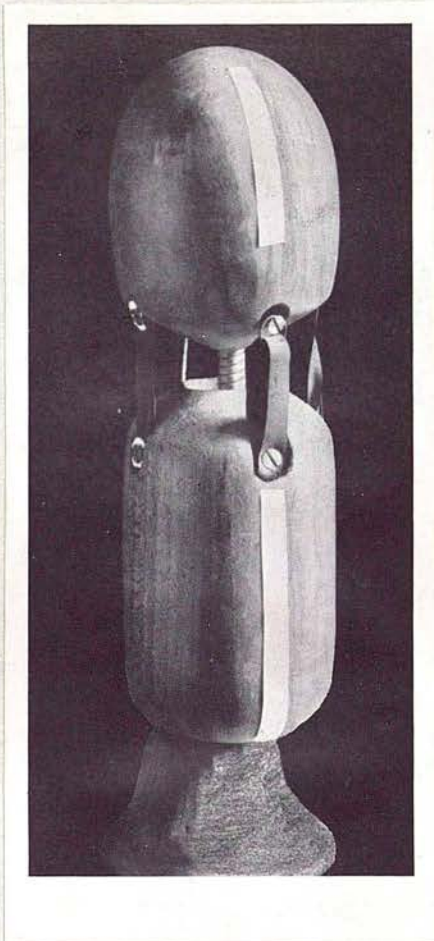


Fig. 22. Model, to illustrate the Mechanical Laws which govern Internal Rotation.

(The white band marks the position of the "occiput".)

Fig. 23. The "Foetus" entering the Canal in the Right Occipito-Posterior Position.

Fig. 24. The "Foetus" emerging from the Canal in the Occipito-Anterior Position.

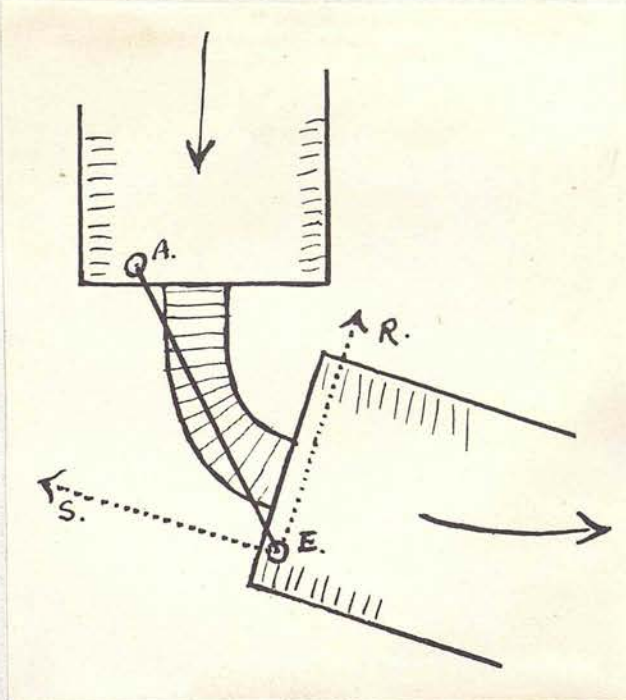


Fig. 25. The Forces which appear when the Model is bent.

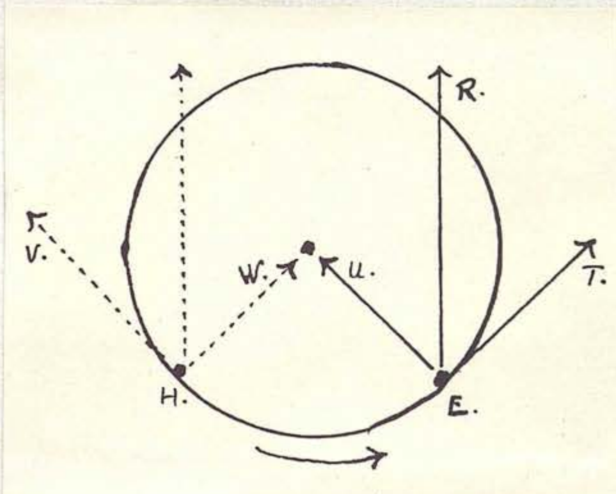


Fig. 26. Cross Section.

Fig. 27. The Head in the Position of Rest is "Deflexed".

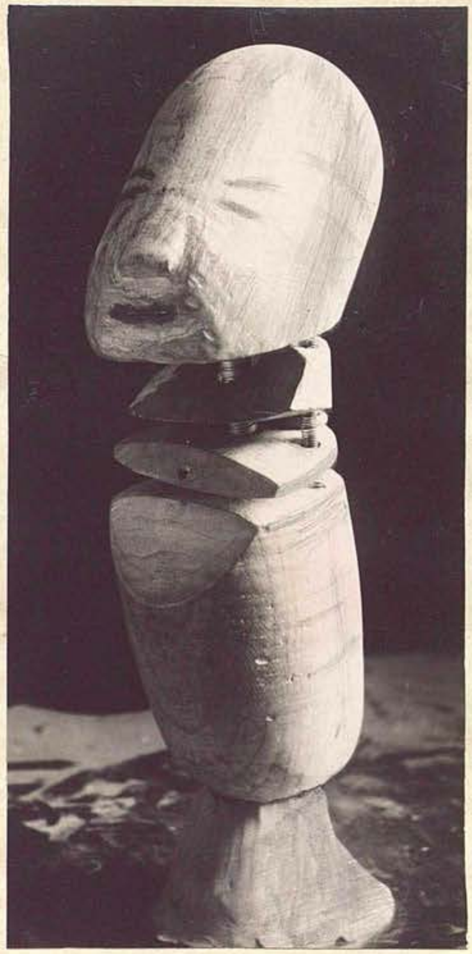


Fig. 28. Model of a Foetus.

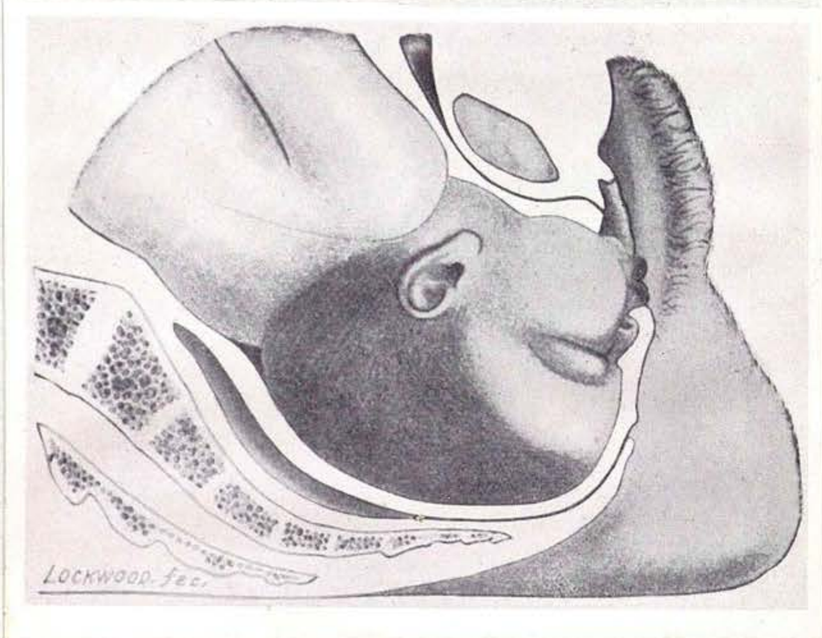


Fig. 29. Face Presentation.

The Foetus is again transformed into a double cylinder.

(Photographed from Whitridge Williams's "Obstetrics".)

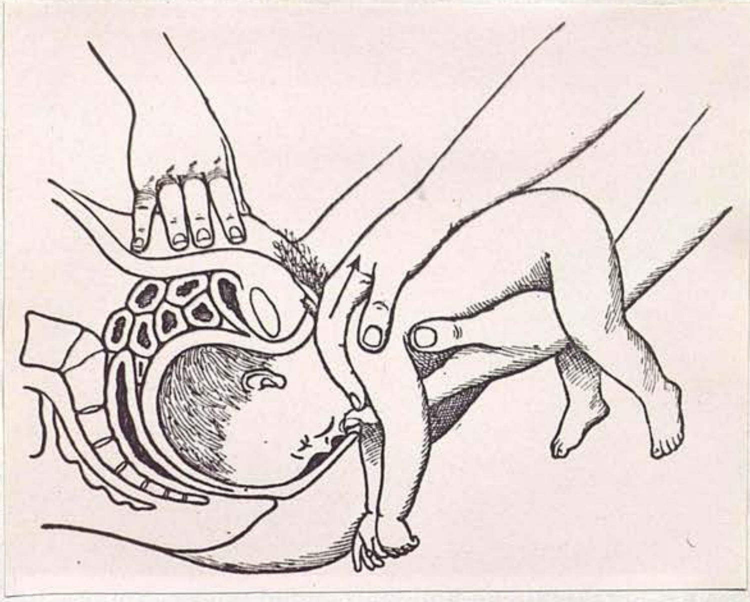


Fig. 30. Delivery of the Aftercoming Head.

Illustrating a contributary factor to the cause of rotation.

(Photographed from Prof. Johnstones Text Book of Midwifery.)

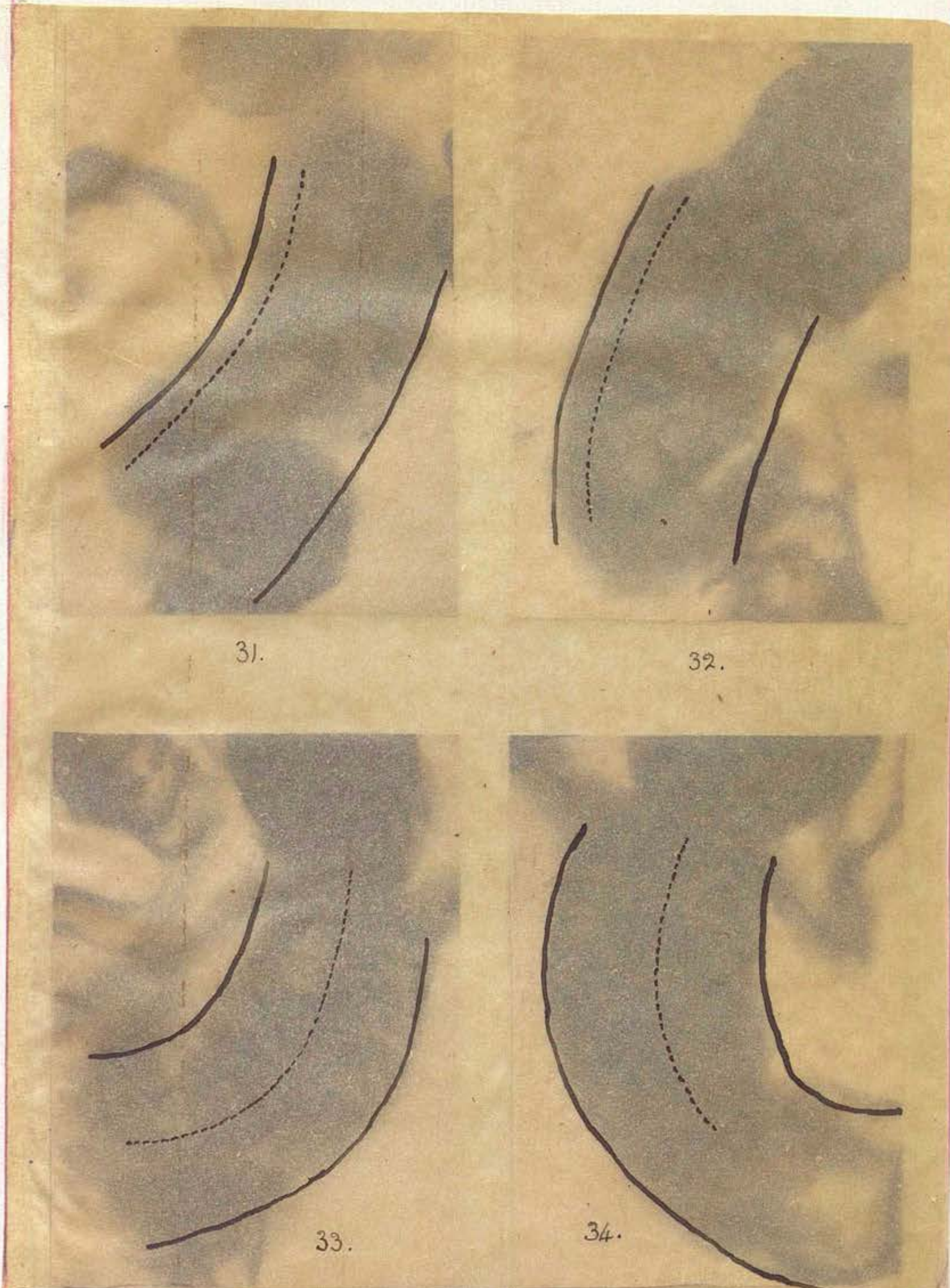


Fig. 31, 32, 33, + 34. Skiagrams of Newly Born Child.

To demonstrate the degree of flexibility of the trunk.

31. Posterior Flexion.
32. Anterior Flexion.
33. Lateral Flexion.
34. Lateral Flexion (Legs extended.)

Fig. 31, 32, 33, + 34. Skiagrams of Newly Born Child.

To demonstrate the degree of flexibility of the trunk.

31. Posterior Flexion. 32. Anterior Flexion.

33. Lateral Flexion. 34. Lateral Flexion (Legs extended.)

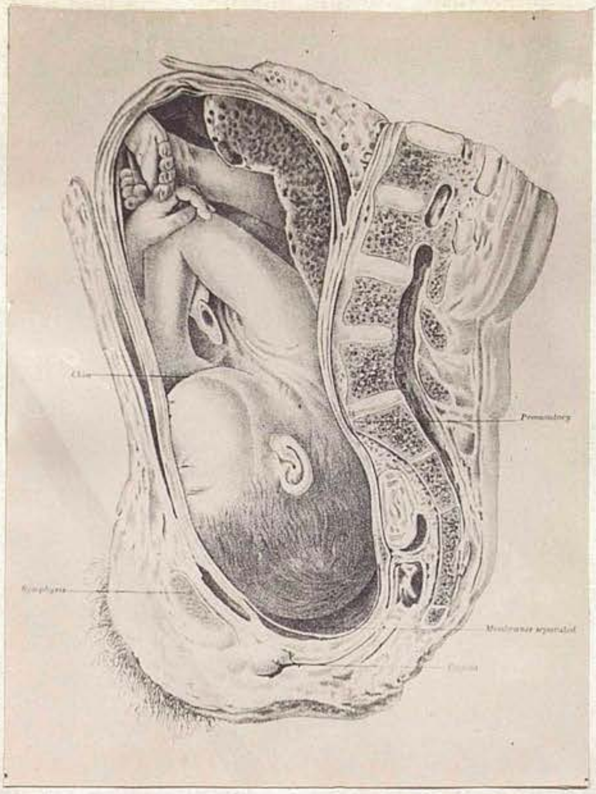


Fig. 35. <u>Frozen Section of a Persistent Occipito-Posterior Case.</u>

The Position of the Chin indicates the lack of complete Flexion.

(Reproduced from Barbour's "Atlas of Anatomy of Labour.")

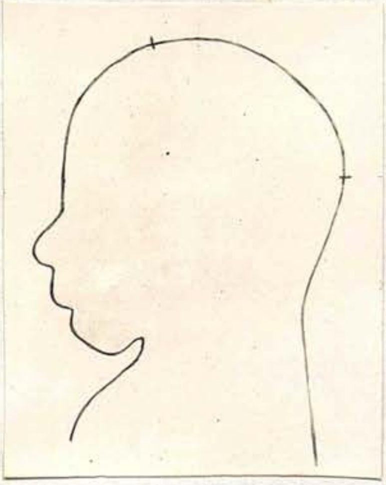


Fig 36. <u>Photographic Reduction of Direct Tracing of Head from a Case of Face to Pubis Delivery.</u> The Character of the Moulding indicates that the Head was incompletely flexed.

Compare Figs. 8 and 9.