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T H E S I S.

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on

THE MECHANISM

of the

SECOND STAGE OF HUMAN PARTURITION

by

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THE MECHANISM
OF THE
SECOND STAGE OF HUMAN PARTURITION.

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INTRODUCTION.

The mechanism of the second stage of human parturition has already been the subject of numerous works, and on many aspects of the problem the treatment has been exhaustive. There are matters, however, which still call for inquiry. Further evidence seems desirable relative to the form of the dilated pelvic canal; the direction of uterine pressure may be said to be unknown; given a variable direction of pressure proof is wanting of its influence, or otherwise, on the mechanism; the known effect of a uniform pressure on a curved surface needs application to the mechanism of labour: it is worth while to attempt to unravel the congeries of movements which go by the names of flexion and extension; the difficult problem of lateral obliquities of the fetal head remains where it was forty years ago; the development of the mechanism at the vulvar outlet may be capable of modification in a manner favourable to easier birth. These and other matters are gone over in the pages that follow.

A definition of what is meant by the second stage is not easy if regard is had to every possibility/

possibility. In most labours the second stage comprehends the period which elapses after the os uteri is fully dilated and the membranes are ruptured until the child is completely born. It is obvious, however, that the mechanical phenomena of the second stage are able to be developed before the os is wide open, and after full dilation before the membranes are ruptured, at any rate until a late period of the second stage. The "expulsive period" of the Germans also is not sufficiently general at least in its clinical manifestations, for the evidence - abdominal action - may be wanting. Nor is it adequate to maintain that the passage of the individual segments of the fetus through the vaginal and vulvar canals constitutes the second stage. For the present purpose the second stage is defined as a period which begins when the fetus is compelled to exercise an uncertain quantity of pressure upon the upper part of the vaginal wall and which lasts until the child is entirely born.

The present thesis is divided into six sections and two appendices. The first section deals with the form of the pelvic canal, the second treats of the direction of uterine and abdominal pressure, in the third the mechanism of flexion is considered, in/

in the fourth lateral obliquity of the fetal head, the fifth is devoted to internal rotation; while the sixth is concerned with the mechanism of extension and the protection of the perineum. In the first appendix a number of simple experiments is described, and in the second are set forth tables of angular distances derived from the published reproductions of frozen sections. Finally a short summary is given of the results embodied in the thesis.

In conclusion I desire to thank the Council of the Royal College of Physicians of Edinburgh for the privilege of reading in the Library of the College, the Librarian of Edinburgh University for a similar courtesy, and the Librarian of the British Medical Association for much kind assistance.

SECTION I/

SECTION I.
THE PELVIS AND THE PELVIC CANAL.

11. The dilated pelvic canal consists of two portions respectively superior and inferior.* The superior portion is roughly cylindrical, straight, and enclosed for the most part by the walls of the bony pelvis. The inferior portion leaves the superior at an obtuse angle which opens upwards and forwards, is more or less cylindrical, and follows a curved course of variable radius downwards, forwards, and upwards.

SECTION I.
THE PELVIS AND THE PELVIC CANAL.

~~BARBOUR~~ appears to have been the first to make casts of the form of the pelvic canal. He did not go so far, however, as BARBRI (1857) whose conclusions, from a study of his casts, are that the canal is approximately cylindrical, has two walls anterior and posterior, both nearly vertical and meeting the floor at right angles.

When/

*The dilated pelvic canal is an ideal construction: as BARBOUR (1895) points out, the soft parts are normally in contact before and after the passage of the fetus.

SECTION I.

THE PELVIS AND THE PELVIC CANAL.

§1. The dilated pelvic canal consists of two portions respectively superior and inferior.* The superior portion is roughly cylindrical, straight, and enclosed for the most part by the walls of the bony pelvis. The inferior portion leaves the superior at an obtuse angle which opens upwards and forwards, is more or less cylindrical, and follows a curved course of variable radius downwards, forwards, and upwards. It is enclosed by the soft parts alone.

NAEGELE (1825) appears to have been the first to make casts of the form of the pelvic canal. He did not go so far, however, as FABBRI (1857) whose conclusions, from a study of his casts, are that the canal is approximately cylindrical, has two walls anterior and posterior, both nearly vertical and meeting the floor at right angles.

When/

*The dilated pelvic canal is an ideal construction: as BARBOUR (1895) points out, the soft parts are normally in contact before and after the passage of the fetus.

When the canal is dilated, the inferior curved portion meets the superior nearly at right angles. HODGE (1864) gives a diagram from a cast of the canal and considers it a cylinder, the head making a straight descent, and then curving forwards to the outlet. HEGAR (1870) who also made casts regards the canal as a nearly cylindrical passage with an anterior opening, alternatively as a short cylinder ending in a gutter.

SABATIER (1880) considers that the fetal part descends in a straight line to the floor, and he contends that the action of the forceps is a striking proof that the descent is rectilinear. BOISSARD (1884) made casts of fifty pelves after death and gives tracings of all of them. His views coincide with those of FABRI, and he argues from the use of the forceps in the high operation that the descent from the brim to the floor of the canal is rectilinear. BOISSARD states that as early as 1877 PINARD made casts of the pelvic canal and arrived at a similar result. Further, TARNIER in his lectures was in the habit of giving the canal this form, and compared it, according to BOISSARD, to an aumonière de bourse. INVERARDI (1887) made a series of casts after having first distended the cavity/

cavity with a fetal head. He describes the canal as roughly cylindrical with an opening on its anterior and inferior aspect, and shows (for the first time) that the pelvic floor does not lie strictly at right angles to the walls of the cavity, but is inclined downwards and forwards. RUTHERFORD (1893) gives a description which is identical with that of FABRI, while PARVIN (1894) accepts the views of BOISSARD, apparently without reserve.

According to DEMELIN (1903) the canal is cylindrical, and consists of two portions united to one another at a right angle. In 1904 Demelin describes the cavity as cylindrohemispherical, and as becoming cylindro-conical, and lastly cylindrical during the passage of the fetus, returning after that event to its original form.

SELLHEIM (1904) regards the initial part of the canal to be direct, and followed by an inferior portion having a gentle bend. In 1906, SELLHEIM published a photographic plate of his casts, which show a remarkable agreement in form with the tracings of HODGE, PINARD, and BOISSARD. In 1907, he defined the axis of the cavity to be straight and that of the outlet to be curved.

BERTHAUT (1908) agrees with FABRI'S conclusions/

conclusions, and elaborates BOISSARD'S argument for the straightness of the superior portion of the canal from the direction of traction with forceps. It appears, then, that those who have adopted the method of investigation by making casts of the pelvic canal differ very little in their conclusions as to the form of the canal. Most authors, on the contrary, ascribe to the canal a course which is more or less continuously curved from the brim to the vulvar outlet, and they apparently do so only on theoretical grounds. Clinically the problem may only be studied during traction with the forceps applied at or above the brim, as SABATIER, BOISSARD, and later BERTHAUT have shown. And particularly when axis-traction forceps are used, there does not seem to be an appreciable error in the conclusion that the descent of the head from the brim to the pelvic floor is rectilinear.

52. FABBRI considers the superior portion to extend downwards from the brim as far as the coccyx, and its depth to be increased in the last period of labour to a maximum, resulting in repulsion of the coccyx, hollowing out of the floor or active portion of the pelvic canal, and increasing the height of the subpubic space, which leaves indefinite the determination of the boundary between the two portions. HYERNAUX (1866) also affirmed the depression/

depression of the coccyx and the increase of height in the subpubic space, and like FABRI thought there is no increase in the antero-posterior diameter of the outlet. BOISSARD and INVERARDI corrected this error and emphasized the importance of the increase. The latter divides the superior portion or excavation into two parts, a superior almost entirely osseous and little elastic, extending from the brim to a plane running from the inferior border of the symphysis pubis to the anterior wall of the sacrum, and an inferior osseous only laterally and at the inferior part of the sacrum, otherwise very soft and elastic. The inferior portion of the canal is inserted nearly at right angles to the inferior and anterior margin of the pelvis which constitutes the inferior strait.

ZWEIFEL (1890) divides the canal into two portions at a level corresponding to the second parallel plane of HODGE and the subdivision of the cavity recognised by INVERARDI, the upper portion having equally long anterior and posterior walls - the cavity, and a lower portion - the "pelvic funnel". VEIT (1887) also attaches importance to the second parallel plane of HODGE which extends from the subpubic ligament to the middle of the second bone of the sacrum, and is parallel to the inlet.

DEMELIN/

DEMELIN (1903) places the line of separation at the level of the sacro-coccygeal articulation and the lesser sacro-sciatic ligaments.

SELLHEIM (1907) divides the canal into three portions - an inlet segment extending from the level of the upper border of the symphysis, or the pubic spine, and the promontory down to the so-called terminal level of von FRORIEP (1881), thus giving articulate expression to a distinction existing between the levels of the conjugate and the transverse diameters of the brim, of which Winter (1887) had already recognised the practical importance; the cavity extending from the terminal level to a level beginning at the lower pubic margin and extending backwards to the spinae ischii; where the inferior portion begins, and whence it extends to the outlet on a level in front of the pubic arch.

The division and subdivision of the pelvic canal into segments appears to be guided mainly by the individual outlook whether anatomical or mechanical, and in the latter case according to the views each one holds on the mechanism of labour. Perhaps, the main division of INVERARDE is the most acceptable from the mechanical point of view, as it comes in at a level which marks the end of the greatest/

greatest change in the mechanism of the ordinary labour.

The line which, from a mechanical point of view, marks the division of the dilated pelvic canal into two portions, extends from the lower margin of the soft parts under the symphysis pubis, these parts being commonly as deep as and nearly as resistant as the region of the symphysis before extension begins, down to the lower margin of the ischio-pubic ramus, across the internal lower surface of the ischial tuberosity, along the lower margin of the great sacro-sciatic ligament to the apex of the sacrum, and round the other side of the pelvic canal in the same manner to the starting point. Within the canal above this level the mechanism of flexion and internal rotation are ordinarily completed, and the phenomena of labour are distinctly conjoined with the form of the bony and ligamentous canal; below this level the mechanism of extension is more especially concerned, and the passenger is mainly enveloped in soft parts. Within the superior portion a subdivision can be marked off, in addition, at a level where commonly the first stage ends and the second begins. This level corresponds to the upper surface of the yet undilated pelvic floor, and is/

is, as a rule, in the parallel plane of the ischial spines and the lower part of the obturator foramen of either side.* The vertical distance from this level to the lowest point of the line separating the superior and the inferior portions of the pelvic canal is comparatively short. But its passage is often the slowest and the most tedious part of normal labour, and within its boundaries in a greater proportion of labours the processes of flexion and internal rotation are completed.

§3 Though the superior portion of the pelvic canal is regarded as being approximately cylindrical, variations from the truly cylindrical form can be observed in a large proportion of examples. These variations appear to have a bearing on the mechanism of labour.

MEYER (1873) divided the sacrum into pelvic and perineal portions, the former consisting of the first and second vertebrae, of which the anterior surface is straight and is inclined upwards and forwards, the latter or perineal portion being curved and directed downwards and forwards; and INVERARDI (1885) came to the conclusion that the differences/

* This level corresponds approximately to the third parallel plane of Hodge, and it is here that rapid contraction of the canal begins.

differences between the two portions arise from the action of pressure in the course of development.

The straightness of the pelvic portion was observed by NAEGELE (1825), and it forms one of the factors in his estimation of the axis of the canal.

TRIDONDANI (1901) claims to have proved a constant relation between the length of the conjugata vera and the altitudinal length of the sacrum, the factors for both being the general dimensions of the pelvis, the projection of the promontory, and the inclination of the pelvis; while PATERSON (1893) considers the size of the sacrum to be influenced by its curve.

In the latter instance, however, it is more probable that both the size and the curve are to be attributed to a less evident cause. SCHWEGEL (1861) found the sharpest bend and greatest depth, measured

perpendicularly from the "airline", at the third sacral vertebra. JOESSEL and WALDEYER (1899) confirm this observation, and also that of MEYER. The greatest depth of the sacrum from the airline is given by SCHWEGEL as 10-14 lines, by BARNES (1885) as $1\frac{1}{4}$ inches, and by GARRIGUES (1902) as 27 mm.*

SCHWEGEL records in addition, that the lateral part of/

* In BRAUN'S section of a male (1874) the depth is 10 mm., in a female 11 mm. The lengths are 44 mm. and 45 mm. respectively, so that the sacrum is relatively less deep in the female than in the male.

of the sacrum on each side is less bent than the middle, and gives 3-6 lines as the lateral depth-- a considerable flattening which is very evident in the frozen sections made parallel and lateral to the mesial plane by CHIARI (1872), PINARD and VARNIER (1892), ZWEIFEL (1893), ALLBUTT and PLAYFAIR (1896), LEOPOLD (1897), and PESTALOZZA (1897), all these sections cutting through normal pelves, with the exception of that of LEOPOLD. These sections further show the irregularity of the lateral anterior surfaces of the sacrum in a direction from above downwards - an irregularity which is also present, though to a much less extent on the anterior surface of the vertebral bodies of the sacrum, and which is recorded in the tracing of the outline in the mesial plane of the cast made by HODGE. In comparison with the relative roughness or irregularity of the anterior aspect of the sacrum, the other walls of the bony canal are very smooth, a fact to which ALLPORT (1912) has directed attention. The inference from these dispositions is that the anterior surface of the sacrum has not been evolving in a manner to correspond with the passage or sliding of a body over it. According to GRAY (1887) the depth of curvature/

curvature of the sacrum is less in the female than in the male (see antea relative to BRAUN'S sections), while as is well known the sacrum has no curvature in the lower animals. It is therefore probable that the curvature of the sacrum is a product of the numerous factors operating through the erect attitude, and the existence of a causal relationship between the fetus and the curvature of the sacrum has not been established. Though at a given moment a portion of the fetal part may occupy more or less of the sacral concavity, it has not been proved that the presence of the concavity is essential to the mechanism of labour. SELLHEIM (1904 and again in 1907) has written vigorously on this matter. "The greater part of the sacrum can indeed be resected without bringing about a disturbance of the progress of birth." "The most varied forms of the sacrum remain without influence on the mechanism of labour." "The posterior pelvic wall possesses the least importance, because the extension of the soft parts has its fulcrum essentially on the anterior and lateral pelvic walls, and on this account presses forwards." These words, if I understand aright, were written on the strength of LIHOTSKY'S case of labour after a KRASKE operation. Granting /

Granting that there is a difference between a sacrum more or less removed and a sacrum without a curve, I hope to show that the hollow of the sacrum does not constitute itself an essential factor in the mechanism of birth.

The postero-lateral wall extends from the margin of the inlet to the inferior border of the great sacro-sciatic ligament. Above, it is formed by the postero-lateral surface of the ilium, the sacro-iliac synchondrosis, and a small portion of the wing of the sacrum; below, by the surface of the sacro-sciatic ligaments. Between the upper and lower portions there is a wide gap - the sacro-sciatic foramen which is filled mainly by the belly of the pyriformis muscle, and over which the soft wall of the dilated pelvic canal is stretched. VEIT considers the pyriformis muscle to project into the canal and to be of importance for rotation - a view which is denied by SELLHEIM (1901), and by WINTER who believes the pyriformis is stretched tightly between its extreme insertions during the passage of the head. In any case this portion of the pyriformis has no solid backing, and it seems unlikely on that account that it will be excessively thinned from pressure. More probably, it remains as a substantial pad behind the intermediate portion/

portion of the postero-lateral wall, so that this wall of the dilated canal extends from the inlet straightly downwards and forwards in a pelvic sense to the upper margin of the lesser sacro-sciatic ligaments. Across the sacro-sciatic ligaments the projection forwards is greatly increased, and these ligaments form a broad tense band which can usually be palpated clinically, after the coccygeus muscle which covers them has been effaced. According to Lusk (1891), however, the sacro-sciatic ligaments are very elastic and yielding.

The lateral wall is a narrow zone extending downwards from the brim behind the ileo-pectineal eminence. At the brim it is centred by the extremity of the transverse diameter of the inlet. Below, it passes behind the obturator foramen and includes the spine of the ischium, the ascending ramus, and the greater part of the tuberosity of the ischium. The internal surface of the lateral wall is inclined downwards and inwards, the projection towards the mesial plane becoming steeper on the internal surface of the ischial tuberosity. In addition, the two lateral surfaces are not equally inclined. An antero-posterior horizontal section in the plane of the ischial spine shows a considerable /

considerable projection inwards of the spine, as it points towards the lower lateral border of the sacrum. Opinions have differed as to the amount of contraction of the lateral walls in a downward direction. Earlier writers (DUBOIS 1849, TYLER SMITH 1858, HODGE 1864, TARNIER and CHANTREUIL 1882 and SPIEGELBERG 1882) allow it to be considerable. GARSON (1881) BARNES (1884) and BRINDEAU (1896) reduce ~~in~~ the apparent contraction to some extent. BOISSARD found the two walls nearly parallel, and with this BERRY HART (1912) appears to agree, though he gives a difference of one inch in the transverse diameters of the inlet and outlet. On the other hand, INVERARDI (1887), LUSK (1891), CALDERINI, (1894), JELLETT (1905), GALABIN and BLACKER (1910), all admit as great a degree of contraction as the older authorities. Thus the balance of opinions among those cited favours a contraction with descent of about one inch or 2-5 cm.

The antero-lateral wall ranges at the inlet from the ileo-pectineal eminence to the symphysis pubis. It includes the obturator foramen, the ischio-pubic ramus, the body of the pubis, and the soft parts under the pubic arch. SABATIER pointed out that the important height of the antero-lateral wall is the level of the ramus. KIWISCH (1846) had already stated the important part taken by the hard border of the ramus/

ramus in the mechanism. HART (1885) admits the guiding influence of the pubic ramus in reference to the mechanism of rotation, but from the Guide to Midwifery (1912) I have no note of its mention.

The antero-lateral wall is remarkably smooth; its general inclination from brim is downwards and forwards, but the ischio-pubic margin projects rather sharply inwards in continuation of the projection along the lower margin of the tuberosity.

The soft tissues under the pubic arch are usually sufficiently deep and resistant to affect the mechanism. They form the lower part of Hart's pubic segment. These tissues are eventually drawn up "in time for the birth of the child." BERRY HART appears originally to have believed that this took place early in labour, but after SYMINGTON (1889) had drawn attention to the appearance of the segment in BRAUNE'S second (1872) section, he limited the period of occurrence to the second stage. The exact range of time during which the segment is drawn up is, however, by no means clear. Clinically its diminution and disappearance are not manifest until extension of the head has begun. Webster (1890), in three cases in pregnancy, found this portion of the pubic segment to be respectively $1\frac{3}{8}$ ins., $1\frac{1}{2}$ ins., and/

disappear/

and $\frac{7}{8}$ in. deep, and in the two former the depth was reduced to $\frac{1}{2}$ in., and $\frac{5}{8}$ in. in the second stage. The anterior wall of the pubis has a mean depth of $1\frac{3}{4}$ ins., (GARRIGUES), so that the total depth of the anterior wall in the mesial plane may be at least $2\frac{5}{8}$ inches (67 mm.) in pregnancy, and $2\frac{1}{2}$ inches (58 mm.) at some undetermined period of the second stage. This greater depth contains, therefore, a possibility bearing on the mechanism of descent.

§4. The pelvic floor is contained within the lower subdivision of the superior portion of the pelvic canal as it has been defined. During the second stage it descends and is distended, until the greater part of it comes to be below the level of the outlet, or boundary between the superior and inferior portions of the pelvic canal. From the mechanical point of view of parturition, the group of muscles known as the pubo-coccygeus ought not to be considered as forming part of the pelvic floor. They rest on the bony and ligamentous walls at, or just above, the outlet, and have no capacity for what may be termed up and down movement which is mechanically a characteristic of the pelvic floor. Further, though they are found clinically to be prominent structures in the earlier part of the second stage, they gradually disappear/

disappear - efface themselves, as it were, as labour advances. That is to say, they are no more part of the pelvic floor mechanically than is the obturator internus. The pelvic floor, therefore, consists mainly of the coccyx, the levatores ani, and the soft tissues associated with them. As these muscles are attached in part to the walls above the outlet, they cannot wholly descend below the level of the outlet. As labour advances, the pelvic floor descends, is distended, and lengthened, and it has a very short superior wall (in an antero-posterior sense) which is formed in part by the pubic arch, so that as early as 1834 DUBOIS rightly compared the inferior portion of the canal to a gutter. HART (1878-9) divides the floor into right and left halves for mechanical reasons, and considers it to be a lever of the first order, owing to the recoil being more apparent in the anterior part of the floor, WON ARX (1911) points out that the coccyx has a spring-like action which acts on the posterior part of the floor, so that for a time at least, the floor may become more horizontal than oblique. INVERARDI (1887) divides the floor into two triangular planes united at an obtuse angle on the level of the inter-ischiatric diameter. He considers it to be a new canal of which the floor is/

is lowered and lengthened, the soft parts of the sub-public arch being much lengthened and widened, an increase of the sub-public space to which Boissard had already directed attention. INVERARDI divides the inferior portion of the canal into a posterior part directed from behind, downwards and forwards, and an anterior part leading from behind, upwards and forwards. The latter portion is formed mostly by the dilated and lengthened vulvar canal, and it ends at the vulvar outlet. The outlet is variable in position, but always surpasses the altitudinal plane of the symphysis, which confirms the earlier views of BOISSARD who found, in addition, that the outlet ends at a variable level on the anterior wall, either higher or lower. In the former case the upper margin of the vulvar aperture lies on the anterior face of the pubis. For INVERARDI, the superior wall of the new canal is not wholly pubic arch, but is, in part, formed by distended vulva. VARNIER (1888) attaches great mechanical importance to the pubo-coccygeus muscles (already referred to) which form a highly resistant "boutonnière" running in an antero-posterior direction along the pelvic floor. These muscles, as it has been shown, are found clinically/

clinically to disappear under pressure, and they are more allied to the pelvic wall than the pelvic floor. Paramore (1909³) who has devoted much attention to the subject describes the pelvic floor as consisting mainly of the coccyx, the coccygeal ligaments, and the "Musculature of the recess." The floor becomes a broad gutter like a declivity, at the lower end of which is the posterior commissure of the pubo-rectalis muscle. The commissure attains to a greatest distance of five inches from the fourchette; so the perineum becomes greatly lengthened and stretched. The vulvar aperture becomes extremely oblique and approaches the coronal plane, while the plane of the "pelvic floor aperture" (the cleft in the pubo-rectalis muscle) is less oblique and approaches the horizontal plane. According to Paramore (1909⁵) this is proved by the position of the posterior commissure of the pubo-rectalis above and behind the anus. These dispositions are probably of significance to the mechanism of extension in so far as the ultimate stretching of the muscle is concerned, but as is the case with the pubo-coccygeus muscles, the pubo-rectalis under distension from pressure becomes uniform with the pelvic floor, and cannot usually be distinguished on clinical examination.

§5. Just as a kind of plant or animal has often a salient feature which is its chief distinction, and which influences the other characters to be taken into account, so with the pelvis whether it is regarded as a part of the skeleton or as a canal, the relative height and projection of the promontory are a valuable index to its form. Thus von FRIEDEL distinguishes two types of normal pelvis - the one with a high standing promontory and a long small sacrum, the other with a low-level promontory and a short-broad sacrum; the former being an infantile type indicative of easier labour, and the latter a more developed form associated with more difficult labour. BALANDIN (1890) in resuming the work of VEIT and ZWEIFEL divides normal pelvises into two groups-- (1) VEIT'S type in which the conjugata vera stands higher above the transverse diameter of the inlet, and the promontory is less projecting; and (2) ZWEIFEL'S type where the conjugata vera is little raised above the transverse diameter, and the promontory is more projecting, being apt to press upon the head. Unfortunately, the relative height of the promontory is not easily determined. The not dissimilar methods proposed by KIVISCH (1846) for anatomical preparations, and by BARBOUR (1898) for frozen sections have an inherent source of error in/

in the fixing of the horizontal plane which is the basis of both methods, while Balandin's procedure does not seem to be of easy application in life. None the less the broad distinction drawn by von FRORIER and BALANDIN is of value whenever the pelvis is thought of in relation to the mechanism of labour

Referring to the influence of the height of the promontory and the symphysis on the comparative length of the conjugata vera, BARBOUR (1900) concludes that the variation in the length of the conjugate is not due to the relative height of the promontory, but to a variation of the inclination of the brim. VON GASZYŃSKI (1905) on the other hand states that little attention has been directed to the position of the promontory relative to the symphysis. Of the three effective factors for the length of the conjugata vera the relative height of the promontory has the greatest and the relative height of the symphysis the least influence. As it regards the mechanism of labour, there is much to be said for FABRE'S attitude (1910). FABRE accepts two planes of the inlet and distinguishes them as transverso-pubic (Fochier) and promonto-pubic respectively, the former bounded by the superior border of the pubis, the innominate line, and the second sacral body; the latter by the superior body of the pubis and by the promontory/

promontory. As we shall see, while the latter is able to cause grave difficulty in labour the former is more intimately connected with the mechanism.

§6. Summing up the form of the superior portion of the pelvic canal, SPIEGELBERG (1882) writes the pelvis has most room in the transverse diameter of the inlet, in the oblique diameter of the cavity, and in the antero-posterior diameter of the outlet; the convergence of the posterior walls below is a factor of great importance to internal rotation. HUBERT (1856) and PABBRI (1857) describe two convergent planes based on the bi-ischiatic diameter, the anterior - the ischio-pubic, and the posterior - the ischio-sciatic formed by the sacro-sciatic ligaments. TYLER SMITH (1858) names four inclined planes in the cavity, and no less than five in the outlet, while the canal is contracted at the ischial spines and tuberosities, and bulged out at the great sacro-sciatic foramina. HODGE (1864) recognises two inclined planes on each side of the pelvis, anterior and posterior divided by a line extending from a point on the margin of the inlet three-quarters of an inch before the sacro-iliac synchondrosis downwards to the end of the ischial spine, and prolonged so as to cross the sacro-sciatic/

sciatic ligament one and a half inches from the ischial tuberosity. The anterior inclined plane lies in front of the dividing line, and is directed from above downwards and inwards, and from behind forwards; the posterior inclined plane lies behind the dividing line, and runs mainly downwards, backwards, and inwards. With the soft tissues in position, the inclined planes are prolonged to the middle of the pelvic floor. LEISHMAN (1876) and PLAYFAIR (1893) base the anterior and posterior inclined planes on a line joining the ilio-pectineal eminence and the spine of the ischium. These authors together with TYLER SMITH attach great mechanical importance to the inward projection of the ischial spines - a projection which appears to have been exaggerated. According to TARNIER and CHANTREUIL (1882), the theory of the inclined planes originated with BAUDELOCQUE. They will be considered more fully in the section on internal rotation.

The increasing recognition of the importance of the soft parts in modifying the form of the pelvis has lessened the value with which these obstetricians esteemed the inclined planes. As it has been repeatedly pointed out in the text books, the main objection to the planes is the stereotyped minuteness of architectural form which is attributed to/

to pelves notable for their variations of shape within uncertain limits.

VEIT (1837) observed a reduction in the transverse diameter of the inlet by the psoas and iliacus muscles, and in the cavity by the pyriformis and obturator internus, "there being a contraction in the postero-lateral region of the cavity and at the outlet transversely and posteriorly". WINTER denied the truth of VEIT'S conclusions, and rather uncharitably attributed them to the results of anatomical manipulations. For WINTER "the muscles carpet the pelvis in such a way as to be thick where the bones are weak". He attaches importance to the coccygeus muscles, the more raised part of the pelvic floor, and considers they limit a vacant space on the anterior surface of the sacrum of value for long rotation. ZWEIFEL (1890) supports VEIT'S conclusions. The parallel BECKENWEITE and BECKENENGE of ZWEIFEL are long ovals even without the soft parts, and with them much more so. In the BECKENENGE the soft parts, namely the obturator internus and levator ani, are very prominent and mechanically significant. According to BÄCKER (1891) the greatest reductions of the diameters by soft parts are in the transverse diameter of the inlet and in the oblique diameters of the outlet.

SELLHEIM/

SELLHEIM (1901) in a primipara found that the obturator internus pressed on the occiput. but the pyriformis and psoas did not do so. In his later writings, however, the obturator internus is not mentioned. Thus in 1907 he says (freely translated) "in large pelvis and in the upper cylindrical segment of small pelvis the muscles clothe the walls like pads, and remain in their usual positions without producing any special effect on the mechanism".

Thus opinions differ regarding the precise mechanical value of the muscles lining the pelvic canal. Clinically, the principal effect of the muscles is in the first instance to reduce the length of the pelvic diameters, and thus to oppose a resistance which spells delay to the presenting part,* but under repeated or sustained pressure of the presenting head they thin out wherever they are backed by bone, and become usually indistinguishable from the general wall of the canal. On the other hand, during the passage of the breech, when it comes first, the thinning and disappearance of the muscles are not so evident, so that it comes to this that, through the presence of the muscles and through their behaviour under pressure, the breech has to traverse/

* Dubois (1849) refers to the "powerful resistance of the pyramidalis and obturator internus," and adds that Flamant and others considered these muscles to contract and thus to influence the position of the head.

traverse a canal of different diameters from that transmitting the head. Partly for this reason, the primiparous canal is primarily, and to a certain extent ultimately, a smaller canal than that of the multipara.

§7. Various planes of the pelvis, horizontal in a general sense, and either parallel or not parallel to the plane of the inlet, are described, and have varying degrees of importance. TYLER SMITH (1858) gives a mid-plane from the middle of the symphysis to the middle of the third sacral vertebra. It descends on each side across the obturator foramen, along the spine of the ischium, the lesser sacro-sciatic ligaments, and then ascends to its posterior end. Its section is therefore a curve which is inclined at an angle of 30° to the horizon, when the inclination of the brim is 60° . HODGE (1864) recognises four parallel planes. The inlet forms the first; the second extends from the sub-pubic ligament to the middle of the second sacral vertebra; and is the plane of the greatest dimensions; the third is on the level of the spines of the ischia, and extends to the lower and most curved part of the sacrum, and to the rami of the ischia; it marks the beginning of rapid pelvic contraction (cf WEIDOW 1888); the fourth is marked by the extremity of the coccyx, and is the pelvic floor. According to VEIT (1887) the second parallel plane (HAUPTEBENE) is the level/

level to which the head descends before labour begins. It is parallel to, and rather higher than, the level of the lower margin of the obturator foramen and the spine of the ischium. ZWEIFEL (1890) distinguishes three planes - 1. Beckenweite, extending from the middle of the symphysis to the under border of the first sacral vertebra; 2. parallel BECKENWEITE, which corresponds to the second parallel plane of HODGE; 3. BECKENENGE.

Reference has already been made to the positions of the second and third planes, and to the forms which ZWEIFEL considers them to have. According to DEMELIN (1903) a plane extending through the ischial spines from the last sacral vertebra is the plane of greatest contraction, and that it is the fourth non-parallel plane of BALANDIN, the lower strait of RITGEN and VEIT, and the least passage of BRINDEAU (1896) who however, states that the posterior level lies near the articulation of the fourth and fifth sacral vertebrae, and adds that the plane cuts the symphysis at the middle of its lower third. For JELLETT (1905), a nearly similar plane forms the true outlet of the pelvis, and at the same time the plane of greatest contraction. On the other hand, VARNIER (1888) like RAMSBOTHAM (1841), fixes the position of the outlet at the inferior margin of the pubis//

pubis, the ramus and tuberosity of the ischium, the sacro-sciatic ligaments and the border and point of the coccyx, which agrees very closely with that one which I have described.

§8. The inlet of the pelvis is ellipsoidal (CALDERINI) inclining towards the reniform, according to the degree of projection of the upper part of the sacrum including the promontory. The conjugate is the antero-posterior diameter in the mesial plane. The plane of engagement is that of the transverse diameter of the brim, the mechanism being modified more or less by the relative position of the promontory. The length of the transverse diameter is reduced primarily by the thickness of the psoas muscle on each side, but it can probably be increased according to the requirements of the presenting part of the fetus. The upper segment of the cavity to a vertical depth corresponding to that of the first sacral vertebra contains posterolaterally a nearly rectilinear space which may be of importance in securing stability of the head, after it has descended into the cavity in the normal position and presentation. Below this level and down nearly to the plane of the ischial spines, the shape of the cavity is primarily a long oval (ZWEIFEL) with its longer diameter antero-posterior, the transverse/

transverse contraction being due mainly to the pyriformis and obturator internus muscles, but under the stress of the birth the thickness of the muscles is lessened, and the form of the cavity becomes secondarily more nearly round.* From the level of the ischial spines downwards to the uneven margin of the outlet, the cavity is secondarily lozenge-shaped, and in addition it is a shallow trough laterally and posteriorly. It is longer from before backwards than from side to side, where strictly the conjugate lies between the ischial tuberosities. It forms the inferior subdivision of the superior portion of the dilated pelvic canal, and may be readily divided into anterior and posterior segments by an imaginary line joining the posterior ends of the ischial tuberosities. The anterior segment formed by the pubic arcade is in a vertical sense approximately the segment of a circle. The posterior segment shows the outline of a truncated V and is the more trough-formed portion of the inferior subdivision. The V form is due to the absence of bony connection at this level between the ischia and the sacrum. In its place are the tense and resistant sacro-sciatic ligaments/

* In this upper subdivision of the cavity the position of the rectum posteriorly and slightly to the left of the middle line, and the position of the bladder anteriorly may influence the position of the head in later pregnancy and during the first stage of labour.

ligaments which form, as it were, two chords of the incomplete bony circle, with as a result a rapid contraction in a transverse sense of the posterior segment of the outlet (SPIEGELBERG). The terminal portion of the sacrum cuts off the apex of the V. The ligaments slope downwards, forwards, and inwards (TYLER SMITH). In consequence of the slope and the chordal position of the ligaments, the ischial spines do not lie in the plane of greatest contraction, as they certainly do in the bony pelvis. The lesser sacro-sciatic ligament is shorter than the greater, and the latter is longer along its lower than its higher border, so that the longer chord of the greater projects more into the imaginary circle of the outlet than does the shorter chord of the lesser, and the degree of projection of the greater is progressive with descent. Thus the plane of the greatest contraction in the obstetrical pelvic canal lies not at the level of the ischial spines, but at the margin of the outlet, as it has been defined in close correspondence with the outlet of VARNIER. Primarily, the outline of the inferior subdivision or segment of the outlet is ovoid, with the greater diameter running from before backwards. This figure is due to the thick encircling roll of VARNIER'S/

VARNIER'S pubo-coccygeus muscles which, however, disappear clinically in the regions exposed to pressure, and so give to the outlet secondarily a nearly lozenge-shaped form. These dispositions of the superior portion of the dilated pelvic canal modify the form which the cervical and vaginal canals would take, if they existed alone - a form which is necessarily that of the object passing through - and the modifications, as they occur at a given moment, *have* a greater or lesser value which is dependent principally on the form, position, and relative size of the passenger. In the inferior portion of the dilated pelvic canal the soft parts have freer play, and the form which they take is controlled mainly by the form of the passenger, so that the shape of the inferior portion may be said to proceed from an intrinsic cause, whereas the factors modifying the superior portion of the canal are both intrinsic and extrinsic. A transverse vertical section of the inferior portion can rarely be truly cylindrical; more often it is deeper than it is broad. The length of the inferior portion tends to vary, being as a rule longer in primiparae than in multiparae, in whom it is shortened when the perineum has been torn. But, in the uninjured condition of the parts the/

the outlet appears always, as already stated, to surpass the plane of the pubic bones. The amount of distension of the inferior portion, in a vertical sense, is dependent on the form, size, and position of the passenger, on the strength of the expulsive powers, and on the form and position of the pubic arch, a high rounded arch having indirectly a less distensible effect than a low narrow one (SELLHEIM 1905 and 1907a). PARAMORE (1909c) shows that in the dilated vulvar outlet the distension, and therefore the pressure, are twice as great along the lower margin as the distension and pressure at each lateral margin, because the lower margin has to execute a movement of extension at least equal to that made by the two lateral margins combined. This circumstance, as Paramore points out, has a practical bearing on the mechanism of rotation at the vulvar outlet.

99. There is a remarkable want of similarity in the average measurements reached by different authors for the diameters of the bony pelvis. The discrepancies are particularly evident in the oblique diameters and in the antero-posterior diameter of the outlet. To form a basis for further remarks, I have taken the only course open to me of averaging the average results, and this has been done for the figures/

figures given by thirty authors. Of course, I am aware that the method is indefensible on mathematical grounds, but when the result is reviewed as a whole, it has every appearance of justifying the method for the present purpose.

TABLE/

TABLE OF MEASUREMENTS OF THE DIAMETERS OF
THE BONY AND LIGAMENTOUS PELVIS.

AUTHOR.	INLET		CAVITY		OUTLET.				
	A-P.	O.	T.	A-P	O.	T.	A-P.	O.	T.
1. Dubois 1849.	110		135.				120		110.
2. T. Smith 1858.	108	121.5	132.				127		107.
3. Hodge 1864.	102	127	133.5.				114.5	102.	102.
4. Lelshman 1876.	123	137	143.	143	143	137.	137.	130	130.
5. Caseaux 1876.	114	119.	132.				(119. (130.	119	109.
6. Milne 1879.	112	136	136.	124	136	130	136	136	112.
7. Garson 1881.	107		133.				116		116.
8. Tarnier 1882.	110	120	130.	120	120	120.		110	110.
9. Spiegelberg 1882.	110	125	135.	127.5	135	120.	115		110.
10. Barnes 1884.	107	127	130	132	132	127.	(107 (132	120	120
11. Schroeder 1886.	110	127	134.	126		124			111.

AUTHOR	INLET		CAVITY		OUTLET	
	A-P	T	A-P	T	A-P	T
12. Winckel 1887.	110	125	135	115	110	110
13. Grouzat 1887.	110	120	135	(110) (130)	110	110
14. Zweifel 1890.	108	122	125	133	113.5	105
15. Farabeuf and) Varnier.) 1891	110	120	135	118	(100) (110)	110
16. Auward 1894.	110	120	130	120	120	110
17. Duhresen 1896.	110	125	135	120	(90) (110)	110
18. Norris and) Dickinson)	114	133	145	115	121	121
19. Schaeffer 1899.	110	125	135	125	(100) (120)	110
20. Fothergill 1900.	112	124.5	126	125	120	124.5
21. Garrigues 1902.	108	127	133.5	114	114	114.5

(95.5
114.5

AUTHOR	INLET		T.	CAVITY		OUTLET	
	A-P.	O.		A-P.	O.	A-P.	O.
22. Webster. 1903.	121	127	135				121.
23. Edgar 1903.		136		131	127	130	117
24. Ahlfield 1903.	110	125	135			(110) (115)	105
25. Jellison 1905.	110	125	130			(95) (115)	110
26. Fabre 1910.	110	120	135			120	110
27. Galabln 1910.	108	120	133.5			(112.5 + 130)	108
28. Eden 1911.	105	120	130			130	105
29. Hart 1912.	102	114.5	127.			127	102
30. Williams 1912.	110	127.5	135			115	110

The averages of these figures for the diameters of the bony ligamentous pelvis are:-

INLET.	Antero-posterior	.....113.3	.....obs.29.
	Oblique	.....128.3	.....obs.28.
	Transverse	.....137.7	.....obs.29.
CAVITY	Antero-posterior	.....126.5	.....obs.10.
	Oblique	.....128.8	.....obs.10.
	Transverse	.....122.9	.....obs.11.
OUTLET	Antero-posterior	.....121.7	.....obs.28.
	Oblique	.....116.5	.....obs.17.
	Transverse	.....111.3	.....obs.30.

The diameters of the bony pelvis are reduced to a degree not very well known by the soft parts. Barbour (1889) from measurements of Braune's second section, Chiara's and Chiari's sections gives the following average reductions by the soft parts. (I have converted them to the metric system).

DIAMETERS.

Ant-post.	Transverse.	Oblique.
Brim 5 mm.	25.5 mm.	6 mm. + post.
Cavity 10 mm.	25.5 mm.	19 mm + 12.5 reduced.

ZWEIFEL (1890) includes the outlet in his measurements of the reductions which are as follows:-

DIAMETERS.

	Ant-post.	Transverse.	Oblique.
Brim	14 mm.	17 mm.	7 mm.
Cavity	31 mm.	0 mm.	7 mm.
Outlet	9 mm.	33 mm.	17.5 mm.

It will be noticed that the two tables do not agree with one another in a single measurement, and that the differences are very great.

Clinically/

DIAMETERS

	ANT-POST	TRANSVERSE	OBLIQUE
Inlet	48 mm.	103 mm.	115 mm.
Cavity	102 mm.	112.5 mm.	115 mm.
Outlet	7 mm.	33.5 mm.	27.5 mm.

Carriegen estimated reduction for the brain only is much less.

DIAMETERS

	ANT-POST	TRANSVERSE	OBLIQUE
Inlet	101 mm.	120.5 mm.	120.5 mm.
		to	to
		127 mm.	127 mm.

For/

Clinically, the hardness of the surface and the sharpness of the margins underlying the wall of the pelvic canal in the regions of greatest pressure, namely the ischio-pubic ramus and the sacro-sciatic ligaments as they are revealed to the exploring fingers, indicate, that even within the limits of what may be regarded as a normal labour, the thickness of the soft parts may be and probably is reduced to a low minimum, whenever the pressure on the parts is considerable.

Zweifel also gives the measurements of the canal with the soft parts in position.

DIAMETERS.

	ANT-POST	TRANSVERSE	OBLIQUE
Inlet.	94 mm.	108 mm.	115 mm.
Cavity	102 mm.	113.5 mm.	115 mm.
Outlet	?	77.5 mm.	87.5 mm.

Garrigues' estimated reduction for the brim only is much less.

DIAMETERS

	ANT-POST	TRANSVERSE	OBLIQUE
Inlet	101.7	120.5 mm. to 127 mm.	120.5 mm. to 127 mm.

For/

For the plane of the last sacral vertebra and the ischial spines, DEMELIN (1903) gives an antero-posterior diameter of 100 mm., a transverse of 118 mm., and an intersciatic of 105mm., which BRINDEAU (1896), however, makes to be 108 mm., while the latter allows the diameter between the tuberosities to vary between 120 and 130 mm. Some difference of opinion also exists regarding the distance between the under margin of the symphysis and the tip of the coccyx during the passage of the fetus. DEVILLIERS (1862) called attention to the variability of this diameter, and found that it was able to attain to a maximum of 117 mm. Previously, FABBRI and HYERNAUX, according to BOISSARD (1884), viewed the repulsion of the coccyx in the light only of increasing the depth of the cavity and the height of the subpubic space. BOISSARD measured increases of 20 to 35 mm., and gives data from fifty observations of the diameter in the undilated state, the average subpubic-coccygeal diameter being 86.5 mm., the maximum 110 mm. and the minimum 63 mm., and he quotes SCHROEDER to show that the diameter measures 87.5 mm., in the multipara and 91.5 mm. in the gravid. VARNIER (1888) who includes the margin of the coccyx from base to apex/

apex and apex to base within the course of the outlet states that the subpubic-coccygeal diameter before dilation measures 85 mm. and is increased by repulsion of the coccyx by 10 to 30 mm. VARNIER appears to have considered that a widely accepted opinion, previous to the publication of his thesis, was in favour of a uniform 110 mm. for all three diameters of the outlet, when, presumably, the coccyx is included in the outlet. (cf TARNIER and CHAUTRIEUL 1882) VARNIER also gives mean diameters for the pubo-coccygeus muscle in repose, namely 85 mm. antero-posterior and 45 mm transverse, and directs attention for mechanical reasons to the great preponderance of the antero-posterior over all the other diameters. It will now be obvious that an attempt to determine the true ultimate diameters of the pelvic canal is bound to be unsatisfactory. The diameters of the bony and ligamentous pelvis are unsettled, and very little is known as to how far the muscles lining the pelvis are capable of being effaced by pressure. At present, the views on this matter depend on the evidence of a few frozen sections and on a modicum of personal inclination. Lastly, the mechanism of the parts forming the outlet, and its relation to the general/

general mechanism of labour, is metaphorically a quagmire of knowledge. Varnier's belief that the antero-posterior diameter of the outlet was before his time held to be only 110 mm is probably wrong in a historical sense. But in any case it is not proven by the evidence of frozen sections. A measurement of 110 mm for the outlet makes the antero-posterior diameter of the outlet less than the conjugate of the brim, whereas it is manifest in the frozen sections that the former considerably exceeds the latter. The average dimension of the antero-posterior diameter of the outlet, derived from the table of measurements - 122 mm, appears to be tolerably near the truth, not only by the test of comparison with the conjugate about whose dimensions most is known, but also from the clinical evidence of labour. Afterwards I shall have occasion to state that in my belief the head at the end of internal rotation most frequently lies on the floor with the occipito-frontal diameter parallel to the floor. That diameter, as I shall indicate by analysis, is commonly about 120 mm in length. In labour at the end of internal rotation, the anterior termination of the frons is approximately in the position of the apex of the sacrum. It may be a little short of the apex, or a little over, but it lies/

lies thereabouts. BOISSARD and VARNIER have been the chief opponents of FABBERI'S view of the mechanism of the coccyx, but I am not at all sure that FABBERI is wrong. It would be an awkward arrangement which caused an extreme angular descent of the coccyx relative to the lower part of the sacrum - an arrangement quite out of keeping with the adaptation of the parts to the twin purpose of rendering possible the erect attitude and the progress of birth. Fortunately, there is no evidence, so far as I can see either in the frozen ~~sagittal~~ sections or in labour itself, for this uncomfortable view. During expulsion, the coccyx remains very nearly in line with the lower vertebrae of the sacrum, and the mechanism exists partly in virtue of the form of the parts and partly, as I shall point out later, by an appropriate rotation of the sacrum. In consequence the head in the movement of extension does not pass the apex of the sacrum, but leaves it, and travels parallel to the axis of the lower vertebrae of the sacrum, and of the coccyx. A further result is that in normal labour, while the antero-posterior diameter of the outlet is probably increased, it is not enlarged to facilitate the passage of the head through that/

that diameter, but in order to increase the depth of the sub-pubic space, as FABBRI and HYERNAUX have it.

In the next table I give in three parallel columns the average dimensions of the bony and ligamentous pelvis from the previous table; the average dimensions of the same reconstructed from ZWEIFEL'S figures; and ZWEIFEL'S dimensions for the soft canal. It will be seen that the average pelvis from ZWEIFEL, in comparison with my compiled averages, is rather small, except in the transverse diameter of the outlet, and that it has a greater curvature of the sacrum. The diameters given by ZWEIFEL for the canal with the soft parts in position might possibly be accepted to represent the stage of dilation in advance of the head, and where the pressure exercised by the head is not severe, but they cannot be taken as a measure of the ultimate possibilities of the soft canal. In this direction history does not lead. As it seems to me, and I have seen it stated somewhere, that the soft parts in complete dilation are not more than six to eight millimetres thick where pressure is most severe, I will apply that reduction to the average diameters of the bony and ligamentous pelvis, whenever it becomes necessary to refer to the diameters/

diameters in the description of the mechanism of labour.

COMPARATIVE TABLE OF THE AVERAGE DIAMETERS
OF THE PELVIS AND THE PELVIC CANAL.

	PELVIS.	PELVIS FROM ZWEIFEL	CANAL FROM ZWEIFEL
Inlet. A-P.	113.3	108	94
O.	128.3	122	115
T.	137.7	125	108
Cavity A-P.	125.6	133	102
O.	128.8	122	115
T.	122.9	113.5	113.5
Outlet A-P.	121.7	116.5	
O.	116.5	105	87.5
T.	111.3	110.5	77.5

The/

§ 10. The study of the axes of the pelvis and of the pelvic canal is difficult, and it is not surprising that the results attained are more or less variant and unsatisfactory. To a certain extent, the differences are due to the centre line, and the direction line of the pelvis and canal, and the course which the passenger takes not being clearly distinguished on paper (cf. HEGAR 1870); and also to an insufficient account being taken, with exceptions, of the differences which exist between the bony pelvis and the pelvic canal. For the pelvis the axis which is due to NAEGELE (1825) is probably the most popular.

NAEGELE defines the axis as a line equally distant from the four walls of the pelvis, and points out that it is neither an arc of a circle nor two straight lines. From an examination of numerous normal pelvises he finds that the internal profiles of the first two sacral vertebrae and the symphysis pubis can be regarded as straight, and as this upper portion of the cavity is surrounded by bony walls a central line is constant for the cavity, and is straight or direct.

But, in the space lying between the three last sacral vertebrae and the anterior pelvic wall, the line is a curve/

curve in accordance with the curvature of the anterior and posterior walls. He further shows that the anterior and posterior walls near the inlet make angles little more than right angles with the conjugata vera, and his conclusion is that the axis of the inlet coincides with the axis of the upper part of the cavity, but he admits that the result is not mathematically exact. NAEGELE'S axis is the axis of the pelvis for the majority of the later authors. His conception, admirable as it is, is no more than a projection of the axis of the mesial plane of the bony pelvis. It takes no account of the modifications induced by the antero-lateral, lateral, and postero-lateral walls, or of the changes promoted by the soft parts. KIWISCH, in 1846, broke new ground and to some extent anticipated the work of later and better known writers. According to Kiwisch, the inclination of the canal is not necessarily in direct relation to the inclination of the conjugata vera. The measure of the inclination of the canal is the angle which the inner surface of the pelvis makes with the conjugata vera. This angle, is always greater than a right angle, is usually about 100° . Then, he writes at length and with some reason to show that deductions/

deductions based on the inclination of the conjugata vera, and the direction of pressure thereto, may prove erroneous when they are applied to the pelvic canal. DUNCAN (1868) defines the axis of the inlet as a line cutting the mid point of the plane of the brim, and extending downwards to the apex of the sacrum. It is also his axis of the cavity, as he makes the head follow it. So also TARNIER and CHANTREUIL (1882), who define the axis of the outlet as a line cutting the mid point of the plane of the outlet at right angles, and extending upwards to the promontory of the sacrum, while a curved line to which the axes of inlet and outlet are tangents forms the axis of the canal. In both instances, however, the axes are obviously true to a certain extent only for the bony pelvis, and no indication is given of possible modifications by the soft parts. Lahs (1870) separates the axis of the bony pelvis from that of the pelvic canal, and assigns to each the mechanical conditions under which it represents the course of the head. But FABBRI, in 1857, had already seen the distinction, and had defined it with considerable accuracy. FABBRI gives the axis of the cavity as a line equidistant from the walls of the cavity and ending at or near the point of the coccyx, and the total axis as a union, nearly at a right angle, of the rectilinear axis of the cavity with the curved axis of the subpubic space.

This/

This view meets with the approval of Boissard who has not much to add. A noteworthy addition to our knowledge of the axes of the pelvis and of the pelvic canal was made by INVERARDI, who cast the canal before and after dilation with a fetal head. INVERARDI clearly recognised the important distinction existing between the axis of the bony pelvis and the axis of the pelvic canal. His intensive studies are therefore of considerable moment; the more so as, so far as I am aware, they have never been excelled.

INVERARDI (1887) defines the axis of the inlet as a centre line, descending perpendicularly from the antero-posterior diameter of the inlet to fall on the pelvic floor, and on the coccyx at a little distance from its end. The axis of the inlet only rarely coincides with the axis of the cavity which, according to INVERARDI, is a line joining at right angles the mid points of the superior and inferior planes of the upper subdivision of the cavity, and prolonged downwards to meet the pelvic floor. The axis of the inlet coincides with the axis of the cavity only once in a series of 54 cases, in 29 the axis of the cavity deviates anteriorly, and in 24 posteriorly./

posteriorly. The axis of the inlet in the 54 cases falls 4 times on the point of the coccyx, 18 times in advance of the point, and 32 times in rear. This axis represents with tolerable accuracy the axis of the bony pelvis, and, as given by INVERARDI, it agrees well with the line of the axis of the inlet according to the majority of obstetricians, and in opposition to the teaching of DUNCAN and TARNIER. The axis of the cavity in the same series falls once on the point of the coccyx, 21 times before the point, and 32 times in rear. The normal axis is that which ends on the point of the coccyx, or not more than 5 mm behind that point: the abnormal axis is that which ends more than 5 mm before or behind the point of the coccyx.

Inverardi gives percentages for the axes coming within the 5 mm circle, namely:- 28% on the point of the coccyx, 38% behind the point, and 33% in advance.

INVERARDI thus amplifies FABBRI'S conclusion by showing that the axes of the pelvis and the pelvic canal even within the limits of the bony segment are not constant from pelvis to pelvis, but fall within or without a circle of ten millimetres in diameter having its centre at the tip of the coccyx. And he further states that they vary with pelvic inclination, the less inclined being the pelvis the closer come the axes of the pelvis and the canal together, and vice-versa.

Contrary/

Contrary to PABBRI, INVERARDI finds the Pelvic floor in repose inclined downwards and forwards from behind, in relation to the plane of the brim in seven-tenths of the casts. After the floor has been distended and lengthened, the axis of the inferior portion cuts the middle point of the outlet at a right angle, the axis of the pelvic cavity nearly at a right angle, and, if prolonged strikes the sacrum between the third and fourth vertebrae. During dilation of the floor, the straight exit line changes not gradually, but abruptly to a curved line, and nearly at a right angle to the axis of the cavity.

It is clear that INVERARDI'S axis of the cavity is in theory a line equidistant from the four walls, the more so as either he or BOISSARD and BAYLIN his reviewers attributes abnormal retro-deviations of the axis to an excessive curvature of the sacrum. But though the ideal is good, the projection of it on paper inevitably suffers from the limitations of a plane surface, and it in fact represents only the axis of the mesial plane of the dilated pelvic canal. It takes no account on paper of the modifications of the form of the cavity without the mesial plane, and, with the important exception that it is an axis of the canal and not of the bony pelvis, it does not go far beyond previous attempts. Further, though BOISSARD deduces a straight/



straight descent of the head from INVERARDE'S conclusions regarding the axis, it does not follow that the head descends in the axis of the cavity unless the cavity is regarded as truly cylindrical. None of the original investigators of the canal appears to attribute a perfect cylindricity to the canal. Most if not all admit the form to be only approximate. The problem, therefore, turns on whether or not the admitted variations from the cylindrical form have a practical value, in so far as they allow the line of descent to be separated from the axis of the cavity, just as this has been clearly separated by INVERARDE from the axis of the bony pelvis. From the nature of the parts, the problem is limited to a consideration of the superior portion of the canal: the course traversed by the head in the inferior portion is unlikely ad naturam to be other than coincident with the curve of this portion of the canal. Most of the material available for a settlement of the matter applies only to the mesial plane of the pelvis: what I have been able to collect for the other diameters is very meagre. DELORE, in a diagram reproduced by TARNIER and BUDIN (1898) gives a mean angle of 95° between the axis of the pubis and the conjugata vera, DUHRRSEN (1896) $90-100^{\circ}$, JOESSEL and WALDEYER (1899) and/

and GARRIGUES (1902) make it 100° , FABRE (1910) no less than 105° , while KIWISCH as already stated gives a 100° as the angle formed by the posterior surface of the pubis with the conjugate. GALABIN and BLACKER (1910) admit that the inner surface of the pubis diverges at only a small angle from the sacrum - a view dating back at least as far as NAEGELE (1825). According to SCHWEGEL (1861), the anterior surface of the sacrum forms with the conjugate an angle varying from $85^{\circ} - 95^{\circ}$, and the lower part of the sacrum an angle of $90^{\circ} - 100^{\circ}$ with the plane of the outlet. For the pelvic canal INVERARDI, while considering the anterior and posterior walls nearly parallel, states more particularly that they are divergent in seven-tenths of his cases, nearly parallel in two-tenths, and convergent in one-tenth. FABBRI and BOISSARD likewise find the two walls nearly parallel, but a study of BOISSARD'S tracings does not altogether bear out to the parallelism. In the first twenty-three tracings given by BOISSARD of which I have copies, and which include two tracings of PINARD, I make out six-tenths to be markedly divergent, three-tenths to be parallel, and one-tenth to be convergent. One of the parallels and one of the convergents are from multiparae, while the/

the other convergent is from a negress. The others are either from multiparae or the parity is not stated. These figures, as far as they go, support those given by INVERARDI, and if the divergence in the majority of INVERARDI'S tracings is as great as that in BOISSARD'S, then it is in relation to both, more correct to speak of divergence than of parallelism for the majority of canals, when they are viewed in the mesial plane.

In appendix B. I give a number of angular measurements from twenty-seven frozen sections of the end of pregnancy, the first stage, and the second stage. The material is not very great, but it may serve to give a tolerably approximate idea of the relations in the mesial plane. First, as to the bony pelvis, the anterior and posterior walls are divergent in 24 sections, parallel in 2 sections, and convergent in one section. The mean angle formed by the upper part of the anterior surface of the sacrum with the conjugata vera is $103^{\circ}4'$, that between the axis of the pubis and the conjugate $95^{\circ}8'$, and that between the posterior surface of the pubis, below the anterior end of the obstetric conjugate, and the conjugata vera $100^{\circ}4'$. The two last figures, it will be noticed, correspond closely with the mean figures of Delore and Kiwisch. The mean angle/

angle of divergence of the anterior and posterior walls above the 180° is 24° approx., the maximum divergence equalling $180^\circ + 50^\circ$. Now, in a cavity, where the value of a few millimetres of space is so well understood, it does not seem logical to neglect a mean divergence represented by an angular distance of 24° , by regarding the anterior and posterior walls as "nearly parallel". Secondly, the angular measurements for the soft walls of the canal are tabled for 8 frozen sections from the second stage. Of these sections, the anterior and posterior walls in or near the mesial plane are divergent in 7, and nearly parallel in only one. The mean angle formed by the posterior wall with the conjugata vera is 92.6° , that by the anterior wall with the conjugate 101° ; the mean angle of divergence above 180° being 14° approx., the maximum being 28° . Here also, though the number of sections given is very small, the results are worth quotation, as they show divergence in the proportion of seven to one. The conclusion to be derived from the casts and the frozen sections is that, in the absence of complete cylindricality of the canal, the projection of the axis, in which the head descends, as a centre line cutting all planes at their middle points can no longer be a matter for mere/

mere statement, but must be submitted to proof, before it can be accepted - unless we are to be content with an axis which has a mean error of 24° .

So far the matter has been looked at only in the mesial plane. As I have already pointed out, the walls of the canal on either side of the mesial plane may be capable of modifying the line of the axis to some uncertain extent, and the attempted projection of the axis is still farther complicated by the occurrence ~~xxx~~ of internal rotation. Though no part of the canal may be overlooked, the antero-lateral and postero-lateral walls would appear to have most influence on the direction of the axis of the descent of the head. These walls descend generally downwards and forwards, the postero-lateral on the whole more rapidly than the antero-lateral, the result being a reduction in the oblique diameters, and a projection forwards of the successive horizontal planes with descent. Clinically, the antero-lateral wall appears to slope forwards, from above downwards, to a greater degree than the inner surface of the pubis in the mesial plane. But the reproduction of the material relating to these walls, and which I have been able to see, is so scanty, the wide angular variations recorded in the mesial plane being remembered/

remembered, that they hardly serve for determinations of even the more or less limited value which must still be placed on those from the whole tabled series of sections. In this connection it falls to be mentioned that Norris and Dickinson (1896) give, in diagram, a tracing of the inlet superimposed on one of the outlet from the bony and ligamentous pelvis, and therewith a number of measurements. Apart from the general trend of the walls from above downwards on which no information is given, the diagram shows the greater projection forwards of the posterolateral margin of the outlet beyond that of the inlet, as compared with the projection delineated in the antero-lateral margins. The measurements record a reduction in the oblique diameter from 133mm. at the inlet to 90mm. at the outlet in the same superoinferior plane, showing that whether it takes place gradually or finally and abruptly, the reduction is considerable, as determined by the authors. The diminution in the transverse diameter is even larger, when the measurements are taken in the superoinferior plane, descending from 143mm. at the inlet to 77mm. at the outlet.

If a point be taken in the middle line of the/

the presenting part of the fetus, it descends in an axis relatively equidistant from the two opposite antero-lateral and postero-lateral walls (oblique position of the head in descent), or relatively equidistant from the two antero-lateral and the two postero-lateral walls (transverse position of the head in descent), until the lower margin of the upper subdivision of the superior portion of the pelvic canal is reached. In the lower subdivision, the axis approaches the mesial plane of the canal, and at the outlet joins the simple curved axis of the inferior portion of the canal, provided that internal rotation occurs in the lower subdivision and not sooner or later. Owing to the direction of the antero-lateral and the postero-lateral walls, and to the relative distribution of resistance within the pelvic cavity as a whole, the presenting part tends to follow the direction of the antero-lateral wall; or rather the antero-lateral and anterior walls form an approximate guide to the normal direction of the line of descent. But, whenever the angular relations of these walls diverge much from what is probably the normal, the line of descent does not follow them, as e.g. in a kyphotic pelvis. This being so, the pelvic bones are not the ultimate determinant/

determinant of the direction of the axis which should perhaps, be sought more deeply in the direction in which the soft canal tends to dilate - a direction which is, however, subject to disturbing factors that are little understood.

§ 11. The inclination of the brim of the pelvis is variable among pelves and in the individual pelvis. Excessive variations of the inclination are no hindrance to labour, provided the pelvis is normal in other respects. NAEGELE (1825), from an examination of 800 subjects, recognised the variability of the inclination among pelves, and controverted the hitherto supposed evil influence of too great variations, giving circumstantial cases in supporting his contention. However, there is reason to believe that the woman in labour is able instinctively to modify the inclination of the brim to suit her varying requirements. KIWISCH (1846) points out that, given weak abdominal walls, it is easier to adapt the inclination of the brim to the axis of the uterus than to adapt the uterus to the brim, and he goes on to show that an excessive inclination of the brim, so far from being a cause of dystocia, may actually be produced instinctively by the parturient woman to meet the difficulty of a pendulous belly; while the attitude/

attitude of general flexion of the body reduces pelvic inclination, as in normal labour.* PARVIN (1895) quotes LOBSTEIN that a brim which is nearly vertical to the plane of the horizon is no hindrance to delivery through a normal pelvis. So also with pelves in which the brim is nearly horizontal (NAEGELE). The determinations of PROCHOWNICK (1882) and MEYER (1861) apply only to variations of inclination among pelves in the erect position of the body. Even under this limitation the variations observed are considerable, and range from 20° (PROCHOWNICK) to 60° (MEYER):

BARBOUR/

*Werboff (1913) has reproduced a number of photographs of a woman in the second stage of labour. Taken with the patient in the erect attitude, they show an increase of pelvic inclination at the end of the first stage. The increase is reduced when the waters come away and the uterus becomes less deep, but reappears with the advent of a pain. Throughout, the uterus appears to remain stationary relative to the horizon. The inclination of the pelvis, however, follows closely the changes which occur in the antero-posterior diameter of the uterus, becoming more inclined as the uterus deepens in the beginning of a contraction, less inclined as the uterus flattens in the course of the contraction. These photographs show in a remarkable manner the truth of Kiwisch's views that the main part of the mutual adaptation of the uterus to the pelvic canal is performed reflexly by movements of the pelvis. The lesson of these photographs has also an important bearing on our knowledge of the postural changes of the woman in labour. These changes are referred to later in the text. (Werboff: Die Gebärmutter des Weibes. 1913.)

BARBOUR (1900) in a historical retrospect pronounces in favour of PROCHOWNICK'S figure.

CALDERINI (1894) traces the inclination of the pelvis from that of the dorsal horizontal position to that of the genu-pectoral, the inlet being referred to the axis of the trunk, or more precisely to the plane of the table on which the body is laid. In the dorsal horizontal posture the angle is 40° : in the same position, but with the thighs flexed and the feet on the table, also 40° ; with the thighs vertical and the legs horizontal 36° ; in the lithotomy position the inlet is nearly parallel to the table. In the ordinary lateral posture the angle is 25° , and in the genu-pectoral only 18° with straightening of the lumbar vertebrae. In consideration of WALCHER'S and KLEIN'S results (vid. post.), CALDERINI considers the third and fifth positions the most favourable for obstetrical operations, the second position which is the ordinary obstetrical position of the Continent and the United States of America the least favourable.

§ 12. As a general rule, in late pregnancy the curvatures of the spinal column are reduced, the lumbar/

lumbar spine is extended, and pelvic inclination is reduced (KUHNOW, 1889, BRAUNE 1890). The cause of these changes is a physical reaction connected with the position of the centre of gravity (DUNCAN 1868). In the presence of some degree of pendulous belly, the inclination of the brim may, however, be increased, together with a greater extension of the spine to counterbalance the excessive anteversion of the uterus. In primiparae with strong abdominal walls, or with tight-lacing, the column is often flexed, and the pelvic inclination reduced more especially after the presenting part sinks into the brim. The capacity of the lumbar spine for movement in a sagittal direction was determined by SCHULTZE (1867) from researches on the dead. He examined twenty-five females and eight males, previous to the onset of rigor mortis. Extension was produced by placing a bolster under the lumbar region, flexion merely by bending the body. The abdomen was necessarily opened to admit the measuring apparatus. The Conjugata vera formed the base of the measurements, though SCHULTZE admits its variability. The angles were read to a perpendicular raised from the base line. SCHULTZE found the Sagittal/

SCHULTZE (1859), ALBINUS in 1782 definitely recog-
 sagittal capacity for movement in the lumbar verte-
 brae equal to an angle of as much as 35.5° . The
 capacity for flexion was small, most of the movement
 being in the nature of extension. The movement
 of the sacrum by the bending of the lumbar spine
 is, according to SCHULTZE, indisputable on the evi-
 dence of his measurements, and this is confirmed by
 FREUND (1885). In labour, the attitude is, with
 rare exceptions, one of flexion which is almost,
 if not entirely, an instinctive habit. The spinal
 column is flexed, the pelvic inclination is reduced,
 and the thighs are slightly flexed on the body,
 whether the posture be up-right or horizontal, dorsal
 or lateral (LAHS, 1877). During pains the attitude
 may be accentuated, or as in other cases the habit
 may be more nearly persistent, while towards the end
 of the labour the flexion of the thighs in many
 cases is gradually or abruptly increased. These
 phenomena will be referred to in greater detail at
 a later stage.

§ 13. The relative mobility of the sacrum and
 innominate bones was denied and affirmed by different
 ancient authors. For the first time, according to
 SCHWEGEL/

SCHWEGEL (1859), ALBINUS in 1762 definitely recognized the sacro-iliac synchondrosis and the pubic symphysis to be true joints, and to possess some slight power of movement. According to the same writer, MORGAGNI, SANDIFORT, HUNTER, CHAUSSIER, BURNS, TENON, BECLARD, BARKOW, KÖLLIKER, ZAGLAS, HENLE, LUSCHKA, and LENOIR are generally agreed, following ALBINUS, that the pubic symphysis is a joint, having a hollow at least during pregnancy and labour, when there are swelling and softening of the joint and its ligaments, with as a result a certain amount of mobility. LUSCHKA (1854) describes a true synovial membrane in the sacro-iliac synchondrosis, and a joint cavity. The symphyseal joint is also hollow and contains synovial cells. Thus, by the middle of the nineteenth century the mobility of the pelvic joints was accepted widely, though not universally as an ascertained fact, an opinion which the investigators of the last sixty years, with certain exceptions, generally support. The admitted softening and relaxation of the ligaments and joints imply a possible mobility of the bones of the pelvic girdle in relation to one another, a variability of the inclination of the innominate bones/

bones and the sacrum either together or independently, and a changeability of the roominess of the pelvis, that is, a capacity for alteration of the lengths of the diameters of the bony ligamentous pelvis.

These changes can be impressed on the pelvis and the pelvic canal by natural apart from artificial means, though the gains and losses may be less, it is true, by the former than by the latter. But those are none the less important, for they constitute a large part of what is known as the accommodation of the mother to the child. The immediate causes by which the changes may be brought about are:-

- (1) Dilation of the pelvis as a whole by internal centrifugal pressure, and due to giving of the joints, periosteal tissues and ligaments.
- (2) Elastic strains of the bones.
- (3) A pushing of the sacrum or the innominate bones bodily backwards or forwards.
- (4) A vertical movement of one innominate bone on the other.
- (5) A rotation of the innominate bones on a sagittal axis.
- (6) A rotation of the innominate bones on a transverse axis passing through the sacrum.
- (7)/

(7) A rotation of the sacrum in a transverse axis within the innominate bones.

(1) Dilatation of the pelvis as a whole.

SCHWEGEL (1859) experimented on pelvises from the puerperium, and found that, as long as the symphysis is intact, the widening which results from pressure is very slight, the mobility at the sacro-iliac synchondrosis being only equal to one to two mm. The method of dilating the pelvis employed by KORSCH (1831) necessarily results in dilatation of the pelvis generally, but the values given by KORSCH are of too general a nature to allow of those for dilation, apart from local movement, to be distinguished.

According to AUVARD (1894), JACQUEMIER found a separation in the joints equal to 1.5 cm. But AUVARD considers the joints merely to act as breaks in the girdle to give it suppleness. From the clinical side HENNIG (1877) advances the circumstance that successive labours in the same woman tend to become easier. HENNIG finds the cause in a give at the pubic joint. AHLFELD and LEOPOLD do not so much doubt the fact, as its permanence.

They/

They hold however, that it is not possible to show a separation in life of more than a millimetre.

(2) Elastic strains of the bones

These have been investigated by KLEIN (1891) who gives 0.5 mm. as a mean value for the elasticity of the bones in the non-puerperal pelvis, and affecting the conjugata vera.

(3) Pushing of the sacrum, alternatively of the innominate bones bodily backwards and forwards.

SCHULTZE (1867) finds that flexion of the lumbar column is accompanied by a backward retreat of the sacrum and coccyx with as a result extension of the pelvic floor. KLEIN, who fixed the sacrum and then moved the innominate bones, gives a mean value of 0.7 mm. for the antero-posterior movement of the ilia. JELLETT (1905) thinks it is possible that the sacrum may be pushed bodily backwards to some extent by pressure exercised through the child's head. FREUDENTHAL (1913) believes the sacrum to be driven backwards, when the parturient woman occupies a position corresponding to the crouching or squatting attitude.

(4) The vertical movement of one innominate bone on another.

BUDIN (9. by WILLIAMS 1912) observed per vaginam that pregnant women, in the act of walking showed/

showed a rocking movement of the innominate bones on each other. Though indissolubly associated with some rotation of the iliac bones on a sagittal axis, much of this rocking motion appears to be due to a vertical to and fro sliding of one pubic bone on the other at the symphysis. BONNIÈRE and BUE (1899) examined over 500 women, and give the results for 470 in regard to the matter. In 10 there was no appreciable mobility in the pubic joint, in 408 the vertical movement equalled 1 m.m., and in 52 it ranged from 1 to 3 m.m. Mobility was thus present in a large majority, and however slight it may be, owing to the movement on each side being independent and vertical, it may be important in easing the largest circumference of the head past the bony outlet.

- (5) Rotation of the innominate bones on a sagittal axis.

This rotation implies a capacity for separation in the joints between the bones. It may arise through this circumstance alone, i.e. without relative change in the positions of the pelvic bones, or it may appear in the course of rotation of/

of the sacrum and (or) the innominate bones on a transverse axis.

MEYER was one of the earliest writers (vide SPIEGELBERG 1858) to recognise the occurrence of rotation on a sagittal axis. When the upper part of the sacrum nears the anterior wall of the pelvis, the sacro-iliac ligaments are expanded and they tend to draw the posterior and upper parts of the iliac bones nearer one another, whereby the pubic arch and its ligaments are stretched.

BONNAIRE (1898) comes to an identical conclusion, and finds that both in a standing and a sitting position the rotation of the iliac bones on a sagittal axis flattens the conjugate, and enlarges the transverse diameter of the inlet. LABORIE (1862) attributes this rotation not to a movement of the sacrum, but to the pressure of the child's head on the ischial tuberosities. The pressure is powerful enough to produce partial separation in the symphyseal joint, and at the same time an increase of the transverse diameter of the outlet. No mention is made of movements at the sacro-iliac joints in this connection, but it is inconceivable that/

that separation may occur at the symphysis without associated changes at the other joints, unless the elasticity of the bones is much greater than KLEIN (1891) believes it to be. LABORIE, however, recognises clearly the value of movements in all the pelvic joints, and states distinctly that, while the movements have little effect on the diameters of the brim, they are of great importance, when the head is in the cavity or at the outlet. DUNCAN (1863) quotes LABORIE with approval, and adds that separation of the thighs helps to separate the pubic bones, especially if the internal femoral muscles are in contraction at the time - an early recognition of the possibilities of muscular action which, in relation to the whole pelvis, have never been given their due.

KÜTTNER (1898), like KLEIN in 1891, finds that the transverse diameter of the inlet varies little through all the positions. So also with the plane of greatest pelvic contraction, but it must always be remembered that KLEIN fixed the sacrum and KÜTTNER came to the conclusion that the sacrum is immobile. PINZANI (1899) finds the rotation/

rotation of the iliac bones on a sagittal axis to be less important than that on a horizontal axis.

Passing from the lithotomy to the WALCHER position results in a separation of the iliac crests. Clinically, PINZANI found no separation in 24 cases; in 22 the distance between the spines was lessened; and in 31 it was increased to a mean 5 m.m. SCHMIDT

(1897), SAMUEL (1903), and FREUDENTHAL (1913) found a clinical advantage from the lithotomy and exaggerated lithotomy positions respectively, and attribute it to enlargement of the outlet in both the antero-posterior and transverse diameters.

JONGES (1903) affirming the value of the lithotomy position with abducted thighs for enlarging the outlet by separation of the tuberosities of the ischium, found as the result of inquiry in twenty-five pregnant and puerperal subjects that the extension of the knees still further increases the outlet by the action or the extension of the flexor muscles running between the tibia and fibula and the ischial tuberosities. DEVRAIGNE and DESCOMPS (1910) independently confirm the value of the JONGES position/

position. On the changes at the outlet, they emphasise the importance of the valuable researches of BONNAIRE and BUÉ, and believe them to support the views of LABORIE and the experimental investigations of TARNIER and POTOCKI, who applied divergent traction to the ischia and measured the increase of the bi-ischial diameter. According to DEVRAIGNE and DESCOMPS, the lithotomy position increases the bi-ischial diameter by a rotation of the sacrum and in addition by muscular action. When the adductors which are attached to the rami of the ischium and pubis are put in tension, the rami are pulled outwards so as to increase the transverse diameter of the outlet. The movement is clearly a rotation of the innominate bones on a sagittal axis. In describing their posture (the JONGES position), the authors recommend abduction of the limbs to relax the gluteus maximus, so as presumably to prevent the muscle on each side resisting the backward rotation of the apex of the sacrum. CORNU (1912) also wrote in favour of the JONGES position.

(6) Rotation of the innominate bones on a transverse axis passing through the sacrum, and

(7)/

- (7) Rotation of the sacrum on a transverse axis between the innominate bones.

The majority of writers appear to consider both rotations to occur in labour. But there are differences of opinion as to their relative values. The transverse axis is the same for both rotations. The fixation of its position has not been easy, and may not yet be regarded as mathematically exact. ZAGLAS (1851) places it in the second vertebra; SCHWEGEL (1859) in the union of the second and third sacral vertebrae; KLEIN (1891) one cm. behind the second sacral vertebrae, very close to where MEYER (1878), as KLEIN points out, places it 1.5 cm. behind the surface of the joint of the first and second sacral bodies ~~(xxxxxxxposition at the level)~~ and differing from the lower position at the level of the third sacral vertebra assigned to the axis by INVERARDI (1885) and TRIDONDANI (1901). Probably the higher position is the more correct, as it agrees better with the evidence derived from the measurements of the pelvic diameters in different positions of the bones of the pelvis.

According to DUNCAN, ZAGLAS (1851) for the first/

first time in the human subject described the rotation of the innominate bones on the sacrum in an antero-posterior direction. In the erect position the promontory is least projecting into the cavity, and the sacro-sciatic ligaments are relaxed. But, when the body is bent forwards, the promontory is displaced into the brim, the sacro-sciatic ligaments are stretched, and the outlet of the pelvis is enlarged. DUNCAN (1854) believed that the symphysis is able to move upwards and downwards. In a later view (1868) DUNCAN admits the pelvic movements to occur either as a rotation of the ilia on the sacrum, or as a rotation of the sacrum between the iliac bones, but does not attach relative values to the movements. HUBERT and VALERIUS (1856) describe the rotation of the sacrum and point out that, when the upper part is projected forwards, the conjugata vera is diminished and the transverse diameter of the inlet is slightly enlarged. SCHWEGEL (1859), in puerperal pelves, found the sacrum able to rotate through an arc of 5° in either direction. In the dorsal and lateral postures the promontory turns backwards and enlarges the conjugate. A similar mechanism/

mechanism occurs in late pregnancy. Thus SCHWEGEL concentrates attention on the nutation of the sacrum, and appears not to have recognised a movement of the innominate bones. His conclusions are important however, in relation to the extended and hyper-extended positions. They were confirmed at a much later date by BONNAIRE and others. BALANDIN (1883) after examining pelves from males and nulliparous females for comparative purposes, studied four pelves from pregnancy and thirty-five from the puerperium. BALANDIN fixed the sacrum and moved the symphysis up and down, recording the length of the conjugate and the antero-posterior diameter of the outlet in each position. All the pelves were mobile. BALANDIN concludes there is softening of the ligaments in pregnancy and that, while little increase of the inlet can be produced, the enlargement of the outlet is considerable; nutation of the sacrum, according to BALANDIN, exists without doubt, but he attaches more importance (fide VARNIER) to the movements of the iliac bones. BALANDIN, by finding the changes of the outlet greater than those of the inlet, confirms the elaborate though indiscriminate/

indiscriminate observations of KORSCH (to be referred to later) but the smallness of the changes with the sacrum fixed in comparison with those found by others under different conditions, indicate that, apart from the effect of extreme variations of the inclination of the iliac bones, another factor for the production of change exists, namely, in the nutation of the sacrum. BALANDIN by neglecting the effect of sacral nutation anticipates the majority of later observers. But, as of them it cannot be said that BALANDIN grasped the full possibilities of pelvic dilation.

In 1839 WALCHER, as the result of studies in the years 1836 and 1839, made the fateful announcement that the conjugate of a narrow pelvis is not invariable, but is capable of enlargement or diminution according to the position of the body. The chief merit of WALCHER'S observation lies in directing attention to the variable possibilities of the narrow pelvis, and in showing the best way to obtain the greatest increase of the conjugata vera. During the next ten years or more, discussion ranged around the amount of increase which can be obtained/

obtained in the conjugata vera. Incidentally, however, the publication of WALCHER'S paper led to a great deal of anatomical and clinical research into the effects of changes in the position of the body and of the pelvis on all the pelvic diameters, with as a result, the gradual accumulation of much valuable knowledge. Though no doubt the newly acquired information refers specially to conditions of pelvic dystocia and the operations of pelvic section, its influence is abundantly manifest in more recent conceptions of the mechanism of ordinary labour. WALCHER attributes the changes to movements of the innominate bones on a transverse axis, there being at the same time with descent of the symphysis a projection forwards of the promontory and an increase of lumbar lordosis. KLEIN (1891) who made extensive anatomical researches into the mechanics of the pelvis, attributes changeability of the conjugata vera to three factors - the rotation of the innominate arc on the sacrum, elasticity of the bones, and an antero-posterior movement of the ilia on the sacrum. The two last factors have been examined/

examined already. To the first KLEIN attaches greatest importance. Inasmuch as KLEIN, like BALANDIN, fixed the sacrum and lumbar vertebrae for his experiments, he at least implies a belief in the immobility of the sacrum. KÜTTNER (1898) investigated the pelvis anatomically with special reference to the outlet in furtherance of SCHMIDT'S (1897) clinical results. KÜTTNER made casts of three normal pelvises in the WALCHER, horizontal and lithotomy positions. According to KÜTTNER the sacrum does not rotate at all, rotary movement being confined to the innominate bones, and that the symphysis rotates on a transverse axis, by which is presumably meant simply an arcuate movement in a vertical direction. This arcuate movement produces the changes in the conjugate vera and in the antero-posterior diameter of the outlet. BAR (1899) found that, when the body is flexed in the dorsal position, there is a movement of the iliaes on the sacrum which has little effect on the conjugate, owing to the contemporaneous reduction of the lumbar lordosis. (This reduction includes retraction of the promontory though not necessarily rotation of the sacrum). The first effect/

effect of extension is a reappearance of the convexity of the lumbar spine, the second a movement of the iliacs which comes later than the first and is the main agent in increasing the conjugate. It thus appears that for BAR the iliac bones move equably with the sacrum, until the latter has reached the limits of its mobility in either direction, when the iliacs continue the movement independently. So that there is no true nutation of the sacrum, only a movement as part of the pelvis as a whole. BONNAIRE and BUÉ, in a valuable report to the International Congress of 1899, state that the diameters of the pelvis can be altered according to the position of the woman in labour. The changes are due to softening of the peristeal tissues and the joints, and a number of predisposing causes are mentioned. The result of an examination of the living is uncertain, according to the authors, as to the sacro-iliac movements. But they suspect them on account of the appearance of pain there, and its relief by local pressure in the line of the articulations. Though the authors are/ .

are probably correct in this deduction, the argument is unsound, as the authors did not exclude the relief by local pressure of pain referred to the rump from the dilating canal. BONNAIRE and BUÉ examined twelve puerperals after death. With the cadaver on the edge of the table and the limbs hanging down, the sacrum rotates so that the base moves backwards. Here they are unaccountably in opposition to WALCHER'S and BAR'S conclusion that lordosis is increased, and the promontory moves forwards. The main result for the present purpose, of BONNAIRE and BUÉ'S researches lies, however, in the distinct recognition, for perhaps the first time, of the simultaneous and independent rotations of the sacrum and of the innominate bones, and in this connection they show also that the lithotomy position produces the greatest degree of rotation of the sacrum, the base coming downwards and forwards, while the apex is driven backwards. CALDERINI (1894) had, however, already shown that the lithotomy position caused the apex of the sacrum to turn backwards, so as to enlarge the outlet/

outlet. PINZANI, at the same congress, supported BAR'S views. Clinically, he took the anterior superior iliac spines as indices, and observed in passing from the lithotomy position to the WALCHER, that they rotate downwards and forwards, while the lumbar lordosis increases. The movement of the spines goes on for a time after the lordosis increases no further, and all movements are eventually checked by the tension of the ligaments and discs which arrests the movement of the sacrum some time before inclination of the brim is completed. JELLETT (1905) attributes nutation of the sacrum to the pressure of the head of the fetus at different levels. As it passes the brim, the promontory is forced backwards: at the outlet the apex of the sacrum is pushed backwards and upwards, the softened sacro-sciatic ligaments being unable to resist the strain. JAKS (1905) takes a similar view. The mechanism of the sacrum is a balance of the pressure acting from without and within. The effect is to widen the inlet when the head is there, and the outlet when the head descends to this level. The curved axis which the head follows is thereby straightened to/

to some extent. JAKS further states that the horizontal turning axis of the sacrum is on a level with the middle of the pubis i.e. the second pelvic plane. The diameters of this plane remain constant. Depression of the symphysis widens the inlet, but produces lordosis. Raising the symphysis widens the outlet to a greater extent. Hence for JELLETT and JAKS, the movements of the pelvic bones, and therewith the alterations of the pelvic diameters, are due largely to the pressure of the fetal head. While no doubt such a mechanism may occur under conditions that approach to dystocia, clinical evidence hardly supports the view for normal labour, and SELLEHEIM (1912) though he does not give an opinion as to cause, puts the matter better, when he says "The mutual adaptability of the child's head and the maternal pelvis makes use to the uttermost of the continual changes of the pelvic diameters and of the moulding of the head, by means of the movements of the pelvis, and can help to overcome a disproportion which is not too great." In 1906^b SELLEHEIM made casts of contracted pelves before and after symphyseotomy. He states the effect of the operation is to cause a simultaneous rotation of the sacrum/

sacrum on a horizontal axis, and of the hip bones on a sagittal axis on the sacrum. The apex of the sacrum moves forwards and upwards. The widening is due both to the result of the operation, and also to the rotation of the pelvic bones. In 1907^b, in order to reconcile the clinically observed advantages of WALCHER'S position with his views on the unique mechanical importance of the soft canal in normal labour, SELLHEIM states that the beneficial effect of the WALCHER position is to extend the soft parts of the pelvic walls posteriorly from the anterior on the hip bones, so as to make the passage of the child easier. SELLHEIM attributes this effect, through the WALCHER position, to the rotation of the sacrum. Thus, at the hands of at least some authors, experimental and anatomical researches demonstrate the occurrence of seven kinds of relative movement in the pelvic girdle, Of these, four are of minor importance while the remaining three - nutation of the sacrum, rotation of the innominate bones on a sagittal axis, and rotation of the same bones on a transverse axis, have a value which is probably great even in normal labour. All three, further, are susceptible of clinical observation, as/

as I have quoted, already, some observations to show. Nevertheless among authors of the modern period, TARNIER and CHANTREUIL (1832), BARNES (1834), who believes the movements of the sacrum to be more apparent than real, FARABEUF (quoted by VARNIER 1894) and SCHICKELE (1901) deny the mobility of the pelvic bones on one another, or at any rate believe the movements to be so slight as to have an inestimable value. TARNIER finds notable dilation only on pelvic section, so also FARABEUF who in addition considers that traction with the forceps lowers the symphysis as much as it can be lowered, whatever the position of the thighs, and that any increase of the brim, if it does occur, lessens the mid-sacro-pubic plane which is the main plane of pelvic dystocia. But if Varnier reports correctly, the last paragraph is no argument, as the greatest circumference of the head cannot be in the mid-sacro-pubic plane, when it is at the brim. SCHICKELE dwells emphatically on the irregular dovetailed articular surfaces of the sacrum and the iliac bones, and considers these not only to prevent all movement, but to exist for the special purpose of transmitting the body weight from the sacrum to the iliac bones -

a purpose to which movement or separation is inimical.

Notwithstanding these digressive conclusions (SCHICKELE), I take it, movements of the pelvic bones in labour are beyond dispute, at any rate under artificial conditions. It is still necessary, however, to strengthen the position in relation to the mechanism of ordinary labour, and which apply to the pelvis during life.

Many regard the special attitude of the woman in labour to be an instinctive habit. We know from the researches and writings of PLOSS (1872) FELKIN (1884), PEDLEY (1887), WITKOWSKI (1887), GLEAVES (1899) and others* that the attitude is common to the whole world of parturient women, and is, indeed, manifest in the great majority of labours, though perhaps the awakening of the habit is delayed in our ultra-civilized primiparae. But even here it is unwise in theory to assume that a wrong attitude is being taken up, and it is worse in practice to interfere on the strength/

* There is a good account of parturition among the Australian aborigines by Gray in the Transactions of the Glasgow Obstetrical Society. Engelmann's observations are described by Witkowski.

strength of the assumption. A woman knows best herself the attitude that suits each moment of her labour, if one may put it so. For of course, the pose is more a function of the organism than a product of the brain. This universally adopted attitude amounts, therefore, almost to a specific character. It is very old racially: the mechanism for its production is probably inherited, and only awaits the appropriate stimulus to set it in motion. Here then, we have the factors for a compound reflex action, or an instinctive habit (LOEB 1900). That being so, we are bound to conclude that the habit has been evolved for the benefit of the woman in labour. The purpose cannot be indifferent, harmful, or useless. For LAHS and SELLHEIM the special attitude and the movements of the bones, which SELLHEIM at any rate admits, exist only for the purpose of extending the soft parts in advance of, or coeval with the descent of the presenting part, as in the greater number of normal labours the bones (except the pubic arch) do not come into contact with, or influence the passage of the head. There are cases for which this statement is probably more or less true, but their number has been exaggerated. In/

In these cases also, the clinically observed movements of the bones are least in evidence. On the other hand, in the greater number of labours, the clinically observed movements are distinctly in evidence, and, though the extension of the soft parts forms part of the result, it is hard to believe that it is the sole consequence. Indeed, on the principle of Nature's simplicity in the working of cause and effect, it is preferable to suppose, in the absence of most distinct evidence to the contrary, that the movements of the bones and the special attitude of the skeleton in labour are directly connected with the passage of the normal child through the normal bony pelvis. The evidence to the contrary derived from frozen sections and from the relations of the diameters of the child to the diameters of the bony pelvis, contain fallacies which deserve exposure; and the view is attractive which regards the mobility of the bones of the pelvic girdle as one of the circumstances disposing of the theory of the soft canal, as the sole maternal passive factor in the mechanism of labour.

The attitude of general flexion of the body to which I have already briefly referred is characteristic/

characteristic of the second stage of normal labour, and also of the first stage, at least when the presenting part has engaged the pelvis before labour begins, and it has been often and very similarly described, as the following quotations show:-

"When the woman in labour is left to herself, she instinctively approaches to a cowering position with the body bent forwards".(KIWISCH)

"In effect, these are the results (certain movements) of an attitude assumed instinctively by the woman in labour." (Duncan 1854)

"Indeed the study of the whole subject illustrates beautifully how nature leads the human female, in the act of childbirth, to assume positions and make exertions which are necessary for perfecting the mechanism of the process." (DUNCAN 1868).

"Abdominal pressure causes flexion of the lumbar spine." "Constantly there is a concavity forwards which increases as the abdominal pressure grows stronger." (LAHS 1877).

" - a position instinctively assumed when labour begins." (BARNES 1834).

"The classic position for the expulsive period of birth is that in which the woman flexes, spreads out, and inwardly rotates the legs, while at the same time the vertebral column is bent forwards and the arms pull on a handhold. The crouching position comes nearest to the ideal." (JAKS 1905).

below, VALTORTA (1912) in affirming his belief that/

that with changes of the position of the body the diameters of the pelvis can be enlarged and that movements of the sacrum at the level of the sacro-iliac articulations and variations of the inclination of the pelvic brim can occur, writes:-

"When we assist at a labour, we are spectators of the mother's instinctive solution of an extremely interesting and difficult problem."

Clinically observed, the phenomena consist of a reduction of the lumbar lordosis, a retraction of the upper part of the sacrum, together with a projection forwards of the apex of the sacrum, and a small degree of elevation of the symphysis pubis. On its external aspect, the profile of the lumbar region may even be convex backwards. These dispositions are common in general to the first stage of labour and the earlier part of the second stage; and the main agent in their production appears to be the flexors of the lower part of the spinal column. In effect, they enlarge the conjugate of the inlet, or at least prevent it from being diminished, and aid in extending the soft parts of the upper portion of the soft canal, while they give a preliminary relaxation to the soft parts below, especially the pelvic floor, favourable to their/

their "active dilation". These arrangements are exaggerated during the occurrence of a pain, not as a rule in the first stage, but often towards its end and during the earlier part of the second stage. Women vary, however, in this respect. Thus FRITSCH (1875) formally records a fact, readily ascertained on clinical examination, that, during a pain, lumbar lordosis is diminished. If the hand is placed under the lumbar region when the parturient woman is in the dorsal posture, the hand is squeezed hard during the pains. FRITSCH attributes the diminution to elevation of the arms, abdominal pressure, and erection of the uterus. These causes appear, however to be inadequate, as with all of them apparently in operation the lumbar spine can still be moved backwards and forwards to some extent. When it is moved forwards, the difficulty with regard to the general-contents pressure of the abdomen is overcome by projection backwards of part of the abdominal contents laterally to the spinal column. Here again, strong action of the spinal flexors appears to be the main agent in the further reduction of lumbar lordosis, coincident with the occurrence of a uterine contraction. It is to be noted, so inherent/

inherent is this instinctive action, that under deep anaesthesia it usually disappears only shortly before the uterine contractions fail. At the same time and during successive pains, the symphysis pubis in the second stage is visibly drawn upwards by the action mainly of the recti muscles, until it remains persistently at a height above which no further rise is possible. DUNCAN (1854) observed the action of the abdominal muscles on the symphysis in the second stage, and believed the promontory at the same time to be projected forwards, so that the outlet is enlarged. This terminal rotation of the sacrum, to which not only DUNCAN but CALDERINI and BONNAIRE and BUÉ have directed attention, is visibly associated with an increased flexion of the thighs on the body. It does not always occur: some women experience little difficulty at the outlet of the bony and ligamentous pelvis. When the knees are drawn up, the symphysis may rise a little further, if it has not already reached its height, the sacrum rotates, as DUNCAN describes, and lumbar lordosis is increased. The two latter phenomena are then mainly due to the involuntary action of the erectores spinae. But, whenever the flexors of the spine/

spine are maintained in powerful contraction, the increase of lumbar lordosis and the projection forwards of the promontory are resisted to the utmost, while the sacrum still rotates as before. In effect, there is some translation forwards of the spine and the promontory, but it is retained to the least degree. In the non-pregnant condition the arrangement is difficult of execution, but it appears to be normal for the end of the second stage. Thus, the outlet is much enlarged, extension and retraction of the pelvic floor are favoured, and rotation of the innominate bones on a sagittal axis is induced, so as to increase the transverse diameter of the outlet, while the conjugate is not materially lessened - a disposition which may often be invaluable for the transit of the face and the shoulders of the child, the latter especially, even when not abnormally large, needing all the available room at the brim of the pelvis. The postural changes and the associated movements of the pelvic bones, usually so evident under clinical observation, and corresponding in character and sensitive to each step in the progress of the labour, are some of them corroborated by an examination of the tracings of frozen sections/

sections. The numbers of these, it is true, are not great, but the calculation of the probable errors of the averages gives some idea of the value of the results. It must also be borne in mind that the appearances of the sections represent the conditions as they are after death (STRATZ 1886^a 1886^b, BR&UNE 1890). That is to say, the dispositions which are the result of muscular action cannot be expected to be preserved in their entirety, if at all. The movements to be looked for are elevation of the symphysis during labour, that is rotation of the innominate bones on a transverse axis, and rotation of the sacrum also on a transverse axis. I measured the angle formed by the axis of the pubis with the conjugata vera in tracings of some of the sections. The results are set down in Appendix B, for the period immediately before labour for the first stage, and the second stage of labour. The figures for each period were arranged and their probable errors calculated. They are as follows:—

Before Labour (7 Sections)

Mean Pubic angle = $97.18^{\circ} \pm 1.55^{\circ}$.

First Stage (12 Sections)

Mean Pubic angle = $96.50^{\circ} \pm 2.06^{\circ}$.

Second/

Second Stage (3 Sections)

$$\text{Mean Pubic Angle} = 93.37^\circ + 1.89^\circ.$$

A progressive lessening of the mean angle is found, to put it roughly, from the beginning to the end of labour. The differences among the three periods, however, do not exceed the sum of the probable errors and are therefore, untrustworthy. But, if the first and the third period are taken, the total difference of nearly 4° exceeds the sum of the probable errors by nearly half a degree, which I take to be a real difference, however many the included sections are likely to be. The reduction may imply either an elevation of the symphysis, or a lowering of the promontory, or it may indicate both. A reduction of 1° of arc obtains for each centimetre of rise of the symphysis, when the ratio of the conjugata vera is to the radius of rotation of the symphysis as 3:4, which it approximately is in Barbour's late second stage section, the centre of rotation being fixed as a mean point between MEYER'S and KLEIN'S determinations. Excluding very small angles of divergence of the radius and the conjugate, the angular differences hold good, whether the promontory lies above or below the radius/

radius of rotation. The arc which the symphysis is able to describe measures 2.1 cm long according to KLEIN. Elsewhere in the same paper, KLEIN also gives data for a rise of 3 cm. The latter figure will, therefore, mean a reduction of 3° of arc, as compared with nearly 4° of the observations. Slight though the difference is, and scanty the material on which it is based, it suggests the possibility that, given the rotation of the symphysis, there may also be a rotation independently of the sacrum. If on the other hand we assume the symphysis to be immobile and endeavour to attribute the angular changes entirely to movements of the sacrum, we find that, under the same conditions as to ratio etc., the reduction of the mean pubic angle for each centimetre of arcuate descent of the promontory ought to be no less than 4° of arc. Regarded in this way, the tendency is to believe that the promontory is either very near the primary centre of rotation, or its movements are restricted by muscular action and in most of the sections, by the presence of the head. The latter view seems the more probable, as the changes in the pelvic dimensions, which will be referred to later, go far to confirm the approximate correctness/

correctness of KLEIN'S and MEYER'S determinations. Considered alone therefore, the observations on the mean pubic angle render a rise of the symphysis probable during labour, but the information they convey regarding movements of the sacrum is at most only a suggestion.

In the next place, the angle was measured which the anterior surface of the upper part of the sacrum makes with the conjugata vera. This was done for each of the sections, and the figures are tabulated in appendix B. The averages for each period, as for the mean pubic angles, with their probable errors are now set forth:-

Before Labour (7 Sections)

Mean Sacral Angle $\bar{=}$ 103'00 \pm 2'41 .

First Stage (12 Sections)

Mean Sacral Angle $\bar{=}$ 96'58 \pm 2'41 .

Second Stage (7 Sections)

Mean Sacral Angle $\bar{=}$ 117'29 \pm 2'60 .

It is observed here that the progression is not uniform, as it is in the case of the mean pubic angle. And indeed, the inference has to be made that the rotation of the sacrum is reversed in the course of labour. To use an inexact though convenient mode of expression, we might say that the promontory moves backwards from late pregnancy into the/

the first stage, and forwards again during the second stage. The differences among the periods are in both cases much greater than the probable errors, and are therefore, in all likelihood real differences. In passing from the first to the second stage, the difference greatly exceeds the sum of the probable errors. The mean sacral angle necessarily increases whether the promontory descends or the symphysis rises, contrary to what happens to the mean pubic angle. Here again, when the total difference of $14\frac{1}{2}^{\circ}$ is considered, raising of the symphysis alone, or rotation of the sacrum alone, seems inadequate to account for its magnitude on the basis of the 4° per centimetre of vertical movement. The observed difference for the mean sacral angle tends, therefore, to confirm rather than otherwise the suggestion raised from the difference in the mean pubic angle, that both the sacrum and the innominate bones take part in the relative movements of the parts of the pelvic girdle. The mean sacral angle in the first stage shows a large reduction in comparison with the slight increase which one might be led to expect from reduction of the inclination of the conjugate. In how far it is real it is difficult to decide, the more so as the mean air-line angles show/

show a nearly uniform progressive:-

Before Labour (7 Sections)

Mean Air-line angle = $72.86^{\circ} \pm 0.67^{\circ}$

First Stage (11 Sections)

Mean Air-line angle = $77.13^{\circ} \pm 1.30^{\circ}$.

Second Stage (7 Sections)

Mean Air-line Angle = $82.04^{\circ} \pm 0.83^{\circ}$.

It is possible, of course, that in a series of sections the correlation of the anterior surface of the sacrum with the air-line has a low value. In any case, the increase of the mean sacral angle in the second stage points to a strong rotation of the apex of the sacrum backwards during that period. A comparison of the progression in the mean sacral angle with that in the mean pubic angle further promotes the view derived from the latter that the actual translation of the promontory through space is restrained. If this is so, it seems likely that there are two rotations of the sacrum. One of these takes place around KLEIN'S or MEYER'S approximate axis, and is functional before labour, during the first stage, and in the earlier part of the second. The other is characteristic of the late second stage and is characterised by the bold translation backwards of the apex of the sacrum. Most probably, the/

the axis of this late rotation lies at a higher level - in or near the promontory and the base of the sacrum. At the same time, it is by no means impossible that the rotation of the sacrum in the late second stage is a simultaneous occurrence of two rotary movements about two separate axes. In the result, the relative movement between the sacrum and iliac bones will be greater than it would be, if there were a common axis, and it will also be greater between the articular surfaces of the bones at a lower than at a higher level. (In this connection it is worth noting that the breadth of the articular surfaces decreases from above downwards and with some rapidity towards the lower part of each surface.) In general, it seems remarkable that the evidence obtained from life should be so largely supported by that of the dead, more especially as all the bodies excepting one or two were frozen in the dorsal extended posture. The expected discrepancy is however, discounted by the presence of the fetus which acted as a block preserving in part, but I expect not entirely, the positions which were given to the pelvic bones during life.

§14. In general terms elevation of the symphysis diminishes the inlet and enlarges the outlet: depression/

depression of the symphysis enlarges the inlet and lessens the outlet. Between the inlet and the outlet there is a plane, the dimensions of which scarcely change whatever the position of the symphysis. This plane for KÜTTNER (1898) and JAKS (1905) is the plane of the greatest dimensions (BECKENWEITE), and in it the radius of rotation ought to lie. But, if it happens that the sacrum has two axes of rotation in life owing to muscular action, then the foregoing statement is true only for the dead. As a more exact statement of the general terms relating to the conjugata vera, it may be said that, when the centre of rotation and the radius of rotation lie below the level of the conjugata vera, elevation of the symphysis shortens the conjugata vera, and, when the centre and the radius lie above the level of the conjugate, elevation of the symphysis lengthens the conjugata vera. In the former case the shortening of the conjugate is proportional to the size of the original angle between the conjugata vera and the radius, and also to the ratio of the vera to the radius of rotation. The greater the angle and the shorter the radius, the greater the shortening of the conjugata vera with a given rise of the/

the symphysis.

Since 1839, investigations of the changes in the lengths of the various pelvic diameters have mainly been occupied with those changes which occur as the result of movements from one artificial position to another. From the earlier period, data relating to the diameters are meagre, but, for the most part, they may be held to apply rather to such changes as are able to occur in normal labour. DUNCAN (1854) apparently by deduction from ZAGLAS'S results and his own clinical observations, believed that, by raising the symphysis, the conjugata vera is diminished one or two lines, while the antero-posterior diameter of the outlet is probably increased twice as much. SCHWEGEL (1859) in puerperal pelves found the rotation of the sacrum is able to increase the conjugata vera by 1-3 m.m. The greatest increase of the conjugate he found only in the dorsal posture with the loins raised, as also LEOPOLD (1849). BALANDIN (1883), after fixing the sacrum, found that lowering the symphysis with a weight of 24 Kgrms. produced a greatest increase of the conjugata vera of only 1.5 m.m. Raising the symphysis reduced the conjugata by 2 up to 3 m.m. with a traction of 12 Kgrms., while the outlet was increased/

increased by 10 to 15 m.m. with the ascent of the symphysis. Already, CROUZAT (1831) had made researches of a similar nature. According to VARNIER (1894) CROUZAT found a variation of 8 m.m. in the conjugata vera between the flexed and the extended positions. As regards the transverse diameter of the outlet LABORIE (1862) found a greatest increase in the bi-ischial diameter of 2 cm. by the pressure of the head alone, while BALANDIN by applying divergent traction to the obturator foramina obtained an increase of the bi-sciatic diameter amounting to 4 m.m. and of the transverse diameter of the outlet amounting to 4-5 m.m., the figures being averages.

Of all the inquiries of the pre-Walcherian period, however, not one, so far as I am aware, approaches within measurable distance of the laborious and comprehensive observations made by KORSCH (1831). From the point of view of the ordinary labour his results have a special value not only because of the method he employed, but also on account of his apparent ignorance of the exaggerated movements which can be forced on the pelvic bones by the special positions of operative obstetrics. And, perhaps, it is not going too far to write that the figures which KORSCH gives represent as nearly as/

as possible the living possibilities of the pelvis in the ordinary labour, when it is borne in mind that the pelves were cut out of the dead, and that muscular action was necessarily absent. The pelves were widened with dilators, and the diameters were measured before and after dilation. KORSCH examined 45 pelves. In 34 of these taken after abortion, in late pregnancy, during birth, soon after birth, and where there were large tumours of the uterus or other pelvic organs, KORSCH obtained increases of the diameters of the inlet and the outlet. These I have averaged for the whole group.

Inlet - Conjugata vera = 4.41 m.m.

Transv. Diam. = 2.84 m.m.

Outlet - Ant. post. Diam. = 5.07 m.m.

Transv. Diam. = 3.52 m.m.

That excessive force was not used is shown by the figures of increase in eleven pelves from men and non-pregnant women, for which the averages are:-

Inlet - Conjugata vera = 0.45 m.m.

Transv. Diam. = nil.

Outlet - Ant-post Diam. = 0.18 m.m.

Transv. Diam. = 0.45 m.m.

KORSCH by his researches demonstrates the changes/

changes which are associated with unusual activities of the generative organs, and especially with the occurrence of pregnancy. These changes are manifest in a yielding of the joints, and in a widening of the pelvis - of the inlet and to a greater degree, of the outlet. According to KORSCH the conjugata vera is more susceptible of increase than the transverse of the inlet; the transverse of the outlet more than the antero-posterior diameter of the outlet. The widening of the transverse of the inlet leads to a shortening of the conjugate: the widening of the conjugate does not alter the transverse of the inlet. The greatest enlargement of the transverse allows a further lengthening of the conjugate: in the greatest widening of the conjugate the transverse diameter can not in most cases, be enlarged further: the widening of outlet always lessens the conjugate and usually leaves unchanged the transverse diameter of the inlet. A similar effect is produced on the outlet by widening the inlet. In many cases, the greatest mobility lies in the sacro-iliac joints. Where movement is greatest, there is the greatest quantity of synovial fluid. The lengthening of the conjugate depends on the mobility of the sacrum: the yielding of the symphysis/

symphysis affects especially the transverse diameter of the outlet. The greater the circumference of the hollow in the pubic joint, the greater the mobility of the joint. The number of births has no visible effect on the mobility of the joints of the pelvis. These conclusions given by KORSCH appear to be an eminently moderate summing up of the changes which can be produced in the pelvis of the cadaver by the action of centrifugal pressure, without the aid of exaggerated obstetric positions. But, for the living subject there are reasons which I have already given for believing that the effect of muscular action still falls to be added to these results for the dead, and it would appear that the work of the muscles produces the greatest effect on the antero-posterior diameter of the outlet, and the least effect, though by no means to a negligible extent, on the conjugate of the inlet, while the transverse diameter of the outlet occupies, in effect an intermediate position. To gain an idea in figures of the greatest possible increases and diminutions of the pelvic diameters produced by all means short of pelvic section, one must refer to the/

the inquiries which WALCHER set in train. WALCHER (1889) referring especially to narrow pelves, found an increase of the diagonal conjugate in the living amounting to 1 cm., and a variation of 3 mm. in the conjugata vera of the cadaver, from the flexed to the hyper-extended position of the body. KLEIN (1891), for normal non-puerperal female pelves, states a variability of 5.3 mm. in the conjugata vera, and of 5.6 mm. in the diagonal conjugate under similar postural conditions. The greatest increase in the conjugata vera, is 1 cm., and the least 3 mm. In contracted pelves the values are slightly greater. KLEIN finds the weight of the legs acting on the innominate arc to equal 24-30 Kgrms. which is much as it was found by BALANDIN. According to KLEIN, this weight is less than that which can be produced by traction with the hands, and as KLEIN'S figures are derived from pelves moved by this means, the changes produced by the WALCHER position will be still less than in the experiments. WALCHER (1899), in affirming the correctness of his position, believes that KLEIN under-estimated the weight of the lower limbs, and very naturally points out the invalidity of KLEIN'S claim to have disproved the value of the WALCHER position on account of the different/

different nature of KLEIN'S material. According to KLEIN, a rise of the symphysis of 3 cm. shortens the conjugata vera by 9 mm., while a rise of 1 cm. effects a reduction of 3 mm. KLEIN here confirms BALANDIN that a rise of the symphysis has a greater effect on the conjugate than an equal fall. KÜTTNER (1893) in the three pelves which he examined found an increase as great as that postulated by WALCHER, while the antero-posterior diameter of the plane of greatest pelvic contraction shows an increase from the WALCHER to the Lithotomy position, nearly, though not quite, double that of the conjugata vera, thus confirming DUNCAN'S inference made thirty years before. For the three pelves the mean increase of the conjugata vera is 1.1 cm., of the antero-posterior diameter of the "BECKENWEITE" 0.17 cm., of that of the "BECKENENGE" 1.74 cm. DUHRRSEN (1893), WEHLE (1894), FOTHERGILL (1896), and HUPPERT (1898) all obtained increases within a millimetre either way of that claimed by WALCHER. DEVRAIGNE and DESCOMPS (1910) cite, in addition LEOPOLD, KUSTER, KALT, CURRIER, MANGIAGALLI, LA TORRE, and CALDERINI in support of WALCHER. They also range PINZANI on the same side of the controversy, but a reference to PINZANI'S report of 1899 does/

does not seem to support the authors. PINZANI examined 62 puerperal women in the lithotomy and WALCHER positions. In 17, the conjugata diagonalis showed no variation, in 45, there were increases of 1 to 8 mm. in favour of the WALCHER position. In five cadavers PINZANI appears to have obtained no greater increases. On this other side to which PINZANI belongs on the strength of the report just quoted, VARNIER (1894) endeavours, in polemic fashion to show that the enlargement of the conjugata vera is less than WALCHER makes out, and in conclusion states that post-mortem examination shows the conjugata vera unable to vary, on the average, more than 6 mm. in labour and 5 mm. in the puerperium. For VARNIER it has not been shown that the WALCHER position increases the conjugata vera to the extent of 1 cm. In a later and more violent communication (in 1899 I think), VARNIER reasserts his view without any new fact to bear on the problem.

From the lithotomy to the WALCHER position BONNAIRE and BUÉ (1899) obtained a mean increase of 6.4 mm. in the conjugata vera in twelve cadavers. By giving data for the increase from the horizontal position to the WALCHER position, the authors made
a/

a useful contribution, as this transition is the one most likely to occur in a case of difficulty at the brim, unless the high application of forceps with the body in the lithotomy position is a common practice. The mean increase they found amounted to only 3.5 mm. Also, LEBEDEFF and BARTOSZEWICZ of ST. Petersburg (1899), from measurements of 25 female (and 2 juvenile) cadavers, arrived at mean increases of only 0 to 1.1 mm. from the horizontal to the WALCHER position, and to the latter from the lithotomy position of 1 to 7 mm. DEVRAIGNE and DESCOMPS also found the increases by the WALCHER position to be much less than 1 cm., while GOENNER (1901) in 74 pelves in the dead obtained a mean increase, by the same position, of approximately 2.1 mm. in the conjugata vera. In 20 of these pelves there was no change: in one only, the increase rose to 1 cm.

For the antero-posterior diameter of the outlet LEBEDEFF and BARTOSZEWICZ give an increase of 1-7 mm. in passing from the WALCHER position to the horizontal, and of 6.4 to 10 mm. from the WALCHER to the lithotomy position. KÜTTNER'S figure, as already quoted, is 17.4 mm. NEUMANN (1902) reports on/

on the enlargement of the outlet which he observed in nine abnormal pelvises. The increases occurred from natural causes, when the head, in each case, was fully in the cavity. In six of the cases, there was an increase of the antero-posterior diameter rising to a maximum of 2 cm. According to JAKS (1905), raising the symphysis widens the outlet to as much as 1 cm.

The transverse diameters of the pelvis, which vary mainly as a result of the rotation of the innominate bones on a sagittal axis, show little change at the inlet, and a very distinct, though variable change at the outlet. KORSCH'S figure for the inlet is 2.84 mm. that for the outlet 8.52 mm. LABORIE (1862) believed the latter to reach no less than 2 cm. in some cases. BALANDIN, on the other hand, limited the increase of the outlet to 4-5 mm. KLEIN found a variation in the transverse diameter of the inlet of only 0.1cm, and, in general, considers the variability to be one-seventh that of the conjugata vera. KÜTTNER confirms the results, and also believed the transverse diameter of the plane of greatest pelvic contraction to be nearly invariable. His mean increase (in three pelvises) for the transverse diameter of the inlet is only 0.07 cm.

According/

According to BONNAIRE and BUÉ, the increases of the transverse diameter of the outlet prove very variable. They are given only for four bodies, the mean being 15 mm. from the WALCHER to the lithotomy position: in three cases, the mean increase from the WALCHER to a position in which the knees were pressed against the shoulders was 17.3 mm. while the mean difference in the same number of cases, between abduction and adduction of the knees, was 3.7 mm. in favour of the former, the figures varying from 0 to 11 mm. In five cadavers, PINZANI found a mean enlargement of the transverse diameter of the inlet equal to 3.2 mm. In NEUMANN'S contracted pelvis the widening of the transverse diameter of the outlet reached a maximum of 2.5 cm., enlargement occurring in all cases. JONGES (1908), by his position, got an increase of 9 mm. in the transverse diameter of the outlet, as compared with the effect of the lithotomy position. WILLINK (1910), in a contracted funnel-shaped pelvis, found only 5 mm. of increase. VAN ROOY (1910) changing the patient from the obstetrical to the squatting position obtained an increase of 3.5 mm., and of 9 mm. in the JONGES position.

Anyone reviewing these results, especially where/

where they relate the history of the WALCHER position, can scarcely fail to be impressed by the confusion of the terms employed, of the different methods applied to the pelvis, of the varied kinds of material examined, and of the distinctions between life and death. The pitfalls which inquirers have not always escaped have proved to be the distinctions between the conjugata vera and the conjugata diagonalis, between normal and abnormal pelves, between the conditions of clinical and of anatomical research. Indeed, few mechanical subjects in obstetrics have been the aim of so much research, and yet have been the centre of so much misunderstanding, and have been left in such a state of gross confusion, as the effect of the WALCHER position on the diameters of the pelvis. The material used and the results hitherto recorded are so various that it seems impossible, at the present time, to co-ordinate the data with any degree of satisfaction.

From the figures here recorded the greatest increase of the conjugata vera is seen to be 11 mm. (KÜTTNER); of the transverse diameter of the inlet 3.2 mm. (PINZANI); of the antero-posterior diameter of the outlet 17.4 mm. (KÜTTNER), or 20 mm./

mm. (NEUMANN, for contracted pelves); and of the transverse diameter of the outlet 20 mm. (LABORIE), or 25 mm. (NEUMANN). But there seems little doubt that the averages will fall considerably short of these figures. What they are in the dead and the living may be said to be unknown in the exact sense: that is, their determination for normal labour leaves much to be desired. I believe the figures given by KORSCH to be the most likely to represent in the dead changes at all comparable to the greatest changes of the ordinary labour, and if 2 mm. be added to the increase in the conjugata vera, and 4.5 mm. to each of the increases in the diameters of the outlet, the resultant figures may be inferred to strike tolerable averages for the greatest possible changes in the diameters which are the result of the movements of the pelvic bones by dilation, by change of posture, and by muscular action in the living. The figures will then read as follows:—

<u>INLET</u>	Conjugate vera	= 6.41 mm.
	Transv. Diam	= 2.84 mm.
<u>OUTLET</u>	Ant- post Diam.	= 9.57 mm.
	Transv. Diam.	= 13.02 mm.

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SECTION II.

UTERINE AND ABDOMINAL PRESSURE.

11. The normal action of the uterus in labour is automatic, intermittent, and peristaltic. There is no fundamental difference between the action of the uterus in the first stage and the action in the second stage. According to BRIDGES (1871), the peristaltic or ganglionic motor action of the uterus was noted by HARVEY and W. HUNTER and has since been confirmed by most physiologists. The frequency of contractions is about 100 (1888), and also SECTION II.

UTERINE AND ABDOMINAL PRESSURE.

WIGAND claimed that the wave of contraction begins in the neck of the uterus and spreads upwards to the fundus, whence it returns to the cervix. BRIDGES (1871) considers the uterine action to be peristaltic and partly peristaltic. BRIDGES (1871), however, accepts the view of BRIDGES as the more correct, that the wave of contraction begins at the tubes whence it spreads over the body of the uterus (WIGAND 1887).

The automaticity of the contractions of the uterus is an inaccurate expression. It is not in the strict sense an inaccurate expression. It is not in the

SECTION II.

UTERINE and ABDOMINAL PRESSURE.

is convenient for a function which is not necessarily connected with the vitality of the spinal cord. Contractility of the uterus is maintained for some time after death. (AVELING 1872, HEIMANN 1877). HICKS §I. served. The normal action of the uterus in labour is automatic, intermittent, and peristaltic. There is no fundamental difference between the action of the uterus in the first stage and the action in the second stage. According to LEISHMAN (1876), the peristaltic or ganglionic motor action of the uterus was noted by HARVEY and W. HUNTER and has since been confirmed by most physiologists. The tracings of SCHATZ (1886), and also those of POLAILLON (1880), show well the peristaltic character of uterine contractions. WIGAND claimed that the wave of contraction begins in the neck of the uterus and spreads upwards to the fundus, whence it returns to the cervix. Hence LEISHMAN considers the uterine action to be "partly diastaltic and partly peristaltic". Modern opinion, however, accepts the view of SCHATZ as the more correct, that the wave of contraction begins in the tubes whence it spreads over the body of the uterus. (WINCKEL 1887). The automaticity of the uterus is in the strict sense an inaccurate expression. But the term is/

is convenient for a function which is not necessarily connected with the vitality of the spinal cord. Contractility of the uterus may persist for some time after death. (AVELING 1872, REIMANN 1877). HICKS observed contractions in a prolapsed uterus after death: BAUDELOCQUE and HECKER (1866) observed them during a post-mortem Caesarean section (REIMANN 1877) Contractions of the uterus occur in paraplegic patients. In three of the cases collected by ROUTH (1897) delivery took place unaided and unobserved. In SCANZONI'S, BRACHET'S and ROUTH'S cases the mechanisms were normal, and only in BRACHET'S was assistance given. Many other cases have been noted. Spontaneous labour occurred in NASSE'S patient who had a fracture in the third and fourth cervical vertebrae; in CHAUSSIER'S patient, in whom an echinococcus compressed the cord near the first dorsal vertebra; and in VON RENZ'S case where a neoplasm had grown in the dorsal region so as to compress or destroy the cord (VARNIER 1900). More recently, spontaneous labour has been recorded by JAKUB (1911), and by COMMANDEUR and BERTOYE (1913).

Contractions of the uterus, like those occurring in normal parturition, occur in animals after the spinal cord has been cut, or destroyed
FOSTER/

(FOSTER 1879). GOLTZ (1874^a) found that in the dog section of the spinal cord in the thoracic region left intact the reflexes of the rectum and the bladder, and (1874^b) under similar conditions of section pregnancy and labour proceeded normally. REIMANN (1877) records that SIMPSON cut the spinal cord of a pig below the first dorsal vertebra, labour occurring three days later. REIMANN repeated the experiment in a cat, destroying the cord from the third dorsal vertebra backwards. A fetus was born shortly before the death of the cat two days later. COHNSTEIN performed a similar experiment on the wolf; MASIUS and HEIDENHAIN divided the cord in the region of the last dorsal vertebra in dogs with similar results (VARNIER 1900). Hence, as REIMANN says, the impulse to birth does not depend on the lower cord. It has been suggested that the sympathetic nervous system is responsible. According to VARNIER, REIN separated the uterus from the inferior mesenteric ganglion without impairing the power of the contractions. GOLTZ, in further experiments with EWALD (1896), rendered the action of the sympathetic system improbable. KRUEGER and OFFERGELD (1907) separated the uterus in animals from all the extrinsic/

extrinsic nerves, and at the same time they cut through the spinal cord. Labour set in at the usual time and proceeded normally, the only visible effect being that the labour was painless. Certain other experiments make it clear that no portion of the central or sympathetic nervous system is essential to the due occurrence of uterine contractions.

REIMANN (1877) suspended a uterus in a glass vessel containing air at blood-heat. Rhythmical and peristaltic contractions were observed independently of any stimulation to last for about an hour, and were sufficiently powerful to expel a fetus through the vagina. KURDINOWSKY (1904) observed the activities of uteri in isolation, and kept alive by the circulation of LOCKE'S fluid through their blood-vessels. He describes the waves of peristalsis as being automatic, and he found the organ to respond readily to thermal and mechanical stimuli, and but little to the electric current. KURDINOWSKY, therefore, concludes that the muscular action of the uterus depends little on the central nervous system, and he suggests the probability of a local innervation. KEHRER (1907) kept excised portions of the uteri of animals and of women alive for several hours in oxygenated /

oxygenated Ringer's fluid, and he recorded graphically their contractions. Hence, we may conclude that the brain is not essential to uterine action, though clinical evidence shows readily enough that the brain possesses the power of inhibiting the contractions of the uterus, while VARNIER (1900) says that stimulation of the brain causes contractions. The uterus, also, acts well enough without the intervention of the spinal cord and the sympathetic system. But, as FOSTER points out, the uterus is largely influenced by the spinal cord, and it may be that the influence lies in the direction of maintaining inter alia the reflex tonus of the uterus, as the experiments of CLEMENTI (1913) and others appear to indicate. Thus, the experimental evidence points towards the automaticity of the uterine body, and to the possible presence of a local innervation. From the anatomical side LEE (1842) appears to have been the first to point out the existence of a large cervical ganglion. HART (1912) who believes in the automaticity of the uterus quotes BRAUN to show that a ganglion is present in the uterus about the level of the os internum. SCHAEFFER (1899) and PISSEMSKI (1903), however, consider the ganglion to be really a large plexus of nerves, grouped on either side of the cervix and composed of fibres derived from the /

the second, third, and fourth sacral nerves, from the hypogastric plexus, and from the sympathetic nervous system. HERFF (1892) and GAWRONSKY (1894) found ganglionic cells in the muscle, and KEIFFER (1908) in the course of the nerves. HOOBKAMER (1913) considers the uterus very rich in nerves, with an abundance of ganglionic cells in the muscles, nerves, and in the mucosa. Apparently these nervous structures develop along with the other parts of the uterus during pregnancy. According to VARNIER (1900) many observers, beginning with W. HUNTER (1802), have recognised this development; and WILLIAMS quotes FRANKENBAUSER that the apparent cervical ganglionic mass doubles its size during the enlargement of the womb. Whatever be the nature and composition of the ganglionic mass and of the nerves ramifying through the body of the uterus matters little in one way. The essential point is that it has been demonstrated anatomically that there are abundant specially conductive protoplasmic connections among the muscle fibres, and it has been shown experimentally that these connections are able to act efficiently in the absence of all communication with the central nervous and the sympathetic systems. In this way the rapidity and rhythm of the peristaltic/

muscles, or if the door of the abdomen is

anxiety/

peristaltic waves can be explained, though not the cause of the peristalsis (LOEB 1901). In short, then, given the initial stimulus which may be chemical, the uterus is able to act, and probably does act efficiently apart from extrinsic nervous elements, and directly in response to a local stimulus which is quickly repeated through the uterine body by the local innervation; while, at the same time, reactivities of the uterus which can be recognised distinctly as reflex in nature, and which will be referred to later, are accessory and not essential to the progress of labour.

§ 2. Most writers regard the action of the abdominal muscles in the second stage as mainly of the reflex type. Some, however, notably TARNIER and CHANTREIUE (1882), NYHOFF (1886), and VARNIER (1900) believe the action to be partly voluntary and partly reflex. AUVARD (1894) states contractions depend on the will, but "the need is so imperious that restraint is impossible". DUNCAN (1875) expresses the opinion that, if the abdominal muscles were the main expulsive power, birth would be a voluntary act. The problem can be studied by clinical observation. If, in the absence of a uterine contraction, the parturient woman be made to contract the abdominal muscles, or if she does so of her own accord in anxiety/

anxiety to end the labour, the contraction which is produced is sudden, jerky, and of short duration. If more than one contraction occurs, the successive movements are irregular in time and force. On the other hand, the contractions which are associated with uterine action have rhythm, they increase gradually in force, they may be long sustained, and they wear off gradually. These are the characters of reflex muscular action. Superimposed on these contractions are those of the recti abdominis which do not, as a rule, act until the broad abdominal muscles are strongly contracted, and the sheaths of the recti are extended (LAWRENTJEFF1885). The recti appear to be most under the control of voluntary action. Of the abdominal muscles, the recti, in the absence of uterine contractions, are the main contractors in response to the will. Their action is the first to weaken and disappear under anaesthesia. Their action, however, when it is associated with a uterine contraction is of the reflex type, but it appears to be capable of great reinforcement by an effort of the will - a remark which does not apply with the same force, if at all, to the broad abdominal muscles. In some cases the voluntary action of the recti may occur at the beginning of an abdominal contraction, and it may then be observed gradually to merge into the/

the combined reflex and voluntary contraction which is characteristic of the fully developed action of the recti abdominis during a pain. Similar phenomena are experienced in connection with urination and defaecation. To repeat, the reflex action of the broad abdominal muscles, and the partly reflex and partly voluntary action of the recti are associated with contractions of the uterus. More particularly, the beginning of an abdominal contraction is not precisely synchronous with the beginning of a uterine contraction. A gradual hardening of the uterus is felt before abdominal action begins. This circumstance, after allowance is made for the appearance of an initial and relatively inefficient voluntary effort, is in itself evidence for the dependence of natural abdominal effort on the action of the uterus. One of the well-known distinctions between the so-called first and second stages is the absence of abdominal contractions in the one, and its presence in the other. As no recognisable difference is observed in the action of the uterus in the two stages, it is clear that abdominal action does not depend on uterine contraction alone. As long ago as 1858, TYLER SMITH stated his belief that abdominal action is/

is excited by the pressure of the uterine contents on the vaginal wall, a view which is repeated by FOSTER (1879) with a saving clause referring to uterine contractions. It is noticeable that, as long as the cervix is not wholly dilated, the pressure exercised on the vaginal wall is slight, and is, moreover, not a mobile pressure. When, however, the os is so far dilated that the uterus can protrude its contents bodily, abdominal contractions set in, whether the membranes are ruptured or not. It is, therefore, probable that the intensity of pressure in the vagina must be relatively high, before the stimulus is effective. Not only the vagina, but the vulvar canal as well, appears to be able reflexly to arouse abdominal contractions. Traction with a finger on the perineum is a more effective stimulus to the abdominal muscles than rubbing the wall of the abdomen, and it is also an effective means by which can be produced an action of the uterus, which is apparently a true reflex, and through which, of course, abdominal action is excited.

§ 3. Little is known regarding the relative values of uterine and abdominal action in the second stage./

stage. SCHATZ, according to AHLFELD (1903), held the two powers to be equal. Most observers, however, have come to the conclusion that the one or the other is greater in effect. Granted an inequality, which is the greater or the more essential? At present the answer is largely a matter of opinion. HAUGHTON (1870) believed the abdominal muscles to be the main expulsive power - a conclusion which rests on the extraordinary results which he obtained from his experimental and mathematical inquiry. According to DUNCAN, SCHATZ and HALLER held the same view. SCANZONI and LAHS appear to have considered abdominal pressure proportional to the uterine contractions, while KEHRER (1867) looked upon abdominal pressure as being subordinate to uterine. (LAWRENTJEFF 1885). In 1872, LAHS believed that the uterus cannot expel its contents without the assistance of the ligaments and the abdominal wall. In a detailed study of the problem, DUNCAN (1875) considers the uterus the chief expulsive force on the grounds of:-

1. The pressure experienced by the hand within the contracting uterus. (cf. AHLFELD 1903).
2. The uterus being sufficient, when the voluntary muscles are weak or restrained (cf. LEISHMAN 1876).

3./

3. The regulating influence of the uterine pains on the second stage.
4. The important expulsive action of the uterus after labour.
5. The arrest of progress by uterine inertia.
6. The insufficiency of violent down-bearing pains in cases of uterine inertia.
7. The birth a voluntary act, if the abdominal muscles were the chief agent.
8. The asserted completeness of birth in animals with the abdomen opened. (HARVEY and DE GRAAF: fide VARNIER 1900).

It is not necessary to review these conclusions in detail. With the exception of the seventh which is capable of controversion, and the last which need not be held to apply to the human female, the conclusions of DUNCAN appear to be correct as statements of fact. But I think that DUNCAN has not proved his case that the uterus is the chief expulsive force. All that has been done is to bring forward satisfactory evidence that the uterus alone is able to expel its contents. Similar evidence might have been used to prove the sufficiency of the abdominal muscles alone/

alone. It has to be remembered that the same muscles are able to expel hard faecal masses, in the absence of rectal peristalsis. SCHROEDER and STRATZ (1886) defend the opposite view that abdominal pressure is all important. Uterine pressure is weaker towards the end of the birth, and is unable itself to expel the child. Abdominal pressure is stronger under slight anaesthesia than it is without, but it fails under deep anaesthesia. Abdominal pressure could empty the uterus without the assistance of uterine contractions. SCHROEDER and STRATZ consider the last conclusion is proved by the occurrence of post-mortem birth which is due to the pressure of gases in the abdomen.

The failure of abdominal pressure under anaesthesia does not necessarily mean that delivery is impossible. As a matter of observation, delivery can still take place, though the time required for its completion may be greatly prolonged. The occurrence of post-mortem birth by the pressure of gases in the abdomen is not a good argument for the sole sufficiency of the abdominal muscle during life. In death, the soft parts of the passages become so greatly relaxed, and the fetus loses so much of the firmness/

firmness and form which are characteristic of the living object, that the resistance to delivery is reduced to a very low grade. In one of the cases collected by AVELING (1872) delivery occurred on the scaffold (GROSS), and ROUTH, in the discussion which followed the reading of AVELING'S paper, stated his belief that gravity was the cause of delivery in this case. SCHROEDER and STRATZ admit, however, that good uterine pains raise abdominal pressure and that traction with the forceps increases both, this effect, like that of traction with a finger on the perineum, appearing to act directly or reflexly on the uterus, and reflexly on the abdominal walls. HART (1893) follows SCHROEDER in considering the intraabdominal pressure, acting on the contracted uterus, to be the main expulsive power, but there is here a qualification which clouds the issue to some extent. AHLFELD (1903) analyses the experiments of various authors to determine this matter, but he does not appear to have discovered facts of any great importance for his assured statement that abdominal pressure is the main expulsive agent, a view which he expressed as early as 1881-2. AHLFELD, however, admits that the uterus is the primary power, as it leads to the production of abdominal pressure.

For/

For SELLHEIM 1904 it is the general rise of inter-uterine pressure, but gravity is unimportant. In 1906a three expelling powers are defined - the weight of the contents, the undifferentiated general-contents pressure which is the chief force, and the concentrated pressure of the fetus on the girdle of resistance. (cf LAHS 1870-1877). In 1912, however, SELLHEIM declares his belief that the contraction of the uterus is "the source of power, and the essential to the progress of birth", thus reiterating the clearly expressed opinion of LEISHMAN (1876) that the uterus is the prime force. WERBOFF (1913) considers the uterus the main agent in the second stage, abdominal pressure being subordinate, though weighty and necessary. He states that, if the uterus is inert, abdominal pressure is incapable of expelling the fetus. Abdominal activity is aroused reflexly by pressure, on the stomach and intestines, of the uterus which becomes longer in the second stage of labour. At the same time, WERBOFF follows TYLER SMITH (1858) and RIBEMONT in recording that DESSAIGNES (1894), expulsive action does not appear, till the head presses on the vagina/

vagina.

In the present state of knowledge, it is obvious the problem of the relative and absolute efficiency of the various admitted powers depends on the point of view. Restricting the problem to the lowest limit, we must admit that neither uterine pressure nor abdominal pressure is essential to delivery. The action of gravity may be sufficient under very easy conditions. In a second group of cases where the resistance is rather more, either the uterine pressure or the abdominal pressure may be sufficient to secure delivery, alone and unaided, within a reasonable time. In a third group which includes all cases ranging from those placed conveniently under the term of normal labour up to those presenting varying degrees of abnormal difficulty, the one power or the other may possibly be sufficient to bring about delivery, provided the available time is unlimited and exhaustion does not occur. But these considerations differ from those which apply to the everyday event. Both uterine and abdominal pressure are then active, and the unsolved problem has come to be, which is the more efficient?

SCHROEDER'S/

SCHROEDER'S argument that the uterine power diminishes with its cubic content, is vitiated by the circumstance that the uterine power can only be estimated with tolerable certainty, when the abdominal muscles are quiescent, and the means employed towards this end necessarily injure the uterine contractions as well. Apart from this defect, the view is at the best an expression of dubious mechanics, and, if correct, it ought to apply with equal conviction to the abdominal muscles. Moreover, we cannot compare the independent actions of the uterus and the abdominal muscles, as the latter when acting alone, behave in a relatively inefficient manner, different in every way from the activity which arises in the course of the normal event. During the second stage, the two powers are inter-related and mutually dependent in a remarkable way, and it is impossible, at present, to define the one from the other. The powers are also connected intimately with the state of the lower canal, as regards dilation and other factors. We know, however, that the uterine effort is the primary force, and that it possesses the property of reinforcing the action of/

of the abdominal muscles to a great extent, while, on the other hand, there is no distinct evidence that the abdominal pressure affects the uterine power to a similar degree. We are, therefore, in a position to say that the uterine effort is primary and relatively essential, while the abdominal pressure is secondary and relatively non-essential; but which of these two powers is the more efficient is still unknown, and we then fall back on personal predilection in attributing the superiority to the one or the other. The matter, at present, has little practical importance, but it does not follow that it will always be so.

4. WILLIAMS (1912), resuming the work of LUSCHKA, HENLE, HÉLIE, and others on the musculature of the uterine body, adverts with caution to the inconclusive nature of the data which have so far been gathered together. Following HÉLIE for the most part, WILLIAMS recognises three layers of muscle in the uterus, an external, an internal, and an intermediate layer. These layers are not to be looked upon as definite and separate strata of muscular substance/

substance, but more after the manner in which species are regarded by biologists, as fairly marked concurrences in a perfect gradation or sequence of interlacing fibres. The external layer, composed mainly of fibres running in the long axis of the uterus, is comparatively unimportant. The internal layer embraces the cavity for the most part circularly, and forms a strong annular layer around the internal os. The intermediate layer it seems impossible to reduce to a descriptive order. Its most remarkable components are the fibres which are looped around the uterus in figures of eight. Of recent writers, IVANOFF (1911) directs attention to the way in which the ligaments are spread out over the uterus. LAHS (1872) had, however, already referred to this feature, and attached considerable importance to it, while BAYER (vide WINCKEL 1887) allowed the ligaments a place in assisting to empty the uterus. IVANOFF, like AHLFELD (1903), considers the transverse or circular fibres to be most important, and states that they lessen the size of the cavity, by acting in a direction perpendicular to its axis. LA TORRE (1913) denies the existence of layers in the uterine musculature even for convenience of description, and insists on the/

the mutual interdependence of the muscle fibres. According to WERBOFF (1913), GRUSDEW gives a description like that of IVANOFF, but traces the innermost layer back into the tubes. WERBOFF himself recognises the practical effect only of the circular and longitudinal fibres. It is evident, however, that the muscular fibres interlace with each other in a highly complex manner; the obvious advantage of the arrangement being that traction can be applied in every bearing, and that the strength and coherence of the uterus can be equally maintained.

BANDL (1875 and 1877) divides the uterus in labour into an active and upper portion, and a passive or lower portion, separated from each other by the so-called contraction or retraction ring which appears to have been recognised first, in this country at all events, by MILNE (1866). The part above the ring is composed of the main muscular substance of the uterus, and in the course of labour it thickens and shortens, while the part below the ring, known approximately as the lower uterine segment, undergoes thinning and extension. In a recent paper (1913), BARBOUR makes it clear that the constitution of the segment varies among labours, while HOLLAND (1913) points out that it/

it may consist in part of vaginal wall. Most obstetricians appear to accept BANDL'S main discovery. IVANOFF (1911), however, regards the whole of the uterus as active in labour, and, following ROSSA (1900), directs attention to the abundance and size of the circular fibres in the vicinity of the retraction ring. At an earlier date (1886), HOFMEIER had shown that the upper portion of the lower uterine segment, consists of muscular fibres which hold a nearly circular course round the canal. D'ERCHIA (1904) points out that the circular and oblique fibres far outweigh the longitudinal in thickness and strength in the same region - an anatomical view of some importance, when the physiological action of the uterus has to be considered. D'ERCHIA also found a great development of elastic fibres in the pregnant uterus, so that it appears to be probable that some elastic force is developed, possibly in the way of resisting excessive distension, but not in the way of assisting contraction; more especially as the cervical portion of the canal is particularly rich in elastic fibres (HOFMEIER 1886).

§ 5. In general, the mechanical function of the/

the uterus is a phenomenon of muscular activity - the activity of plain, or unstriped muscle fibre. And, if the fibres were arranged around an oval cavity occupied by a plastic object, in such a way that all the fibres had an equal effect, an equalisation of all the diameters of the uterus would occur. Such is not the case with the uterus.

SCHROEDER and STRATZ (1886) showed that the fundus is higher late in the second stage than it is at an earlier period. HOFFHEINZ (1888) states the fundus is as high, when the head is born, as it is before engagement, and the distance of the fundus to the summit of the head increases in the course of labour as 28 : 40.5. FOTHERGILL (1895) confirms these views from clinical evidence and from frozen sections. It is not until the shoulders are being born that the fundus begins to approach the level of the pubis. WERBOFF'S measurements indicate a similar change in the course of labour (1913). At the end of the first stage, the fundus is $3\frac{1}{2}$ -4 fingerbreadths below the ensiform cartilage: in the second stage, the fundus rises to the level of the free borders of the ribs. It is, therefore, apparent that the uterus does/

does possess the power to shorten, i.e., to reduce proportionately all its diameters, but that the occurrence of some event, or events is a necessary preliminary.

During the greater part of the second stage and to a certain extent in the first stage, the uterus is observed during a pain to lengthen, stiffen, deepen, and narrow. (PARVIN 1895). Similar words are used by KÜNECKE (1869), SPIEGELBERG (1882), RUNGE (1891), DESSAIGNES (1894), GALABIN (1910), WERBOFF (1913), and others. Under abdominal pressure, the antero-posterior diameter of the uterus is eventually flattened (TARNIER 1882, ZWEIFEL 1893). With each pain there is a reduction of all the transverse diameters of the uterus, and, as the uterus never returns completely to its original form in each pause, the reduction is progressive up to a certain point (HART 1893). When this limit is reached (the factors which determine it will be considered), the uterus can then begin to shorten, and it does so, provided dystocia does not arise. The active portion of the uterus does not merely act in this manner; it undergoes an actual shortening of the muscular body, and in doing so pulls upon its attachments, mainly through/

through the medium of the lower uterine segment which is attached "ringwise to the pelvis" (SELLHEIM 1912), and becomes thinned and greatly extended. The occurrence of this extension, together with the relative displacement upwards of the active portion of the uterus, renders it difficult to determine the actual amount of shortening of the muscular body, but it probably occurs. In extreme cases the shortening of the active portion and the extension of the passive portion may lead to the retraction ring being displaced upwards nearly to the level of the umbilicus (WILLIAMS 1912). This function of the active portion of the uterus is, as HART (1893) observes, more a retraction than a contraction. To put the whole matter succinctly, we may describe the active portion of the uterus as a constrictor and a retractor, and eventually as a detractor. The uterus squeezes its contents into a more slender form, pulls on its attachments through the medium of the passive portion, and eventually, shortens itself and approaches its attachments, when the contents have attained the greatest possible degree of constriction. The capacity to constrict is, perhaps, the most important function of the active portion/

portion of the uterus, and, judged by experiences in internal version, it is most strongly developed in the vicinity of the retraction ring, and where anatomical investigations appear to accord the greatest development of circular fibres. Paradoxical though it seems, this disposition is in accordance with the mode and effect of peristaltic action observed elsewhere, that the most vigorous action is developed on that part of the moving object nearer the direction of motion. The retraction, or shortening of the muscular body of the uterus argues strongly for the passivity of the lower uterine segment. By pulling on its attachments, the active portion renders the passive portion tense and sufficiently resistant to lateral displacement, let us say, in the absence of abdominal contractions, and such is the sensation conveyed to the exploring hand under anaesthesia of the patient, there being little to choose between the palpable condition of the lower uterine segment and the vagina. Both exercise an uncertain amount of tension which is employed in the direction of resisting undue dilation rather than of producing active contraction. The essential shortening and approximation of the uterus is not so clearly due/

due to muscular action as the other functions of the uterus, and the slender importance which is attached anatomically to the longitudinal lamellae of the uterus makes it possible that a large part of the shortening is due to the same cause or conditions which produce shortening and narrowing in the lower uterine segment and vagina. The foregoing account places in the forefront the view that the prolonged maintainance of the elongated condition of the uterus is due essentially to the uterus being a constrictor rather than a contractor ~~or contractor~~. The circular and, to some extent, the oblique bundles of muscle fibres outweigh in active power the longitudinal, and, as a consequence, constriction becomes inevitable, and continues paramount, until such time as further constriction becomes impossible. The reduction of the transverse diameters of an absolutely incompressible body is possible only in the presence of elongation which takes place at both poles, for the simple reason that the longitudinal muscle fibres are relatively ineffectual, and because, for a time at least, the resistance is as great, or as small at the one pole as at the other. Gradually, however, the resistance diminishes at the lower pole (or should/

should diminish normally), and the object tends to move in this direction, while further elongation of the uterus at the superior pole, under the altered conditions, is able to be restrained by the uterine body; the ultimate control being, under natural conditions, the ligaments of the uterus, the diaphragm, and more generally intra-abdominal pressure. The principal alternative explanation of the elongation of the uterus resides in the fetus, and is identified with the name of SCHATZ, its discoverer. Not a few, notably TARNIER (1882), DESSAIGNES (1894), and GALABIN (1910) has written in favour of this view, but the general trend of opinion, especially in later times, denies its probability. SCHATZ (1872^a, 1872^b) postulates a persistent tendency of the uterus to assume a spherical form, and a continual effort on the part of the flexed fetus to extend. The former is the Form-restitution-power of the uterus; the latter the form-restitution-power of the fetus, the whole being called simply the form-restitution-force. In the contest which must be supposed to occur between the fetus and the uterus, the fetus is the winner, unless there is an excess of liquor amnii, or the fetus is macerated; while it ceases to exist/

exist, when the head has completely passed through the os uteri, that is, when the fetus is fully straightened, but it reappears on the fetus entering the curved portion of the canal, and it is then due to over-extension on the convex side of the fetus. By means of this force SCHATZ accounts for the elongation and narrowing of the uterus in the second stage. Many objections can be raised to the theory. LAHS (1872) has already stated some of them. The principal difficulty, however, consists in the presence of the fetus not being necessary for the development of uterine phenomena identical to those of the second stage. This aspect of the problem has been examined by FABRE (1910) and by RUBSAMEN (1913), and, as it has a direct bearing on the uterine mechanism of the second stage, it may here be repeated. FABRE, by means of careful measurements in the third stage, proved that the uterus lengthens and narrows in the course of its contractions, and in spite of the fact that it contains the soft and relatively formless placenta. The increase in length and the diminution of breadth are considerable, as the table appended shows. I have already suggested that the active portion of the uterus actually shortens by its activity./

activity. Measurements which I made on FABRE'S drawings do not immediately bear out this view, but it has to be remembered that the lengthening by diminution of breadth tends to obscure real shortening. The figures for the active portion are given in the third column of the table.

TABLE of MEASUREMENTS of the UTERUS in the THIRD STAGE of LABOUR (from FABRE.)

Period.	Fundus to Pubis. (FABRE)	Transv. Diam. (FABRE)	Length of Active Portion (SELF)
I. Repose after child born.	20 cm.	12 cm.	16 cm.
II. After first contractions.	26 cm.	12 cm.	17 cm.
III. Complete separation.	26 cm.	9 cm.	17 cm.
IV. After expulsion.	19 cm.	9 cm.	17 cm.

These figures show that the seat of elongation is the lower uterine segment, and, proving the existence, as they do, of lengthening and narrowing, they further show that lengthening and narrowing are inherent to uterine activity and independent of the nature of the contents. The results obtained by RUBSAMEN confirm those of Fabre on all the essential/

essential points.

WERBOFF (1913) brings forward some novel considerations relative to uterine action. Starting from analogies with the invertebrates and with all cavities or tubes enclosed by plain muscle fibres, he reaches the conclusion that the longitudinal fibres of the uterus are alone active in the first stage, and the circular fibres in the second. In the result, the uterus shortens, deepens, and broadens in the first stage, lengthens and narrows in the second. The pressure of the abdominal walls gives support to the circular muscles of the uterus which, otherwise, would have according to WERBOFF, no fixed point from which to develop their power. At the same time the abdominal muscles resist excessive elongation of the uterus, and they also straighten it. WERBOFF applies the same theory to the period of the after-birth. And here he arrives at a possibly important point. The placenta must be separated before it can be expelled, whence he argues that the circular muscles are unable to act until the contents are able to move. Thus, the expulsion of twins is explained by saying that the upper twin is not loosened, and so it is merely compressed, while the lower twin, being loosened, is expelled by the action of the lower circular/

circular muscles in the same way as is the placenta. In trying to strengthen his views about the separate action of the two groups of muscle fibres, WERBOFF refers to the known actions of various drugs, and also to the effect of section of certain nerves on the functions of the rectum. He admits, however, that a double nerve supply to the uterus, though probable, has not been demonstrated.

There is much in WERBOFF'S views that is attractive, the more so as they are developed from the biological standpoint. If, however, Werboff had been so situated geographically as to be able to include sea-anemones in his studies of invertebrates, he might not have gone so far as he has done. Each anemone is a miniature uterus, and the analogy is completed by the circumstance that much of the activity of the anemone depends on a general-contents-pressure. An examination of the animals shows that the two groups of muscles, the longitudinal and the circular or radiate, can act independently, or simultaneously, and that the form which the anemone assumes depends largely on these facts. On the uterine side, the vast complexity of the arrangements of the muscle fibres is against WERBOFF, and it is by no means clear that the circular fibres need

a fixed point of the kind indicated. The contents must be sufficient, otherwise no contractions would be observed in the isolated organ. On the whole, it seems more probable that all the fibres of the uterus are active throughout labour, the longitudinal taking a predominating part in the first stage, and the circular in the second.

Inference derived from the muscular structure of the uterus, and analogy taken from other engines of peristaltic motion lead one to believe that the uterus performs its work by squeezing its contents, and by retracting over its contents. This mode of motion is essentially preservative and, therefore, in accordance with the natural laws. It implies elongation of the uterus, and it does not demand the transmission of power, or of resistance through a special part of the contents, or from one part of the contents to another. Rather, it gives the impression of the conversion of force into movement throughout the contents as a whole.

§6./

§ 6. The abdominal walls form a muscular tube which is maintained in a more or less extended state between the thorax and the pelvis, by the spinal column and the erectores spinae, and which embraces the body of the uterus. The tube is closed above by the diaphragm, and below by pelvic floor which is eventually made to yield. The action of the muscular tube is mainly constrictive, that is to say the tube intermittently and progressively reduces all its horizontal diameters. (Lesshaft q. by Lawrentjeff 1885). The analyses of abdominal action is, however, complicated by the presence of the spinal column, by the inequality in the strength of the several muscles which form the abdominal walls, and by the successive periods at which the different groups of muscles come into contraction. A supplementary though unessential action is to support the body of the uterus. SCHATZ (1870) regards the abdominal wall as an apparatus to reduce the size of the abdominal cavity and divides it into two parts: (1) the diaphragm, and (2) the abdominal and lumbar muscles, based on the spinal column. SAPPEY (1876) attributes two forces to the abdominal muscles, an upper and a lower. The upper reduces the size of the cavity, and the lower furnishes a resistance. TARNIER and CHANTREUIL (1882) consider/

consider the abdominal muscles to exercise antero-posterior pressure on the uterus. They point out that abdominal pressure cannot force the uterus downwards, owing to the diaphragm being fixed whenever the glottis is closed.

It was not until LAWRENTJEFF published the results of his unique researches in 1885 that much was known of the nature of abdominal action. LAWRENTJEFF enumerates sixteen muscles in the abdominal complex, and separates them into two groups. (1) those which lessen the size of the abdominal cavity, and (2) those which act as a support (- the *erectores trunci communes*). He finds, in general, that the right and left sides are equal in power (so also SCHATZ); the anterior wall is four times more powerful than the posterior wall; and the upper twice as strong as the lower, which last is the *locus minoris resistentiae* of KEHRER (1864). More in detail, the upper half of the anterior wall is more powerful than the lower in the proportions of 23; 21, the posterior portion of the diaphragm more so than the anterior (SCHATZ regards them as equal). LAWRENTJEFF draws attention to the large aponeurotic areas and surfaces of origin and insertion of the abdominal muscles, both being factors leading to a great increase of the power/

power of the muscles, according to the researches of LESSHAFT. LESSHAFT showed that the muscles can work longer and more powerfully the greater the extent of their insertions, and the smaller their relative physiological cross-sections. For LAWRENTJEFF, the pelvis is fixed by the lower limbs, the rima glottidis is closed, the diaphragm is fixed in one position and the erectors of the spine are stretched. These arrangements form the basis, stable for the time being, for the contraction of the abdominal muscles. Both side groups of muscles contract simultaneously. They flatten the curve of the abdomen and increase the attachments of the recti abdominis so as to favour their action. The middle wall is flattened gradually. In the order of the beginning of their action we have, first, the diaphragm which contracts and is lowered into the abdominal cavity; secondly, the broad abdominal muscles which contract and extend the sheath of the recti, and, thirdly, the contraction of the direct abdominal muscles.

In the course of a "pain" the sequence of events occur quickly, but not so quickly as to leave any doubt as to the correctness of LAWRENTJEFF'S observations which have met with the approval of SCHROEDER and STRATZ and others. They seem, however, to/

to be deficient in one respect, in that they do not give a more prominent place in the scheme to the spinal column and the lumbar muscles. The former, being temporarily fixed, disturbs the contraction of the abdominal muscles towards the central axis and it would appear that, in practice, the central line must approach the spine during an abdominal contraction. It can readily be shown, however, that the spine is not an essential factor in the compression or contraction of the uterus. During the earlier part of an abdominal contraction, the lumbar region on both sides of the spine is distinctly, though slightly bulged. Thereafter, it remains firm, hard, and resistant, and in the result it must play its part in the development of abdominal pressure, and also in determining the ultimate direction of that pressure. The view that the diaphragm resists undue elongation of the uterus is unsatisfactory, though I have already admitted it in cataloguing the resistances. A special as opposed to a general resistance in this region might conceivably be injurious to the liver and other organs which would experience a special compression between the diaphragm and the uterus. The apparent strength of the diaphragm does not seem adequate for the purpose, while/

while LAWRENTJEFF'S finding that the diaphragm is twice as strong as the pelvic floor is rather startling. The special resistant function of the diaphragm appears unnecessary, when the uterus is felt in the powerful grasp of the broad abdominal muscles, and when the recti abdominis muscles come into action with a strength which is greater above than below. In the meantime, it is not easy to avoid the conclusion that, in the midst of the complicated stresses and strains of abdominal action, the diaphragm is not called on to develop any specialised or active resistance, but only to assist in maintaining the general state of intra-abdominal pressure. The main differentiation of the abdominal stresses is produced by the ultimate voluntary contraction of the recti abdominis, and especially of their upper portions. It results in a marked shortening of the antero-posterior diameter of the abdominal cavity and, to a less extent probably, of the uterine hollow. This may result in increased strain of the lateral walls, at least as long as organs intervene between the uterus and the spine, but in the event of the uterus coming to press directly on the lumbar column the whole of the force will then be absorbed by the spine without injury, and without additional stress being brought to bear on the diaphragm, and the organs lying beneath it.

§ 7. In the preceding section proofs have been adduced of the essentially similar actions of the uterus and the abdominal walls. Both are above all constrictors, seeking to reduce the moveable content to its most slender form. When this state is reached, the constrictive effort is maintained and, under certain conditions, is gradually increased. Meanwhile, the movement of the moveable content becomes inevitable towards and through the area of least resistance. The effect of uterine and abdominal action, therefore, becomes a single problem in relation to the second stage of labour. The general history of this part of the mechanism is eclipsed by the outstanding contribution which was made by LAHS in the year 1869.^{*} At that time LAHS introduced his conception of uterine and abdominal pressure as a general-contents pressure, and his original/

* The theory of LAHS was anticipated in a remarkable way by RITCHIE in 1865. From the presence of fluid in the cavity of the uterus during the first stage the late Dr. RITCHIE inferred that the internal pressure must be equally distributed all over the inside of the uterus. He extended his view to the second stage by assuming that the head then acted as a ball-valve, preventing the escape of waters. For this reason he denied emphatically the possibility of fetal-axis-pressure, and declared his belief that the resultant of uterine pressure acted in the line of the axis of the uterus. Still earlier, HUBERT (1858), as LAHS admits, had applied the hydrostatic theory to explain uterine action in the first stage.

original hypothesis now ranks as the only possible theory of the action of the dilating and expulsive forces. By general-contents pressure it is meant that, when a force is applied to any part of the internal wall, the pressure is distributed equally in all directions throughout the contents of the cavity. The theory implies that the contents are of a liquid nature, or that they behave as if they were mainly liquid, and that, when the uterus and the abdominal muscles contract, the pressure is equalised over the whole of the internal wall of the uterus, and also over the area of least resistance. In the second stage, LAHS considered the general-contents pressure to act as far down as the "girdle of resistance" around the presenting part of the fetus. For the first stage, with the membranes intact, the theory met with ready acceptance, but its application to the second stage has been recognised more slowly, for here the problem is not quite so simple, and probably because some confusion may have arisen between the immediate and the ultimate effects of intra-uterine pressure. Even in the first stage the general-contents pressure is not a complete explanation of the observed phenomena. LAHS himself admitted as much. In 1877, he repeated that gravity due to the greater specific/

specific gravity of the fetus, and, for a limited time, fetal-axis pressure due to the shortening of the uterus have a place in the mechanism in keeping the head against the cervix, and in the second stage, acting along with the elasticity of the uterine walls in forcing the head as a ball-valve against the girdle of resistance. But even this is not enough. When the head presents in the occipito-anterior position, the membranes are more likely to be preserved in an unbroken condition until dilation of the cervical canal is complete, than when the head is in the occipito-posterior position, or when the breech is presenting. The explanation of this difference appears to be that, with the head in the occipito-anterior position, some of the force of the general-contents pressure is absorbed at the greatest circumference of the head; and, as the cervix must necessarily grasp the head as effectually in the occipito-posterior as in the occipito-anterior position, and the breech as effectually as the head, the difference must ultimately be due to the suitability or otherwise, of the presenting part to the pelvic canal which, in the occipito anterior position of the head, must considerably absorb the general shock/

shock, and resist communication between the general contents of the uterus and the forewaters. At the same time, as long as the membranes are intact, the pressure in both regions is necessarily a general-contents or hydrostatic pressure: only, with the favourable position of the head, there is a difference in the strength of the pressure between the two regions. Also, the distribution of the rate of absorption of the pressure around the greatest circumference of the presenting part will depend on the physical nature of the presenting part. This problem naturally becomes more prominent in the second stage, and when the membranes are ruptured: it leads, as a matter of course, to a discussion of the physics of the fetus. The mode of transmission of the uterine and abdominal power in the second stage has been and is the subject of diverse opinions, much of the difference turning on the real or supposed capacity of the fetal spine specially to direct pressure on the presenting part, this mode of transmission being hitherto known obstetrically as fetal-axis-pressure. Before the publication of the views of LAHS on the second stage, the fetal spine was considered to be the sole medium by which the/

S. Simpson believed in fetal-axis-pressure when over the breech came into contact with the fundus (in 1878).

the powers were conveyed to the presenting part. No doubt the fetal spine was there; it gave the impression of rigidity and incompressibility: and it led to a ready and comfortable explanation of the mechanism of flexion. So strongly was fetal-axis-pressure favoured to the exclusion of all other ideas that LAHS was induced to handle the subject with great care, and at a length which seems unnecessary to the modern reader. In 1870, he quotes from the "Zur Mechanismus der Geburt" (1869), and argues further that general-contents-pressure is the true theory and not fetal-axis-pressure. He returns to the subject in 1872 and again in 1877, dealing in a lively fashion with the criticisms of his opponents, and seeking always to strengthen the position of the theory.

Subsequent to the issue of the "Zur Mechanismus der Geburt", the theory of LAHS has been ably supported by HAUGHTON (1870), SIMPSON (1878),* HART (1879 a.b.) SCHROEDER and STRATZ (1886), ZWEIFEL (1890), who firmly denies the existence of fetal-axis pressure/

* Prof. Simpson believed in fetal-axis-pressure whenever the breech came into contact with the fundus (in 1878).

pressure, BARBOUR (1895) and SELLHEIM (1904); and it is worthy of note as a tribute to the theory of the general-contents pressure that no well-known writer in the last forty years, so far as I am aware, has relied on fetal-axis pressure alone in the second stage of all labours. Several authorities have however, advocated the combined action of the general-contents and the fetal-axis pressures, and under certain conditions of fetal-axis pressure alone. SPIEGELBERG (1882) considered the general-contents pressure to be the more important, and the fetal-axis pressure by the fundus to act only in the second stage. OLSHAUSEN holding both the general-contents pressure of LAHS and the Form-restitution force of SCHATZ inadequate to explain the powers (1870), returned to the subject in 1901, when he pointed out the frequent contact of the breech with the fundus in both stages of labour, and he argued from the disposition of the parts for the direct pressure of the fundus on the fetal spine, especially in the second stage. WINCKEL (1887) observed the same circumstance in two of the sections but does not seem to have been led to infer therefrom a fetal-axis/

axis pressure. Again in 1906, OLSHAUSEN refers to the special case of a delayed breech when the waters have drained away, and in it he believed general-contents pressure to be ineffectual without the addition of fetal-axis pressure. D'ERCHIA (1901) found the breech in contact with the fundus in four cases of Caesarean section, and further refers to sections and quotes OLSHAUSEN for its frequent though not invariable occurrence in the first as well as the second stage. D'ERCHIA does not actually name fetal-axis pressure, but he assumes from the foregoing observations that the fundus is able to exercise direct pressure on the fetal spine. JELLETT (1905) believed both to act in the second stage, the fetal-axis pressure acting as part of SCHATZ'S form-restitution-force. In the 1910 edition of GALABIN and BLACKER, the older theory with its later improvements is still advanced, Briefly, the authors state that, where the uterine walls touch the fetus the force is transmitted through the spine to the condyles of the skull. This direct pressure on the fetus is the form-restitution-force, because, when the uterus contracts, it tends to assume a certain definite/

definite form, dependent on its natural shape and the relative strength of its muscular fibres. The uterus is lengthened in spite of the pressure on the fundus. This explains how the fundus can transmit a force to the head through the spine in spite of the latter's pliability, because it is supported all round and prevented from bending. DAKIN (1900) had already advocated a similar mechanism. In a delayed labour as waters drain away, the general-contents pressure becomes less and the fetal-axis-pressure more important. GALABIN calls them general intra-uterine pressure and direct uterine pressure respectively. I have extracted GALABIN'S views rather fully, and I hope fairly, because they contain the principle argument against the validity of fetal-axis pressure as it has been conventionally defined. Neglecting the cervical spine which need not have anything to do with the transmission of power we have the spinal column of the dorsal and lumbar regions - a pliable segmented rod, incapable of resisting lateral stresses, and of transmitting pressure in its long axis without bending so considerably as to waste a large part of the force. The inefficiency of this way of applying/

applying pressure can be cautiously experienced in the unsupported body of the new born. GALABIN attempted to overcome this difficulty of transmission by stating what is perfectly true that, when the uterus contracts, the soft parts of the contents are placed under pressure and completely support the spinal column, so that it becomes a rigid rod and, as such, efficient in the transmission of pressure in the long axis of the fetal body and of the uterus. Now, in order that this arrangement may come about, the general pressure must be as great in the soft parts of the uterine contents as in the spinal column, because, whenever the pressure in the spinal column becomes greater than it is in the surrounding soft parts, the spinal column of the fetus will at once begin to bend and will no longer remain efficient in the forwarding of longitudinal pressure. Seeing, therefore, that the pressure must be the same in the soft parts as in the spinal column of the fetus, and that the soft parts are virtually incompressible it follows that the soft parts under the intrauterine conditions are as efficient transmitters of pressure in the longitudinal axis of the fetus/

fetus as is the spinal column itself and that in so far as the conduction of the force of the uterus is concerned the mechanism would be just as efficient as it now is if the spinal column of the fetus were absent. The supporters of the theory of fetal-axis pressure as an auxiliary or a principal expulsive force, rely on a longitudinally directed pressure from the fundus through the spinal column of the fetus. The existence of a pressure transmitted in this manner does not appear to have been satisfactorily proven. Nor has it been shown that the fundus is extended by straightening of the fetus, to which GALABIN resorts for the production of longitudinal pressure. Anatomical and other considerations, already referred to, rather point to the cause of elongation of the fundus being an inherent property of the uterus itself, which would be operative, even supposing the uterus were to contract on a cavity filled with air. And, seeing that the abdominal muscles cannot force the fundus downwards (PARNIER 1882), we reach the conclusion that the fundus is no more than a maintainer of intra-uterine pressure like the diaphragm, and eventually a follow-through/

through as the contents of the uterus are expelled (WINGKEL 1887). I have quoted FABRE on the action of the uterus in the extrusion of the placenta. Here, there is no fetal spine and no evidence of special longitudinal expulsive pressure exercised by the fundus. The successive expulsion of twins is also better accounted for by the constriction and retraction of the uterus acting by a general-contents pressure, than by a fetal-axis pressure longitudinally directed from the fundus, especially if WERBOFF'S views on the effect of the "loosening" of the twins are taken into account. So it is also with the circumstance, to which DUNCAN (1875) has referred that a part more moveable than the rest of the fetus may be propelled alone or more quickly. Moreover, the theory of fetal-axis-pressure is gravely injured by the discovery from frozen sections that the spinal column, as well as the true axis of the fetus, does not always coincide with the axis of the uterus. (De SEIGNEUX 1901).

As long as any quantity of liquor amnii remains in the uterine cavity, the theory of the general-contents-pressure applied to uterine and abdominal/

abdominal action is readily comprehended. But it has not been clearly shown that the general-contents pressure, thus developed and applied, is transmitted purely as a general-contents pressure through the fetus, and that, in the complete absence of amniotic fluid, the fetus re-acts as if it were a fluid, by manifesting a general-contents pressure at its lower pole. In other words, the powers are potentially and optimally hydraulic or hydrostatic in action, while it has not been shown beyond doubt that the fetus under pressure re-acts as the optimum passenger which recent views demand of the mechanism. In the course of time opinions have varied regarding the physical properties of the fetus. One uses the term "opinions" advisedly, as owing to the complex nature of the object, the matter has been and is incapable of experimental study, and can still only be approached by direct observation and by speculation. Here again the valid history of the subject is limited to the period subsequent to the year 1870, and of general views there are not many to record. DUNCAN (1875) regards the fetus as a peculiarly modified viscous mass. When it is propelled, its parts are all squeezed together and compressed, and as the head is/

is born fluid is pressed out of the mouth and nostrils. There is a want of uniformity in the composition of the fetus; it contains an elastic beam the spine near its posterior surface; and it causes varying degrees of resistance in the canal. BARNES (1885) dwells upon two properties of the fetus - elasticity and ductility. The fetus is very elastic when alive. The elasticity compensates for the state of incompressibility. A little absolute compression occurs through loss of fluid from the head and the expulsion of meconium from the bowel. Ductility, the other property of the fetus, is according to BARNES a form of plasticity. ZWEIFEL (1890) finds the fetus neither a formless nor an indefinitely conformable mass. On the other side, BARBOUR (1895) holds "The old idea of the fetus as a more or less rigid body has been displaced by one which emphasizes the plasticity of the fetal mass, the non-rigidity of its spine, and the mobility of the head on the shoulders." In 1899, BARBOUR describes the head as being "plastic within certain limits so that it can be moulded, but its size and shape are important factors in the second stage." SELLHEIM defines the fetus/

fetus (1904) as a soft pliant cylindrical body, (1905) as incompressible but conformable. In 1907, he states "the head is the largest, hardest, and most unyielding part of the fetus: yet it has a certain plasticity." The body offers a not insignificant degree of resistance. "The fetus is accordingly a firm-soft (festweicher) body which offers moderately great resistance to the expulsive forces." In 1912, SELLHEIM gives more details. The uterine contents are in general, plastic to a certain extent, although they include very unequally plastic parts, namely, the fully plastic waters, the moderately conformable soft parts of the fetus, and the as good as unconformable skeleton. In picturesque phrase "the mother molds and modifies the fetus, the fetus the mother". "Mother and child struggle with one another in mutual size and form-conformability." In the event, the greatest volume is lodged under the smallest superficial area of the "slender circular cylinder." HART (1912) describes the fetus shortly as "a sluggishly plastic fluid." As in the expulsion of the urine and the faeces, the mass is fluid or semi-solid, and is capable of elongation and expulsion.

In/

In its physical properties, the fetus has to be considered in all the gradations of state ranging from that of the living object to that of advanced decomposition. At the two ends of the series the physical problems are widely different. During life, and to a lesser degree before decomposition sets in after death, the fetus, like other animals, has a form which is definite and characteristic for the moment and for the individual. (Into the causes of the distinctive form it is not necessary here to inquire.) Further, it is a matter for common observation that, if from any cause the fetus is deformed, it tends to return in all its parts gradually and perhaps completely to its original form. If, however, the deformation is produced beyond a limit, a breaking or a bending of the body occurs, and the return to the original form is partial or incomplete. It is apparent, therefore, that the fetus possesses the special property of elasticity, and that it has elasticity of shape, though not of bulk. According to SIR JAMES THOMSON (1877), a body which possesses elasticity of shape in any degree is a solid; if it has no elasticity of shape, it is a fluid. And, if the deformation of the solid is pushed, so as to cause/

cause a break, the body is a brittle solid; if a bend, then the body is a plastic or ductile solid. Both of these events may occur within the body of the fetus, so that in parts it is a brittle, and in parts a plastic solid; the former parts being the bony, and the latter the cartilaginous and imperfectly ossified membranaceous portions of the skeleton.

The soft parts contain a large percentage of water, and are of a more or less fluid nature. They show the property of elasticity, or a return after deformation to their original form, only so long as the hard parts are intact. Hence the skeleton of the fetus exercises a permanent influence over the soft parts, and causes them to behave, in some respects, as if they were solid. Even where the hard parts are most abundantly covered by soft parts, there is a slow but certain return to the original shape after the exercise of a pressure which has not ruptured the hard parts. Hence, whatever may be the molecular constitution of the fetus, as a whole, during life and after death before decomposition has set in, the fetus reacts physically as an elastic solid. It is not strictly correct to speak/

speak of the fetus in any of its parts as a plastic or viscous solid or fluid, unless reference is being made to the effects of excessive applications of force sufficient to cause injury. Again quoting THOMPSON, we find "The word Viscosity..... when solids or heterogeneous semi-solid semi-fluid masses are referred to, has rather been employed to designate a property of slow continual yielding through very great, or altogether unlimited extent of change of shape, under the action of continued stress. It is in this sense that FORBES, for instance, has used the word in stating that 'viscous theory of glacial motion',... .. he and many other writers after him have used the words plasticity and plastic, both with reference to homogeneous solids (such as wax or pitch even though also brittle, soft metals, etc.) and to heterogeneous semi-solid semi-fluid masses (as mud, moist earth, mortar, glacial ice, etc), to designate the property common to all these cases of experiencing, under continued stress, either quite unlimited change of shape, or gradually very great change at a diminishing rate through infinite time.

In this carefully expressed opinion the essential/

essential point, for us, about plasticity or viscosity is the capacity for unlimited deformation, however slowly produced. In relation to the mechanism of labour we observe that the limit to deformation without injury is reached comparatively early. Hence for practical purposes, we return to the definition of the living fetus as an elastic solid; there being implied in the use of the word elasticity both a limited degree of deformation without injury and a capacity to return to the original form, when the stress is removed, and in the use of the word plasticity an unlimited degree of deformation without injury, and no capacity to recover the original form. The resistance of a solid to change of form is measured by its rigidity, and the resulting deformity is called a strain. If the body is perfectly elastic, the rigidity is measured by the ratio of the deforming stress to the resulting strain, the value being the modulus of elasticity. Usually, an appropriate modulus comprehends both rigidity and compressibility. That is to say, a strain consists, as a rule, both of change of volume and of distortion. In a strain with change of volume (compressibility) the associated pressure is of the hydrostatic/

hydrostatic type, while in a strain with distortion (which contains no change of volume) the associated pressure is a shearing stress. In the former the pressure is distributed equally all over the applied surface; in the latter it is locally differentiated in a special way. Now, the absolute and the relative compressibility of the fetus is vouched for by several observers (FEHLING 1874, DUNCAN 1875, PERLIS 1879, and SELLHEIM 1907, among others). Fluid may be transferred from the head to the body, and possibly vice-versa, and from the thorax to the abdomen and back again. And the escape of fluid from the mouth and nostrils, and of meconium from the bowel may readily be observed under appropriate and well known conditions. On the other hand, the distortions of all parts of the fetus in the birth are still more evident, on account of their magnitude, and are generally admitted to be the principle mechanical changes which the fetus undergoes in the course of labour.

Thus we are led to infer that, while the pressure exercised by the uterus on the upper pole of the fetus is hydrostatic as long as any quantity of liquor amnii remains in the uterine cavity, the transmission/

transmission of the pressure through the fetus is different partly in degree and partly in order; that it continues to a small extent hydrostatic and becomes to a much greater extent a distorting or shearing stress with differential results, and that, after the total escape of the amniotic fluid, the pressure of the uterus (and of the abdomen) is conveyed directly to the fetus, and is then, both immediately and ultimately, hydrostatic in the least degree, and for the most part a shearing stress.

The preceding sentences refer properly to the living fetus and to the fetus after death and before decomposition has begun, or advanced far. The appearance of decomposition signifies the end of somatic life, and with the advance of corruption the specific, or characteristic form of the individual disappears. For the mechanism of labour, it is not necessary to go beyond the penultimate stage in the process, when the fetus has been converted into a bag of fluid containing disjointed bones. Obviously, in passing from the living fetus to a body in this advanced state of decomposition, we would have to record a gradual loss of rigidity, that is of resistance to change of form; of elasticity, that is the/
the/

the capacity to recover the original form; and, there with, a gradual increase of the mobility of the body, that is of the capacity for change of volume. In short, we would observe a change from an object having in the main the characters of a solid to an object having chiefly the attributes of a fluid. And in the transmission of the uterine and abdominal powers to the fetus, during the process of decomposition we would be led to infer a gradual loss of the shearing or differential stress, and a gradual gain in hydrostatic pressure, until ultimately the pressure was wholly of the hydrostatic type, and similar to that produced in the amniotic sac.

The assumed greatness of a shearing stress, as compared with a pressure of the hydrostatic type in the transmission of pressure through the fetus, does not necessitate return to the direct longitudinal fetal-axis pressure of former days. Ever since AHLFELD showed that the fetus at the end of pregnancy measured only half the length it has when it is straightened (1871), it has been known that the second stage progresses as far as the birth of the head by a straightening and elongation of the fetus within the birth canal, with only a small movement of/

of the fetus, as a whole, relative to the mother. And, as the delivery of the head constitutes, in most cases, by far the hardest and longest part of the labour, it so happens that the most important part of the labour takes place without the necessity of any pressure being exercised through the fundus, other than that of maintaining a general resistance. The exercise of a special pressure is the more unlikely in view of the observation of SCHROEDER and STRATZ (1886) that, when the head is born, a distance of nine centimetres, as a rule, separates the breech from the fundus, and water and feet are found where the breach was before. HART (1893) accounts for this phenomenon as being due to a displacement of liquor amni and feet taking place, when the intra-uterine pressure falls, and states that expulsion is completed by pressure exercised by the powers through the water and feet on the fetus. If this explanation is correct, it may be taken to imply during relaxation of the uterus, either a relative increase of pressure in the body of the uterus or a relative diminution of pressure in the fundal region. (The one is a necessary consequence of the other, but each may arise independently). If the internal pressure is/

is raised in a rigid tube closed at both ends, the tube contracts radially and extends longitudinally, and the reverse occurs whenever the pressure is reduced. (Harmsworth Encyclopedia 1906). An analogy may be traced here between the behaviour of the tube and the action of the uterus. And the conclusion to be drawn seems to be that, though the fundus is hardened during a pain, it is not moving towards the contents as strongly as it might be supposed to do, and though it softens during a relaxation, it is not moving away as quickly as the explanation demands. The result is that in relation to the rest of the uterus the fundal pressure may be relatively, though not absolutely, greater during a relaxation than during a pain. Clinical observation, so far as it goes, suggests the validity of this impression. In the result, the tendency would be rather for the mobile fluid to be transferred to the fundal region during a pain, and to the surroundings of the fetus during a relaxation. This is borne out in those cases where the radial expansion of the uterus during an interval is considerable, and where the fetus reassumes more or less its primitive curved form. When this happens, there is no option but to believe that/

that the fluid returns partially or completely around the body of the fetus. Another probable factor in the displacement upwards of the liquor amni is the gradual retraction upwards of the retraction ring. ROSSA (1900) believes the ring to be a sphincter, and the ordinary sequence of events which come under clinical observation lend the view support. When the membranes rupture, there is usually a gush of water. Water thereafter escapes repeatedly in smaller quantity during several pains (SMELLIE 1752) and then ceases altogether, until the child is born when, as SMELLIE observed, there is a final rush of amniotic fluid, unless, as sometimes happens, it is retained until efforts are made to express the placenta. If, after the early discharges have ceased, the hand is introduced into the uterus, an escape of water usually occurs, as the hand enters into the cavity of the active portion of the uterus. The opinion of SMELLIE (1752), RITCHIE (1865), LAHS (1877), NORRIS and DICKINSON (1896), JELLETT (1905), and others that the head acts as a ball-valve is difficult to confirm, after the cervix is fully dilated and the head has descended below the plane of engagement. It was long ago recorded that, in the/

the vagina, there is a space readily admitting the fingers on each lateral aspect of the head (SWAYNE 1893), while BARBOUR'S statement that the observed space in the vagina is created by the fingers does not speak well for the efficiency of the vaginal canal as a hindrance to leakages of fluid. These circumstances, therefore, indicate the presence of a close sphincter at a higher level, and the most likely situation is where the retraction ring encircles the body of the fetus. If that be so, then the gradual retraction upwards of the ring will inevitably favour a displacement of the liquor amni towards the fundal pole of the uterus. The preceding paragraph extends the mechanism suggested for the independent displacement of small parts of the uterine contents to explain the displacement of the liquor amni. This displacement is due mainly to the constrictive action of the uterus, and possibly to the retractive action of the uterus in a lesser degree. In all probability, the displacement proceeds by degrees with the successive pains, the return movements in the intervals never being completed to the previous conditions.

A further item in connection with the action of/

of the fundus I have deferred till now, as it is entirely speculative in origin. If the fundus were the cause of the expulsion of the fetus, it would be necessary to suppose that the fundus is then stronger than the lateral walls of the uterus. In this event it is conceivable that a tendency would develop towards partial inversion of the uterus, and also towards a return of the fetus more or less to its primitive curved attitude. The former possibility would be injurious, the latter wasteful of power; and as any organic mechanism which contains obvious disadvantages to the individual is a priori improbable, the theory of fundal action stands in need of the strongest possible proof, before it can meet with acceptance.

Under the constrictive and retractive action of the uterus assisted, it may be, but not necessarily, by the constrictive action of the abdominal muscles, the fetus is straightened, "stiffened partly through its bones", and elongated, until ultimately it is converted into a slender cylinder of which the bulk is contained under the smallest superficial area (SELLHEIM 1912). Meanwhile and perhaps partly in consequence, any remaining liquor amnii together/

together with the lower limbs is removed to the fundal region of the uterus. By the time these dispositions are reached, the head is born and the hardest part of the labour is over. It is just possible that the head is born without a movement of the fetus as a whole, in relation to the mother. In the absence of further evidence, it is unwise for reasons already given, to assume that the presence of amniotic fluid in the fundal region is associated with a movement of the fetus, as a whole. Whenever the uterine contents are reduced to the most slender cylindrical form, several things may happen, if pressure is maintained continuously, or intermittently. 1. The uterus may rupture. When the presenting part is resisted permanently or unduly at any level in the pelvic canal, the contents continue to be elongated and radially contracted, to an extent depending on the height of the obstruction, the bulk of the contents, and the available room within the abdomen. The process of retraction of the active portion of the uterus may then proceed to such an extent that the passive lower uterine segment thins excessively and tears.

2. The presentation may be changed by the so-called spontaneous evolution of the fetus, as in transverse/

transverse presentations and in cases, where in longitudinal presentations, the head and possibly the breech are arrested at the brim. In these cases it is probable on mechanical grounds that the evolution is set in motion long before the maximum radial contraction has occurred, that is, when the fetus is still more or less curved and before it is greatly compressed. And it is possible the equal or nearly equal elongation of both ends of the cylinder forms an essential part of the normal process of radial contraction and polar extension of the uterine contents. Where the resistance to one pole of the fetus is excessive or unyielding, the tendency is for the one pole to be substituted for the other in the uterine effort to produce radial contraction and bipolar extension. As in the case of twins already cited, the constrictive and retractive action of the uterus seems a more feasible cause or explanation of spontaneous evolution than fetal-axis pressure from the fundus. In a complete and unmodified cross-birth the theory of fetal-axis pressure from the fundus breaks down altogether.

3. Movement in the direction of least resistance may be initiated and completed. This is the course of events in the majority of births, and, as/

as already noted, it either does not begin or, at any rate, is not greatly developed, until after the birth of the head or the breech, when the greater resistance to delivery has been removed. On first thoughts, it may seem impossible that a purely constrictive action should be capable of producing longitudinal movement in a given direction. In a closed tube equally strong at both ends no such movement is possible. The birth canal is, however, open at one end and closed at the other, and LAWRENTJEFF found, as already noted, that the upper end (the diaphragm strictly speaking) has twice the resistant power of the lower, while SELLHEIM (1912) has emphasised the progressive disparity developed in the strong and the weak ends in the course of the birth. When the contents of the uterus have been converted into the utmost cylindrical form, the uterus, and also the abdominal tube, have by no means reached the greatest degree of radial contraction. FOTHERGILL (1895) showed that the radial contraction of the uterus is approximately four times its degree of elongation as measured at the fundus alone. During the expulsion of the last portions of the fetal contents, the uterus continues to act by constriction and/

and retraction, as it was doing before. The fundus sinks then, but the sinking does not appear to be due to a shortening of the active portion of the uterus relative to its transverse diameters. More probably it is due to the rapid shortening of the passive lower uterine segment. There is, of course, an actual decrease of all the diameters of the uterus but the longitudinal diameter is not reduced proportionately to the transverse diameters. When, therefore, the contents have reached their maximum degree of constriction, no further elongation can take place, and, as the uterus and in most cases the abdominal muscles go on constricting, the radial pressure which up to this time was developing its longitudinal resultants in both directions now finds one of these avenues closed, and it tends inevitably to develop a single resultant in the direction of least resistance - the lower pole. The mechanical conditions at this time do not imply a severe strain on the maintenance pressure of the fundus and on that of the diaphragm, as the resistance at the lower end of the canal is already low. Probably, the accommodation of the remaining liquor amnii at the fundus, when it is present, favours the development of this resultant/

resultant, as being fluid it permits of greater constriction of the uterus behind the fetus, and in cases where the fluid is absent, the strength of the resultant progresses rapidly, once the uterus is able to obliterate its cavity by constriction behind the fetus. In practice, at this stage the voluntary action of the recti abdominis is most efficient in hastening the final expulsion of the fetus, partly by contraction in their whole length and partly by their upper parts being stronger than the lower (LAWRENTJEE). And when the head is the presenting part, the radial measures of the fetal body diminish from below upwards, and possibly assist expulsion by a wedge-like action. And as the radial diameters of the fetal body diminish from the shoulders to the breech, the final expulsion of the body in a case of head presentation may be assisted by the wedge-like reaction of the body of the fetus. In breech presentations the frequent slowness of the labour has been attributed to a relative inefficiency of the breech as a dilator. In addition, however, the delay may be due to the wedge-form of the body being reversed, so as to present diameters that grow successively larger.

Frozen sections, provided they are admitted to represent the conditions of life, as I expect/

expect here they do, confirm rather than otherwise the views developed in this section on the importance of the constrictive action of the uterus, as opposed to a special fundal action. In BRAUNE'S second stage section, in which rotation is not ended, the active portion of the uterus has approximately the same length as the active portion of the uterus in BENCKISER'S section from the end of the third stage. The positions relative to the maternal body in each case, however, are different. In BRAUNE'S section the active portion extends from the promontory to the top of the third lumbar vertebra; in BENCKISER'S the active portion is nearly the depth of a vertebral body lower down. In the section by ZWEIFEL, and in which the head is born, the active portion of the uterus is rather longer than is that of BRAUNE'S. It extends over three and a half vertebrae, namely, the fourth, third, and second vertebrae, and half of the first vertebra, so that it lies at a still higher level. In this section the fetus appears to have reached its greatest degree of elongation, and the feet are extended above the breech. Above the feet the fundal portion of the uterus, as seen in mesial section, is triangular in shape, produced to a sharp point/

point, and solid throughout for a distance equal to that from the middle of the third vertebral body to the middle of the first. The antero-posterior diameters of the cavity of the uterus diminish quickly from the level of the retraction ring to the topmost limit, that is, throughout the active portion of the uterus. In BENCKISER'S section, already referred to, the cavity as seen mesially is represented by a narrow longitudinal slit, extending nearly the whole length of the active portion of the uterus. In a section made by WEBSTER from a woman immediately after delivery, the length of the active portion of the uterus is nearly the same as that in BENCKISER'S section. So also is the length of the cavity, but it is more open than in the latter section. In both WEBSTER'S and BENCKISER'S sections the thickness of the fundal wall, between the topmost limit of the cavity and the external surface, is only about half that of either the anterior or the posterior wall. These data, then, speak for the constrictive and retractive action of the uterus, and not for the special activity of the fundus. They indicate that the fundus is weaker than the lateral walls, and that the actual shortening of the active portion of the/

the uterus on the final expulsion of the contents is much less than might be supposed, and indeed is so small as to render a special expulsive act of the fundus improbable.

§. 8. Seeing that the uterus in a state of contraction approaches to the cylindrical form, that it has an upper strong end and a lower weak end, and that the intrauterine pressure is, at least, potentially hydrostatic, it follows that a line drawn along the central axis of the uterine cavity will represent with considerable accuracy the position and direction of the sum of all the pressures within the uterus. This line, if prolonged, will intersect the circle of the more or less dilated os, and also more generally the circle of the girdle of resistance, in each case through its centre. This central point is conveniently known as the centre of pressure. If, now, it can be shown that the centre of pressure is also situated, in all cases and at all times, at the centre of the greatest circle of the presenting part, then the study of the direction of uterine pressure relative to the pelvic canal becomes a matter of no practical importance for the theory of internal rotation. If, on the other hand, the centre of pressure is found to be sometimes, even if not always, placed eccentrically in the greatest circle of the presenting part, then the direction of uterine pressure in those cases, in which the centre of pressure is asymmetrically placed in the greatest circle of the/

the presenting part, will influence the direction of internal rotation in a determinate way, and its estimation, relative to the pelvic canal, becomes a necessity for the theory of internal rotation. The proof of the variable position of the centre of pressure in the greatest circle of the presenting part will be given in the next section. At present I anticipate the conclusions of that section by stating that the centre of pressure not only need not be concentric in the presenting part, but is frequently eccentric and this eccentricity, so far from being irregular, is a part of the essential conditions of normal labour. From these primary considerations we turn to the determination of the direction of uterine pressure, or uterine-axis pressure as it is often called.

The direction of uterine-axis pressure has been, and is still, assumed by the majority of obstetricians to be at right angles to the plane of the inlet, by which I think they mean the plane of the conjugata vera, though in many pelves the plane of the true conjugate and the plane of the brim, properly so called, are not coincident. It stands as an acceptable probability on the assumption that the upper portion of the pelvic canal is approximately/
ly/

approximately cylindrical, and that the axis of the upper portion of the canal intersects the plane of the inlet at a right angle. These views necessitate a strict adherence to the belief that the axis of uterine pressure, must invariably coincide with a perpendicular let fall on the plane of the inlet and with the axis of the upper portion of the canal, for, given a deviation of the uterine axis from the pelvic axis, the delay to advance is then proportional to the cosine of the angle of deviation, and the amount of additional force wasted on the walls of the canal is equal to the product of the force and the sine of the same angle (GALABIN and BLACKER 1910). The statement, when taken by itself, is without doubt correct. It is in the application of the two fundamental propositions to the human body that doubts arise. It has not been shown that the upper portion of the pelvic canal may be regarded as cylindrical for practical purposes, and even if this supposition is correct, it has not been proved that the axis of the upper portion of the canal cuts the plane of the brim at a right angle.

The problem in the present thesis is confined to the determination of the direction of uterine/

uterine pressure in the expulsive stage, which occurs normally when the presenting part is in that portion of the pelvic canal extending from the lower margin of the upper part of the superior moiety of the canal to the vulvar outlet, for, as a rule, the upper part of the superior portion is traversed by the presenting part during pregnancy, or in the first stage of labour. In those cases in which engagement is delayed until the expulsive stage has begun it does not appear that the mechanism of entry, including the direction of uterine pressure, has any permanent effect on the position of the presenting part, except possibly in cases of antero-posterior presentations. In the section on Internal Rotation it will be argued that the direction of rotation is finally determined by the direction of uterine pressure, when the presenting part is below the upper part of the superior portion of the canal, so that in all cases with the possible exception just mentioned we are concerned with the relation of the direction of pressure to the lower part of the pelvic canal. For a comparative standard to which to refer the direction of uterine pressure, the pelvic floor or the outlet of the bony and ligamentous canal would be the most perfect. But there are great difficulties in the way/

way of defining the mechanically operative parts, and of determining their inclination to the horizon. Hence it is still most convenient to refer the direction of uterine pressure to the conjugata vera, even though during the most critical period of the labour the conjugata vera is not concerned in the mechanism.

I. SMELLIE (1752) states that the os uteri is usually to be found in a straight line with the fundus and a point midway between the umbilicus and the ensiform cartilage. (I. 304). (Cf. also I. 69, on DEVENTER'S views). This remark seems to be the foundation for the assertion of SCHATZ (1870) and DUNCAN (1875) that SMELLIE held the direction of uterine pressure to be inclined behind the axis of the inlet, though DESSAIGNES (1894) and VARNIER (1900) hold that SMELLIE (with the aid of CAMPER) figured a posterior inclination of the axis. It would appear however, that SMELLIE'S idea was that in this position the axis of the uterus, if prolonged, would fall through the middle of the pelvis. He seems to have had only vague notions about the inclination of the brim, or the direction of a pelvic axis, and could not be expected to attempt an exact estimation of the relations of the uterine-axis pressure to the pelvis, even/

even if he had realised the possibility, or the value of doing so with the exactness now demanded. A perusal of the history of the subject given by VARNIER rather supports this opinion. Some of the older writers did not trouble to make their pictures tally with their descriptions, and those of their drawings which VARNIER reproduces are so crude, that they can hardly be handed in at the present day as evidence of the direction of uterine pressure.

GUILLEMOT (1837), KIWISCH (1846), and SPEIGELBERG (1867) consider the expulsive powers to drive the head against the anterior wall of the pelvis, and hence to act downwards and forwards. KIWISCH gives as factors the force of gravity, the position of the anterior abdominal wall, the direction of the expulsive powers especially the abdominal, the position of the child's body, and the projection of the promontory. In accepting the forward as well as downward direction of the expulsive powers, KIWISCH is only acting consistently with his anatomical view of the pelvic canal, in which the most important item is the want of coincidence of the axis of the inlet with the axis of the upper portion of the canal, the latter being inclined downwards and forwards relative to the brim, and being more important/

important mechanically than the former. KIWISCH'S description of the pelvic canal has already been detailed. (vide Section I.).

II. SCHULTZE (1858) sustained the view that uterine axis pressure is normally inclined obliquely to the plane of the inlet, so that the axis falls in the region of the anus, and he believed perhaps without sufficient reason that, whenever the inclination of the canal is greater than the normal, the axis of uterine pressure falls anteriorly to the anus. SCHULTZE was acute enough to see that the direction of a force cannot be changed, a fact which DUNCAN (1868) emphasised in another connection, and SCHULTZE sought a cause for the observed change of direction of the head in the bend forwards of the sacrum and ligaments, the corollary being that the more the head is directed forwards the further back is uterine pressure applied to it. He further inferred that the more obliquely uterine pressure strikes the pelvic floor, the less the floor is strained, - an observation, the truth of which my experiments seem to confirm. In 1867 and again in 1908, SCHULTZE repeated his views on the direction of uterine axis pressure, and detailed his experiments in the dead body to determine the effect of extending the lumbar spine on/

on the direction of pressure. His conclusions are that extension of the spine favours oblique action of the uterus, the more oblique is the line of action the less pressure is lost in any part of the canal, and more generally the direction of pressure changes with the posture of the woman in labour. The last remark was made in reply to BUMM (1905) whom SCHULTZE quotes that the direction of pressure is not affected by the position of the woman, but always tends towards the area of least resistance. SAMUEL (1908) takes a similar view to SCHULTZE that the direction of pressure is obliquely inclined when the lumbar spine is extended.

III. Another method employed by SCHULTZE was to take profile drawings of the woman in late pregnancy and early labour. The position of the pubo-spinal level was determined, as well as its angular distance from the brim of the pelvis, and marked on each chart, together with the position of the fundus. From the charts conclusions were drawn regarding the relation of the axis of the uterus to the plane of the brim, Obviously, these conclusions cannot be permitted to apply to the condition of affairs in the second stage. KÜSTNER'S (1885) and SEIGNEUX'S (1901) experiments which were similar in/

in principle and differed only in detail need not be referred to more fully for a similar reason. DUNCAN (1875) in raising objections to the obliquity of uterine-axis pressure, argued against SCHULTZE that the fetus fully occupies the canal, it has a nearly uniform consistence (which in view of his other statements is a trifle sophistical), and therefore a change in the direction of uterine pressure can have no effect on the mechanism. The main objection to SCHULTZE'S views appears, however, to be that he boldly transferred the results of experiments in the dead and in late pregnancy or early labour to the second stage. KUSTNER and de SEIGNEUX did not go beyond their data, and therefore do not come under criticism. But if the profile method is to yield further results, the difficulties of its application to the second stage must be overcome, and its technical details must be improved. OLSHAUSEN (1870) also determined the direction of uterine-axis pressure in late pregnancy, and appears to have taken the view that the uterine axis is normally inclined forwards from the axis of the brim, in direct opposition to the opinions just recorded. So far as it goes, this does not matter. But, OLSHAUSEN goes on to say that the appearances of the child's head after birth are a/

a strong argument for the anterior inclination of the uterine axis which he, therefore, evidently believed to continue so in the second stage. De SEIGNEUX (1901) quotes the results of similar investigations made by MARTIN and KREIS, and apparently till then unpublished. The sources of error inseparable from this mode of deduction will be enumerated in Section 4. They appear to me of sufficient importance to render the method of little or no value.

IV. A study of the exact mode of presentation of the head has been used to fix the direction of uterine axis pressure, the criterias being the position of the sagittal suture relative to the successive planes of the pelvis, and in practice the relative degree of advance of one or other parietal eminence. So far as I am aware, evidence has been led only on the disposition of the parts during the mechanism of engagement, and confusion has arisen through attempts being made to compare the observations taken from normal pelves with those from contracted pelves. In the former engagement is generally a phenomenon of late pregnancy, or the first stage, in the latter entry is usually though not always effected during the expulsive period.

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The complexes of factors in the two groups are thus more or less different. In the first or normal groups the investigations have been made chiefly by de SEIGNEUX in 1896 and again in 1901, by FARABEUF (1886) who showed by experiment that the head engaged more easily with a posterior obliquity, and by PINARD and VARNIER (1892). The last authors state that SMELLIE described a posterior parietal entry which is corrected on engagement. While SMELLIE gives a description of what is to all appearances NAEGELE's obliquity. I have been unable to discover anything which will bear the interpretation which PINARD and VARNIER give. These authors postulate a posterior obliquity of the head only during engagement. They distinctly state that at the end of engagement the deviation is corrected, and does not exist during the expulsive stage. De SEIGNEUX appears to take a similar view.

In the second or abnormal groups, MICHAELIS (1851), LITZMANN (1870, 1871, 1872), VEIT (1879), GOENNER (1894), FARABEUF (1894), PAZZI (1895), and many others have described the lateral obliquities occurring during engagement, but it does not appear that any one of them was led thereby to infer the direction of uterine pressure, as others have tried to/

to do. The remarks made in connection with OLSHAUSEN'S deductions apply equally well here and in addition, the disposition of the parts may be, and often is, complicated by the occurrence of flexions of the uterus and independent lateral flexions of the fetus to an extent, sufficient to render the evidence derived from this mode of enquiry of no value at all for the determination of the direction of uterine pressure, more especially in the second or expulsive stage.

V. KÜNECKE (1869) based his conclusions on a foundation composed of assumptions. He assumed the normal inclination of the brim to be 60° , and the normal inclination of the uterine axis to the horizon to be 30° . He projected lines to represent the brim and the uterine axis, and then proceeded to show that, if the lower and anterior end of the former is joined to the lower and posterior end of the latter by a line drawn to represent the horizon, a triangle is formed, of which the two lower angles together form a right angle. The third angle must then be rectangular and it is the angle which the uterine axis makes with the plane of the brim, hence the direction of uterine pressure is perpendicular to the plane of the inlet.

It/

It cannot be said that KUNNECKE'S determination is a valuable contribution to the problem. But, in fairness to the author it must be said that, in 1869, the variations of pelvic inclination, and of the uterine axis were not so well grounded as they were a few years later. Possibly, KUNNECKE intended only an ideal construction, in which case it ought not to have served as the basis of a wide generalisation.

VI. The value of evidence, derived from post-mortem examinations and from frozen sections, depends chiefly on the extent to which these preparations represent the conditions of life. This problem has occasioned much controversy. In the earlier days of frozen sections, there was a tendency to believe that they reproduced the living state with no material alterations, in spite of the warnings of anatomists and others who had no theories relative to the direction of uterine pressure. The anatomical plates of HUNTER (1773) and of SMELLIE (1764) (VARNIER (1900) and the reproductions of frozen sections from late pregnancy and from labour show the uteruses inclined backwards from the inlet, that is in a condition of retroversion. And on these appearances, PINARD and VARNIER (1892) based their chief argument for posterior parietal entry, though already SCHROEDER (1886), STRATZ (1886), and BRAUNE/

BRAUNE (1890) had maintained that the retroverted appearance of the uterus was a condition or a consequence of death, while BARBOUR proved that it is not due entirely to the circumstance of the body being manipulated in the dorsal horizontal position, for in a body frozen in the erect attitude retroversion was present. The writers just quoted, held that in life the uterus is in a position of relative anteversion, if not all the time, at least certainly during a uterine contraction; and I think the majority of later authors have agreed with their conclusions which, of course, are necessarily founded on general evidence. As to the cause of the anteversion there is still however, room for doubt. Like PINARD and VARNIER, BARNES in 1883 advocated the retroversion of the uterus on sectional evidence in primiparae, though he admitted that anteversion probably occurred in multiparae. In 1885, BARNES developed his mechanism of a lumbo-sacral curve in conjunction with the curve of CARUS, on the evidence of frozen sections. DOORMAN (1895) appears to have accepted the sectional appearances as valid before the pains begin, the uterus being bent and moulded on the spine during the engagement of the head. De SEIGNEUX (1901) has summed up some of these views and/

and others as well. And in spite of the fact that frozen sections appear strongly to support his views on posterior deviation of the uterine axis during engagement, de SEIGNEUX considers the sections of no value for his purpose, chiefly on the grounds that the mobility of the uterus is quickly recognised clinically during life, and similar movements cannot safely be excluded from occurrence either during the process of death, or during the freezing of the body—an argument which appears to be equally valid for the second stage.

VII. RITGEN (1855) observed that the diaphragm is fixed in position during the time of a uterine contraction by the holding of the breath, and he inferred that intra-abdominal pressure is directed at right angles to the perineum, so as to hinder rotation, but the curve of the canal trending forwards helps to overcome this difficulty. TYLER SMITH (1858) who believed uterine pressure to be most efficient during the first stage, when it is directed at right angles to the plane of the inlet, states that during the second stage the direction of pressure is changed by the addition of abdominal pressure, and is then inclined downwards and forwards towards the outlet of the canal. After referring to excessive anteversion and/

and retroversion of the uterus as causes of delay, he remarks that the woman in labour moves herself instinctively "so as to throw the axis of the uterus into the axis of the canal". HODGE (1864) took rather a one-sided view of the resultant of abdominal action. When the uterus contracts, it is driven forward by the abdominal muscles and by the diaphragm acting through the liver, this special pressure being increased by the woman in labour bending forwards. In effect, the axis of uterine pressure is brought into the axis of the inlet, thus implying a pre-existing condition of retroversion of the uterus. And, when the head is in the outlet of the vagina, the intra-abdominal pressure is still acting in the axis of the inlet. KEHRER (1864) who, as already observed, attached most importance to the action of the direct abdominal muscles gave the outlet as the direction of the resultant force. According to SCHATZ (1870) the axis of uterine pressure is perpendicular to the inlet at the beginning of labour, but it moves back later, owing mainly to the action of the abdominal muscles. The uterus appears to be regarded as a rigid system during contraction and its axis as being intrinsically constant, while its direction/

direction can be modified by the action of the abdominal muscles and the diaphragm. The lateral abdominal muscles act equally in opposition and are therefore ruled out, the diaphragm acts parallel to the spinal column, while the anterior muscles act horizontally backwards. The resultant is inclined at 45° to the horizon and at 100° to the plane of the inlet, the latter being evidently taken as a constant at 55° to the horizon. Hence, the axis of uterine pressure is inclined 10° behind the axis of the inlet in the second stage. This view of abdominal action is incomplete in several ways, and it by no means warranted the assurance with which SCHATZ put forward the resultant. LESSHAFT had already expressed a different opinion on the action of the diaphragm—that it acts downwards and forwards (LAWRENTJEFF 1885) and as regards the combined abdominal action later writers arrived at a different conclusion. SAPPEY (1876) drew the resultant from the navel to the sacro-coccygeal articulation, a line corresponding in most cases to the axis of the inlet. LAWRENTJEFF (1885) from his careful analysis of the individual muscles making up the abdominal combination, arrived at a similar resultant, that is one perpendicular to the plane/

plane of the inlet. The diaphragm acts downwards and forwards at an angle of 47° to the vertical line passing through the centre of the diaphragm. The anterior wall of the abdomen acts downwards and backwards because the upper portion is stronger than the lower - at an angle of 84° to the vertical. The final resultant is then directed at an angle of 89° to the plane of the brim. The lateral walls of the abdomen act in direct opposition to one another and their force is exploited in the horizontal diameter of the abdominal cavity and ultimately expended in its long diameter, thus reinforcing the resultant of the direct muscles. SCHMIDT (1893) criticises the resultant of LAWRENTJEFF, on the ground that there is no true antagonism between the anterior and posterior groups of abdominal muscles, owing to the presence of the spinal column. Contraction of the muscles, according to SCHMIDT, raises the general contents pressure in the line of the long axis of the abdomen and forces the uterus and its contents backwards, the movement being greatest at the fundus. LAWRENTJEFF in determining his resultants, if I take his meaning correctly, did not divide the broad muscles into anterior and posterior groups, but into lateral groups, a right and a left, and he placed the/

the resultant in the horizontal diameter of the cavity. There is, however, a difference in the activities of the anterior and posterior portions of each lateral group, and the difference ought to be taken into account for the resultant. The posterior portion, being close to and intimately connected with the spine, has a limited range of movement. In the beginning of an abdominal contraction, it is forced backwards to some extent, and then exercises a kind of passive resistance during the remainder of the general contraction. The anterior portion has a greater range of movement, and moves strongly backwards, along with the recti muscles, during the earlier part of an abdominal contraction, and then maintains itself in a state of tonic contraction during the rest of the "pain". Hence, the resultant of the lateral groups of muscles extending on each side from the margin of the recti in front to the margin of the spine behind appears not simply to be directed inwards in the horizontal diameter of the cavity, but to be also inclined backwards, with an ultimate resultant in a line running downwards and forwards towards the axis of the inlet, which would be maintained so during the persistence of the tonic contraction/

contraction of the abdominal muscles. Even if the calculation of the directions of the individual resultants be reasonably possible, there still remains the problem of the direction of the ultimate resultant compounded of the others, the greatest difficulty in the determination of which being to make reasonably accurate allowances for the relative strengths of the several groups of muscles. LAWRENT-JEFF made an allowance, in the calculation of his resultant, for the unequal powers of the diaphragm and the anterior wall of the abdomen, but, even in this simple form and where an error of say 5° may alter our conception of the mechanism, it cannot be said that the method of making the allowance is sufficiently precise. Addition of the other primary resultants, with allowances for relative strength by the same method, will not make the final resultant anyway nearer the truth. Lastly, we reach that general source of erroneous conclusions - the assumption of a constant angular inclination of the plane of the brim. It will thus be seen that the determination of the resultant of abdominal pressure promising though it looks at first, holds out no more hope of fixing the direction of uterine-axis pressure than the methods which have been described already/

already.

VIII.

In the course of time many opinions have been founded on clinical observation and have been given expression. Necessarily they are vague, being mostly confined to general estimations in such terms as retroversion, anteversion, and coincidence of the uterine axis with the axis of the brim. Most have accepted the view that uterine-axis pressure is coincident with the axis of the brim. VELPEAU (1835) held the uterus to erect itself, during a pain, into the axis of the brim. WEST (1857), LEISHMAN (1864), TARNIER (1865), DUNCAN (1868, 1875), HEGAR (1870), LAHS (1870) OLSHAUSEN and VEIT (1893) SCHMIDT (1893) BARBOUR (1895) de SEIGNEUX (1901), and others argued in favour of coincidence of the uterine axis with the axis of the inlet, while TYLER SMITH (1858) PARVIN (1895) and BARBOUR (1899) conclude the uterine axis coincides with the axis of the upper pelvic cavity, or with the axis of the bony pelvis. Anteversion was held to be normal by FARABEUF and VARNIER (1891), by OLSHAUSEN (1870), and, at least in the first stage, by FRITSCH (1894). Retroversion was defended by TYLER SMITH (1858), BARNES (1885), DEMELIN (1903, 1904), BERTHAUT (1908), and GALABIN and/

and BLACKER (1910). DEMELIN and BERTHAUT believed the fetus to be propelled downwards and forwards, especially when the parturient woman lies in the dorsal position; and GALABIN ends with the conclusion that uterine axis pressure is, on the whole, inclined behind the axis of the inlet. Changeability in the direction of uterine pressure is considered by CASEAUX (1868) and by FRITSCH (1875) to render exact estimation of the direction impossible, though CASEAUX considers the direction to become more oblique and more active, as the labour proceeds. FRITSCH finds the endless variety of uterine direction to be due largely to variations of pelvic inclination, and to variations in the position of the vertebral column and of the lower limbs, but he decided in 1894 for anteversion. GARRIGUES (1902) and FABRE (1910) believe retroversion to be normal in primiparae and anteversion in multiparae.

As might be expected, the clinical method has given rise to a diversity of views amongst obstetricians, and in the case of some observers at least their opinions have fluctuated in the course of time. Clinical observation, then, has little or no value, except to reveal the trend of opinion. It has not even been able to say definitely anteversion retroversion/

retroversion, or coincidence.

IX.

The use of the Roentgen rays to obtain a profile photograph of the parturient woman has also to be considered, more perhaps with reference to the future than the present. De SEIGNEUX (1901) states that the rays have not given satisfactory results during pregnancy. In labour a serious difficulty remains for the present in the length of exposure which is required, and it seems that a distinct shadow of the pelvic bones cannot be obtained, except when the woman is laid in the prone position. (FABRE 1910). These are imperfections which will no doubt be overcome.

§9. While it is impossible with the methods so far employed to determine with precision, at any period of labour, the direction of uterine pressure, it is important, nevertheless, to examine the evidence relating to the phenomena which take place during a "pain", and more especially as to the axial changes which are believed by many to occur during a uterine contraction. The problem is the manner in which the uterus operates relative to the pelvis and the pelvic floor. And as the sequence of events from the correction of an extreme example of/

of anteversion, such as MICHAELIS remarked in 1851, to the complete engagement of the lower pole (in the sense of VARNIER) may be delayed till the expulsive stage, it is necessary to include as well the mechanism of engagement under the expulsive powers. For practical purposes, we may rank the phenomena in two grades of the same state - the correction of pathological anteversion, and the mode and direction of action of the powers after engagement is complete.

The uterus is anchored "ringwise" within the pelvis, partly by the vagina and surrounding tissues, and partly by ligaments of which the most important are the paired round and broad ligaments. HOMBURGER (1885) states the former to hypertrophy during pregnancy and to begin contracting weeks before labour pains are manifest. Most writers consider the round ligaments to pull the fundus forwards, and the broad ligaments to pull the cervix backwards during a contraction. TARNIER (1882) records that the erection of the uterus by the action of the round ligaments has been verified in animals. Whether the action of the round ligaments in the human subject can be safely inferred from the observed facts in the lower animals is not evident. AHLFELD (1903), in discussing the data derived from inspection/

inspection at CAESAREAN sections, states that the round ligaments contract and pull the uterus downwards and forwards, but it does not follow from this that they are able to do so, when the abdominal walls are active. Notwithstanding the views antecedent to his time, HOMBURGER considered the anteparturition contraction of the round ligaments to effect the engagement of the lower pole of the uterus within the pelvic canal before labour. It would appear, however, that the unresisted action of the large and the round ligaments while tending to approach the uterine body to its attachments, would more quickly produce a condition of anteversion. Hence it becomes necessary to seek another factor or other factors, and the most apparent factor is the temperate resistance of the abdominal walls, when it is present. The combination of the resultants of the actions of the ligaments and of the resistance of the abdominal walls may favour an ultimate direction coinciding with that of the upper portion of the pelvic canal. But, it is necessary to think of the absence of abdominal resistance, and also of less evident possible factors contributing towards the resultant engagement. One of these is the force of gravity. In the presence of normal abdominal resistance, it may operate, as do the round ligaments and/

and regardless of the position of the body, provided it is more or less upright. On the other hand, wanting abdominal resistance and in the erect attitude, gravity would obviously favour anteversion, but the difficulty may be, and probably is, overcome by the excessively erect attitude of multiparae, and by the flexed or cowering attitude of primiparae, both being dependent, to a great extent, on the position of the centre of gravity (DUNCAN 1868); that is on the relative situation of the uterus anterior to the appearance of effective contractions in the ligaments and anterior to the "active dilation" of the pelvic canal (TARNIER 1882). The possibility of the action of gravity in the process of engagement is, I suppose beyond question; the measure of its effect however, is open to discussion. Perhaps it is alone capable of producing engagement, when it is associated with a condition of extreme eutocia; but, so long as the gravid woman is going about, its force will always be added to that of the other factors. In passing, I have mentioned one of the secondary factors - the active dilation of the pelvic canal, on which TARNIER has insisted. There can be no doubt that this possibly reflex dilation does precede the descent of the uterus and the presenting part, at least as far as the floor of the pelvis, and by diminishing/

diminishing resistance it must favour the operation of the comparatively light forces of engagement. Given a greater or lesser degree of pendulous belly, the factors just mentioned may be sufficient to procure engagement, in spite of the great stretching to which the attachments of the uterus have been subjected. There is implied, above all, a certain amount of resistance remaining in the abdominal walls otherwise, it is difficult to escape the view that the contraction of the ligaments, in the absence of abdominal resistance, will increase rather than diminish the excessive ante-version. The difficulty of engagement may be overcome in still another way - by excessively inclining the pelvis, until the plane of the brim approaches more or less nearly to the vertical (LOBSTEIN (q. by PARVIN 1895) showed it to be possible). This was KIWISCH'S view. KIWISCH (1846) held it easier to adapt the inclination of the brim than that of the uterus in a case of pendulous belly. In dwarfs, in whom the vertical depth of the abdomen is not sufficient to accommodate the uterus, excessive inclination of the pelvis is a necessary preliminary to the production of engagement (TYLER SMITH 1858). In the opposite condition of excessive retroversion, with arrest of the presenting part on the upper border of the pubis, PARVIN (1895)/

(1895) has shown that posturing of the pregnant woman, so as to make the inclination of the brim more horizontal than it is normally, may cause the lower pole of the fetus and the uterus to slip off the pubis, and enter the pelvic canal. If these naturally aroused measures fail during pregnancy, then engagement is delayed until the first, or even the second stage, and, as will be shown in the sequel, the mechanism of engagement during labour differs in many respects from that which is supposed to occur during pregnancy.

If the lower pole of the uterus and the presenting part are engaged in the pelvis and labour is in progress, we have to consider how the uterus directs itself during a pain, more especially during the second stage. Most writers (VELPEAU 1835, HODGE 1864, HEGAR 1870, OLSHAUSEN 1870, TARNIER 1882, WINCKEL 1887, ZWEIFEL 1893, DESSAIGNES and LEPAGE 1894, PARVIN 1895, BARBOUR 1898 and 1899, VARNIER 1900, AHLFELD 1903, JELLETT 1905, GALABIN and BLACKER 1910 and others) have expressed the opinion that the uterus comes forwards during a pain, as compared with its position during an interval, but they differ as to the cause. Most regard it as due to the contraction of the round ligaments alone, or to the contraction/

contraction of both the large and round ligaments. But HODGE, as it has been already noted, attributes it to the pressure of the abdominal walls and of the diaphragm, acting through the liver, while GALABIN finds the cause in the combined action of the diaphragm and the round ligaments; and de SEIGNEUX (1901) though he considers the various postures and pressures to change the direction of the axis, leaves the final control to the contraction of the abdominal muscles. This aspect of the problem leads insensibly to the opposing views of older authors. SCHATZ (1870) held the abdominal muscles to be far more powerful than the ligaments and to force back the uterus against the spine, in spite of the contraction of the round ligaments. This is also the mechanism SCHATZ finds for the correction of pendulous belly. According to BARNES (1885) and SCHMIDT (1893), the uterus is carried forwards during a pain, and is then forced backwards against the spine by the contraction of the abdominal muscles. For PINARD and VARNIER (1892), the uterus rests on the spine all the time and cannot come forward, unless the abdominal walls are weak. After reviewing these varied opinions, I venture to suggest that, out of the group of complex actions which occur during a pain, each writer has seized that/

that constituent which seemed to him the most striking, or the most important, and in one or two instances the bias of preconceived notions has been at work, while in others the line of least resistance has not failed in attractiveness.

During the second stage it is certain that in the majority of instances the uterus does appear to come forwards in the beginning of a pain, and it does appear to be pressed backwards during the acme of a pain, when the abdominal muscles are developing their greatest effect. But it is a problem of a higher order to determine in how far these appearances have a reality. In this connection it is worthy of note that at one time doubts appear to have attacked Dr BARBOUR. In 1895 he states it is an open question whether the uterine axis ever changes during a "pain," but unfortunately nothing, so far as I am aware, has come of the query, and indeed afterwards BARBOUR represents the generally accepted view.

In the state of repose the uterus forms a soft, thin-walled, malleable body which is moulded in the spinal column in the dorsal posture of the individual, and in the erect attitude when the abdominal walls are sufficiently tense. Whenever these last/

last are relaxed, the uterus in the standing position tends to decline limply on the abdominal walls. In repose, the transverse diameters of the uterus greatly exceed the antero-posterior, and a central line, drawn longitudinally through the uterine cavity from the fundus to the lower pole, is more or less curved, whether the uterus is in retroversion or in anteversion. At the same time, the uterus during life probably never approaches the degree of softness and want of resistance which is evident post-mortem and in the reproduction of frozen sections. The difference can be traced to several factors (SCHROEDER 1886, STRATZ 1886, BRAUNE 1890), such as the displacement upwards of the diaphragm, the sinking of the pelvic floor, and the relaxation of the uterine ligaments which appear in life exercise some persistent quantity of tension on the uterine body. Also the researches of HIS (1878) cannot be overlooked in this connection, for they may apply quite well to the gravid uterus. HIS showed that the non-pregnant uterus becomes retroverted after death, and he attributed the change from the normal anteversion of life to a loss of the blood-pressure-content, as he found that, when the arteries and veins are injected after death, the uterus occupies a position of anteversion similar to that observed/

observed, or palpated during life.

In contraction, the active portion of the uterus, as a part of its functional activity, pulls upon its attachments to the pelvis, as I have already collated evidence to show. The whole uterine body thus becomes a hard "rigid system or body", and a central line, drawn through its cavity from the fundus to the lower pole, will be, if abnormal disturbances are neglected for the moment, a nearly or an absolutely straight line which will take a direction more or less at right angles to the mean plane of the pelvic attachments, wherever that mean plane may be determined. At the same time, the transverse diameters of the uterus are greatly reduced, while the antero-posterior diameters are increased, especially towards the fundus. Also, the round ligaments are contracting and can be palpated in contraction through abdominal parietes which are not over-fat. If now we consider the relative disposition of the parts independently of the influence of the abdominal muscles, we admit an apparent projection forwards of the uterus in contraction, and we also recognise circumstances which are capable of disposing of the reality of the projection, or at least which are able/

greater/

able greatly to modify its degree. The uterine axis has been straightened, and as in repose the curve of the axis, in the most frequent arrangement of the parts whether of anteversion or of retroversion, is most developed in the upper part of the uterus, and is directed posteriorly from below, the straightening of the axis results in a projection forwards of the fundus uteri without there being necessarily any inclination forwards of the axis as a whole. Secondly, the increase of the antero-posterior diameters must distance the anterior wall of the uterus from the central axis and create an appearance of projection, but it does not necessarily imply a projection forwards of the uterus as a whole, or an inclination of the axis in the same direction. For, though the distance of the posterior wall from the central axis may, and probably does, increase as much as that of the anterior wall, it appears invariable to be compensated for, in the beginning of a pain, by the reflex or instinctive hollowing out of the lumbar region of the spine to which, following FRITSCH, I have directed attention in Section I. The asserted capacity of the round ligaments to pull the fundus forwards I have not been able to observe beyond doubt at this stage, and I prefer to believe in greater/

greater consonance with the anatomical appearances that the tractive effort of the active portion of the uterus from its attachments greatly outweighs any deviating pull which the round and large ligaments are able to produce. This view does not detract from the recognised action of the ligaments before the uterus itself has begun to contract with vigour, nor does it minimise the beneficial restraining influence which the round ligaments are presumably able to exercise in resisting undue extension and thinning of the lower uterine segment and vagina. If now abdominal contractions are added to uterine contractions (the phenomena, as already observed, are nearly simultaneous), the uterus has every appearance of being forced backwards against the spine, more especially whenever the recti abdomini contract with vigour. Here again I believe appearances are mostly deceptive. The general effect of abdominal pressure and of the selective action of the recti is to reduce once more the antero-posterior diameters of the uterus - an effect which is still further enhanced by the continued contraction of the uterus itself, as it proceeds from the more or less globular to the more or less cylindrical form. In this case also the reduction of the antero-posterior diameters of the uterus/

uterus may take place without any alteration in the direction of the uterine axis, and there is probably no such change in the normal event, partly because there is no evidence that the retraction of the lumbar column is progressive throughout a pain, and partly because of the nature of intra-abdominal pressure. If the theory of a general-contents pressure, as extended to apply to intra-abdominal pressure, is true, and there is no valid reason for doubting that it is true, then it makes no difference whether the uterus rests on the spine or on the contents of the abdomen. In neither case is it possible to force the uterus backwards, in the first absolutely owing to the complete resistance of the spine; in the second so long as the lateral walls do not yield which they show no signs of doing, and so long as none of the fluid contents of the abdomen is expressed which cannot often be observed in a quantity, sufficient to effect the general result. The third possibility is the presence of a large quantity of gas in the bowel which, by its compression, may allow the uterus to be forced backwards. Such a contingency must be rare in the second stage of labour. In these last passages it will be observed the argument has returned to the dictum of KIWISCH that, during a pain, it is impossible to alter the position of the uterus by pressure directed against it/

it. Further, as I believe the uterus to be superior to the round ligaments in controlling the direction of the axis, so also I follow SCHATZ (1870) to the conclusion that the power of the normal abdominal muscles greatly exceeds that of the round ligaments. And indeed the abdominal muscles would need to be weakened to a very grave degree before they give way to the round ligaments; in any case the contracting uterus as "the primary and throughout the essential power in the birth" is always in place to control the direction of uterine pressure independently of abdominal pressure and other circumstances. Hence, the present argument which has been advanced as far as the available means permit is that, once the lower pole of the uterus and the presenting part are engaged in the pelvic canal, and thereafter during the course of the labour, the observed apparent changes in the direction of uterine pressure during a pain are unreal. This view seems most in accordance with the anatomy and physiology of the parts, and in my opinion it is a great advantage to the development of the normal mechanism of labour, and especially of internal rotation. There are, however, at least two adverse factors which have to be taken into consideration. It is conceivable that the lower uterine segment/

segment and the vagina may be unequally resistant to extension throughout their circumference. One meridian may give way more rapidly and more easily than another, and if the relatively weak portion were confined to one half, or even to one quadrant of the tube, a distortion of the uterine system might be supposed to arise, with, as a consequence, a disturbance of the direction of uterine pressure. A greater retractility of one portion of the uterine body than that of another might have a similar effect. There is more certainty about the second possible adverse factor; it has been investigated by PINARD (1887). If the presenting part, together with the lower pole of the uterus, does not closely fit the superior portion of the pelvic canal, the uterine system tends to incline forwards even during contractions, and disturbances of the position of the presenting part about its vertical axis and eventually of internal rotation are apt to arise. It appears as if the optimal relation of the lower pole to the pelvic canal has a stabilising, controlling, or modifying effect on the action of the uterus and its direction of pressure. Possibly the closeness of the fit acts, as SCHAEFFER (1899) suggests, by fixing or holding the cervix and vagina in one position in the mechanically/

mechanically important diameters of the canal. In practice, these adverse factors are checked by instinctive posturing and by the pressure of the abdominal muscles - generally a slow and gradual process which is exercised in the former during a pain, and in the latter during an interval. It is, however, most important to recognise that the relation of the presenting part to the pelvic canal has nothing whatsoever to do fundamentally with the mode of uterine action. This is rendered certain by the investigations of RÜBSAMEN (1913) and others who have shown that the uterus during the third stage behaves in a precisely similar fashion in this respect to that observed during labour. It is thus evident that the contracting uterus itself is able properly to determine the direction of uterine pressure by pulling upon its attachments to the pelvic canal, and that other provisions are merely adjuvant to hasten the mechanism, when from any cause (e.g. pendulous belly) the uterus has grown in a disadvantageous position during pregnancy.

In the event of engagement being delayed until after the onset of labour, we have generally to deal with a marked example of pendulous belly. In such a case, the uterus obviously is acting at a marked /

marked disadvantage, owing to the necessarily greater extension and weakening of the posterior wall of the lower uterine segment and the vagina. And, perhaps, the result of uterine contractions, together with the direction of action of the round and broad ligaments, that is during the first stage, were it not for a latent factor of which there will be occasion to speak later, would be to increase rather than diminish the state of anteversion. Actually, however, the uterus as a rule slowly approaches towards a position, in which its axis is aligned more or less correctly perpendicular to the mean plane of the attachments, in spite of the direction of action of the ligaments which under uterine control tend to recover their tone, and gradually draw the lower pole of the uterus into the pelvic canal. Instinctive posturing is able to hasten the event which may, however, be delayed by the resistance, offered to the lower pole of the uterus and its contents, by the lumbar column and the promontory, and finally by a contracted brim which is the most common associate of an exaggerated pendulous belly. If, on the other hand, engagement does not occur during the first stage of labour, events take place during the second stage which, perhaps, render its occurrence in the strict/

strict sense unlikely. Expulsion then begins, and therewith usually the action of the abdominal muscles. The uterus continues to act in the usual way and slowly to erect itself; the abdominal muscles cannot alter the position during a pain, but they may gain a little at the beginning of each pain by uterine effort starting a little earlier, as it normally does, and before abdominal general-contents pressure is effective. It is probable that the further restitution is produced, the more effective is the resistance of the abdominal muscles in the intervals, it being difficult to follow in its entirety LAWRENTJEFF'S conclusion that the greater extension of the abdominal muscles is the more favourable to their efficient action (SCHATZ (1872) was evidently not of this opinion). Here also instinctive posturing aids by adapting the inclination of the pelvis to the axis of the uterus. It is only necessary to recall the frequency with which women of pendulous belly try in this country to turn on to their backs during the second stage, and at all stages in the primitive state the habitual use of the crouching position may favour the correction of pendulous belly by the pressure exercised by the thighs on the abdomen, as also it is believed by some to favour the correction/

correction of injurious presentations. (e.g. King 1913). Though the uterus may succeed more or less in coming into proper line with the pelvis at some time during the second stage, it is just possible that engagement, in the strict sense of the lower pole of the uterus, never actually takes place. I am not aware, however, of any exact observations on this matter. But it does not seem a priori impossible that, whenever extrusion of the contents begins, the process of extrusion may be substituted for the descent of the cervix uteri which may then remain above the brim of the pelvis, and connected with it by the greatly extended vagina and uterine ligaments. Such an event will be most likely to occur in association with a contracted pelvis, and the difficulties will not be lessened by the frictional resistance developed by the presenting part against the lumbar spine; the modifications to which the presenting part has then to submit forming a considerable part of the corrective mechanism, the condition from one point of view being recognised clinically as LITZMANN'S obliquity with bending of the fetal cylinder, a collation of circumstances long since denoted as unfavourable. Lastly, labours occur in which/ uterus is clearly evident. The reproductions

which the misdirection of the uterine axis is never properly or completely corrected, and it is in these cases that anomalies may be expected in the position, the presentation, and the dynamic processes of labour. But so refined are the means of correction that persistent deviations are tolerably rare.

§ 10. An early notice of the occurrence of lateral obliquities of the gravid uterus was made by DEVENTER (1701). According to SMELLIE, DEVENTER described lateral in addition to antero-posterior obliquities, and though the latter overshadowed the former in DEVENTER'S mind to both were attributed various difficulties and dangers in labour. These views were vigorously contested by OULD (1742) (fide McCLINTOCK 1876) and LEISHMAN (1864). But the explanation given by SMELLIE (1752) seems fairer to DEVENTER who, no doubt, correctly described what he saw, and only committed an error of judgement in attributing to abnormal obliquities of the uterus faults of the mechanism which were more probably due to contractions of the pelvis. In the reproductions of plates of the gravid uterus, given by VARNIER (1900) from the works of W.HUNTER, SMELLIE and CAMPER, and MOREAU and JACQUEMIER, lateral obliquity of the uterus is clearly evident. The reproductions by/

by HUNTER, moreover, were made from preparations in which the blood vessels had been injected, previous to dissection (cf. HIS 1878). Most, if not all, later writers have admitted the existence of lateral obliquities of the gravid uterus. They differ only on the nature, frequency of direction, and cause of the obliquity, and in a lesser degree on the course of events during a pain. On the frequency of direction a number of observations of a more or less exact nature have been made, and those, to which I have had access, are given in the form of a table as follows.

Table/

TABLE.

AUTHOR AND DATE.	NUMBER OF CASES.	OBLIQUITY PER CENT.			REMARKS.
		Rt. Lat.	Nll.	Lft. Lat.	
Dubois and Pajot*	?	100	76	20	4 Pregnancy
Winckler	1868	800	50	43	7 Labour Pain
Spiegelberg	1867	900	96	0	4 Labour
Parisot	1893	30	57 ⁺	37	3 ≠
Auward	1894	100	55	40	5
Fabre	1910	?	50	20	30

* Quoted by Earnier and Chantreuil (1882).

+ Five of these had only apparent slight lateral obliquity.

≠ One of Parisot's examples was "irregular".

Excluding the figures given by Fabre, of the total number of whose cases I have no note, and averaging the remaining original figures, we obtain approximate percentages for 1929 observations.

These are:-

Right lateral obliquity = 73%

No obliquity = 22%

Left lateral obliquity = 5%.

WINCKLER determined the direction of lateral obliquity by observing, during a contraction, the relative positions of the places of insertion of the round ligaments into the uterus. I have no note of the method, or methods, employed by the remaining observers. And, though the determination of lateral obliquity would appear to be easier than that of antero-posterior obliquity, it cannot be more easy, whenever extreme exactness is required. At any rate, in the absence of further and more precise observations it is safer to attribute the discrepancies observed in the table to faults of method rather than to an excessive variability of the uterine axis, such as FRITSCH (1875) postulates. Even in their imperfect state, however, the observations are sufficient to show a great preponderance of right lateral/

lateral obliquity over all other positions in the coronal plane. DUNCAN (1875), who admits the relative frequency of right lateral obliquity, has determined the angular values of the lateral obliquity in a number of cases. The method adopted was to compare the apparent centre axis of the uterus with a median line joining the symphysis pubis to the sternum. The angles given are 8, 10, 11, 14, and 15, and DUNCAN regards 10° as the probable average value of right lateral obliquity. Of general expressions of opinion there have been many. Among others, LEVRET (1751), DESORMEAUX(?), BOIVIN (1824), MARTEL (1879), PLAYFAIR (1880), TARNIER (1882), BARNES (1885), SCHROEDER and STRATZ (1886), BRAUNE (1890), DESSAIGNES and LEPAGE (1894), VARNIER (1900), and GALABIN (1910) record right lateral obliquity as the most frequently observed condition. On the other side, SCHMIDT (1893^b) favours left lateral obliquity. For HOMBURGER (1885), it may be noted in passing, the left ligament is stronger than the right. According to AUVARD (1894), BOERNER and HALLIDAY GROOM believed the median position of the uterus to be the most common. So far the authors quoted have written, I believe, of lateral obliquity as/

as a real condition. Attempts have been made, however, to show that the observed obliquity is apparent and not real. HERRGOTT (1839) pointed out the inequality in the development of the fundus. The right half, being usually occupied by the breech, is larger and more raised. This view is reinforced in a remarkable manner by the appearance of the anatomical plates, to which I have already referred. The plates all show a greater development, laterally and antero-posteriorly, of the right half of the uterus which appears to project more to the right than the left, without there being, at the same time, evidence of true lateral obliquity. Further, one of BARBOUR'S transverse sections shows the uterus in that instance to be divided into two unequal moieties, the larger right portion being occupied by the limbs and most of the liquor amnii, and the smaller left part by the body and very little amniotic fluid. At the same time, in all these plates the insertion of the left round ligament is higher than that of the right, so that evidence of true lateral obliquity derived from the ligamentous insertions is unsatisfactory. LASAREWITCH (1885) considers the observed lateral obliquity to be due to relative shortness of the vaginal/

vaginal wall on the one side, and to the greater action of one of the round ligaments. But the axis of the uterus is preserved in parallelism to the axis of the brim, as the obliquity is not uterine and, therefore, not real. According to BOURRUS (1891) lateral obliquity is apparent and not real, and is due to asymmetry in the growth of the uterus. When a real inclination appears, it is secondary to the apparent inclination, the uterus tending to drag towards the more developed side. AUVARD (1894) appears to accept this explanation in its entirety. KUSTNER (1912) maintains that lateral obliquity is apparent, and is really a lateral displacement of the uterus in toto, together with torsion.

In the face of the clinical evidence on the one hand, and of the anatomical on the other, it seems wise to assume in the meantime that apparent and true lateral obliquities may occur in the same person, either alone or together; and in the event of both being present, the one may be secondary to the other, or each may have an independent origin.

Various reasons have been advanced to account for lateral obliquities, but it is obvious that, in the absence of exact knowledge of the nature of

of lateral obliquities, none of them can be very satisfactory. LEVRET (1751) attributed them to the position of the placenta; DESORMEAUX (?) to the sigmoid; MADAME BOIVIN (1824) to habitual lying on the right side, the use of the right arm, and to relative shortness of the round ligament of the same side; WINCKLER (1868) to the bowels being on the left side, and perhaps also to the lie of the child; MARTEL (1879) to the presence of the spinal column in the middle line and the lateral pressure of the vault of the diaphragm; PLAYFAIR (1880) to the frequent distension of the rectum; SCHMIDT (1893^b) to the pressure of the lateral walls of the abdomen; while TARNIER (1882) sought a cause in the mesentery, and at the same time pointed out that pelvic tumours, when they become abdominal, also show signs of right lateral obliquity. Possibly, the views of BOURRUS (1891) are nearer the truth than any, unless it happens that TARNIER is correct in his observations of pelvic tumours.

The course of events during a pain, and with reference to lateral obliquity, does not appear to have been the object of much research. DUNCAN (1875) found usually a slight amount of lateral obliquity/

obliquity during a pain, and considers a little generally to persist. According to DESSAIGNES (1894), lateral obliquity diminishes during contraction.

But the uterus comes to the middle line according to SPIEGELBERG (1867), TARNIER (1882), BARNES (1885), and GALABIN (1910). The general view is then that lateral obliquity, if not abolished during a pain, is reduced to the vanishing point. Little appears to be known regarding the mechanical effects of lateral obliquity. Reference has already been made to the views of DEVENTER. GALABIN (1910) states that lateral obliquity is of no consequence unless it persists into the second stage, when it may be a cause of delay. Excessive lateral obliquity, in the second stage at least, must be very rare. Much the same means are available for its correction as for the correction of antero-posterior obliquities, but circumstances seem favourable to the more rapid correction of the former. The problem turns to a large extent on how long apparent lateral obliquity, due to asymmetry of growth, persists during labour. This is a factor about which nothing seems to be known. And as both an apparent and a true obliquity will affect the direction of the uterine axis, its determination/

determination is necessary for a complete understanding of the mechanism of labour. In so far as my experiments go, lateral obliquity, when it does not exceed an angular deviation of 10° , has no apparent effect on the mechanism, and, if it exceeds that degree, injurious results are observed more in the form of delay than in any special selective effect on the mechanism. An angular deviation of 10° probably covers all the lateral error in the majority of labours during the second stage. At the same time slight deviations cannot be without some effect, if the postural treatment of delayed internal rotation is due to this cause. These slighter deviations correspond in degree to the asymmetry of the pelvis noted by JURGENS (1891), and exhibited in BARBOUR'S coronal sections,* and may persist partly in consequence of these slight pelvic abnormalities, and partly as a result of the asymmetry of the uterus, if it is really persistent.

Torsion of the uterus about its vertical axis in WINCKLER'S series of 800 cases was directed to the left in 38%, to the right in 18% and absent in the remainder. According to SPIEGELBERG, in the 865 cases of right lateral obliquity which he observed torsion was present in 163 and absent in 702.

The/

* Especially Plate VI, fig I. (1889).

The torsion was directed to the right. Similar views to the last have been expressed, more generally by TARNIER (1882), DESSAIGNES (1894), VARNIER (1900), FABRE (1910) and GALABIN (1910). VARNIER states that torsion from right to left is exceptional and points out that it is shown in the plate of MOREAU and JACQUEMIER which he reproduces. The causation is obscure. VELPEAU, afterwards confirmed by PINARD as DESSAIGNES and LEPAGE point out, found that torsion is usually inverse to lateral obliquity. WINCKLER believed torsion to be unaffected by the position of the child, but SPIEGLEBERG states that the frequency and direction of torsion correspond to the frequency of entry of the fetus in the first oblique diameter. According to SCHATZ (1904), torsion is increased by the pressure of the abdominal wall; while SPIEGELBERG and DESSAIGNES believe it to be rectified in the birth. It is possible that here, as in the case of lateral obliquity, there is both a real and an apparent torsion. In connection with the causation of the former the views of FISCHER (1887) are undeniably attractive. No effect on the mechanism of labour has, so far as I am aware, been attributed to torsion of the uterus.

To resume the contents of this section
in/

in as far as they concern the direction of uterine pressure, I have endeavoured to show that the direction of uterine pressure is in the strict sense, unknown, and that the generally accepted view of pressure at right angles to the plane of the brim is based on an assumption which I have brought forward evidence to show is erroneous. Further, once engagement is complete, the direction of uterine pressure is remarkably constant during a uterine contraction, as I believe in spite of assertions to the contrary. The constancy of direction has an important influence on the mechanism of labour, and its determination ought not to be so difficult a matter, once means have been discovered of eliminating the effects of apparent variations. The proof of the primary importance of the direction of uterine pressure will be given in the next section. That importance being granted, it becomes necessary, in the face of present ignorance of the true direction of uterine pressure, to consider the development of the mechanism of the second stage under every direction of uterine pressure. As it was pointed out, it would be most natural to refer the direction of uterine pressure to the plane of rotation, but for several reasons the proceeding/

proceeding is inconvenient. And as the plane of the brim (strictly the true conjugate) has long been employed for this purpose, and is the most familiar to obstetricians, the direction of uterine pressure will still be referred to it. In order to simplify matters as much as possible, I think it best to segregate the possible directions of uterine pressure into three inclinations, namely, downwards and forwards, at right angles, and downwards and backwards to the conjugate, the more so as these three directions are capable of producing, or are able to be associated with, three distinctive types of the mechanism of the second stage.

At the same time though direct proof of the direction of uterine pressure is wanting, it is possible, and indeed legitimate, to infer from a consideration of the varied factors connected with the mechanism the most probable direction of uterine pressure, if it is always borne in mind that the result is only inferred and not ascertained. I find by experiment with a model on a plane rubber-sheet and in a canal formed so as to represent the pelvic canal (the details of these experiments are given in an appendix), that less weight is required to produce advance (or descent) and internal rotation, when the pressure is inclined at an angle of 10° - 15° to/

to the plane of the rubber-sheet, or to the plane of the inlet of the canal than at any other angle, and also that, whenever the pressure is directed at right angles to the plane of the brim, or to the plane of the rubber-sheet, the most pressure is required to produce advance (or descent) and internal rotation, and in the latter case repeated experiments proved so injurious as rapidly to wear out and rupture the sheet of elastic. In addition as will be shown more fully later, the proper direction of internal rotation and the least dangerous mechanism of extension are favoured, if not actually produced, by an inclination of the direction of pressure downwards and forwards at the same angle either to the plane of the brim, or to the plane of the rubber-sheet.

Secondly, in the first section of this paper I have given in considerable detail that which appears to me to be the most probable form of the dilated normal canal. The main essentials for the present purpose are that the superior portion of the pelvic canal is not cylindrical strictly speaking; the posterior surface of the symphysis leaves the conjugate at an angle of 100° ; the antero-lateral walls/

walls leave the plane of the brim at the same or an even greater angle; the postero-lateral walls trend forwards at a greater rate than do the antero-lateral walls; and the axis of descent is represented by a line which is closely related to the antero-lateral and the postero-lateral walls, whatever may be the position of the presenting part, whether oblique or transverse. These conditions, then, point to the probability that the normal line of descent in the normal dilated canal is inclined downwards and forwards from the plane of the conjugate and towards the plane of the floor, and the approximate angle of inclination is once more 10° from the rectilinear line. With the coincidence of the direction of uterine pressure with this axis of descent there need then be no loss of power such as DELORE (1865) asserts to be the case, when traction with forceps is not made at right angles to the plane of the brim. Hence, if this view of the pelvic canal be the right one, then the main objection to the 10° deviation of the direction of uterine pressure falls to the ground. While the normal line of descent follows the normal contour of the anterior pelvic wall it is not necessarily determined by it, although any departure from it/

it in the normal pelvic canal is evidence of an error lying somewhere in the mechanism. There is reason, however, to believe that the form of the normal pelvic canal is merely an association with or adaptation to the mechanism of labour, it being remembered that the predominating adaptations of the pelvis and its soft parts are connected with the mechanical requirements of the erect attitude, and only in a minor, though none the less important, degree with the demands of parturition. This being admitted, we have to look further than the pelvis for the ultimate determinant of the direction of uterine pressure (I have not thought it necessary here to repeat the reasons for believing that abdominal pressure has no essential bearing on the direction of uterine pressure), and here we come to grief so far as observation and experiment are implied. All that it is possible to say is the direction of uterine pressure is probably determined by the inclination of the planes of rotation, the direction in which the vagina tends to dilate, and the relative position of the exit of the canal, that is to say, the "locus minoris resistentiae" of KEHRER (1864); the mechanical adjustments being produced by the active body of the uterus pulling/

The Frison Sections especially referred to pulling against its attachments. But why the uterus, or indeed any mobile expulsive machine, should seek to train its pressure on the weakest area is an unsolved problem of physics.

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fl. Flexion denotes a process whereby the presenting part is adapted to the pelvic canal. The process, in a comprehensive sense, consists partly of change of form and partly of movement about an axis which is nearly horizontal in relation to the pelvis. The breech, the shoulders, and the head severally undergo changes which are included within the term. But, the extent of the modifications is least in the breech and greatest in the head, while the shoulders occupy an intermediate position. These differences in degree are correlated with the relative dimensions of the several parts, for, though in late pregnancy, with a head presentation, the breech of

SECTION III.

the fetus forms the larger end of the ovoid, such is not the case as the parts are presented to the pelvic canal. When the head has the largest, and the breech the least dimensions. The amount of change in the parts is, therefore, roughly proportional to the horizontal diameters of the parts, the greatest alterations taking place where the dimensions are greatest. Further, the quantity of change in the breech, the shoulders, or the head is proportional to the relations existing between the horizontal diameters of the individual parts and the horizontal/

FLEXION.

§1. Flexion denotes a process whereby the presenting part is adapted to the pelvic canal. The process, in a comprehensive sense, consists partly of change of form and partly of movement about an axis which is nearly horizontal in relation to the pelvis. The breech, the shoulders, and the head severally undergo changes which are included within the term. But, the extent of the modifications is least in the breech and greatest in the head, while the shoulders occupy an intermediate position. These differences in degree are correlated with the relative dimensions of the several parts, for, though in late pregnancy, with a head presentation, the breech of the fetus forms the larger end of the ovoid, such is not the case as the parts are presented to the pelvic canal. Then the head has the largest, and the breech the least dimensions. The amount of change in the parts is, therefore, roughly proportional to the horizontal diameters of the parts, the greatest alterations taking place where the dimensions are greatest. Further, the quantity of change in the breech, the shoulders, or the head is proportional to the relations existing between the horizontal diameters of the individual parts and the horizontal/

horizontal diameters of the pelvic canal, but, so long as the relative proportions of the three parts are normal, the changes will always be greatest in the head and least in the breech. So far, we have been considering the changes or modifications of the parts, as if they were purely the result of the centripetal pressure of the pelvic canal, but we find that anatomical and physiological provisions exist for conducing towards the changes and that they are also proportional to the dimensions of the several parts, being most elaborate in the head and least developed in the breech, that in point of fact the breech has one kind of provision, and the shoulders two, while the head has no less than three. Further when we inquire into the nature of these provisions, we observe the sole modification submitted to by the breech, is such as might be produced by concentric pressure alone, whereas the changes impressed on the head are such as could not possibly be reached only by pressure, that is, without the existence of specialised mechanical arrangements, and in the case of the head we note that the effect of the mechanical arrangements far exceeds in value that of the simple concentric/

concentric pressure, while for the shoulders, where two provisions exist, it is difficult to determine a superior value for either the one or the other.

We thus see that the anatomical and physiological provisions are most elaborate where they are most required, and most simple where the least difficulty is to be expected. And as the general outline of the parts and the mechanical arrangements for the production of flexion persist throughout life, we may regard them as adaptations to the pelvic canal, as the acquired and inherited products of evolution towards that end. (MUELLER 1907)

Flexion, then, may be produced in three different ways:-

1. By moulding,
2. By a rotation of the parts about a horizontal axis, and
3. By a peculiar radial movement of the parts about a centre which lies outside the parts.

1. Is the only kind of flexion experienced by the breech;

2. Belongs both to the shoulders and the head;

3. /

25. Is confined to the head alone, ~~and has not~~
~~as far as I am aware, been described,~~
~~or at any rate its real significance~~
~~has not hitherto been recognised.~~

Following up the previous line of argument we regard moulding as the oldest and the most primitive form of flexional change, axial rotation as younger and less primitive, and radial rotation as the most recent and the most elaborate form. Though it is possible that moulding may appear at a tolerably early stage of the descent, it is most natural when proceeding to describe the nature and mechanism of the different forms of flexion, to begin with the axial rotation, follow with the radial rotation, and take the phenomena of moulding last of all, considering each mode for the head, the shoulders, and the breech in turn. And in order to distinguish, if possible more clearly, the forms of flexion I propose to call them movements, and to separate the three forms axial rotation, radial rotation, and moulding from one another as the first, second and third movements of flexion.

§ 2. First movement of flexion. Axial rotation of the head. Appearance of true flexion.

Primary/

Primary flexion of Dorland (1907). Rotation of the head about a horizontal axis (flexion of most observers) is the means whereby the chin of the fetus is approximated to the sternum. Most of the older obstetricians regarded flexion as a movement which occurred during the descent of the head through the cavity of the pelvis. They were no doubt led to do so by frequent palpation of the more or less marked dipping of the occiput which occurs during each pain about that time, and this, the most readily evident flexional movement, they were probably led to explain as a rotation of the head about a horizontal axis, so as to approximate the chin to the sternum. At the same time, so far as I can find out, they had no direct evidence that the chin previously was apart from the sternum, or that the movement actually applied the chin to that region. And I fully believe that, whenever these older observers wrote of flexion as occurring when the os was fully dilated, or when the waters broke, they were really referring to another kind of movement (of which the dipping of the occiput is the evidence and to which I shall afterwards have occasion to refer), although they themselves believed they were the/

the witnesses of a true movement of flexion in the sense of directing the chin on to the breast of the fetus. Thus the great difficulty in collating the history of flexion lies in discovering what kind of movement each observer was describing, and whether the result which he attributed to the movement was ascertained, or inferred, and as it is, I am able to understand the situation only by assuming that the general body of observers described several movements under one name, and inferred the results only from the nature of these movements. From this aspect of matters it is apparent that for many years after the foundations of the mechanism were laid the general belief in the absence of flexion at the end of pregnancy, and its production during labour was an inferential conclusion and not an ascertained fact. And this in spite of Smellie's knowledge that the normal fetus is flexed all over, and Velpeau's emphatic assertion that flexion is complete long before labour begins, that the fetus is rolled up on itself, and has the chin applied to the sternum (1835). Later in the century a succession of observations made it clear that flexion was complete before labour, and this view met with fairly/

fairly general acceptance for a time. Among others, HALAHAN (1862) held flexion to be complete before labour, SCHROEDER (1875) believed the chin to be applied to the sternum during pregnancy, TARNIER (1882) considered it generally the case, while HART (1887) asserted that the chin never leaves the sternum in normal labour. BARBOUR (1895) in reviewing 23 frozen sections from before labour, states that the chin is applied to the breast in all except one, in which the head is in the occipito-posterior position, and the separation of the chin from the sternum amounts to one and a quarter inches. From these considerations BARBOUR concludes that flexion is an attitude and not a movement in normal pregnancy and labour, but it may become a movement, if the attitude of flexion has been undone. There can be little doubt that this summing up forms one of the strongest reasons ever advanced for the completeness of flexion before labour, the more so as it is difficult to see how, in this particular matter, the peculiar disabilities of the method can affect the disposition of the parts. This important contribution apparently settled the problem for some time after, in fact until SELLHEIM revived the discussion/

discussion by returning to the opinion advanced especially prior to 1895 by many observers, notably in France, that before labour the head presents in an attitude midway between flexion and extension. DEPAUL (1872) CROUZAT (1887), FARABEUF and VARNIER (1891), DESSAIGNES and LEPAGE (1894), AUVARD (1894), DEMELIN (1903) and in Germany, MUELLER (1885) and MUELLER (1898) have been of this opinion. On the other hand VARNIER, in 1900, states that the chin is on the breast before labour and has been observed in this position as early as the fifth month of pregnancy. In 1904, SELLHEIM states that moderate flexion is present before labour; in 1907, he describes his elaborate experiments on the production of flexion, and from these he makes the deduction that, though the attitude of the fetus in general is one of flexion, yet the head lies midway between flexion and extension, and that flexion is completed on descent by reason of the conical formation of the cavity into which it descends, but the flexion is undone in the interval between every two pains, and when there is much amniotic fluid, the head having in fact, according to SELLHEIM, a natural tendency to extend, to such an extent indeed that, if sufficient/

sufficient room exists, the attitude will be converted into a face presentation. Though much of what SELLHEIM here records is probably true, it is impossible to avoid the belief that the extensibility of the child's neck has become exaggerated in the mind of the author, and that the attitude of the head, described by SELLHEIM as the normal, is by no means universal, or even the most frequent, though it does occur under certain conditions. AHLFELD (1903) had however already deduced complete flexion from the conical form of the uterine cavity, while FABRE (1910) who devoted considerable attention to this subject considers that the head normally presents in an attitude midway between flexion and extension. There can be little doubt that the general desire to regard the head in a position midway between flexion and extension before labour arose, as I have said before, from the difficulty of explaining the intra-pelvic movements, if flexion is already regarded as complete, and that such a difficulty existed is shown by the vague explanations given by those who postulated complete flexion at the brim for the movements which usually occur during descent. Thus VELPEAU (1835) says merely that flexion is increased during labour, SCHROEDER (1875) holds/

holds a movement of rotation to bring down the occiput during descent, PARVIN (1895) is not any clearer than VELPEAU, BARBOUR (1899) suggests a rotation of the fetus, as a whole, round its axis to account for the dipping of the occiput, DORLAND writes of an exaggeration of true flexion and calls it secondary, HART (1912) considers the more rapid descent of the Occiput an appearance only which may be called flexion, and suggests that the sinciput descends to a greater extent than was formerly believed.

The normal arrangement of the parts is such that the chin of the fetus is applied to the sternum during the late months of pregnancy, if not earlier, and throughout the whole course of labour. Clinical experience and the evidence derived from frozen sections determine that conclusion, while the removal of the chin from the breast is the sign of some abnormality, however transient and ineffective it may be in result. The normal attitude of complete flexion is dependent primarily and essentially on the healthy vigour of the living fetus, and is, as BARBOUR puts it, an attitude and not a movement. That is to say, the attitude of complete flexion is a simple reflex, and it can be shown to be evoked by an appropriate stimulus, if for any reason the attitude/

attitude is undone. Secondly, the normal attitude depends secondarily and non-essentially on those conditions, for which PAJOT'S law is the succinct expression, and of which SELLEHEIM'S investigations are the experimental proof. That such is probably the case is the impression derived from a labour which I had under observation. The head was still in the upper part of the pelvic canal, in the most frequent position and presentation, and the relative proportions of head and canal were easy. Expulsive efforts were in progress and were associated in the intervals with an excessive "drawback", if I may so term it, during which the uterus greatly expanded, and the head receded, as if the fetus on the whole was returning, more or less, to its original state of curvature. These drawbacks undid flexion. The sincipital region of the head began its retreat later than the occiput, and the retraction of the former never equalled that of the latter. Matters were uncomplicated by the second flexional movement (dipping of the occiput of observers) which had not as yet appeared even during a pain. When the excessive drawback ceased, there was a slight recoil, like that of a train when it comes to rest, and this/

this was followed immediately by an active movement of the head, whereby the sinciput retreated rapidly and nearly beyond reach, while the occiput moved to a comparatively slight extent, and not to the degree which is required, as I shall later point out, by the second movement of flexion. The active movement of the head ended abruptly with the conveyance to the fingers of the appearance of an unyielding resistance, not in the region of the sinciput, but at a higher level and apparently in the region of the chin. The feeling of a slight impact and of a sudden arrest of motion was succeeded by an impression of, literally, the grinding apparently of the chin on the breast of the fetus. The grinding sensation wore off gradually, and gave place after a slight recoil to a feeling of gentle contact, in the continuation of which no vertical movement could be impressed on the sinciput, without at least disturbing the position of the whole head. When the next pain arrived, there was no impression of retardation of the sinciput, as compared with the rest of the head. The feeling was, however, that the chin then pressed heavily on the sternum, but without that grinding or boring sensation which had been/

been noticed before. Now, these impressions were conveyed to the fingers not on the cycle of a single pain, but during a considerable succession of pains, and the observations, in fact, ended only when the second movement of flexion began to appear, and rendered further inquiry inadvisable. In this case the behaviour of the child's head invited comparison with the mode of action of the sphincter ani.

There was present in the case just recorded, and there is present in the action of the sphincter ani the same gradual rise to an acme of contraction, in which the muscles were and are tremulous in their fervour of action, and this was and is followed by a gradual relaxation, with finally a slight recoil to the position of repose, that is a state of light tonic contraction. In the one a stimulus is known to be required to evoke contraction: in the other a stimulus was forward in the recoil of the child's head, and which was to all appearances the factor determining the movement of flexion. Looking back over this interesting example of parallelism, I have no doubt that the movement of the child's head was a purely reflex act, as much as is the contraction of the sphincter ani; and seeing that everything that/

that was reasonably possible was done to exclude deception, I fully believe that the movement was a true movement of flexion in the sense of approaching the chin to the sternum from a previous position in which they were apart. Further, the second event which gave the impression of the chin being applied more firmly to the sternum without, however, an actual movement of the chin towards the sternum, because to all appearances the chin was already on the sternum, was, if not the actual production of flexion, even in potentia, at any rate the preservation of flexion together with an increase of the pressure existing between the head and the body of the fetus. This second event supervened upon the arrival of a uterine contraction, was indubitably connected with it, and was indeed an example of the operation of Pajot's Law of accommodation. Thus at one period of a single case of labour, owing to the happy combination of an excessive "drawback" and a fairly roomy pelvis, the two chief methods of producing true flexion, as I understand it, were demonstrated almost simultaneously and yet separately. The inference to be made from these observations, and it is generally confirmed by the evidence of frozen sections, is that the healthy vigorous fetus presents above/

above the brim with the head in a state of complete flexion, independently of all extrinsic conditions, while the dead or weakly infant presents with the head between flexion and extension, in the absence of all extrinsic conditions. But as a rule, in the latter case circumstances arise which complete flexion independently of the fetus, and before it has passed the brim. The most important of these is the growth of the fetus to an extent completing its occupation of the uterine cavity, provided the walls of the lower pole of the uterus are sufficiently tense to exercise pressure on the fetal head, and the quantity of amniotic fluid is not so great as to buoy the fetus off the uterine walls. The mechanism of these arrangements will be discussed later, but it may be as well to point out now that all mechanical hindrances to complete flexion intrinsic to the fetus, though they may absolutely prevent flexion, do not evade the probability of the movement of flexion, as is the normal occurrence, from being, at least, attempted. There thus remain, as factors for the presentation of the head above the brim in an attitude of demi-flexion, death or debility of the fetus associated with weakness of the walls of the lower uterine cavity, or with an/

an excessive quantity of liquor amnii. And it is tolerably certain that this combination of factors is of rarer occurrence than its alternative. At the same time, whenever labour sets in with the head in a state of demi-flexion, it is probable that in many of these cases extrinsic conditions favouring complete flexion do not arise until a comparatively late stage of the labour, that is to say, it is quite possible for uterine pressure to be exercised on the head, over a long period, without flexion being produced.

§3. The second movement of flexion. Radial flexion of the head. Appearance of ROEDERER'S obliquity. Secondary flexion of DORLAND (1907).

The second movement of flexion (the dipping of the occiput of most observers) is recognized clinically by the descent of the occiput into the axis of descent within the pelvis. It is the most easily observed, as it is the most extensive movement of flexion to which the head and it may be repeated the head alone is submitted. I feel sure this second movement is that which alone was denoted as flexion, though it was regarded as true flexion by, among others, BAUDELOCQUE (1789) GARDIEN (1824) STOLTZ (1826), DUBOIS (1834) VELPEAU (1835), GUILLE-

MOT/

GUILLEMOT (1837) for occipito-posterior positions, KIWISCH (1846), HYERNAUX (1866), DUNCAN (1868), LAHS (1870), DEPAUL (1872), SCHROEDER (1875) who came nearer the truth than any of his predecessors, CROUZAT (1887), SCHATZ (1890), LUSK (1891), PINARD and VARNIER (1892), PARVIN (1895), DESSAIGNES and LEPAGE (1894), AUVARD (1894), HIRST (1900), WEBSTER (1903), DEMELIN (1903), AHLFELD (1903), SELLHEIM (1904, 1907), JELLETT (1905), OLSHAUSEN (1906), DORLAND (1907), FABRE (1910), and GALABIN and BLACKER (1910), and in greater part by FABBRI (1857 et seq.), HUBERT (1858), RITCHIE (1865), and MARX (1892). Most of these observers stipulated a marked increase of flexion when the cervix was fully dilated, when the waters broke, or when the head reached the pelvic floor. Others have written in similar terms, but their views are expressed rather vaguely.

The second movement of flexion consists of a rotation or sliding of the whole head around the summit of the trunk, and about a centre of rotation which is situated somewhere within the body of the child. It is strictly speaking the appearance of ROEDERER'S obliquity. ROEDERER appears to have described the movement correctly, but I am ignorant/

ignorant of what it was ROEDERER understood exactly by his movement. It is entirely independent in mechanism of the first movement of true flexion, though it is readily understood that the two movements may occur in variable amounts of admixture in a series of labours. In the normal event, when true flexion is complete in the sense of the chin being applied to the sternum, the neck of the fetus is still hyperextended, and the supervention of the second movement of flexion is marked by a straightening, or even by a slight flexing of the cervical spine, together with a sliding of the chin forwards and downwards (in the sense of the fetus) over the breast, and a marked dipping of the occiput so that within the pelvic canal the last approaches more or less nearly to the centre of the pelvis. It is clear that this movement can take place without the chin ever reaching the sternum, and that in the reverse movement the chin need not leave the breast, or need not become more distant from it, if they are already apart, until the maximum degree of movement in the horizontal sense has been reached. Thereafter a continued movement of hyperextension necessarily implies an increasing separation of the chin from/

from the breast, which reaches its limit, when the occiput is applied to the dorsum of the trunk. But, here it is observed that, so far as the chin is a guide, the vertical element has developed disproportionately at the expense of the horizontal element of the hyperextending movement. And indeed, using the chin as an index, we might condense or summarise the differences existing between the first and second movements of flexion by stating that in the former the principal movement of the chin lies normally in the arc of a circle whose chord is placed vertically, and in the latter the principal movement lies in an arc whose chord is placed horizontally, in relation to the long axis of the fetus. It is obvious, however, that these distinctions are not so real as they appear to be, if the movements are carried to extremes, for the chin can reach its position of greatest extension, either directly by a movement of true extension, or by sliding up the chest, until movement is limited in that way, and the chin has, perforce, to be elevated from contact with the breast. In both instances, a circle is described, but it is noteworthy that in the former the centre of rotation lies within the head, and antero/

antero-posterior movement of the head, as a whole, is at a minimum, while in the latter the centre of rotation lies within the body of the child, and the antero-posterior displacement of the head reaches a maximum, though it is partly corrected as the face presentation appears. In the greater number of labours, however, that is in the normal event, true flexion and true deflexion do not betray an angle much in excess of 40° , and the second movement of flexion ranges about 90° more or less. Within these limits which may be regarded as the normal and most frequent, the distinction as regards the chin between movement through a vertical and movement through a horizontal segment of a circle holds good and is valid for descriptive purposes. (SELLHEIM (1907) allows an angular distance of 160° for the antero-posterior movement of the cervical spine, 45° being flexional and the difference, namely 115° , of the nature of extension. KALTENBACH (1891) limits the total movement to 120° or 130° . But SELLHEIM'S figures are more probably correct. The angular distances I have given are those I believe to occur in the normal labour in the left occipito anterior position, and they are derived from the measurement/

measurement of a corresponding movement of the child's head after birth. It represents the movement which takes place from a position of repose to a position of the head like that seen in BRAUNE'S second section).

The second movement of flexion is usually absent in pregnancy and during the first stage, though it may make its appearance, when there is some degree of relative disproportion between the head and the canal, and in the first stage when the cervix is well dilated, especially if the waters under the head are little in quantity. But, as a rule, the resistance of the cervical canal and the upper part of the pelvic cavity is not so great, and it is then only during uterine contractions, that a variable degree of the second movement arises as the head is forced down, though it disappears once more as the head rises up at the end of each pain. After the waters break, the second movement is produced to an extent increasing with every pain, and after the successive pains the disappearance of the radial flexion becomes less and less marked, until a time comes when the second movement becomes an attitude of a more or less marked character.

This/

This condition is reached normally in the lower part of the superior portion of the pelvic canal, and it precedes the movement of internal rotation in the most frequent relation of the parts. Under clinical examination, it is customary to find the two fontanelles nearly on a level with one another before engagement is completed (STOLTZ 1826, DUBOIS 1834, SCHROEDER 1875, NAEGELE and GRENSER 1880), that is, until the lower pole of the uterus reaches the boundary between the two divisions of the superior portion of the pelvic canal. After that time, until the cervix is fully dilated, the relative positions of the fontanelles often do not change, though in many instances some degree of the second movement is produced, either permanently or temporarily, during a pain, and is characterised by the large fontanelle reaching a higher level than the small, and by the head being displaced as a whole, so that the occiput approaches towards the centre of the canal. On rupture of the membranes no immediate change may be apparent (JACQUEMIER 1846, PARISOT 1893), but generally sooner than later a more extensive approach of the occiput to the centre of the canal becomes apparent, and this approximation may either/

either be progressive and permanent, or for a time it may be temporarily obliterated in the intervals of the pains, depending on the relative proportions of the parts, but in the latter case the swinging of the head in each cycle of contraction and pause diminishes with the descent of the head, and, so far as I am aware, is always completely excluded in the lower part of the superior portion of the canal. The effect of the second movement is to place in the centre of the canal a point on the surface of the head which lies midway more or less between what is strictly the vertex and the little fontanelle, and it necessarily results in a smaller circumference of the head coming into correspondence with the successive horizontal planes of the pelvic canal. Contrary to what we find in the case of true flexion, it is not advisable in the instance of the second movement to speak of radial flexion being complete, because in the normal case of labour, when that point on the surface of the head of which I have just written reaches the centre of the pelvis, the second movement has not reached its extreme limit, though it has approximately arrived at its optimum limit. For, the head is still/

still able to carry on its sliding movement to a still greater extent, until, in fact, the little fontanelle reaches the centre of the pelvis. Probably this degree of "forced flexion" is more than can be produced by a bending of the neck spine alone, and it appears always to be associated with more or less flexion of the dorsal spine. Presentation of the little fontanelle has long been known as a sign of disproportion existing between the head and the pelvis, usually owing to general contraction, but it has recently been demonstrated that the enforced flexion of the head may be a cause of difficulty in itself. The flexion and descent of the upper portion of the body of the fetus leads to a diameter of the fetus engaging in the pelvis - a diameter which is in itself apt to be disproportionate, as it extends from the middle line of the back to the forehead (FABRE 1910). The dystocia which may then arise from the attitude of forced flexion parallels the better known obstruction which may appear from a similar, though a reversed arrangement of the parts present under forced extension, such as may occur in a face presentation.

§4. The third movement of flexion. Deformation of/

of the head.

The third movement of flexion (the moulding of most observers) is not a movement of the head as a whole, but rather a movement of one part relative to another. Moulding is divided conveniently into deformations of the soft parts and deformations of the hard parts (OLSHAUSEN 1870, AUVARD 1894). On any other grounds, however, the distinction can hardly be justified, as to quote an instance it is obvious that the moulding of the bones must be associated with more or less deformation of the brain which is a soft part, and it is not usual to include the latter, about which I have been able to find very little information, within what is ordinarily termed the deformation of the soft parts. These consist mainly and ordinarily in the production of the caput succedaneum. So far, as one can judge, the caput has little or no effect in the mechanism of labour, and as Matthews Duncan observed it cannot furnish the information, which it otherwise might be expected indirectly to do, regarding debatable questions like the direction of uterine pressure, and the orientation of the head within the pelvic canal. It is not necessary therefore to enter here into its nature/

nature, cause, and mode of production. But it is necessary to refer in passing to the researches of Budin and Martellière who, according to Auvard (1894) state a formation of the caput after death and maceration of the fetus, and also before the membranes are ruptured; while VARNIER (1900) records the presence of a caput in three frozen sections with unruptured membranes. Probably, the caput would be found clinically to be more frequent in the first stage than it is supposed to be, if special attention was directed to the matter. The importance of the observation lies in the indication which it gives of the difference of pressure normally existing between the general contents of the uterus and the bag of waters below the head, and to which I have already referred.

Much research has been devoted to the deformations of the hard parts and with good reason, as however opinions may differ in a casual connection of moulding with the mechanism of labour, the view meets with general acceptance that moulding plays an important part in the development of the mechanism.

FEHLING (1874) divides moulding into absolute/

absolute and compensatory deformations. The former is represented by a real reduction in the cubic capacity of the head, by an ~~extension~~^{↑u} of fluid from the skull, and is of small consequence, as Fehling's experiments proved: the latter implies no change of bulk, consists solely of change of shape, and comprises the more important deformity. The distinction of absolute and compensatory deformations is confirmed by the researches of PERLIS (1879).* VARNIER (1900) divides the total phenomena into 1. overriding of the bones, 2. formation of the caput, and 3. deformation of the head. As it is clear that the moulding of the head is not entirely due to overriding of the bones, it is convenient to divide compensatory deformations under the first and third headings of VARNIER.

STADFELDT (1861) showed that the right parietal bone, that is the anterior, is usually pushed over its neighbour. In 1870, OLSHAUSEN published some elaborate observations on the subject. He states that the frontal and occipital bones are pushed under the parietals, and that in a preponderance of examples the anterior parietal is pushed over the posterior, while the frontal bones experience a greater degree of flattening than does the/

* Grossmann (1871) preceded both Fehling and Perlis in this discovery.

the occipital bone. In 112 head presentations the frontal bones passed under the parietals in 105: one frontal was pushed over and the other under the parietals in 6: and both frontals overrode the parietal bones in only one. In 156 head presentations the posterior parietal bone lay deeper in 79, the anterior in 36, and no difference was found in 41. In 42 cases the anterior frontal bone lay deeper in one half, and the posterior in the other half. MUELLER (1898) especially confirms OLSHAUSEN'S main conclusions for the occipito-posterior positions of the head. MURRAY (1888), accounts for the deformation of the head by a sliding of the occipital and frontal bones under the parietals. DE SEIGNEUX (1901^b), in observations which were made during engagement of the head, found in 110 cases the anterior parietal over the posterior in 39, the reverse in 37, and no overriding in 34. DE SEIGNEUX, further, quotes KREIS (ex litt.) who found under similar conditions the anterior parietal overriding the posterior 43 times, the posterior over the anterior 31 times, and an absence of overriding 26 times, in 100 cases. FABRE (1910) considers it normal for the occipital and frontal bones to be pushed under the parietals, /

parietals, and for one parietal to override the other. From these observations it is clear that by far the most frequent arrangement is the retreat of the frontal and occipital bones under the parietals, the anterior of which usually overrides the posterior.

Turning next to the general change of shape which the head undergoes in labour, it is necessary first of all to refer to the findings of STADFELDT (1861) and RUNGE (1890). Both obstetricians have stated an innate asymmetry of the skull to be present prior to labour. STADFELDT describes the asymmetry as a greater prominence and rotundity of the left side of the head as compared with the right, which is confirmed by RUNGE who adds that the distance from the occipital protuberance to the parietal tuberosity is less on the left side than it is on the right. STADFELDT says that this "physiological asymmetry" is observed as early as the sixth month of pregnancy, and is independent of the processes of labour. The physiological asymmetry, as it is described by these authors, is precisely contrary to the asymmetry which is the associate of labour. The greater development of the/

the left side of the head in the former is apparently correlated with the greater frequency of right-handedness. I am not aware of any extended observations in the extent of innate asymmetry before labour, and it is therefore impossible here to determine its counteracting effect on parturient asymmetry.

~~51-parturient~~ DOHRN (1864) carefully investigated the general results of the deformation of the head in labour. He showed that the anterior lying side of the head is deepened and rounded, while the posterior is flattened, and that, in addition, there is a lateral "shoving" of the head, so as to give it an obliquely distorted appearance, when it is viewed from behind or before. This oblique distortion which DUNCAN (1868) called a "shear" was found by DOHRN in 38 out of 40 heads examined after birth. In the left occipito-anterior position the lateral displacement amounted to 5.3 mm., and in the right occipito-posterior to a greater amount - 6.6 mm. BARNES (1865) emphasised what he called the screw-distortion of the head, and divided the deformity into three components - elongation, asymmetrical flattening, and twisting of the conified portion of the head around its axis. OLSHAUSEN (1870) also describes the torsion of the head, and states that the/fox/

the posterior surface of the occiput and the entire frontal region become flattened, the latter to a more or less extreme degree, which generally confirms STADFELDT'S view, expressed in 1861, that the occipito-frontal diameter is much reduced by moulding, while a lesser reduction occurs in the posterior bi-parietal region. LABAT (1881) holds views which in some ways contradict the preceding. The anterior parietal bone is displaced backwards towards the middle line of the pelvis, while the posterior parietal scarcely changes its position. There is also a movement of the parietal in an antero-posterior direction relative to the head, the anterior parietal being displaced towards the occipital. But LABAT adds that the flattening and displacement of the anterior parietal bone which he describes occurs during internal rotation. It is therefore rather different in its nature and origin from the deformity described by most observers. BERTHAUT (1907) has made similar researches, and is in complete agreement with LABAT. BERTHAUT sums up the changes as a rounding, flattening, and bulging of the head, and he considers the greatest deformities to appear in the oblique positions of the head, especially in the long rotation of the occipito-posterior/

posterior positions and to be absent in the primitive occipito-sacral position. It is apparent that in this instance BERTHAUT is referring more particularly to the deformities described by LABAT, and not entirely to those especially associated with the name of DOHRN. MURRAY (1888) practically investigated the potential deformations of the head in connection with his theory of the axis-traction forceps. The author found the head most compressible antero-posteriorly. The reduction of the long diameter of the head was compensated for not by an increase of the transverse diameter, but by an elongation of the skull approximately in the axis of the pelvic canal. Incidentally the late Dr. Milne Murray was, perhaps, the earliest obstetrician to grasp the significant value of moulding, and to describe tersely and clearly the mechanically important aspect of FEHLING'S "compensatory deformation". In the elegant phrasing of FABRE (1910), "the head is malleable and reducible The cephalic mass is nearly incompressible and, as a general rule, the diameters perpendicular to those compressed extend". From OLSHAUSEN (1870) to MUELLER (1907) the specific character of the moulding for each position and presentation of the head has been recognised, and its/

its diagnostic importance is admitted. In a vertex presentation the forehead is depressed, and compressed, the posterior surface of the occiput is flattened, the right and anterior parietal is bulged and projected towards the occiput, the posterior parietal is flattened, while the head as a whole is elongated towards the vertex, and obliquely distorted from left to right and from base to apex. In the occipito-posterior position, with vertex presentation and after short rotation, the moulding, just described and characteristic of the occipito-anterior position, is greatly exaggerated along the same lines, the elongation of the head being especially notable. In the same position, with a presentation of the anterior fontanelle and after short rotation, the frontal and anterior parietal regions are bulged, while the posterior parietal and occipital parts are depressed and compressed. The moulding otherwise is similar to that first described. In forehead presentations, whether in the occipito-anterior or occipito-posterior positions, the frons is the centre of the presentation, and is the area of greatest protrusion, the head and face sloping away from the frons and being compressed and depressed/

even/

depressed roughly in proportion to their distance from the forehead. In face presentations, the frontal bones are projected forwards, while the occipital bone is recurved on itself and thrown behind. At the same time the parietal region is depressed medially and bulged laterally, with as a result - the "sugar-loaf head" (FABRE 1910). The aftercoming head is on the whole dome-like. The greatest circumference of the head is constricted to proportions corresponding more or less with those of the cephalic base, while the vertical diameters are lengthened over a much greater area than is the case in a vertex presentation, or, in other words, the head is round rather than conical. These descriptions are taken partly from personal observation, and partly from descriptions and figures of which many have been published in periodicals and textbooks. But it cannot be too strongly affirmed they are descriptions of the appearances after birth, and it by no means follows that the forms of moulding are, in all respects, similar prior to the occurrence of internal rotation.

Though it is convenient, and to a limited extent proper, to regard moulding as the third movement of flexion, it may appear at an early stage, even/

even when the relative proportions of head and canal are easy. According to POLOSSON (1892), VARNIER (1900), HIRST (1900), and AHLFELD (1903), who have referred distinctly to the matter, moulding of the head may begin at the brim of the pelvis even under normal relations. DOHRN (1864) and BARNES (1865) were of the same opinion; and though they were probably correct in their observations, it is certain that their premises were wrong. There is no reason however, why moulding should not occur at an earlier period, if we suppose descent into the pelvis to be delayed till the last moment, and the head to be large enough to distend the lower uterine segment. And of course, when the brim is contracted - the commonest form of pelvic dystocia - the normal head must necessarily be moulded, and often very severely compressed in order to pass. But, when the proportions of head and pelvis are normal, moulding is very slight until the head descends into the lower part of the canal, that is to say, generally in the second stage. At some obscure level of that part of the canal moulding reaches its maximum development. For RUNGE (1890) and HART (1912) it is the pelvic floor - which is too indefinite. LABAT and BERTHAUT consider it to take place before the/

the outlet is reached and during the period of internal rotation. POLOSSON (1892) fixes the level at the bony outlet. Others have favoured a still lower level, but as that appears to me normally to be included in the phenomena of extension, I shall consider it separately. If RITCHIE'S views on flexion are held to include moulding, and I think they probably did, then his dictum that flexion increases up to the moment at which internal rotation begins appears to me to be incontestable, as the most frequently occurring event and as a piece of well-found clinical evidence. I shall hope to show that internal rotation occurs most often in the lower division of the superior portion of the pelvic canal, and it is there that, in my experience, the greatest development of moulding - as a flexional movement - is most often observed. This level in the pelvic canal corresponds very closely to that given by OLSHAUSEN (1870) for the same effect. The first movement of flexion persists properly until the birth of the forehead: within the lower part of the superior portion of the pelvic canal the second and third movements reach their greatest development and begin to resolve themselves into the movements/

movements of extension. As a rule, the change coincides with the beginning of internal rotation, and in that event is seen in its purest form. But, in some cases internal rotation is delayed to a lower level, and we then find the mechanism, in this respect, complicated by a variable admixture of persistent flexional and newly arisen extensional movements. It is then impossible to say that moulding - strictly flexional moulding - attains its greatest development just previous to internal rotation, but it disappears at a more rapid rate after rotation is completed than it was doing before. More rarely, internal rotation is carried out at a higher level within the pelvic canal. Flexional moulding then rapidly diminishes with internal rotation, but the second movement of flexion is preserved, and may continue to increase until the outlet of the superior moiety of the canal is passed. In primitive occipito-pubic and occipito-sacral positions the moulding appears to correspond closely in character to that observed in normal extension, with the exception that, so far as I can gather, the compression and depression of the sinciput and of the posterior surface of the occiput are much more severe.

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It will thus be seen that the most significant characters of the third movement of flexion, when the position of the head within the pelvis is oblique, are the oblique distortion of the head and the apparent twisting of the elongated head around its axis. When these phenomena disappear, there remains little or nothing to distinguish the form of the head from that usually observed during the movements of extension which will be considered at a later stage.

§5. When we proceed to consider the several theories of the mechanism of flexion, we are immediately faced by the circumstances that the historic authors regarded flexion as a unique phenomenon, and did not always, so it would appear, deduce correctly the true nature of their experiences. Thus it happens, as I have already suggested, two authors may assign two different natures and origins to two entirely similar events, or the same authors may ascribe the same nature and origin to a pair of movements that are essentially unlike, though of course the movements readily group themselves under the one term - flexion. Hence a review of the various/

various explanations must evidently be of a general character, and indeed it is possible only here and there to assert the phenomena, and post hoc to remit to each the appropriate cause.

In the very beginning of all considerations relative to flexion stands PAJOT'S Law of accommodation which, though it does not amount to an explanation, is yet the most complete and precise account of the phenomena that we have. "When a solid body is contained in another, if the container is the seat of alternate movement and repose, if the surfaces are slippery, then the contained will tend without cease to accommodate its form and its dimensions to the form and capacity of the container" (TARNIER and CHANTREUIL 1882). It is surely obvious, however, that PAJOT'S Law is not ^{an} explanation of flexion, and far less is it the definition of a cause. So also, the tendency of an "ellipsoid", or a "prolate spheroid" (SCHATZ 1890, GALABIN 1875) to become synaxonal with the canal is not an explanation, but merely a description of the most probable event. It would not have been necessary to mention these preliminary considerations, had not some obstetricians expressed the view that the discovery of the fact, or rather the probability of accommodation is, in this connection/

connection, the legitimate end of scientific enquiry. We desire to find out the means to an end, and the mode of its action, whereby the changes, of which the law of accommodation is the expression, become accomplished facts.

Some form of the so-called lever-theory seems to have been the earliest explanation offered to account for flexion. The lever-theory dates back to the latter half of the eighteenth century. It is noteworthy that SMELLIE (1752-1764), so far as I can find out, expressed no opinion on the production of flexion. SOLAYRÈS (1771), apparently for the first time, stated the lever theory. According to SCHROEDER (1886), however, WIGAND originated the idea. But WIGAND lived on the whole at a later period than SOLAYRÈS, and the GEBURT DES MENSCHEN did not appear till 1820, VALTORTA (1912) attributes the theory to ASDRUBALI who is stated in the Dictionary of International Biography to have been "a flourishing physician in the middle of the eighteenth century", and who, therefore, possibly preceded SOLAYRÈS in the discovery. The views of SOLAYRÈS, according to PLAYFAIR (1880) were that pressure is transmitted through the fetal spine/

spine to the head at a point which is nearer the occipital than the sincipital pole. In consequence, the relative lengths of the skull before and behind the articulation of the skull are unequal, and, the resistance below the skull being everywhere the same, the effect of pressure, exercised from below on the anterior part (fetal) of the skull, will be greater than that on the posterior. As a result the occiput descends and the sinciput is pressed upwards. As long as the validity of fetal-axis pressure was not questioned the lever theory of flexion was generally accepted as an adequate explanation of the phenomenon. Various obstetricians modified the theory more or less, but they did not do away with its essential principle. CAPURON (1816) does not seem to have recognised the lever theory as such, and values especially the concentration of uterine pressure on one end of the head. DUBOIS (1834) dwells on the influence of the walls of the cavity, especially the form of the uterine orifice in causing flexion, and therein he is entitled to the credit of anticipating the views of the following years.— JACQUEMIER (1846)/

though of course as to the fetal-axis pressure and a mistake as to the fetal-axis pressure

ary/

(1846) attributes flexion mostly to the resistance offered by the cavity of the pelvis. GUILLEMOT (1837) advocates a theory of flexion which in structure, if not in time, is more primitive. The inclined plane of the cervix posteriorly causes flexion by its resistance to the sinciput, in the occipito-anterior position of the head; and extension in the occipito posterior position, by a restraining effect exercised on the occiput. This result is partially attained during pregnancy, and the uterine contractions make the flexion more complete, for then the rounded occiput receives all the force of the uterus. In the occipito-posterior positions flexion is at first not present, but it is eventually produced and advanced to an exaggerated degree, owing to the uterine pressure forcing the forehead forwards and upwards, and allowing the occiput to descend towards the centre of the pelvis. Thus, GUILLEMOT clearly distinguishes a mechanism operative in pregnancy from one acting in labour, and in his account of the occipito-posteriors, he not only accurately describes the usual clinical course of events, but seems to have arrived very near to the truth regarding its origin, though of course an adherence to fetal-axis pressure and a mistaken substitution of the secondary/

secondary for the real primary effect mars the complete effectiveness of the explanation. DOHRN (1864) describes a mechanism of flexion - if I understand correctly, as the normal mode - which to all appearances is that, really of flat pelvis, and is, after all, rather a descriptive account than the discovery of a cause. DOHRN considered the head to be arrested on and marked by the promontory; and that, if this portion of the head is pushed forwards, the occiput descends and flexion appears, while, in the event of it being directed backwards, the forehead descends and extension is produced. Apart from the circumstance that no explanation is given why the direction of movement is sometimes one way and sometimes the other, it was long since agreed that the conditions which DOHRN attributed to the promontory are really due to other causes, and that his description does not apply to the ordinary passage of the brim (DUNCAN 1868 and others). RITCHIE (1865) made an important advance by denying the truth of the lever theory, and at the same time he foreshadowed LAHS'S theory of the general-contents pressure. RITCHIE states that, before the waters break, the intrauterine pressure is developed equally all over/

over the head, and, after the waters break, the head acts as a plug preventing the escape of the amniotic fluid, so that the pressure continues to be general all over the head. Hence, according to RITCHIE uterine pressure, is applied not in the axis of the fetus, but in the axis of the uterus. These views, if correct, amount to the denial of one of the factors of the lever theory - fetal-axis pressure - and they have been abundantly confirmed by the researches of LAHS and other investigators. The abolition of the lever-theory, however, led RITCHIE into an impasse from which he retreated rather lamely by supposing the fact that the sum of the pressures on the child's head in front of the spine is greater than it is behind, is a sufficient cause or explanation of the mechanism of flexion. The next contributor to the theory of flexion was LAHS (1870-1877), the originality of whose views, together with the fullness and skill with which they were explained, soon led to a special recognition of their later form as the wedge or tangential theory of flexion, though these names by no means include all the factors that LAHS postulated. In passing, it is worth noting that one of LAHS'S factors/

but I am unable to say what this was.

factors for the production of flexion was anticipated by HUBERT (1858). HUBERT states that "if a propulsive force is exercised centrally on a mobile, and there be resisting forces not directly opposite each other but at different levels, rotation occurs" (PARVIN 1894). This is apparently the mechanism of flexion for HUBERT, and it corresponds in principle to that given by LAHS for his third factor, (1870) and it is subject to a similar criticism.

§6. LAHS begins by reaffirming his belief, expressed for the first time in 1869, in the theory of the general-contents pressure, and therewith in the relative inefficiency of fetal-axis pressure. LAHS then gives, as the first of the three known factors of flexion, the lever theory - in a form slightly modified from that of SOLAYRÈS, for he writes, in effect, that in the upright position of the mother the body of the fetus owing to its higher specific gravity, the greater shortness of the occipital lever, and the equal resistance acting on/

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According to VALTORTA (1912) INVERARDI advocated a theory of flexion which is identical to HUBERT'S but I am unable to say when this was done.

on the frontal and occipital poles of the head, causes a deeper descent of the occiput and the application of the chin to the breast. This, the first factor, acts all through the second stage as long as the weight of the body of the fetus acts on the skull.

When the occiput is deeper than the sinciput, the girdle of resistance is no longer at right angles to the axis of the canal, but is inclined towards the occipital side. Hence, the weight of the uterine contents is greater on the occiput than on the sinciput. This constitutes the second factor of flexion.

The resistance of the elastic walls of the canal forms the third factor, and it is able to operate, because in most cases the direction of the girdle of resistance is oblique.

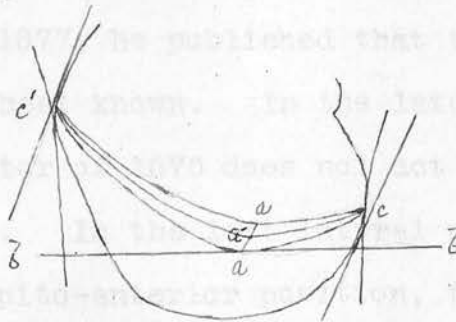
A levelling movement occurs as the occiput comes under the pubic arch, and is due to pressure being then concentrated more upon the sinciput. Whenever this movement occurs the first factor alone operates to maintain flexion.

In the dorsal position, the forehead comes deeper because the greatest weight of the fetus acts on the parietal tuberosities which meet with increased/

increased friction on the pelvic floor. This point becomes the fulcrum of a one-armed lever, and the weight of the fetus causes the forehead to descend. The general-contents pressure acting perpendicular to the girdle also brings down the forehead. The descent of the forehead is then due to the point of contact with the floor being equidistant from the two poles of the head. In the erect position, on the other hand, the occiput usually descends more because of the greater column of fluid pressure it has to bear.

In the flat pelvis with transverse entry, NAEGELE obliquity, and the fontanelles level, or the great deeper than the small fontanelle, general-contents pressure is heavier anteriorly. The two lever (Fig. I)

Fig. I. (LAHS).



arms /

arms a c and a c' are unequal and c' sinks, while c moves away from the inlet. The movement begins, when the general-contents pressure is higher than the pressure of the head against its resistances, and is dependent on the form of the head and on the position of the girdle.

In anterior parietal and forehead presentations, the anterior parts of the parietal region and the forehead tend to flatten, and to lessen the surface angles: in face presentations, the posterolateral wall pushes the chin forwards to the middle of the canal, and the event is hastened by the vaginal canal widening from inlet to outlet.

In 1872, LAHS discusses the influence of gravity on the pressure at the lower end of the column of fluid, and adduces a reason why it must be of less importance than the general-contents pressure.

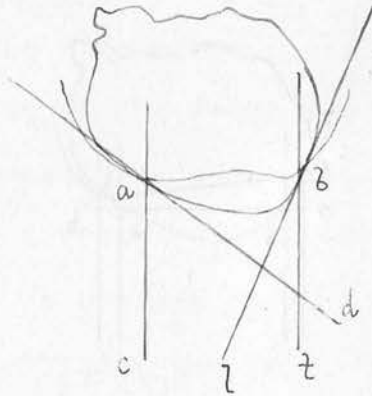
In 1877, he published that theory of flexion which is best known. In the lateral posture the first factor of 1870 does not act so as to cause flexion. In the left lateral posture and the left occipito-anterior position, the weight of the contents drives the occiput against the left lateral/

lateral wall of the canal. The occiput is exposed to greater friction as a result, hence the sinciput tends to come down. Secondly, the resistance offered to the trunk of the fetus inside the uterus acts through the neck and holds back the occiput, the retentive power acting on the sinciput being to that acting on the occiput as one to two. In the right lateral posture with the head as before, both the occiput and the sinciput are held back equally. With the addition of the effect of the slope of the girdle, the result is that in the left lateral posture the occiput comes deeper, in the right lateral the forehead comes deeper.

Fetal-water-pressure + frictional resistance = more pressure on the occiput in the left lateral posture and the left occipito-anterior position. Fetal-water-pressure + frictional resistance = more pressure on the sinciput in the right lateral posture and the left occipito-anterior position. In the pains the general-contents pressure has to be added. But, as it acts equally all over the head, its addition makes no difference to the nature of the result which is flexion, if the head is round. The head, however, is always an oval/

oval, and its shape constitutes the fourth factor (1877) of flexion. In the diagram (Fig. 2.),

Fig. 2.

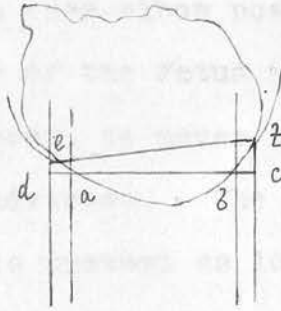


the head is represented in transverse entry with the fontanelles level, the os being about 6 cm. in diameter. The general-contents pressure acts. The head is a wedge whose surfaces are found through the tangents which are drawn to the surfaces of the head lying immediately over the os. The tangents are a d and b l. The pressure acts in the direction of the parallels a c and b f perpendicular to the surface of the os. The surface b l presses downward proportionately, as the angle l b f is smaller than the angle c a d, that is, the occiput descends.

LAHS also illustrates the mechanism as the os opens wider. In Fig. 3. the os is widened to/

to c d from a b and drawn back.

Fig. 3. (LAHS)

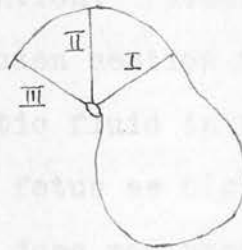


The widening results in a descent of the head on the side a to e, on the side b to f. On the side b the descent of the occiput is greater, which LAHS attributes to the wedge-shape of the head. LAHS directly transfers the effect of the angles to the general-contents pressure, saying that, if the angles are as 1:2, then the general-contents pressure will be as 1:2 on the sinciput and occiput, and he sums up the total effect of body frictional resistance, head frictional resistance, fetal-water-pressure, general-contents pressure, and the effect on the latter of the tangential angles, as being in the left-lateral position as 10:5 on occiput and sinciput/

sinciput, and in the right lateral posture as 10:6. LAHS further holds that the tangential theory makes the occurrence of flexion independent of the lie of the parturient woman.

In the knee-elbow position, the greater specific gravity of the fetus restrains the occiput. Its action, however, is never great, and becomes less as labour advances. The effect of fetal-water pressure is present as long as the girdle of resistance is oblique, and is greatest at the level marked II in Fig. 4.

Fig. 4. (LAHS).



In the knee-elbow position, the weight of the contents is passive and the pains are weaker.

§7. In 1870 LAHS depends for the initial production of flexion on the greater specific gravity of the fetus, that is when the mother is in the more or less erect posture. According to LAHS 1877, the specific gravity of the fetus is 1030, while that of the liquor amnii is 1015; and it is on these figures that the author builds his superstructure. It does not appear, however, that the ratio of the specific gravities is by any means constant. Certain preparations make this clear. The figures reproduced by VARNIER (1900) from the earlier months of pregnancy show the fetus floating in the upper part of the uterine cavity - a circumstance to which VARNIER draws attention. WILLIAMS (1912) gives a photograph of a frozen section from the first stage. It shows the amniotic fluid in the lower part of the canal, and the fetus as high up as it could go. While this section does not necessarily indicate an inversion of LAHS'S idea of ratio of the specific gravities, it shows that circumstances, more powerful than the specific gravity, must have acted to raise the fetus from the position it occupied under pressure, during life. It has not been shown, even if LAHS is right about the specific gravities, that the difference//

difference which he records is sufficient to bring about flexion under intra-uterine conditions. The resultant from the greater specific gravity is so slight, and the opportunities for recoil are so great, that it does not appear certain that the greater specific gravity of the fetus could exercise sufficiently continued pressure to produce and maintain the first movement of flexion. The first factor for the production of flexion is therefore deficient in some respects, and, as it is stipulated by LAHS (1870) to be primarily essential to the operation of the other factors, its defects are sufficient to open the whole 1870 theory to suspicion.

If, however, we suppose the first movement of flexion to be completed, we can think of the mechanism of the second factor. This is due solely to the different weights of the column of fluid on the fore and hind parts of the head. The difference depends on the amount of inclination of the girdle of resistance. Of the possible efficiency of the second factor, we have direct evidence. Even in multiparae, in whom the resistances are often slight, it cannot be said that the normal head descends to any appreciable extent between two pains (in the squatting/

squatting position). All that the force of gravity may then do is to maintain the head in that position to which it had advanced in the preceding pain. So limited a capacity is not always evident: indeed, it is frequently annulled by other circumstances. Hence, so long as the head is stationary or retrograding, an increase of flexion is hardly possible by the action of gravity. And as the evidence of this action is difficult to find in the intervals, it is unlikely to have much value during the pains.

If however, the effectiveness of the fetal-water pressure acting on the inclined plane of the girdle is admitted, it can easily be shown that the efficiency of the mechanism is proportional to its uselessness. The weight of the column of fluid acting on the plane of the girdle of contact cannot be unequally distributed over that plane as a constant phenomenon (This is admitted indirectly by LAHS). In the primitive deflexion of the head, accepted by many authors, an absolute horizontality of the contact girdle to the long axis of the uterus must arise, at least sometimes. When this condition appears, the weight of the uterine contents must be equally distributed over the whole of the plane of the girdle, and as the resistances acting from below are /

are everywhere equal (one of the postulates of LAHS) it is difficult to see how flexion can arise. If the weight of the column bears more heavily near the sinciput than it does near the occiput, extension in some degree is already present, but the distribution of the weight is such as inevitably to increase rather than to diminish the deflexion. If, on the other hand, the weight of the column is less on the anterior part of the plane of the girdle than it is on the posterior, then an element of flexion is already present. When the degree of flexion is very slight, the differences in the weight of the column are very slight, and their effect in producing flexion correspondingly small. When, however, flexion is already well advanced, the differences of weight are greater, and the production of increased flexion more easy. Thus, we are led to believe that, in the first and second examples, the second factor of LAHS will fail where the need for the production of flexion is greatest: in the third example, the need is still great, but the means are small: while in the fourth example, the demand for increased flexion is nearly exhausted, though the mechanism is theoretically at least, at its very best.

best. The deduction to be made from these observations is that, in the second factor of flexion, the appearances to which LAHS attached so much importance are incidental and not primarily essential to the mechanism. Though unable to initiate flexion, as LAHS freely admits, the conditions signified by the dipping of the girdle of resistance cannot in all probability make flexion greater.

The third factor, according to LAHS, operates in the increased production of flexion, only when the girdle of resistance is inclined. The walls exercise a pressure which is perpendicular to the axis of the canal, as long as the direction of the apposed surfaces is parallel to the axis of the canal. In most cases, however, that is when the stipulated flexion produced by the first factor is present, the surfaces in contact are directed obliquely to the axis of the canal, and the direction of the lines of resistance is correspondingly inclined. Rotation of the head about a horizontal axis follows. To this portion of the theory, either as enunciated by LAHS or by HUBERT, no objection can be raised, so long as the theory is confined to the periods of uterine contractions, after the first movement /

movement of flexion has been produced. When, however, due regard is paid to the clinical signs of the periods of uterine inactivity, the third factor of LAHS loses much of its importance. Excepting possibly when the resistance of the soft parts is of great severity, flexion does not go on increasing, in the interval after a pain, at the same rate as that at which it may have been increasing during the pain, and in a very large number of instances flexion actually diminishes after the forces which constitute a pain are withdrawn, while, in the first mentioned group of cases with very resistant soft parts, I am inclined to expect that the amount of flexion remains stationary in the interval following a pain. The reason of these signs in the majority of labours is the partial withdrawal of the head from the level, to which it was forced by the preceding pain, to a region of the canal which has already been dilated to a degree in excess of the requirements of the horizontal planes of the head which now occupy it. Level for level, and plane for plane, there is a general reduction of resistance, and the reduction is manifested clinically by the rising of the occipital pole further away from the axis of the pelvis, a//

a decrease in fact of the second movement of flexion. The easing of the pressure and resistance is more than sufficient to nullify the contractile and elastic effects of the pelvic walls. In other cases where retraction does not occur, and in all cases, where the head has descended into the lower part of the superior portion of the pelvic canal, the disposition of the parts remains either in statu quo, or changes slightly in the direction of reducing the degree of the second movement. In labours under observation, I have not been able to detect an increase of flexion during the intervals such as LAHS'S third factor demands. Another argument against the real effectiveness of the third factor is derived from the comparison of primiparae and multiparae. How often in the former flexion in the sense of the second and third movements is imperfect until far on in the second stage! In many multiparae flexion is frequently perfected when the second stage begins: in the remainder the phenomena resemble those of the primipara. Yet the resistance of the soft parts is mainly greatest in the primipara, and least in the second group of multiparae. The third factor may explain the clinical signs /

signs of the last group, but it entirely fails in primiparae and in the first group of multiparae. That the third factor, as announced by LAHS, though it operates beyond doubt during uterine contractions, is in other respects unsatisfactory, is evident from the differences observed between primiparae and multiparae.

In 1877, LAHS again grapples with the difficulty of the initial movement of flexion, and here he seems to be slightly inconsequent, for, after providing the most elaborate arrangements for the production of the first movement, he discovers the tangential theory, and makes it retrospective in application. As the head is always oval in shape, the tangential theory explains the production of flexion from its beginning, not only in the lateral posture, but also presumably in other positions of the parturient woman. Of the four factors of 1877, the first, or fetal-water pressure, goes back to 1870 and has been examined: the second composed of the frictional resistances of the head and the body is new: the third, or the general-contents pressure, is also old, but it appears under a new form as LAHS assumes a dip of the girdle of resistance ab origine: the fourth is the tangential theory. As regards the

the second, LAHS appears to arrive at the quantities of frictional resistance in the head and the trunk by a comparison of their respective superficial areas. If this be so, then the second factor stands condemned, for the frictional resistance is not proportional to the area exposed, but to the pressure applied. Otherwise LAHS comes perilously near to SCHATZ'S negative Form-Restitution-Force in the second factor which, if true, would seriously impair the rotative effect of the head on the shoulders, by acting in the intervals so as to separate the one from the other, and by relatively retarding the body during the pains, so as to diminish the mutually raised frictional resistance between the head and the body. It must be admitted, however, that here there are problems which have never been properly investigated.

As to the tangential theory we have, in addition, to the explanation given by LAHS, very full accounts of the theory written by SIMPSON (1878) and HART (1879), though DR. HART subsequently denied the correctness of LAHS'S conception. (1887 and 1912), SIMPSON showed that the theory applies to the head in BRAUNE'S second section, while HART experimentally demonstrated the truth of the theory (in itself) //

itself) with an asymmetrical wedge placed between two movable blocks of wood, and giving the angles of the head in BRAUNE'S section. HART considers it necessary to explain the descent of the sinciput under two vertical and opposite forces, the downward force acting on the sinciput being less powerful than the downward force acting on the occiput, though he goes on to point out that the greatest pelvic resistance is offered by the posterior wall of the canal. HART then extends the theory to explain a variety of conditions.

The dipping of the forehead at the brim of a flat pelvis is due to the head forming a steep side at the promontory. In a mal-rotated occipito-posterior position the asymmetry of the wedge is increased at the occipital pole. During descent, the posterior resistance counteracts the tendency of the occiput to dip. The head becomes impacted and is compressed antero-posteriorly, thereby obliterating the asymmetrical wedge-shape of the head, so that neither the occiput nor the forehead tends to come down more rapidly. In a mal-rotated occipito-posterior position excessive flexion in the sense of all three movements has to be produced, and the more flexion is advanced in such a case, the more difficult //

difficult does its further production become, yet Dr. HART states - and quite correctly - that the asymmetrical wedge form disappears during the process.

The forehead in a frontal presentation is a nearly symmetrical wedge (HART). For HART the wedge theory applies to face presentations and to the aftercoming head, and he includes the shoulders and the oncoming breech as being wedge-formed. By subsequently denying in toto the views contained in his paper, as I have already observed, DR. HART disarms criticism. It is still necessary, however, to point out the defects of the wedge theory, in order to clear the way for other views. CROOM (1881) was inclined to doubt the efficacy of LAHS'S theory from the sinistral formations which he had observed in delayed occipito-posterior positions. BALLANTYNE (1890) gives the impression of scepticism regarding the primary relations of the wedge-shape of the head to the occurrence of flexion, and he points out that the movement of flexion increases the wedge-shape of the head, both by the change in the form and position of the head, and as well by the growth of the caput succedaneum. BALLANTYNE thus prepares the way for the view that the wedge-shape of the head is a consequence and not a cause of

of flexion, or, as I prefer to put it, as a possible or transient consequence of the necessity for flexion. When the two fontanelles are in one horizontal plane there is no satisfactory evidence to show that one end of the head is in all cases steeper than the other. In one of BARBOUR'S coronal sections in which the head is in this position, there is no appreciable difference between the tangential angles of the two ends of the head. In this case the wedge theory appears to be inoperative. Were the theory of LAHS the cause of flexion, we should expect all persistent occipito-posteriors to be born by extension, whereas we know that most are born by flexion. The shoulders and the breech form even clearer objections to the theory. Both are symmetrically formed. There is no primitive wedge-shape. On the contrary, the asymmetrical wedge-shape appears secondarily in the course of the mechanism of labour. Yet, both behave mechanically in labour very similarly to the head. The fact, moreover, that the asymmetrical wedge-shape, while flexion is being produced, increases in some cases and diminishes in others, is presumptive evidence against the wedge theory as an efficient cause of flexion.

§8 ~~essential~~ In the decades which followed the seventh no one-minded advocates of the theory of LAHS appear to have been forthcoming with the exception of the two authors I have named, and the theory itself fell more or less into oblivion. But the effect remained, and can be felt as an undercurrent through many of the later views. No doubt, to some extent, this curious state of affairs is due to a partial or apparently complete acceptance of the theory of the general-contents pressure, for whenever the latter theory is admitted, the explanation of flexion becomes a matter of difficulty. The history of the struggle which followed between the theories of the general-contents pressure and the fetal-axis-pressure brings out how difficult it is to be done with the old and to begin with the new. Where the former theory was denied or but little believed, the lever theory remained good enough to explain flexion: where the theory of the general-contents pressure was more or less fully admitted, the lever theory was adhered to almost pathetically and was modified, sometimes quite unintelligibly, to suit the altered circumstances. SOLAYRÈS I believe and LAHS certainly considered the resistances to be uniform in character - a uniformity which was an essential/

essential part of their respective theories of flexion - and they sought the primary cause of flexion in the fetus. The theory of the former became inept owing to the recognition of the truth of the general-contents pressure, the theory of the latter mainly owing to the outspoken variability of the fetus. Attention thus came to be concentrated on the nature of the resistances, in which FOTHERGILL (1900) finds "the true cause" of flexion, although as I have partly shown similar views were expressed long before 1870. Since that time, almost every variety of opinion has been recorded. The upholders of fetal-axis-pressure, as might be expected, attribute flexion to the lever theory, and they form the majority of those of whose writings I have notes. They include LEISHMAN (1876), BARNES (1885), BAYER (1885), CROUZAT (1887), LUSK (1891), MARX (1892), DESSAIGNES (1894) DUHRSEN (1896), JEWETT (1899), HENKEL (1902), GARRIGUES (1902), OLSHAUSEN (1906), and VALTORTA (1912). SPIEGELBERG (1882) and TWEEDY and WRENCH (1910) add to the lever-theory the shape of the child's head that is the wedge theory of LAHS. TARNIER 1882 and SCHAEFFER (1899) combine the lever-theory with the third factor of LAHS/

LAHS (1870). GALABIN and BLACKER (1910) add to these the resistances in the canal. For SCHATZ (1890) and SELLHEIM (1904), the third factor of LAHS (1870) is the cause of flexion together with the ellipsoidal form of the head. PLAYFAIR (1880 and 1886) believed the general-contents pressure to operate a modified form of the lever principle in the first stage, and the lever theory to apply to the second, under both the general-contents pressure and the pressure in the axis of the fetus. JELLETT (1905) states flexion to be produced either by the general-contents pressure acting against the resistances, or by fetal-axis pressure and the lever theory. HODGE (1870), CASEAUX (1876), PARVIN (1894), NORRIS and DICKINSON (1896), AHLFELD (1903), and FABRE (1910) postulate the lever-theory and the resistances of the canal. Lastly, the special nature of the resistances is the principle factor for STEPHENSON (1881), FRY (1888), ZWEIFEL (1890), POLOSSON (1892), PARISOT (1893), FOTHERGILL (1900), WEBSTER (1903), and SELLHEIM (1907). The last cited view perhaps comes nearest to the truth, but there are other considerations which have to be taken into account, as they appear to be intimately connected with the production/

production of flexion. SELLHEIM, in 1904, showed experimentally that a head, when it is placed in a glass cylinder, is flexed according to the degree of tightness of the fit, and that the pressure of an elastic canal presses both poles of the head towards the centre of the cavity. The author's views are set forth more fully in 1907. If the head is supported by a plane surface, the head comes to a medium position between flexion and extension, or at any rate to a position, where the apposed surface of the head is horizontal when the plane is horizontal. And, if the head is inserted into a conical cavity, the head sinks in such a way that the occiput moves towards the middle of the cavity, thus producing the flexion and the dipping of the occiput of most observers, and my first and second movements. SELLHEIM further shows that this attitude is one of constraint, and that, if the fetus has plenty of room, the head presentation is easily converted (under SELLHEIM'S experimental conditions) into a face presentation in the cavity. As factors in pregnancy, SELLHEIM (1907) postulates the position of the woman, the lie of the fetus, and the form of the surfaces lying below and applied to the head of the fetus. These cause the head to take up/

up a medium position between flexion and extension, the intra-uterine attitude being, however, unstable. With descent during labour, flexion is improved and ultimately completed by factors which, to the best of my belief, are the ellipsoidal form of the head and the conical form of the cavity.

Against the sufficiency of these views for the period of labour it may do to state two objections. Before the cervical canal is fully dilated the cervix is moulded by the head, and ordinarily is not conical in form. Further, so long as the two fontanelles remain nearly on a level with each other, the cervix retains a form which comes nearer to that of a plane surface than a cone. And it is only when circumstances (such as relative disproportion of the head and pelvis, early rupture of the membranes, or a deficiency of the liquor amnii) favour the descent of the occipital pole through the os externum, that the cervix assumes an evident conical form. After the cervix is fully dilated, the head escapes from it either in the primitive position of the first movement, or else it returns to the primitive position for a time. During the descent continued in the second stage, the second movement/

movement is usually not well developed until the outlet of the superior portion of the pelvic canal is nearly reached, and, before this happens, the soft parts of the vagina, more or less according to their degree of "active dilation", are moulded on the head and follow the changes of its position, being more planiform at first and more coniform at length. Thus it seems more probable on clinical evidence alone that the ultimate conicity of the cervix and vagina follows and does not precede the better flexion of the head, and therefore cannot be a cause of flexion in the sense of the second movement.

and in SELLEHEIM'S experiments and explanations do not give an adequate view of the differences which are observed between the mechanisms of descent of the head in the occipito-anterior, and of the head in the occipito-posterior positions. A characteristic feature of the mechanism of the latter position is the delay arising in the production of flexion. Were the conic form and the elasticity of the passage a sufficient cause, flexion (or indeed for that matter extension) ought to be produced as readily and as quickly as it is in the mechanism of the occipito-anterior positions. As it is, the observed/ head in the pelvic canal, when the head is exposed/

observed differences between the two positions afford a clue to a better understanding of the movements of flexion.

§9. For the production of cephalic flexion, as it is observed, three fetal provisions are essential, namely, the ability of the head to rotate about an internal horizontal axis, a capacity to revolve about a horizontal axis which is external to the head, and a submissiveness to compensatory deformation. These are the intrinsic factors: the others are extrinsic, and they are different in pregnancy and in labour.

During pregnancy, the factors appear to be:-

1. The reflex activity of the living and healthy fetus, whereby the chin is applied to the sternum at an early stage of the pregnancy, and maintained there to the last.
2. The contact of the forehead with a resistance, whenever and wherever it may be brought about. Usually, the movement takes place during the engagement of the head in the pelvic canal, when the head is exposed/

During labor, the fetus is exposed to pressure from above resulting from the action of the forces impelling the lower pole of the uterus into the canal, and to the resistances acting from below and within the canal. There being a partial solution of continuity between the head and the body of the fetus, the resultant is the application of the chin to the sternum, provided that the uterine walls are in contact with the body of the fetus without the intervention of the amniotic fluid.

These two factors are probably able to produce the first movement of flexion only. Engagement during pregnancy seldom takes place except when the lower resistances are slight, that is, when the pelvis is normal and the soft parts are dilating actively, the forces which produce engagement being relatively weak. In consequence, the head enters the pelvis without being submitted to excessive pressures, and is able to retain its position of repose, in which the ligaments and muscles lying behind the cervical spine are not stretched and the occiput projects posteriorly.

During/

During labour the following factors have to be considered:-

1. the position of the centre of pressure in relation to the presenting part e.g. the head.
2. The excentric position within the pelvic canal of the opening, or foramen in the partially dilated cervix and vagina.
3. The total resistances of the soft parts of the canal.
4. The total resistances of the bones and ligaments of the pelvis.
5. The influence of adaptive moulding (the third movement of flexion) in modifying the distribution of pressure over the presenting part e.g. the head, and in favouring the production of a delayed second movement of flexion.

If in the second stage the sum of the uterine and abdominal pressures is transmitted through the column of the fetal body to the head, in such a way that the centre of pressure is truly centred in the head and is equidistant from all points in the greatest circumference of the head,

then/ It is possible that the asymmetry of the normal pelvis which JURGENSEN (1931) found in more than fifty per cent of pelvis, and which is evident in one of BARBOUR'S coronal sections may promote the occurrence of flexion in these impacted cases.

then no mechanism of flexion can take place. Descent usually proceeds with the head in the occipito-transverse position, either primitively or secondarily, and if the relations of the head to the pelvis are easy, delivery may occur (and has been observed) with the head still in this position and without flexion having been produced. On the other hand when the pelvis is smaller, or when the head is larger, the head may become impacted in the transverse position. Then, one of two events may happen. Either the progress of delivery ceases, or with the continuance of energetic and sufficient pains, the difficulty is overcome by means of adaptive moulding and the mechanism of internal rotation, but still without the development of flexion as a primary phenomenon, though it may supervene on the occurrence of internal rotation. * In most cases however, labour in the second stage, and also as a rule in the first stage, is associated with an excentric position of the centre of pressure, the first movement of flexion having already been completed, or else a definite amount of true extension being present/

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It is possible that the asymmetry of the normal pelvis which JURGENS (1891) found in more than fifty per cent of pelves, and which is evident in one of BARBOUR'S Coronal sections may promote the occurrence of flexion in these impacted cases.

present. That is to say, in the greatest number the centre of pressure is definitely nearer to one pole of the head than the other, when labour is beginning. At the same time, when the relations of the head and the pelvis are normal, the deviation is slight, but the importance of the deviation lies in it being more or less lateral within the pelvis, and more or less mesial within the head. In case of misunderstanding, I repeat here that pressure is distributed over the whole sectional area of the greatest circumference of the head in the first stage, and during the second stage as long as the head continues to act as a ball-valve, and that, after the water has been evacuated from the canal up to some higher level, pressure is conveyed to the whole of the head by the column of the fetal body as long as the first movement of flexion is complete, and even when true extension is present comparatively little of the head can be admitted as free from pressure. Further, though the pressure is distributed equably over the whole area of the girdle of resistance and the superjacent parallel greatest circle of the head, it is not the case that the pressure is applied evenly over the whole/

whole area of the greatest circumference of the head, excepting when that plane is strictly parallel to the girdle of resistance. In the presence of true flexion (the first movement) or of true extension, however slight it may be, pressure is unequally balanced in the area of the greatest circumference of the head. Such is evident clinically during the expulsive period, whenever the forces required to restrain the sinciput and the occiput in a vertex presentation are compared. Thus it happens that, while the centre of pressure is nearly true to the centre of the plane of the girdle of resistance and to the centre of the superjacent greatest parallel plane of the head, it can only be true to the centre of the greatest circumference of the head, when that circumference is parallel to the girdle of resistance, and this condition there are good reasons for believing to be uncommon.

The theory which underlies these statements is due to LILIENTHAL who, it is said, discovered the existence of a tangential force acting on a curved surface. Long afterwards, when LILIENTHAL'S views had barely survived the controversy which they had excited, the theory was confirmed by the experiments/

experiments of WILBUR and ORVILLE WRIGHT (1901).

If a square plate is exposed to a uniform pressure, say that of moving air, at right angles, the sum of all the pressures acting on the plate coincides with the true centre of the plate which is also the centre of pressure. Moreover, however much or little the pressure may be inclined, or which comes to the same thing however much or little the plate may be inclined, the centre of pressure always coincides with the true centre of the plate. When a curved surface is used, the pressure is normal to the chord of the surface of contact only so long as the pressure is directed at right angles to the chord. Whenever the pressure is inclined to the chord, the pressure does not remain normal to the chord, but is inclined in the direction in which resistance is being overcome. That is to say, the centre of pressure on a curved surface is excentric to the true centre of the surface of contact whenever the pressure is inclined to the surface, or equally whenever the chord of the surface is inclined to the pressure. The effect of a uniform pressure on a curved surface is then an explanation of the superior adaptability of a curved surface, as compared with a/latent/

a flat surface, to overcome a resistance. It is the tangential force of LILIENTHAL and, as I believe, a more ultimate explanation of the tangential theory of LAHS. It is the cause of the consequence which is the theory of LAHS.

Whenever the first movement of flexion, or of extension, is present, there is a slight relative descent of the appropriate pole of the head - sufficient to produce a slight deviation of the centre of pressure by the inclination of the uniform general - contents pressure to the chord of the surface of contact. The deviation, though slight to begin with, tends to progress with descent, and it also tends to persist in that portion of the head, towards which the first deviation was directed. Incidentally the second movement of flexion (or of extension) is produced, and the more resistance is overcome the further the centre of pressure deviates towards the margin of the surface of contact, the more the second movement is advanced.

The centre of pressure may even be displaced beyond the chord of the surface of contact and be still effective in promoting the second movement, as in the marked flexion of the well flexed persistent/

persistent occipito-posterior position of the head.

§10. The slight deviation of the centre of pressure, to which I have referred, would probably be sufficient in the presence of equally distributed and superable resistances to produce the relative descent of whichever pole of the head the centre of pressure was nearer, the capacity of the head to rotate around the upper end of the fetal trunk being granted. The slight excentricity which it is necessary to postulate for the centre of pressure and in the normal conditions of the first part of the descent into the pelvis, may safely be assumed to render the production of what is really the second movement of flexion intolerably slow against equal resistances. As it happens, however, we can point with certainty to a second factor of great importance. The axis of pressure tends 'persistently to seek the area of least resistance (KEHRER 1864), and in doing so I believe it perseveringly endeavours to coincide with or approximate to the mesial plane of the pelvis, and that ultimately, if not immediately, it reaches that position in the anterior moiety of the pelvic canal. Further, and this is a matter of great/

great importance in the mechanism of occipito-posterior and occipito-transverse positions, the axis of pressure tends to carry along with it whichever portion of the head contains the centre of pressure, that is, towards the mesial plane and the anterior moiety of the canal. (In one of BARBOUR'S sections (1889) the head is in the transverse position and the fontanelles are nearly level. But the occiput, on close inspection, is seen to be dipping slightly. The frons is pressing against one lateral wall of the pelvis, while the occiput lies at a considerable distance away from the corresponding wall. The lateral excentricity of the head in this section is noteworthy in the present connection). The second factor which is the tangible cause of this tendency of the axis of pressure we find in the direction in which the cervix and the vagina dilate within the bony pelvis. When the cervix and vagina are fully opened, their circumferences are approximately concentric with the circumference of the bony canal, and hence have no special influence in the direction of pressure. So also, when the opening is very small, its effect may for the present be disregarded. But, during the middle stage/

within/

stage of dilation when the possibility exists of extrusion of the presenting part through the girdle of resistance, the position of the girdle is decidedly excentric, lying, as it does, in the anterior part of the canal. As dilation proceeds the opening moves forwards in transit across the bony pelvis, and the anterior circumference of the girdle coincides with the anterior wall of the pelvis some considerable time before the posterior and posterolateral margins coincide with the corresponding pelvic walls, when the girdle becomes concentric with the pelvis and ceases as such to exist. The excentric position of the cervical opening can be felt clinically, when the os is three-quarters dilated. Then, the anterior margin of the cervix forms the "anterior lip" and is free from the head, while the posterior margin extends below the head to a breadth of at least an inch. At this time, also, the anterior margin virtually coincides with the anterior wall of the pelvis. A similar, though not quite so distinct, excentricity can be recognised as far back as a time when the os is the size of a five-shilling piece, if not indeed earlier, and with rare exceptions the trend of the centre of the os is sooner or later forwards from the true centre of the pelvis.

Within/

Within the vaginal canal, the phenomenon of excentricity is even more evident. When the head is ready to escape from the lower pole of the uterus, "active dilation" has already rendered the anterior and antero-lateral walls of the vagina concentric, to a degree which increases from behind forwards, with the anterior segment of the pelvis. Posteriorly and postero-laterally the soft parts oppose to the descent of the head a voluminous fold or mass which is later added to by the bony and ligamentous resistances of the lower part of the superior portion of the pelvic canal, and by the often bulky commissure of the pubo-coccygeal muscles at the same level. Thus, the excentricity of the girdle of resistance in the vaginal portion of the descent is present from the beginning of the descent, and the excentricity is anterior, not posterior. This arrangement is of special importance here, as it continues during the second stage, until the head passes the outlet of the pelvis. Further, continuous observation of the relations of the head to the advancing girdle of resistance, and especially of the course of events in occipito-posterior positions, makes one believe that the excentricity of the girdle of/ in the pelvis; and is forced downwards through the girdle/

of resistance is the primary condition and not the anterior excentric direction of pressure, though actual proof would be difficult, if it is not impossible. We have then the known tendency of the axis of pressure to seek the area of least resistance, the position of this area mesially and anteriorly within the pelvis, the deviation of the centre of pressure to however slight a degree within the circle of the greatest circumference of the head and due to the existence of some amount of flexion (first movement) or of extension (first movement), and the tendency of the centre of pressure i.e. the axis of pressure to carry along with it whichever portion of the head it occupies. These circumstances, acting in combination, result in the transit of the area of the centre of pressure towards, or its persistent occupation of the anterior moiety of the pelvic canal, together with a relative advance of the area containing the centre of pressure and a relative retardation of the area of the head which is not concentric with the centre of pressure. In other words, when the first movement of flexion is complete the occiput contains the centre of pressure; is carried forwards by a transit, but not by a rotation, within the pelvis; and is forced downwards through the girdle/

girdle of resistance, whether it is formed by the cervix or the vaginal walls, while the sinciput is relatively though not absolutely retarded by the resistances to which it is exposed; and thus the second movement of flexion is rendered more or less complete. When a degree of true extension is present, the centre of pressure is on the sincipital side of the true centre of the head. The sinciput is carried forwards by a transit, but not by a rotation within the pelvis, and is forced downwards through the girdle of resistance, while the occiput is retarded, as was the sinciput in the preceding example, thus rendering the second movement of extension more or less complete. Such might be the mechanism of a head in the occipito posterior position with some degree of primitive extension. When, on the other hand, primitive flexion is more or less present, or at any rate the centre of pressure lies on the occipital side of the true centre of the head, the mechanism is more laborious, though it is essentially the same. The tendency in these cases is for the completion of the first movement of flexion, or the production of the second to be delayed. The slowness is due to the fact that the sincipital region of the head/

head lies over the area of the girdle of resistance, and the occipital portion which contains the centre of pressure is exposed to the posterior or posterolateral resistances, which I have already described. Under normal conditions, the axis of pressure still seeks the area of least resistance, and notwithstanding the disadvantageous position the axis of pressure carries with it the centre of pressure and the occiput towards the anterior moiety of the pelvic canal. In the absence of pelvic walls, the sinciput would simply be pushed forward out of the way. But, within the pelvis the sinciput is resisted by the antero-lateral wall, and it is pushed upwards, compressed, and depressed, as the first, second, and third movements of flexion are developed. The process continues until these movements are as fully developed as the conditions of the occipito-posterior position allow. The subsequent phenomena form part of the mechanism of internal rotation, but not as a rule, before flexion has reached a high grade. In those relatively rare examples, where it is possible to point to a persistent misdirection of pressure downwards and backwards towards the plane of the brim, or maybe at right angles to the plane of the brim, the axis of pressure does not directly seek/

seek the area of least resistance, and whenever the upper structures fail to produce the necessary correction the duty devolves on the soft parts of the pelvic canal and indeed mainly on the pelvic floor. The successful issue of the balance of force and resistance arising here depends mainly on the persistency with which the centre of pressure tends to remain within one segment of the head, whenever its position becomes excentric, and partly on the tendency of the centre of pressure to be inclined to the chord of the surface of the head. Were that not the case, the mere interaction of pressure and resistance would inevitably convert true flexion into true extension and vice versa. I find, by experiment, that flexion cannot be produced very far with a misdirection of pressure, without a readjustment of the head within the pelvis in the sense of internal rotation. Thereafter, though flexion is enormously increased, the phenomena belong rather to the mechanism of extension and the lower portion of the pelvic canal than to the mechanism of flexion.

becomes further dilated.

area of least resistance.

§11. *Before the os externum is fully dilated and the membranes are ruptured, the second movement of/*

of flexion frequently happens as a passing event, but it seldom becomes persistent. The bag of waters prevents the extrusion of the occiput or the sinciput, as the case may be. They do not avoid, but rather encourage a temporary dipping of the presenting part into the centre of the girdle. During a uterine contraction in the first stage, the fetus, if it is sufficiently mobile, is first slightly withdrawn from the os; secondly, pressed downwards, with an associated dipping of the presenting part; and thirdly, withdrawn again to a position of repose. These movements seem inexplicable without calling in a preliminary widening and a subsequent shortening of the uterus, along with some degree of fundal pressure on the upper pole of the fetus. And the explanation would indeed be necessary, if no change took place in the lower pole of the uterus. As it is, however, the essence of progress at this stage is an uncertain amount of "give" at the lower pole of the uterus, with a greater or lesser protrusion of the bag of waters through the os externum which becomes further dilated. The "give" entails an area of least resistance, even though the intra-uterine pressure remains everywhere equally distributed. In accordance with the theory of the general-

contents/

*

contents pressure, the view that the fetus alone moves is untenable, and it is more probable that the fetus and the liquor amnii move as one body. In the beginning of a uterine contraction, the uterus becomes more globular by an increase of its horizontal diameters. The greater space, thus formed, draws up the liquor amnii, along with the fetus. Then follows the constriction of the uterine body, and the displacement of the amniotic fluid and the fetus downwards towards the lower uterine pole, where the axis of pressure tends to force the occiput or the sinciput, accordingly as flexion or extension is present, in the direction of the "give" of the bag of waters. The third movement is a lesser edition of the first, and the restoration of the head to a position of repose, in which the fontanelles are nearly level, depends on the resistance which the nuchal muscles and ligaments offer to being stretched. When the membranes remain intact until the os is fully dilated, the head generally passes into the vagina with the first movement of flexion alone developed, or at any rate persistent in the intervals of the pains. On the other hand, when the membranes rupture early, the head passes through the os with the second movement more or less well advanced/

advanced, but the second movement usually disappears when the head entirely escapes from the cervix.

It reappears at the bottom of the excavation.

§12. Closely connected with the eccentricity of the opening in the soft parts as a factor in producing or marring flexion is the rapidity of dilation, and the size of the area of the girdle formed in advance of the head, largely by a process of "active dilation". Thus, in primiparae in whom the area of the opening is usually small we have often a deficient and a delayed second movement of flexion: in pluriparae in whom the area is larger we have an early and a well developed second movement while it often happens in multiparae that "active dilation" opens the whole canal in advance of the head which in such cases descends with the two fontanelles nearly level (LUSK 1891) and without any second movement of flexion until the floor is being approached.

It is scarcely possible to separate much of the foregoing paragraph from application to the third factor of the total resistances of the soft parts. These, as I have already pointed out, are incapable/

incapable of producing flexion when the greatest circumference of the head coincides with any parallel plane of the canal, but whenever the axis of the cephalic ellipsoid becomes in any degree oblique within the canal, the general resistances of the soft parts act, as HUBERT and LAHS have shown, during the pains (but probably not in the intervals as LAHS believed) by developing centripetal forces on opposite poles of the head at different levels. The good or bad effects of the constriction exercised by the soft parts cannot be measured for the soft parts alone. When the rigidity, want of dilatibility, and therefore the centripetal pressure of the soft parts, are greatest flexion in the sense of the second and third movements is often least developed, and this is due, as I have just shown, to a closely connected defect of the girdle of resistance. Such a deficiency is compensated for whenever the child is small and soft: very narrow, soft parts and a small girdle of resistance may be associated with extreme second and third movements. In SIMPSON'S (1878) case of premature labour, however, the extremely flexed attitude of the head appears to have been due to a combination of moderately resistant soft parts with a large girdle/

girdle of resistance, and therefore to have been comparable to the state of affairs normal for a pluripara with a full-time child of average size.

§13. The fourth factor is the total resistances of the bones and ligaments of the pelvis. The transverse and oblique diameters of the pelvis contract from above downwards, the latter more rapidly in the lower than in the upper part of the superior portion of the canal. Hence it follows that a head which passes the brim comfortably with only the first movement of flexion developed, will have the second produced in the course of the descent by a mechanism of opposing forces operating at different levels, like those of the soft parts. It is the fashion to state that the bones and ligaments exert no effective pressure on the head, except in cases of serious disproportion (STADFELDT 1861, LAHS 1870, and later authors). The assertion appears to be based on the appearance and attitude of the head at the vulvar outlet, it being assumed that the suboccipito-bregmatic diameter, which is then the mechanically important diameter, has a similar value within the cavity of the pelvis; and as/

as this diameter is smaller than any of the diameters of the pelvis, the bones and ligaments can have no effective influence on the head. The assumption is, however, unsupported by clinical examination, and by the appearances in BRAUNE'S second section and in BARBOUR'S late second stage section. It is true that, when the head is fully flexed, the sub-occipito-bregmatic diameter is engaged in the sense of being nearly parallel to the parallel planes of the excavation. But it does not follow that this diameter is mechanically engaged in the pelvis. The appearances to which I have just alluded and to which I shall return make it clear that the effective diameter is one which corresponds in magnitude to the occipito-frontal diameter of the head. It is effective in every part of the descent through the excavation, and it is larger than either the oblique, or the transverse diameters of the lower part of the bony pelvis. The changes in the form of the bony pelvis are responsible, under the normal relations of the head and the pelvis, for the fixing or the rendering permanent of the second movement of flexion, previous to internal rotation. They are also concerned under/

under normal conditions, in the production of the third movement of flexion. But in neither instance is it necessary for the bony pelvis to act. The second and third movements can be produced, through the instrumentality of the first factor, by the third - the total resistances of the soft parts - and in the absence of the third by the second. Indeed, the only common factor is the position of the centre of pressure in relation to the head. That alone, under uterine and abdominal pressure, may possibly produce flexion against uniform resistances, but it acts normally and with tolerable rapidity in combination with anyone, or with more than one of the subsequent factors. Further, it is quite inconceivable that flexion in the sense of the second and third movements need never occur at all, even after the first movement has been completed, the head descending in an oblique diameter of the pelvis and rotating without any change in the relative position of the two fontanelles. (Cf. PAJOT q. by TARNIER and CHANTREUIL 1882). Such I have observed in a less completely negative form in multiparae, while the fact may here be recalled that delivery without flexion in the sense of any of the/ diameter (BARRIACQUE, PERRAQUIN, quoted by

the three movements has been known to occur.

§14. Adaptive moulding (the third movement of flexion) is able to modify the distribution of pressure over the presenting part e.g. the head, and under certain circumstances to favour the production of delayed first and second movements of flexion. It is in itself, an increase in the totally flexed appearance of the head. The factors concerned in the production of moulding are fetal and maternal. The bones of the cranial vault are malleable and elastic; the cranial contents are able to be displaced and re-arranged in a form different to that which is primitive, the degree of absolute compression and extension of the contents being however, very small. The ultimate limit of moulding is determined by the breadth of the base of the skull. The base is relatively incompressible (BALLANTYNE 1890), and probably cannot be compressed to any extent without entailing serious injury to the child. As FABRE (1910) observes, the diameters perpendicular to those compressed extend, while the diminution of the antero-posterior diameter is not compensated by an increase in the transverse diameter (BAUDELOCQUE, PETREQUIN, quoted by DELORE/

DELORE 1865), but by an elongation of the vertical diameter (LABAT 1831, MURRAY 1838). The maternal factors are the same as those for the first and second movements, namely:- the tendency of the axis of uterine pressure to seek the area of least resistance, the phenomena of the action of a uniform pressure on a curved surface, the excentric position of the girdle of resistance, the total resistances of the soft parts, and the total resistances of the bones and ligaments of the pelvis. If the forms of moulding in the various positions and presentations are recalled, it will be observed that protrusion and elongation occur in the parts which are concentric with the area of the girdle of resistance, compression and depression in the parts which are excentric to the girdle of resistance. POLLOSSON (1892) has expressed the opinion that moulding is effected by the resistance of the soft parts at first, and only by the bones and ligaments when the head is in the lower part of the excavation. Apart from the direction of pressure and the excentric position of the girdle which I regard as paramount, POLLOSSON'S view seems to be correct, and is at any rate in keeping with the most commonly/

commonly observed facts. The bones and ligaments play an important part, at an early stage, in moulding the head in the occipito-posterior positions, in occipito-transverse with and without the first movement of flexion, in occipito-pubic and occipito-sacral positions, and in face and forehead presentations. As I shall quote FABRE to show, moulding effects a comparatively small change in the diameters of the head, and is indeed more intimately connected with the production of internal rotation. The importance of moulding for the mechanism of flexion lies in its capacity to alter the curvature of the cranial vault without there being at the same time necessarily any change in the orientation of the head. Incidentally, the position of the centre of pressure is altered by the changed curvature of the head without the head having moved as a whole. And though the moulding merely hastens the excentric displacement of the centre of pressure in the ordinary labour, where true flexion or true extension is present from the beginning, it becomes of the greatest importance in those cases where no flexion or extension is present, where the general contents pressure is normal to the chord of the surface of contact. I have already mentioned one example/

example in which pressure is at right angles to the chord, and in which the position of the head is occipito-transverse within the pelvis. In this case moulding, so far as I can see, never favours flexion, for the moulding in adaptation to the distribution of the resistances itself as a uniform bulging of one lateral half of the head (anterior within the pelvis) and a uniform flattening of the other lateral half (posterior within the pelvis). When, however, the head is in the occipito-transverse position and the first movement of flexion is primitive, the centre of pressure lies in the occipital side of the true centre of the head, and tends to be carried towards the mesial plane of the pelvis and forwards within the canal. Descent is greatly aided by the moulding which, as well as the second movement of flexion, is apt to be excessive. Here, as in the normal event the moulding aids in carrying the centre of pressure towards a more excentric position. In other and rare labours, where the pressure is directed at right angles to the chord of the surface of contact, but where the head lies in the oblique diameter of the pelvis, the moulding which then corresponds in type to that observed in an ordinary summit presentation, may/

may be the sole originator of an excentric position of the centre of pressure, the protrusion or elongation of the occiput altering the curvature of the surface of the head and producing in that way a form which would otherwise have to be attained by an impossible second movement of flexion. In such labours it is to be observed that the moulding precedes the movement of the head as a whole, and therefore is primarily concerned in the production of flexion, by altering the position of the centre of pressure. At first, the pressure acts uniformly at right angles to the chord of the lower surface. When, however, the occipital region of the head is elongated by the repeated application of pressure to the head over an area which is mostly resistant posteriorly and non-resistant anteriorly, the lower surface of the head becomes inclined away from the parallel plane of the pelvis in which it once lay. Therewith the chord is displaced and in fact dips towards the occipital pole. The pressure is now no longer at right angles to the chord of the surface and can no longer be normal to the chord. It becomes unevenly distributed in such a way that the centre of pressure, representing the average of all the pressures, moves towards the occipital pole, and takes/

takes up a position which is excentric within the head. In consequence, the force of the general-contents pressure is developed more on the occiput than the sinciput, and this circumstance, when coupled with the other factors and especially with the excentric position of the area of the girdle of resistance, results in the production of the first and second movements of flexion of a head which primitively showed neither flexion nor extension.

§15. As regards the relative conditions which determine the onset and the development of the three movements of flexion and the periods of time which witness them, it is not possible at present to review the subject in a comprehensive manner. Probably the methods employed up to a certain degree of intensiveness by PARISOT (1893) and by VALTORTA (1912) lead the way to a general and inclusive account of this part of the problem. The chief present difficulty of the method is to measure the diameters of the pelvic canal in the living subject, in whom it must be done if a sufficiently large number of useful reports is to be gathered together. PARISOT and/

and VALTORTA measured the weight of the fetus after birth, during which they noted the degree, the periods, and the levels of the various stages of flexion. The former author also took measurements of the fetal head, and instituted a comparison in a series of labours between the above group of fetal factors and the dimensions of the corresponding pelvic canals, which were indirectly measured. The well-known uncertainty of this mode of mensuration constitutes a serious defect in PARISOT'S laborious and carefully executed work. Another objection may justly be raised to the measurement of the head after birth. In a large proportion of labours, perhaps in the greater number, the form and dimensions of the head at the vulvar outlet differ radically from those of the head when it is within the superior portion of the pelvic canal, and the difference works in a sense adverse to a true conception of flexion and internal rotation. At the same time PARISOT'S conclusions seem truthful in a general way and may therefore be quoted. In the subjoined table I have condensed PARISOT'S results for the two more frequent positions - the left occipito-anterior and the right occipito-posterior. The data are grouped in the order/

order of the frequency of their occurrences (the author's arrangement), beginning with the commonest and ending with the rarest. The second column of figures gives the square roots of the products of the average occipito-frontal and bi-parietal diameters in each group, the third column the square roots of the antero-posterior external and inter-cristal diameters of the pelvis. The quotients of the roots in both groups are given in the fourth column: in the last column of figures are the results of dividing the square roots of the weights by the quotients of the other roots. Each figure is then a measure of the three factors used by PARISOT, and the figures for the successive groups of labours should stand in some sort of relation to the clinical findings which are given in the last column, the lateness of the occurrence of flexion being proportional to the smallness of the figure.

3320	9-35	20-70	2-08	27-55	trial
3244	PARISOT/	21-72	2-07	27-50	causity.
3683	?	?	?	?	earlier.
3300	10-49	?	?	?	causity.

The/

PARISOT : LEFT OCCIPITO-ANTERIOR POSITION.

Fetal Weight in Grammes	<u>Head</u> $\sqrt{\text{OFXBP}}$	<u>Pelvis</u> $\sqrt{\text{APXIC}}$	Ratio of	$\sqrt{\text{Weight}}$ ÷	Flexion occurred on or in
A. 3325	10.16	21.30	2.09	27.58	floor brim
B. 3650	9.98	21.93	2.19	27.58	} > floor brim.
C. 3271	10.16	?	?	?	
D. 2883	9.45	20.70	2.19	24.52	cavity
E. 3300	10.25	20.00	1.95	29.59	brim
F. 3283	?	21.40	?	?	cavity.
G. 2980	10.39	21.00	2.02	27.03	cavity
H. 2730	9.67	20.40	2.11	24.76	none.

RIGHT OCCIPITO-POSTERIOR POSITION.

A. 3149	10.16	21.30	2.09	26.82	floor
B. 3320	9.95	20.78	2.08	27.55	brim
C. 3244	10.45	21.72	2.07	27.50	cavity.
D. 3683	?	?	?	?	cavity.
E. 3320	10.49	?	?	?	cavity.

The/

The figures given in the second last column - the quotients of the square root of the weight divided by the ratios of the square roots of the head and the pelvis - show a wonderfully close agreement with the clinical findings. In the occipito-posterior position the agreement seems perfect. But in the occipito-anterior, though the highest figure is associated with flexion at the brim and the second lowest with no flexion at all, the discrepancies otherwise seem greater than can be accounted for by PARISOT'S methods. They suggest that in addition to the three factors measured by PARISOT - the weight, the head and the pelvis - there are others. Looking to the differences known to exist between primiparae and pluriparae, and between these and multiparae, and to the most obvious cause of the differences, namely, the relative rate of dilation of the soft parts, and the extent of the primitive "active dilation" of the soft parts, we are justified in insisting on the addition of these last as a fourth factor, to be taken into account, while a comparison of the behaviour of the head in the occipito-anterior and occipito-posterior positions/

positions is inadequate, unless it takes note of the effect of the excentric position of the area of the girdle of resistance within the canal. Methods of accurately determining the relative proportions of the fourth factor and of making allowance for the excentric position of the girdle do not readily occur to the mind, and it may well be long before anyone improves on PARISOT'S work.

VALTORTA (1912) gives data for the right and left occipito-posterior positions only, and compares the weight alone with his clinical findings. In the next table I give in parallel Columns the views of VALTORTA and PARISOT on the time of occurrence of flexion relative to the weight of the fetus. Taken on the whole the results agree fairly well.

Right/

RIGHT OCCIPITO-POSTERIOR POSITION.

Fetal weight in Grammes.	Level at which Flexion occurs.	
	VALTORTA (1912)	PARISOT (1893).
Below 3000.	Brim, increased in cavity.	-----
3000-3500	Brim, increased in cavity. (very great).	Brim, cavity, cavity, floor (4 groups).
Above 3500	Cavity	Cavity.
At 4000	Brim	-----

LEFT OCCIPITO-POSTERIOR POSITION.

Up to 3000	Brim, increased in cavity.	-----
3000-3500	Cavity increased on floor: No Flexion (4 out of 7 cases).	
Above 3500.	Brim, increased in cavity. (entry transverse).	-----

In/

In the left occipito-anterior position, according to PARISOT, flexion takes place most commonly on the floor of the pelvis. Less often there is a first flexion at the brim. Third in order of frequency is the production of flexion in the cavity of the pelvis, and the fourth is flexion at the brim.

In the right occipito-posterior position, according to the same writer, the order is first flexion on the floor, and secondly flexion at the brim. In the third form, rotation begins first and flexion is fully developed when the head is in the transverse position. For the latter position, VALTORTA admits flexion to occur either at the brim or on the floor, but usually with difficulty, owing to a tendency of the head to extend. He represents the older authors (BOIVIN, NAEGELE, STOLTZ, DUBOIS, VELPEAU, GUILLEMOT, CASEAUX, LOCHARD) as believing flexion to be contemporaneous with the descent of the head; FABBRI and JACQUEMIER as stating flexion to occur on the floor; TARNIER, CUZZI, DESSAIGNES and LEPAGE, and FABRE as postulating a minor flexion at the brim in addition, as in the left occipito-anterior position. In the left occipito-posterior position, PARISOT considers flexion to be very difficult/

difficult. Out of seven labours under his observation only three developed flexion of the head, and then only after the head in each case had rotated to the transverse position. PARISOT further distinguishes a left transverse position of which he records four cases. In these flexion at the brim was the more common event.

For the present purpose the observations of PARISOT and VALTORTA need analysis into the three separate movements of flexion. But an attempt to do so did not prove very satisfactory, though it is obvious in places that the authors are writing first of one movement and then of another.

GUILLEMOT (1837) believed flexion to be completed when the cervix is well dilated. TARNIER and CHANTREUIL (1882), CHARLES (1837) placed the level of flexion at the brim, while DESSAIGNES and LEPAGE (1894) point out that flexion is often completed at the brim in primiparae. PESTALOZZA (q. by BARBOUR 1899) adverts to the occurrence of marked flexion before labour and believes that it cannot be due to the walls of the cavity, but must result from the resistance of the lower uterine segment. DUBOIS (1834) considers the uterine orifice to have most effect, and secondarily the walls/

walls of the cavity act. NORRIS and DICKINSON (1896) state that flexion occurs in first part of the descent: GALABIN and BLACKER (1910) when the membranes rupture. DEPAUL (1872) favours the brim first, and then the cavity; while PINARD and VARNIER (1892) regard flexion to be produced slightly in the brim and afterwards increased with descent. FRY (1888) asserts that flexion is most developed on the pelvic floor, where I believe the movement of which the author writes is more concerned with the mechanism of extension, under which it will be considered later. MARX (1892) gives a list of circumstances unfavourable to flexion. Some are hypothetical; of the others, GOITRE is known not to prevent flexion (KAMANN 1913), and the effect of dolicocephaly is I think disproved by PARISOT'S figures.

By far the most frequent course of events to my belief, is as follows:- The first movement of flexion is an attitude formed in pregnancy, or it is completed whenever the head grows into contact with the lower pole of the uterus, or as soon as a "give" begins to appear at the os externum (in the first stage). The head is able to and does pass the brim with the first movement of flexion alone. (DUNCAN 1868, LABAT 1881, BARBOUR 1899). No further/

further development takes place until after engagement is complete. At this level in one of BARBOUR'S sections the head shows no more than the first movement of flexion. The second movement of flexion is made as complete as is necessary in the lower part of the superior portion of the canal, after many transient manifestations of the second movement during successive pains. The third movement of flexion is produced very slightly during engagement, and is fully developed as a flexional movement when the head is in the lower part of the superior portion of the pelvic canal. At this moment and at this level the appearance of the head is very much what it is in BARBOUR'S late second stage section. That is to say, the occipito-nuchal aspect of the head is parallel to and in contact throughout its whole length with the anterolateral pelvic wall. The appearance depends mainly on the extent to which the second movement is produced. An exaggeration of this movement tends to bring the little fontanelle into the axis of descent and is normal for the generally contracted pelvis. It brings with it, however, as FABRE (1910) points out the risk of an engagement of the dorso-frontal diameter of 12.5 cm., in a higher/

higher level of the canal, just as forced extension of the head may cause an engagement of the presterno-sincipital diameter of 13.5 cm. Hence, FABRE considers moderate flexion better than forced flexion and similarly with extension.

§16. When we turn to the task of describing departures from the most frequent course of events, and of assigning these departures to the anomalies to which they are no doubt due, we meet with an undertaking of some magnitude, and one which is impossible in the sense of completion, so long as the mechanism of flexion is understood only in general terms.

PARISOT was unable to come to a conclusion regarding the effect on flexion of obliquities and other irregularities of the uterus. He found, if I read aright, increased flexion more frequently associated with an excess of liquor amnii than otherwise. But, SELLHEIM(1907) and GALABIN(1910) are of a contrary opinion. In twenty labours the effect of the rupture of the membranes was noted by PARISOT. In four, no change was observed, and the head was not flexed (? second movement); in four, the anterior fontanelle lowered; in eight, flexion was already present/

present and no change happened; in one, flexion was increased; in another, flexion occurred simultaneously with the escape of waters; and in the remaining two, flexion was produced after some pains followed the rupture. Unfortunately, I omitted to note whether or not PARISOT mentioned, or took into account the state of the cervix at the time of rupture. If the cervix is fully dilated, there is no a priori reason why flexion should be increased on the escape of the waters (cf. JACQUEMIER 1846). On the other hand, if the cervix is not fully dilated, the second movement is produced sooner or later to a considerable degree, as I have already described, but it passes off as the cervix approaches the state of complete dilation (HODGE 1864, PLAYFAIR 1880, GALABIN 1910). In a general way it may be said that the second and third movements may be produced at the brim, if severe relative disproportion exists, and that neither the one nor the other need occur at all. In the occipito-posterior positions, the second and third movements often do not occur until the head is in the second division of the straight portion of the canal. They may, however, be produced extremely from the brim downwards, and cases in which it occurs are the/

to flex, once it has entered the pelvis until it reaches/

the hardest to diagnose in time as of one or the other of these positions. To occipito-transverse positions I have already referred. In the direct occipito-sacral and pubic positions, the second and third movements seem always to be grossly exaggerated during the passage of the brim, and to ease off a little during the subsequent descent.

Extension when it comes in the superior portion of the pelvic canal manifests the same three movements as those of flexion, but in a reverse direction, and they are subject to the same factors of production, always excepting the initial circumstance favouring the first or true movement of extension. Whether it be an extended occipito-posterior, a forehead, or a face presentation, the head goes through the same movements in the same order, as those which it does go through when flexed, but of course in the opposite direction. In general, it may, however, be said that the level at which a given event occurs is rather higher in the extended group than it is in the flexed. And it is noteworthy that whenever the relative proportions of head and pelvis are what may be regarded as normal, it is impossible for a flexed head to become extended, or an extended head to flex, once it has entered the pelvis until it reaches/

reaches the outlet. It is probable, however, no efforts are wasted in this direction as the persistent tendency of the centre of pressure, once it has become excentric within the head, is to preserve and increase its excentricity in whichever part of the head it first arrived. There is an apparent exception to this rule. It will be considered along with the mechanism of kyphotic pelves in which it most frequently appears (Section V). The mechanism of descent in face and forehead presentations, embracing as it does phenomena sometimes of flexion and sometimes of extension, is more conveniently described under extension (Section VI).

In flat pelves, according to JARDINE (1903), the bi-parietal diameter stands in the conjugate of the brim, while the anterior and posterior fontanelles are nearly level. A movement then occurs which substitutes the bi-temporal for the bi-parietal diameter, and entry takes place. JARDINE attributes the movement to the wedge-shape of the head. But, supposing the conjugate to coincide exactly with the bi-parietal diameter, we have no explanation here why the occipital pole is not substituted instead. GALABIN and BLACKER (1910) give two possible mechanisms/

mechanisms, namely:-

1. The bi-parietal diameter coincides with the conjugate, and descent takes place with extension, (SCHROEDER, GOODELL 1876);
 2. The bi-parietal diameter lies to one side of the conjugate, and entry occurs with flexion (LITZMANN, PLAYFAIR, SPIEGELBERG, LUSK).
- With the latter opinion GALABIN appears to agree, as he says that the head must either flex or impact. Once the head is even partly within the canal, it must be admitted that flexion and impaction are the only alternatives. As the occipito-frontal diameter averages 12 cm., and the transverse diameter of the brim equals some 15 cm., it is hardly possible for the bi-parietal diameter to coincide with the conjugate so long as the two fontanelles are nearly level. And the true position seems to be much as it is described by GALABIN. The bi-parietal diameter lies on one side of the conjugate, while the centre of pressure which occupies very nearly the centre of the head lies mesially in the conjugate. The bi-temporal diameter is in the conjugate from the beginning. It is, as LABAT (1881) has shown, more/

more compressible than the bi-parietal diameter.

The mechanism of flexion does not appear to differ from that of a persistent transverse position which has already been described.

The three movements of flexion are developed in the aftercoming head in the same way and from the same causes or factors, as in head-first labours. The third movement however, is more or less modified by the circumstance that the head is descending into a canal which is already dilated. As a result, the appearance of the cranium is more dome-like and less elongate than it is in the ordinary labour. But the head is always incompletely domed and always partially lengthened, owing to the fact that the segments of the fetus which precede the head in the passage of the canal are not so large as the head itself and hence do not dilate the canal as fully as the head demands for its descent.

According to my experiments, misdirection of uterine pressure tends to produce a movement of the oncoming head towards extension instead of flexion. But, unless the misdirection of uterine pressure is altogether excessive, the ultimate effect is not serious. On the other hand, the aftercoming head at least experimentally, is remarkably sensitive to the/

the direction of traction. A variation of so little as $+ 10^\circ$ is able to affect the production and maintenance of flexion. So long as traction is made parallel to, or downwards and forwards from the anterior wall of the model canal, flexion is, if necessary, increased, and is maintained without any tendency being manifest towards flexion coming undone. When, however, traction is made downwards and backwards from the anterior wall, to an extent even as small as that represented by 10° of arc, a movement towards extension arises with eventual impaction of the head within the canal.

§17. Uniform force acting on a plane surface develops it is said, the maximum effect when the surface is inclined to the force at an angle of 35° . According to a reviewer in *Nature* (1913), the observation has been confirmed by experiments made at the Koutchino Laboratory in the years 1910 to 1912.

In my experiments which do not pretend to the accuracy obtained by the Russian workers, the maximum effect is obtained on a curved surface when its chord is inclined to the pressure at an angle of 27° . In any case these figures indicate the range of

of flexion which is best adapted, in relation to the pressure alone, to bring out the best results of a given pressure. And whenever flexion is greater or less than that suggested by the figures, the force employed is not developing its best work, though of course the greater or less degree of flexion may be demanded by intra-pelvic conditions, and may indeed be absolutely essential to the progress of the labour. There is thus evidence for a compromise between the pelvic demands for flexion (or extension) and the requirements of the uterine and abdominal pressures for their most efficient action.

§13. As I have already pointed out, the measurement of the diameters of the head immediately after birth is no safe criterion of the dimensions of the head before rotation occurs, and still less so of the head before its entry into the pelvis. I happen to have notes of only two series taken anterior to rotation. FARABEUF and VARNIER (1891) give as averages for the head not moulded O.M. 13.5, O.F. 12, S.O.B. 9.5, Bi.-P. 9.25, and Bi-T. 7.5 cm. BARBOUR (1899) has measured the head in his coronal sections when engagement is complete, but the head is not moulded/

moulded. The approximate figures are O.M. 12·6, O.F. 11·4, and S.O.B. 10·8 cm. BARNES (1865), on what data I am unable to say, concludes that the head before labour has the following dimensions:- O.M. 13·3 - 14, O.F. 11·4 - 12·7, Bi-p. 9·5 - 10·1, and Bi-T 8·9 cm.

Measurements have frequently been made of the head after birth and in some cases extended series were taken. The results are, of course, indicative of the effects of the process of labour. But, when taken in conjunction with the previous figures, they measure the changes which go on occurring until the head is born. VALLOIS (1903) gives the detailed measurements of forty heads taken just after birth. His averages are:- O.F. 11·3, S.O.B. 9·6, Bi-P. 8·9, and Bi-T 7·9 cm. Compared with these are the averages given by PERRET (1899) for twelve heads:- O.F. 11·3, S.O.B. 9·3, Bi-P. 8·6, and Bi-T. 7·4 cm. The averages for the combined series of 52 heads I find to be O.F. 11·3, S.O.B. 9·5, Bi-P. 8·8 and Bi-T, 7·8 cm. It is therefore apparent that FARABEUF and VARNIER'S average is too large at the one end and too small at the other, while BARNES'S average is too great all over. BUDIN (1886) and VARNIER (1900) averaged their measurements in/

in groups by weight, the latter measuring 300 heads at birth, while PARISOT (1893) averaged the measurements and weights in groups separated according to the period at which flexion and rotation were observed to occur.

1. BUDIN.

FETUS.

2000-2500g. 2500-3000g. 3000-3500g. 3500-4000g. 4000g.

Average measurements in Cm.

O.M.	11.5.	12.	12.5.	12.5.	14.
O.F.	10.5.	11.	11.5.	11.5.	11.5. 12.5.
S.O.B.	8.5.	9.	9.5.	9.5.	10.
Bi-P.	8.7.	9.	9.	9.5.	10.
Bi-T.	7.5.	8.	8.	8.	8.5.

2. VARNIER.

FETUS.

2500-3000g. 3000-3500g. 3500-4000g. 4000-4500g. 4500-5000g.

Average measurements in cm.

S.O.F.	10.2.	10.5.	10.9.	11.2.	11.7.
S.O.B.	9.3.	9.5.	9.8.	10.1.	10.3.
Bi-P.	9.	9.3.	9.6.	9.7.	9.9.

3. PARISOT.

FETUS (L.O.A. POSITION ONLY).

2730g. 2883g. 2980g. 3271g. 3283g. 3300g. 3325g. 3650g.

Average measurements in cm.

O.M.	11.4.	12.	12.	12.5.	12.5.	12.	12.5.	13.3.
O.F.	10.4.	10.5.	12.	11.5.	11.3.	11.	11.5.	9.5.
S.O.B.	9.	8.5.	9.	10.	10.	9.	9.	9.5.
Bi-P.	9.	8.5.	9.	9.	-	9.5.	9.	9.5.
Bi-T.	7.7.	8.	8.	8.	7.5.	8.	8.	8.

Average measurements in cm.

The arrangement of the average measurements according to the total weights in an ascending series forms a useful contribution but is not a conclusive method. VARNIER'S weights begin and end higher than do those of BUDIN. Weight for weight VARNIER allows a larger head than does BUDIN, as may be seen from the tables by comparing the measurements of the suboccipito bregmatic diameters. PARISOT'S table is valuable, for it records in print what had been long previously known in a general way that the size of the head is not always proportionate to the total weight/

weight of the fetus. Further even the averages in PARISOT'S table bring out the facts that the size of the head does not necessarily rise in an orderly progression with a rising weight and that individual groups show surprising local variations among the diameters.

With PARISOT'S L.O.A. table may be contrasted the one the same author gives for the right occipito-posterior position.

4. PARISOT.

FETUS (R.O.P. POSITION ONLY).

3149g. 3244g. 3320g. 3320g. 3683g.

Average measurements in cm.

O.M.	12.	12.	12.5.	12.5.	12.5.
O.F.	11.5.	11.5.	11.	11.	-
S.O.B.	9.	9.5.	9.5.	-	10.
Bi-P.	9.	9.5.	9.	10.	10.
Bi-T.	8.	8.5.	7.75.	8.	8.5.

Comparing the R.O.P. table with the L.O.A. table we do not find such differences as might be expected. On the whole, perhaps, the size of the heads/

5. BARNES.

FETUS.

Average measurement in cm.

O.M.	14.7. - 16.6. 14.7.	17.2. 16.5.	16.5. 17. 16.5.	17.2.	15.3.
O.F.	12. 12 13.4. 13.9.	13.9. 13.4.	13.5. 12.7. 15.3.	15.3.	12.
Bi-P.	9.6 - 10.2 8.2.	9. -	9. 9.6 10.2.	9.	-
Bi-T.	9. 9. -	- -	- -	-	-
	Aftercoming head. Contracted Pelves.	Forceps. Contracted.	L.O.A. Forceps.	R.O.P. to O.A.	R.O.P. to O.P.

These measurements represent on the whole larger heads than those of the previous tables.

Perhaps /

Perhaps, the largeness of the heads is connected with the pelvic contraction. In any case the figures show the great lengthening of the occipito-frontal and especially of the occipito-mental diameters which is clearly the result of the pelvic contraction. At the same time the compression of the transverse diameters is not excessive. BAYER (1885) gives the measurements of two heads, both forehead presentations:-

O.M. 15, O.F. 13, Bi-P. 10, Bi-T. 7cm.

O.M. 12.5, O.F. 12, S.O.B. 9, Bi-P. 9.5, and Bi-T. 8 cm.

and one series of a face presentation:-

O.M. 12.5, O.F. 12, S.O.B. 9, Bi-P. 9, and Bi-T. 7 cm.

AHLFELD (1903) measured a head from a direct or primitive occipito-anterior position:-

O.M. 12.2, O.F. 13, Bi-P. 9.9 cm.

DE RIBES and BOUFFES (1903) measurements of a head which had come through a flat pelvis show the great lateral pressure to which the head is exposed:-

O.F. 12, S.O.B. 9.5, and Bi-T. 7.5 cm.

FABRE (1910) correlates the measurements of the head with its position as regards flexion or extension, in the following way:-

1. Head between flexion and extension.

O.F. 12, Bi-P. 9.5, and Bi-T 8 cm.

2./

2. Chin on the Breast.

S.O.F. 10·5, Bi-P 9·5.

3. Forced Flexion.

S.O.B. 9·5, Dorso-frontal diameter 12·5 cm.

4. Moderate extension.

S.O.M. 13·5, and Bi-P 9·5 cm.

5. Forced extension.

S.M.B. 9·5, and Bi-T 8 cm. Presterno-sin-
cipital 13·5 cm.

These measurements are intended to correspond to the successive planes of engagement in the pelvis, and on the strength of them FABRE argues in favour of a moderate degree of flexion as the best mechanism. These figures bring out the small effect which moulding per se has in reducing the diameters of the head relative to the pelvis. I have already alluded to this fact, and will subsequently have occasion to show that moulding is much more intimately concerned with the production of internal rotation than with the descent of the head. Lastly, reference may be made to BARNES'S (1835) ideal comparison of the skull and the pelvis, which I reproduce below in tabular form.

BARNES/

BARNES 1885.

PELVIS-DIAMETERS IN CM. SKULL - DIAMETERS IN CM.
BRIM.

Antero-posterior	10.8 - 11.5.	Bi-P.	9.6-10.2.
Transverse	12.7- 13.4	O.F.	11.7-12.7
Oblique	12.7.	S.O.B.	10.8-11.5.

CAVITY.

Antero-posterior	12.1-12.7.	Bi-P.	9.6-8.9
Transverse	12.1	O.F.	11.5-12.1.
Oblique	12.1-13.4.	S.O.B.	9.6-10.2.

OUTLET.

Antero-posterior	10.8-13.4	O.F.	12.1-13.4.
Transverse	10.8	S.O.B.	9.6.
Oblique	10.8-11.5.	Bi-P.	8.9.
		Bi-T.	8.3-8.9.

BARNES'S comparison is valuable from a relative point of view, even though it was made in the dried state of the parts. In an absolute respect very little would escape criticism which is however forestalled to a large extent by BARNES himself in the qualifications which he subjoined. Relatively considered/

considered, the figures are consonant with the most frequent clinical findings; and they show, after allowing for the soft parts, how the head can descend far into the pelvis without the occipito-frontal diameter meeting with lateral obstruction, that is, without any need arising for the second movement of flexion. It is only towards the outlet that flexion must be produced to the greatest degree.

So far we have not come any nearer the true average diameters of the head, as it is just before engagement begins to occur. I accept the average figures derived from VALLOIS and PERRET as probably representing the average size and indirectly the average form of the head immediately after it is born. But I decline to believe that they accurately reproduce the size and form of the head, when it lies in the cavity of the pelvis.

The correlation of the size of the head, the weight of the fetus, and the dimensions of the pelvis contains invaluable possibilities, but it has not yet been extended over a sufficiently large number of observations, even in relation to the first and second factors. As to the size of the head in the cavity of the pelvis, FARABEUF and VARNIER'S figures/

figures seem too high for an average. How far they really reproduce the anti-labour form and not one which is the result of some degree of moulding and other flexional movements is in my opinion doubtful.

It seems well-advised, when proceeding to relate the mechanism of internal rotation, to have regard not only for the well-attested averages which have been obtained after the birth, but also for the smallest diameters which the figures record for the full-time fetus. They may be utilised either as a composition of all the minima, or as indices of the grouped series which are important on account of the smallness of one or more of the included diameters. The foregoing does not exclude the proviso relative to the supposed true size and form of the head when it is within the cavity of the pelvis, nor does it reckon with the mechanism of premature fetuses which are known to rotate and must therefore be taken into account. A composition of the smallest diameters taken out of those I have quoted or referred to, gives a theoretical and presumably improbable head having the following dimensions:-
O.F. 9.5, S.O.B. 8.4, and Bi-P. 8.0 cm. The sub-joined measurements are those of actual heads and contain/

contain in each case a minimum diameter (marked by an asterisk)

O.M. 11.5, O.F. 10.5, S.O.B. 8.5,	*	and Bi-P. 8.7 cm.
		(BUDIN).
O.M. 12, O.F. 10.5, S.O.B. 8.5,	*	and Bi-P 8.5 cm.
O.M. 13, O.F. 9.5, S.O.B. 9.5,	*	and Bi-P. 9.5 cm.
		(PARISOT).
O.F. 11, S.O.B. 9.5, and Bi-P. 8 cm		(VALLOIS)
O.F. 11.7, S.O.B. 9.7, and Bi-P 8 cm.	*	
O.F. 11.7, S.O.B. 9.3 and Bi-P 8 cm.	*	
O.F. 11, S.O.B. 8.4	*	and Bi-P 8.1 cm. (PERRET).

It will be observed from these figures that unusual smallness in any one diameter is compensated for by an excessive lengthening of some other diameter, and so renders the hypothetical very small head the more improbable.

§19. The shoulders exhibit two movements of flexion, the second and third. The second movement may possibly be primitive in the sense of being an attitude arising at an early stage of development. But in any case some inclination of the shoulders towards the head is necessary to the complete development of the first movement. Otherwise a movement of extension will develop so as to carry the shoulders/

shoulders away from the head. With the second movement of flexion, the shoulders are carried towards the head to the fullest possible extent (BARNES 1885 SELLHEIM 1904), and the shoulders as a whole become more moulded in outline. The third movement of flexion is the moulding of the soft parts which are conformed or adapted to the surrounding pressures and to the area of least resistance below. According to SELLHEIM, all the phenomena of flexion exhibited by the shoulders are due to the constriction exercised by the soft canal. This is true when the shoulders are small, but under normal relations, as well as in mutual disproportion, the lateral walls of the pelvis exercise a powerful influence on the parts, and eventually oppose a solid bony resistance to the passage of the shoulders.

The centre of pressure, according to my observations and experiments, is situated at a very short distance from the mesial plane of the shoulders, but much nearer the dorsum than the breast in the dorso-anterior position. And though the centre of pressure lies in the lateral half of the lower surface of the shoulders, the bias is so extremely slight, that in so far as clinical observation can determine/

determine, the two shoulders descend simultaneously through the pelvis. It is necessary in this connection to eliminate the effect of moulding which, owing to the slight Solayrean obliquity of the shoulders and the presence of the area of least resistance in the anterior moiety of the canal, produces a local bulging of the soft parts on the anterior aspect of the anterior shoulder, and creates the impression that the latter is descending first. At the same time, there is another arrangement sometimes observed, in which the obliquity of SOLAYRÉS corresponds in degree closely to that seen normally in head presentations, and in which the anterior shoulder is descending considerably in advance of the other. Here, experience of the quantities of pressure felt at the two shoulders and the type of internal rotation observed render an excentric displacement of the centre of pressure far into the anterior shoulder highly probable. Indeed, in this anomalous mechanism of the shoulders which is comparatively rare in my experience, the whole mechanism of flexion approaches closely to that of the head, and it is possible sometimes to record an imperfect attempt at a second movement of flexion.* The third movement has little effect/

* In the sense of the head.

effect on the diameters of the shoulders: Most of the change is effected by the second movement of flexion and is said (SCHROEDER 1886) to reduce the bisacromial diameter from 12 cm. to 9.6 cm. It should be noted however, that, if the acromial processes are used as the determinants, the measurements are erroneous, for though in the relaxed position the great tuberosities of the two arm bones project but little, they do so very appreciably when the shoulders are carried towards the head.

The breech possesses only the third movement of flexion - moulding which is similar in character to that seen in the shoulders. The breech descends in an oblique diameter with the two trochanters nearly level with each other within the pelvis, the apparent earlier descent of the anterior breech being due to moulding. The breech normally keeps well forwards within the canal. The centre of pressure probably has only a very slight excentricity relative to the mesial plane of the breech, and lies well forwards in an antero-posterior sense. The bi-trochanteric diameter according to EDEN (1911) is 10 cm. The third movement of flexion in the breech may well be produced by the concentric resistance/

resistance of the soft parts, together with the ex-centric distribution of the area of least resistance. The former at the time when the breech is oncoming have not been excessively extended and partly paralysed, as they usually are when the head is making its descent.

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SECTION III

REFERENCES/

REFERENCES.

SECTION III.

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Fig. 5.

Tracing from frozen section at eight and a half months to show fetus in the attitude of the completed first movement of flexion only (from VARNIER, *Obstétrique Journalière*.)

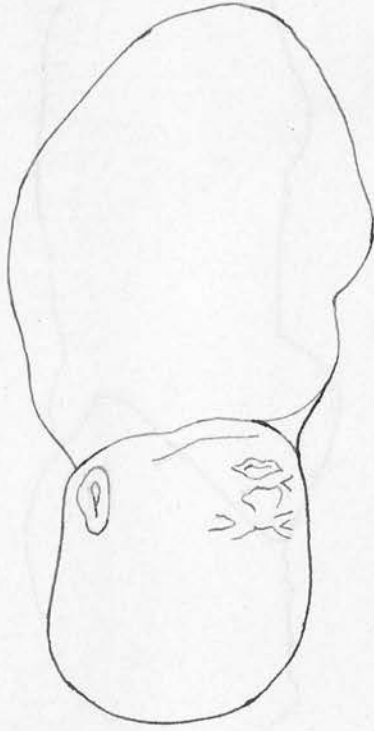


Fig. 6.

Tracing of fetus from BRAUNE'S second section to show the first movement of flexion complete, the second movement well developed, the third movement absent.

Anatomy of Larynx.

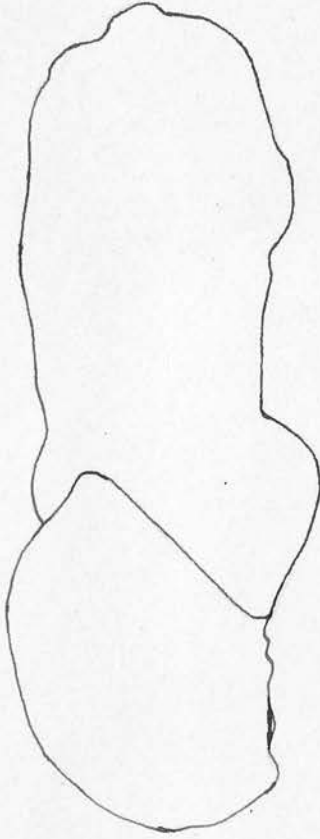


Fig. 7.

Tracing of fetus from late second stage section to show first movement of flexion complete, second movement fully developed, third movement well advanced or beginning to lessen (after BARBOUR, The Anatomy of Labour).