THE AXIS-TRACTION FORCEPS: THEIR MECHANICAL PRINCIPLES, CONSTRUCTION, AND SCOPE.

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IT is about thirteen years since Tarnier described the forceps with which his name is now universally associated, and there can be no doubt that the instrument then described marked the beginning of a new era in operative obstetrics. The difficulty which he attempted to overcome was one which had been recognised for long, and solutions, some partly successful, others entire failures, had been offered by others.

But to Tarnier belongs the credit of having applied to its solution an entirely novel principle, and one which has solved the difficulty, if not wholly, at least to a very great extent. The instrument first described, while it contained the essential principle in its construction, was faulty in detail; and his later instrument, which he seems to regard as the perfect model (at least it has remained unmodified for ten years), seems by no means an ideal piece of mechanism. I think it is open to obvious criticism in several respects, and is certainly quite unadapted for left-side midwifery; but the fact remains that Tarnier applied a *new principle*, and in great measure solved a problem which had proved a recognised difficulty for more than 100 years. His instruments and the principle they contained were met by a flood of criticism, a good deal of ridicule, and even some angry abuse. But they have stood the test of all this, and Tarnier has the satisfaction of seeing to-day the principle he so ably advocated in 1877 practically accepted by ever increasing numbers of teachers and practitioners. It is, at the same time, not a matter for surprise that obstetricians should hesitate to abandon the simple and well-tried forceps of the Smellie or Simpson type, which had stood their fathers and them in so good stead, for a new-fangled and somewhat complicated instrument of this sort. While many of them recognised only too well the mechanical inefficiency of the older forceps in many cases, they were naturally unwilling to lay aside an instrument absolutely simple, though so far admittedly defective, for one whose efficiency was obtained at the sacrifice of its simplicity.

Yet this reluctance has been overcome. The more the principle underlying its construction is considered the sounder does it appear, and the general adoption of the Tarnier instrument, or some modification of it, is only a matter of time. But while the instrument in some form or another is becoming more frequently adopted, it is a very remarkable thing that, so far as I know, neither Tarnier nor any of those who have modified the instrument have given either a definite account of the principle on which the instrument acts, nor have they given a mechanical construction of the instrument, which would enable a mechanic to construct a pair *de novo*, or to determine whether a given instrument was properly made.

Now this omission is all the more remarkable because, if the instrument has any advantage at all, it is that it approaches the character of an instrument of precision; it is certainly more so than the instruments it is meant to supersede, and yet the construction is left much to the judgment or caprice of the individual instrument-maker. Now, in an instrument involving so many curves and dimensions as an axis-traction forceps, it is obvious that the possibility of variation must be unlimited, and one has only to go the round of the makers' shops to be convinced of the unlimited differences which may be found in the examples of a single type of forceps.

As every one knows, the claim made by Tarnier is that the axis-traction forceps enables us to pull the fœtal head through the whole length of the pelvic canal in the axis of that canal; and while he points out that this may be effected through the agency of certain rods attached to the blade, he gives us no indication of the length, curvature, or intimate relationship of these rods. Precisely the same objection applies to Professor Simpson's description of his convenient adaptation of Tarnier's instrument for British practice. Yet it must be obvious to every one that the length, curvature, and other characters of the rods will determine the fact whether the instruments are *axis-traction* or not. It is quite possible to have a pair of forceps with traction-rods, and the instrument may be as far removed from being axis-traction forceps as any could well be.

I do not deny the force of the arguments advanced by Pajot, Charpentier, and others, who, while admitting the correctness of axis-traction as a principle, deny its practical applicability, in so far as it is impossible to determine with absolute accuracy the direction of the pelvic axis in any pelvis, and more especially in those cases where forceps are most necessary—namely, deformed pelves. I quite admit that there is always a certain element of possible error, but this fact all the more strengthens the demand for the mechanical construction of the instrument by as accurate and scientific a method as possible.

If we are working in a canal of doubtful curvature with an instrument whose construction is unknown, we are exposed to two sources of error. If, on the other hand, we are dealing with a canal, our knowledge of whose relations is defective, with an instrument whose construction is accurately known, we diminish the element of error by a half.

The objects I have placed before me in the paper I present to the Society to-night are:—

1. To define with accuracy, as far as possible, the principle on which the axis-traction forceps acts, and to give a definite mechanical construction of the instrument based on these principles.

2. To indicate the scope and limitations of the instrument.

I. The Principle of Axis-Traction Forceps.

It is first necessary to ask what is the problem presented to us in delivery by the forceps. The answer to this may be briefly put thus: "To draw the fœtal head through the pelvic canal with the least expenditure of force." It is quite plain that all force expended in this operation above the minimum necessary to overcome the resistance of the canals is transmitted to these canals, and will injuriously affect the mother. It then follows that the best instrument is that one which will enable us to accomplish our purpose with the least amount of force.

Now this problem (simple as its statement seems) is rendered somewhat complex by two circumstances,—1. The pelvic canal is curved; 2. The fœtal head is not a sphere, but must be regarded as an irregular ovoid or asymmetrical wedge.

A. *The Straight or Chamberlen Forceps.*

Putting aside in the meantime the second condition—the asymmetry of the fœtal head—let us consider the difficulty arising from the curvature of the canal.

Now we must bear in mind that the axis of the inlet along which the axis of the mass of the fœtal head will enter the brim is a line joining the umbilicus and coccyx, while the axis of the outlet along which the forceps must enter the pelvis is a line joining the tip of the promontory and the centre of the vulva. These lines cross each other at an angle at a point about the centre of the middle plane of the cavity; and it is obvious that if a pair of straight forceps are carried along this line they will either miss the head altogether or seize it so far back, *i.e.*, so near the promontory, as to render a firm grasp of it almost impossible.

Let us suppose, then, that the forceps are now so adjusted that the handles are brought back towards the perineum so as to stretch that structure, then the blades can be correspondingly carried forwards so as to grasp the head in such a way as to avoid slipping.

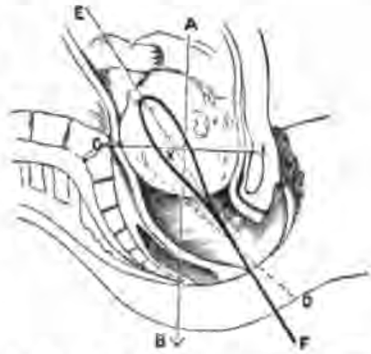


FIG. 1.—Application of Straight Forceps at Brim. C I, conjugate of brim; A B, axis of brim; O D, axis of outlet; E F, axis of forceps and line of traction; B X F, angle of error.

Let the line E F (Fig. 1) indicate the position occupied by the axis of the forceps. Supposing traction is now made along that line, it will be obvious by simple inspection that a certain amount of the force exerted will be spent on the pubis—in other words, only a certain amount of the force expended serves to advance the head, the remainder is dissipated in crushing the head against the pubis; and it is equally obvious that, in order that all the force expended on the forceps be effective in advancing the head, the axis of the forceps must be in the line A B, but the anatomical disposition of parts renders this impossible.

There is thus with the straight forceps an inevitable expenditure of ineffective force, measured in the diagram by the angle X formed between A B and E F. By a simple proof it can be further shown that the ratio of effective to ineffective force bears a distinct relation to the value of the angle B X F. Thus the effective force is as the cosine of X, while the ineffective force is as the sine of X.

Accordingly, so long as the angle at X exists—in other words, so long as the line A B and E F do not coincide—a certain amount of the force expended in traction will be ineffective. This amount will be measured by sine X. Now, the smaller X becomes (or the more E F approaches A B) the further will the value sine X recede from unity, while at the same time the more will cos. X, the measure of the effective force, approach unity. When the lines A B and E F coincide, X of course disappears, and the total force becomes effective. The efficiency of the forceps used as a tractor will thus be measured by the angle X, and will be inversely proportional to sine X, and directly proportional to cos. X. But it is perfectly obvious that with straight forceps E F can never coincide with A B, so that the angle at X always exists.

The first and essential error of the straight forceps then is, that some of the force applied in traction is expended on the tissues of the mother, and not in advancing the child's head.

But now we must consider the relations of the forceps to the fœtal head.

The fœtal head is not a perfect sphere. Looked at from above it is an ovoid, its major axis A B (Fig. 2) antero-posterior, its minor C D transverse, but somewhat behind its middle diameter. Looked at from the side, it presents the appearance of a truncated asymmetrical wedge. The posterior end O (Fig. 3) abrupt and

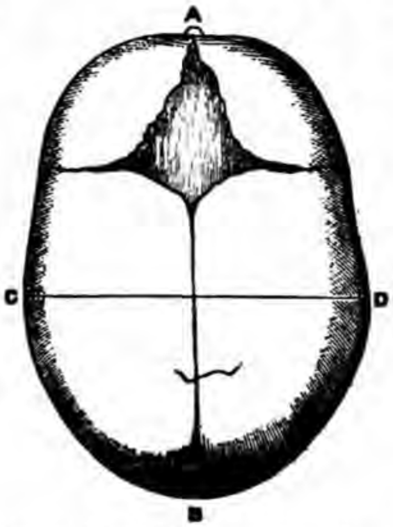


FIG. 2.—Fœtal Head seen from above. A B, occipito-frontal diameter = major axis; C D, biparietal diameter = minor axis.

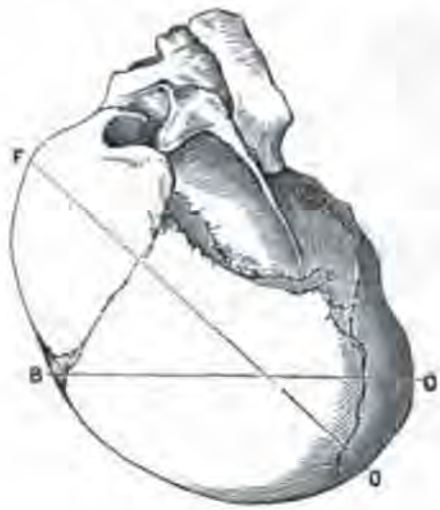


FIG. 3.—Fœtal Skull as it enters the Brim. F O, fronto-occipital diameter; B O, sub-occipito-bregmatic diameter.

steep, the anterior F flat and sloping. According to Lahs' view, it is this conformation of the fœtal head that permits the more rapid descent of O through the girdle of resistance, which descent effects the introduction of the short sub-occipito-bregmatic diameter into the pelvic inlet. However this attitude of the head is brought about, it is, of course, of essential importance in the mechanism of labour, substituting as it does the sub-occipito-bregmatic for the occipito-frontal diameter, a difference of 1½ in. or thereby. Thus, in a typical L.O.A. case, we may say that the plane formed by the expansion of the sub-occipito-bregmatic diameter enters the brim parallel with the plane of the brim.

Now, a glance at the relation of the line E F to the fœtal head at the brim will show that on account of the blades grasping the head too near the sinciput the inevitable result of traction must be to depress the sinciput, the occiput forming a pivot on the anterior pelvic wall. Now, were the head a sphere, this would not be of any consequence, because all diameters of a sphere are equal; but with the fœtal head it is different, because its immediate effect is to drag down the sinciput and replace the sub-occipito-bregmatic by the occipito-frontal, and so undo "flexion."

Now this is a point of most essential importance in relation to the action of *straight* forceps, and is not quite sufficiently insisted on in our books, because it is really the one point in which straight forceps fail as compared with the curved. Being incapable of taking a mesial or symmetrical grasp of the head, they drag down the sinciput, and so naturally increase the difficulty by dragging in the larger diameter.

This fact is further borne out if we consider their action in the treatment of occipito-posterior cases. It is assumed by those who advocate the straight forceps that they are specially useful in these cases, and this claim chiefly rests on the ease with which they permit internal rotation. I do not deny their advantage in this respect; but it is probably of much more consequence that in posterior cases they, in virtue of their inherent defect in relation to anterior cases, grasp the occipital end of the head (which is now posterior), and so pull it down, tending thereby to increase flexion and favour the mechanism natural to such cases. No doubt the absence of the pelvic curve is of advantage in expediting internal rotation, the forceps requiring no re-application after the process is complete, but their chief advantage lies in the direction I have indicated.

It follows, then, that the faults of the straight forceps are—(1), *Faulty direction of traction*; (2), *Unsymmetrical grasp of the fœtal head, tending to substitute the O.F. diameter for the s.O.B diameter*, i.e., "*to undo flexion.*"

B. *The Curved or Smellie Forceps.*

Let us now consider the advantage to be obtained from the addition of the pelvic curve to the forceps. Here, as in the straight instrument, the line E F (Fig. 4) represents the direction of the handle and shank, but the blade now lies in the line A B. By this means we obtain a grasp of the head which is symmetrical to its mass. In other words, when traction is made on the instrument, having such a grip, the relation of the anterior to the posterior end of the head is not altered. The traction *a fronte* being symmetrically distributed on the head, just as Lahs has shown the pressure *a tergo* is in normal labour, the contour of the head determines the relative depression of the occiput as compared with the sinciput during advance; and traction by means of this forceps, whatever the direction may be, tends in no way to interfere with the entrance and descent of the head by the sub-occipito-bregmatic diameter. This is obviously an enormous gain, and at once eliminates a primary defect of the straight forceps. The curved forceps then enables us to effect delivery with the fœtal head mass in the most favourable diameters.

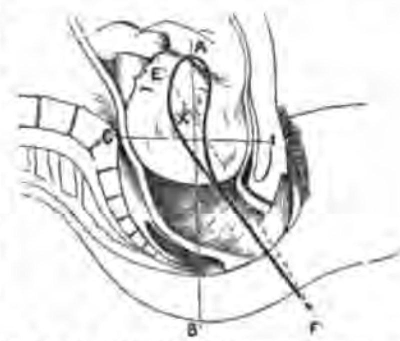


FIG. 4.—Application of Curved Forceps at Brim. C I, conjugate of brim; A B. axis of inlet; E F, axis of forceps and line of traction; B X F, angle of error.

But having stated this, we have stated the whole mechanical advantage it possesses over the straight forceps, for the direction of its traction is just as defective as that of the straight instrument.

The line of traction will be represented by the line passing through the shanks and handle E F. This line, again, meets the axis of the inlet at an angle whose cosine measures the effective force, and whose sine measures the ineffective. It is thus plain that the advantage of the curved forceps over the straight, when employed in simple and direct traction, consists solely in the fact that it avoids displacing the most favourable diameter of the child's head for a less favourable one, and that it has the disadvantage of faulty direction of traction to the same extent as the straight instrument.

The faulty direction of traction of the Smellie forceps has, of course, been recognised for many years; and with the view of obviating the loss of power to some extent, various devices in employing them have been made by different obstetricians. I shall only refer to two of them, because they are the types under which all the others may be classified. Many of the devices have been claimed as prior applications of Tarnier's principle, but this is quite unjustified, as can be readily understood on considering the principles involved. The first of the devices is that known as "Pajot's manœuvre" (Fig. 5). This is performed with the well-curved, long-handled Levret forceps, both of which characters are essential in the instrument employed for this purpose.

FIG. 5.—"Pajot's Manœuvre."

Suppose the head is at the brim and the well-curved Levret forceps applied, the blades will grasp the head in or at least parallel with the axis of the brim. The handle forming an obtuse angle will be somewhat behind the axis of the outlet. By grasping the lock in the left hand, which acts as a sliding fulcrum, while the handles are carried upwards towards the abdomen, the blades are made to descend downwards and backwards in the axis of the inlet, and in this way the head is dragged into the cavity approximately along that axis. This pivotting action of the instrument must at the same time be combined with traction, so that a complex movement of the hands and instrument is necessary. The left hand is not a fixed fulcrum, but must move downwards and backwards at a rate corresponding with the advance of the head.

Now it is quite obvious that the success of the operation depends entirely upon the adjustment of the amount and direction of the forces contributed by the two hands. The resultant of these two forces ought to move the head in the axis of the pelvis for the time being. But as we can see neither the head nor the pelvis, it is obvious that the adjustment of the two powers is a matter of skilled judgment. Further, as the head advances, the direction of the canal is continually altering, and it is obvious that the accurate adjustment becomes a matter of increasing difficulty, and, indeed, practically impossible. Precisely the same objection applies to the second type of device, of which the instrument of Hermann is an example. This instrument has, by more than one writer, been placed in competition with Tarnier in the claim for priority. But as a matter of fact, it is simply a mechanical appliance for facilitating Pajot's manœuvre, and has nothing in common with Tarnier's.

FIG. 6.—Hermann's Forceps.

In Hermann's instrument (Fig. 6) a second pair of handles (straight), attached by a link joint to the blade, are held in the left hand, while the handles proper are held in the right. It is easy to see, without any special demonstration, that a movement of the blade in any desired direction could be obtained as a resultant of component forces acting on B and A. But the difficulty again arises, in what direction to apply this resultant force; in other words, how are the components to be adjusted?

A moment's consideration will show that Hermann's instrument is thus simply a mechanical elaboration of Pajot's principle—has the same advantages and the same defects.

To this class belongs, too, the instrument shown and described to the Society by Dr Foulis. The difference of Hermann and Foulis' instrument is simply this—that in the latter the second traction handle is attached by a rigid attachment, and in Hermann's by a link. The rigid attachment in Foulis' instrument probably gives an easier method of adjusting the component elements, but the difficulty of fixing the direction of the resultant remains precisely the same.

We thus see that the curved forceps, used as a simple tractor, while grasping the fœtal head at the best advantage, transmits the force to the head at a loss, and that the devices suggested to remedy this so far are unsatisfactory, in so far as they demand the skilled judgment of the operator to employ them.

C. *The Axis-Traction or Tarnier Forceps.*

There can be no doubt that to Hubert of Louvain is due the credit of giving the first practical suggestion of the solution of the axis-traction difficulty; and imperfect as his instrument is, it contains the germ of the later appliance. Hubert solved the problem, so far as the brim of a normally pitched pelvis is concerned, by simply adding a rigid bar, which projected at right angles to the shanks of the forceps to a distance such that a line joining the umbilicus and coccyx, *i.e.*, the axis of the brim, passed through it (Fig. 7). By making traction on this bar only in this line, which

FIG. 7.—Hubert's Forceps. The arrow shows direction of traction.

FIG. 8.—Hubert's Forceps applied at the Brim. A B, the axis of the inlet corresponds with the direction of traction, hence angle of error has disappeared.

can be always determined with practical accuracy, the head will be dragged into the brim in a line corresponding to the axis of the inlet. Thus, so far as the brim is concerned, the problem is solved. The curved blades grasp the head at the best advantage, and the rigid traction bar applies the tractive force in such a way that the angle X (Figs. 1 and 4) disappears (Fig. 8). Thus the head enters the brim in the proper axis, and the forceps up to this point are axis-traction (Fig. 8). But now the head is in the cavity, the direction of the axis immediately begins to alter, but we are still dragging in the axis of the brim, hence we are no longer applying the traction to the best advantage. The instrument now ceases to be an axis-traction forceps, and re-adjustment of the line of traction is necessary. But how is this to be done? The instrument offers no guide or hint, and again we have to fall back on individual judgment. Thus, theoretically perfect as an axis-traction instrument as this is at the brim, it loses all claim to this at a lower level.

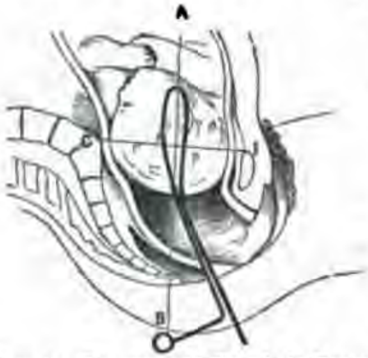


FIG. 9.—Diagram of Tarnier's Forceps at Brim. The traction-bar of Hubert's instrument is continued up by a rod which is fixed by a movable joint at the lower end of blade.

In 1877 Tarnier first announced the construction of his new forceps, but it was four years later when the permanent or improved pattern was described. His invention consists in the application of suitably curved traction rods to the back of the blades by a joint, allowing antero-posterior movement (Fig. 9). These rods are exclusively used for traction, the ordinary handles being only employed for applying the instrument. The advantages claimed for such an instrument are:

—1. The head is caught in the best attitude; 2. The movable traction rods allow of traction in the axis of the inlet; 3. As the head descends into the cavity, the application-handles of the forceps move forward in such a way as to indicate how the traction-rods are to be re-adjusted, in order to continue the traction in the direction proper to the plane of the pelvis through which the head is passing.

Or, put briefly, we have with the Tarnier instrument:—A, a proper grasp; B, a means of traction in the pelvic axis; C, a means of indication as to the axis of the pelvis wherever the head may be. It is of importance to analyse these claims, and see how far they can be conceded to the instrument under discussion.

A. *As to the Proper Grasp.*—The blades being curved, they come under the same conditions as the ordinary curved forceps. These, as we have seen, give us the means of seizing the fœtal head to the best advantage, and in this respect Tarnier's instrument possesses the same advantage as the ordinary form. The entrance and descent of the head by the most favourable diameter are in no way interfered with.

B. *As to the Means of Proper Traction.*—This involves a study of the proper dimensions, curvature, and attachments of the traction-rods. So far as I am aware, this has not been discussed by Tarnier or any of those who have modified his instrument. Yet it is obviously a matter of vital consequence to the construction and efficiency of the instrument; and one has only to look for a moment at the instruments supplied by different makers—say of the Simpson-Tarnier model—to see the possibility of error and variation. Let us then consider the mechanical principle involved in the construction and attachment of the traction-rods.

1. Let us suppose we have a head about to enter the brim, and suppose we apply a pair of forceps whose blades, instead of being curved (like the ordinary instruments), are bent sharply at an angle. The line P V (Fig. 10) will represent the axis of such blades, while P R will represent the axis of the shanks and handle.

2. Let A B represent the axis of the inlet, which will also indicate the line on which traction must be made with the head at the brim. It follows, then, that the handle of the rods by which traction is made must be on the line A B, outside the pelvis. As the anatomical arrangement of parts renders the adaptation of a straight traction-rod along it impossible, we must adopt a modified shape of rod. Let the said rod spring from the angle P, run close to and parallel with the shanks P R, and then at a suitable distance, say S, curve backward until it crosses the line A B. At this intersection the handle T must be fixed. With such a construction it is certain, so long as the rods P S and P R remain parallel, that traction will be in the line A B, just as if the rod were a straight one from A to B.

This may not appear obvious at first, but a mechanical illustration will make it clear. Suppose T P S (Fig. 11) is a steel plate fixed

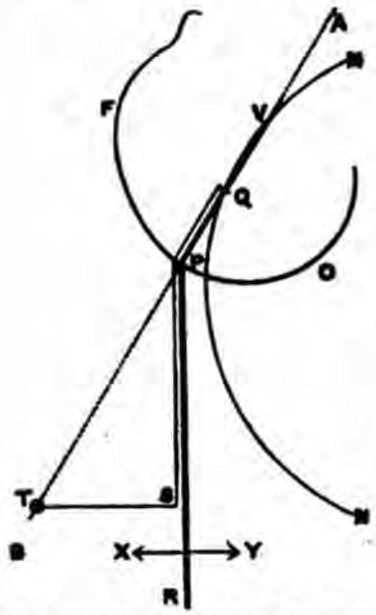


Fig. 10.—F O, fœtal head; M N, curve described by middle point of fœtal head as it passes along canal; P V, blade of forceps; P R, application handle; Q P S T, traction-rod; A B, line along which traction on T tends to draw fœtal head.

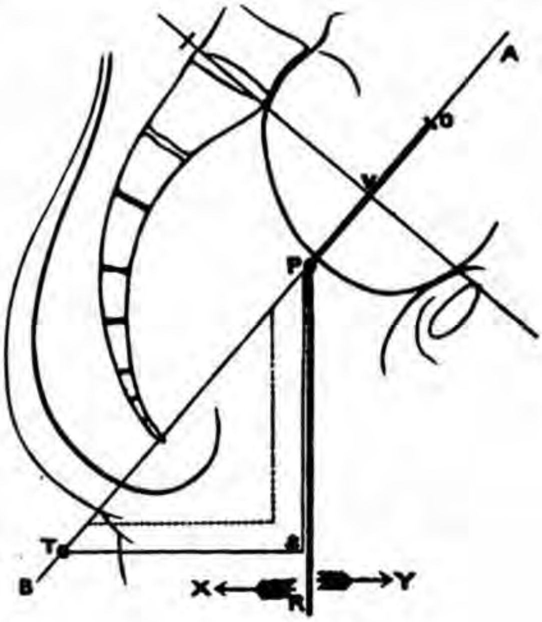


Fig. 11.

by a link at P, and traction is made at T along A B, then the mere cutting out of a section of T S P along the dotted line will make no difference to the direction of the transmission of force from T if the remainder remains rigid.

3. Now, if the junction of the traction-rod at P is made rigid, we have simply the construction of Hubert's forceps; and as soon as we have cleared the brim, since traction should no longer be in the line A B, we have no means of knowing in what way we must now direct it.

4. But suppose the junction at P is made by a joint which permits of antero-posterior movements, the case is different. For now, as the advancing head enters the cavity the blades of the forceps will be under the influence of two forces.

a. Supposing the blades are so firmly applied as to be immovable on the head, they will be carried along the curved axis with the head, and the handles will tend to move forwards in the direction of the arrow Y, and thus indicate a change in the line of movement of the head.

b. But this movement of the blades and handles will be modified in amount by their being acted on by another force at the point P in the direction A B, assuming traction is still kept up in this direction. But this will not annul the influence of the first, so that a certain movement of the handles P R away from the rod P S will indicate that a change in the direction of descent has occurred, necessitating a change in the direction of traction. By now bringing the traction-rod P S T up to the handle P R until close to it, we are again in a position to apply the tractive force in the direction appropriate to the new position of the head relative to the pelvic curve.

5. But it is obvious that unless the blades grasp the head with considerable firmness, the force in the line A B will greatly tend to annul the directive influence of the head on the handles, tending to displace the lower end of the blade backwards round an axis piercing the tips of the blades,—it will tend, in fact, to displace the blades on the head.

6. But now, let us shift the hinge of the traction-rod to the middle of the blade Q (Fig. 10), bending the rod along the lower half of the blade. Traction at T will still act along A B, but this traction will have no tendency to interfere in any way with the directive influence of the head upon the blades and handles of the forceps.

Accordingly, with the rods hinged at Q, the application handles will act as a most sensitive index of the movements of the head in descending the pelvis, while at the same time indicating the direction of proper traction. This is, of course, a point of vital importance in the theory of the instrument, and it may be well to discuss it a little more fully.

Let F O (Fig. 10) represent the fœtal head, and M N the curve along which it will travel under the influence of the pelvic curvature during delivery by the forceps. Now let us suppose that the traction-rod T S is attached, 1st, at P. Then as the head descends along M N the traction applied at T along A B will tend to displace the blade P V on the head backwards. For as the pelvic walls will guide the head along M N, the traction at T will tend to keep the blades P V in the line A B. There is thus an inevitable tendency for the traction-rod so placed to cause rotation of the forceps on the head, so that the handles will tend to move in the direction of the arrow at X. In this way, as has been already indicated, the attachment of the rods at P tends to diminish the sensitivity of the instrument as an index of the movements of the head in the pelvis. Now, 2nd, suppose the rods shifted up until attached to the tips of the blades at V. It will be seen that the condition of things is altered, for now traction at T along A B to V will be followed by a tendency to tilting forward on the part of the blade V P, and a corresponding movement of the handle R in the direction of the arrow Y. The influence of the head in carrying the blades and handle forward will be greatly increased, and out of all proportion to the effect of the pelvic curvature. Obviously, then, the attachment of the rods at either P or V would be a faulty construction,—at the former the sensitivity of the handles as an index would be impaired, while at the latter the whole system would be obviously highly unstable, and there would be a tendency to exaggerate the influence of the pelvic curve. It follows, then, that there must be a point somewhere between P and V, at which the tendency of the traction-rods to interfere with the directing influence of the movement of the head on the handle of the forceps is *nil;* and that point must be one half-way between P and V, namely, Q, the point of the blade which lies against the centre of the mass of the fœtal head. It will be readily seen that when the traction-rods are hinged at Q, the slightest change in the direction of the movement of the head will make itself evident by the handles of the instrument R tending to move forward away from the traction-rod T S.

It follows, then, that for a theoretical arrangement such as this, —the blade of the instrument forming an obtuse angle with the handle, and being itself straight,—the maximum sensitivity will be obtained by attaching the traction-rod to the centre of the blade.

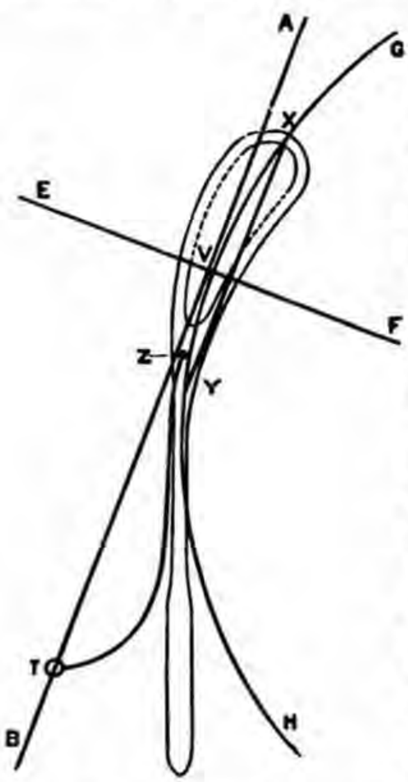


FIG. 12.—Mechanical construction of Tarnier's Forceps. X, centre point of blade tip; Y, junction of blade and shank; X Y, chord of arc of blade; X V Y, arc of blade; E F, bisects chord at right angles; G X V Y H, circle whose centre is on E F, and of which X V Y is an arc; A B, tangent to arc at V; V, theoretical position for attachment of traction-rods; Z, best practicable position for do.; Z T, traction-rod.

But an instrument with the blade P V straight as in the figure is obviously impracticable. It remains to be seen, then, how we can construct an instrument in which the blade P V has a curve, as in the ordinary forceps, provided with traction-rods of proper construction, and attached at the point which will permit of the maximum efficiency of the instrument as a tractor and indicator being secured.

Let the outline (Fig. 12) be a pair of curved forceps to which traction-rods have to be attached. Let Y be the point at which the curve of the blade joins the straight shank. Join the points X and Y (X being the centre point of the end of the blade). Bisect the chord X Y by a perpendicular E F. Describe a circle G X V Y H whose centre lies on E F, and whose periphery will pass through X and Y. Now draw a tangent A B to the circle G X V Y H at the point V, *i.e.*, where E F intersects it.

The conditions required, namely, maximum sensitivity and accuracy of direction, will be met if the traction-rod is attached to the blade at the point V, and the rod has such a curve that the handle lies on the line A B.

If the rods are attached at the point V in X V Y, it is obvious that the force will be distributed symmetrically to the blade, and that the tendency to produce rotation of the blades on the head is zero. In other words, the point V corresponds to the point Q in Fig. 10. The movements of the application handles will accordingly be determined entirely by the change in direction of the head.

Unfortunately for the mechanical accuracy of this construction, the point V occurs in the centre of the fenestrum. Poullet and others have attempted to get over this difficulty by attaching the traction-rods to a bar crossing the fenestrum, and fixing the pivot there. The objectionable nature of this arrangement is obvious when we consider the use of the fenestrum. This bar adds a dangerous edge to the instrument, and might readily do much damage to nose, ear, etc.

But the disadvantage is not so great as it seems at first. The chord of the curve is 5·75 in. in ordinary forceps, and the position of V should theoretically be 2·87 in. from the lower end. The construction of A. R. Simpson's instrument allows it to be only 1·8 in. from the lower end. This fact no doubt diminishes the sensitivity of the instrument as an indicator of the direction of traction, but only to a certain extent. That is to say, the point of insertion Z of the rods is sufficiently near the centre of equilibrium to permit the head to exercise far more directive force on the handles than the rods can, and this is practically all we want.

Now, as to direction of traction, it will be seen from the diagram that the fenestrum involves us in a slight difficulty too. But the defect here is even more insignificant than in relation to directiveness.

It will be seen that the tangent A B passes a little behind the stud of the traction-rod hinge Z, but the distance is so small as to make no appreciable difference in the direction. Were it desirable to obtain perfection in the matter, it could be obtained by broadening the lower part of the blade to take the stud a little further back.[1]

It will be well now to recapitulate the points to be attended to in the construction of a pair of axis-traction forceps on the Tarnier principle.

1. The forceps must be of the Levret or Smellie type, *i.e.*, with straight handles and shanks, and a well-defined "pelvic curve."

2. The fenestrum should be of such a shape and size as to leave a considerable part of the blade solid at its junction with the shanks.

3. The traction-rods must be united with a joint permitting of free antero-posterior movement only.

4. The upper part of the traction-rods must fit as close as possible behind the shanks and handle so as to save room, and avoid stretching of the tissues at the perineum.

[1] This will be better seen in the diagram at the end of this paper.

5. The traction-rods must curve back for the attachment to the traction handle, so that when the rods lie close to the shanks, a line joining the traction-bar and the pivot will form a tangent to the middle point of the arc of the curve of the blades.

6. The traction-rod hinge must be attached to the blade as near the centre of it as the fenestrum will permit.

These may be regarded, I think, as the essential mechanical principles of this important instrument, and I wish now to ask attention to the manner in which I have attempted to carry these out in the instrument I have brought before the Society this evening, and in doing so I shall at the same time draw attention to some other matters of less vital importance, but which, I think, tend to add to its efficiency as an obstetric instrument.

The instrument is a modification of the Simpson-Tarnier model, which has, I think, many advantages over the French instrument. Lightness, compactness, and suitability to the left position are not its least advantages.

Fig. 13.—Author's pattern of Axis-Traction Forceps.

My instrument (Fig. 13) is made entirely of steel, there are no wooden handles —even the traction-bar is made of metal. The advantage of getting rid of the wooden handle is considerable.

1. The application handle being no longer used for traction, the massive handle of the Smellie forceps, so important in giving a good hold, is of no further use.

2. If any one who has used a pair of ordinary handled forceps for a year or two will take the trouble to unfasten the wood from the metal plate, he will find between the surfaces a much more potent argument than I can give in words for abandoning them. Owing to the wetting of the handles in cleaning the instrument, and the expansion of the metal plate in heating, a space is ultimately formed between the two, which is a receptacle for filth, putrid blood, grease, etc.,—a museum of septic matter.

The application handles are made smooth and light, and 6 in. in length. The ordinary Smellie lock is used, and the shanks are straight, strong, $2\frac{1}{2}$ in. in length, and ·75 in. between their inner surfaces. The blades are 5·75 in. in length, measured along the chord of the pelvic curve (this arc has a radius of 7 in.) The termination of the arc joins the shanks, so that the axis of the instrument and the chord form an angle of 120°. The solid part of the blade measures $1\frac{3}{4}$ in. The fenestrum is 4 in. in length. The blades are kept in position by a fixation screw of the ordinary pattern, the butterfly nut being prevented from coming off by a pin driven through the upper thread of the screw. The traction-rods are hinged to the blades. They lie on the outside of the solid part of the blade, against which they fit snugly. They are fixed by a pivot, which pierces the blade at right angles to their length. This pivot is held by a small screw nut which fits flush into a countersink in the inner side of the blade. It is of importance that this nut be screwed down to a shoulder on the pivot and work free of the countersink, otherwise the to-and-fro motion of the rods will inevitably loosen it and lead to inconvenience, and even disaster, if it come off inside the pelvis. The hinge of the traction-rods is 1·4 in. below its theoretical point, and ·1 in. in front of the tangential line.

From these figures its error can be calculated. From their attachment the rods curve round the blades, and are bent at an angle so as to lie straight beside and a little to the outside of the shanks. One inch below the lock they are bent by an easy curve backwards, and terminate in two flattened surfaces, in which are inserted the traction-handle studs. About half way along the back curve is the traction-rod lock. This appliance (which formed a part of the model I described to the Society in 1881) is, I think, a device of some importance. It consists (Fig. 14) of a pin fixed

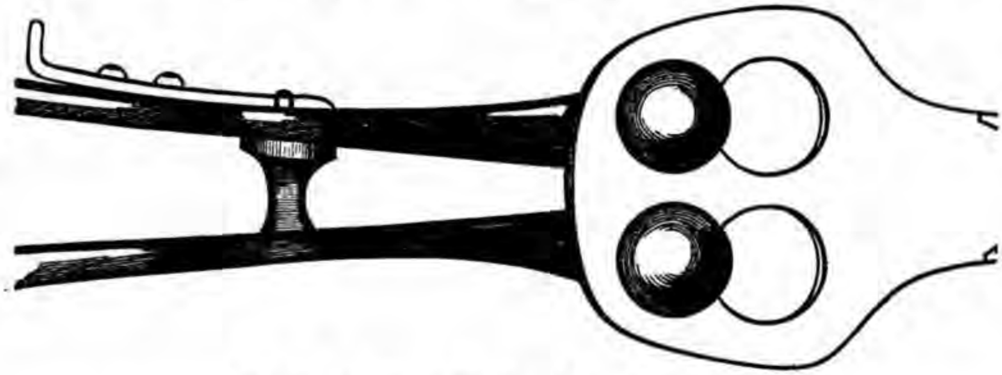


FIG. 14.—Traction-rod Lock, and Traction-bar Plate.

to the lower traction-rod which enters a mortise on the upper, in which it is held by a simple bolt. Its object is to bind the two rods into one system, and make sure that the force of traction is equally distributed on the two blades.

The inclination of the flattened surfaces terminating the rods and carrying the traction-bar studs is a matter of essential importance. Its inclination must be such that the traction-bar plate when attached must be absolutely in the tangential line of the curve when the rods are touching the shanks. This is the part of the instrument which is most likely to be bungled by makers, and it is one which, when faulty, vitiates the whole mechanism of the instrument. The angular measurements are of little use to makers, and there is nothing for it but to try each pair of instruments with the projection, and adjust the curve until it coincides.

The distance of the studs from the centre of the handles in these instruments is 3·5 in. The studs are square in section, with large heads. The traction-bar plate is attached by a couple of key-holes, and when drawn down should fit firmly without to-and-fro motion of any sort, and this is a detail which makers require much persuasion to carry out. The traction-handle possesses a hinge joint giving lateral motion, and the bar is attached by a swivel.

II. The Scope of the Axis-Traction Forceps.

I desire now to draw attention to some special points regarding the scope of the axis-traction forceps in obstetric surgery.

1. We may consider the case of a *normal pelvis* where, from uterine inertia or other cause, it is necessary to apply the instrument at the brim. Our object here is not to overcome special resistance so much as to apply a force in the appropriate direction so as to effect delivery with the least amount of that force. Our object then resolves itself into seizing the head in such a way as to develop and keep up flexion, and to pull at all times in the proper axis. Now, if the principles we have discussed are sound, we accomplish the former by applying the curved blades in the proper way.

As regards the second point, we have in the simplest manner, as we have seen, a continuous indication as to how the pelvic axis varies, and as to the proper direction of traction. And here I wish to enter my protest against the teaching of Fabbri, Pinard, Parvin, etc., that the curve of the bony pelvis is not to be regarded as influencing the direction of traction between the brim and the lower part of the pelvis. These authorities claim that they have proved that the pelvis in the living subject is so modified by its soft parts that its curvature is in great measure lost. They hold that the pelvic canal is not a continuous curve, but may be regarded as a cylindrical tube whose direction is at first downwards and backwards to the level of the coccyx, and after this directly forwards almost at a right angle to the centre of the vulva.

"Obstetricians for a time held that it was represented by the curve of Carus, and then a parabolic curve was substituted, as better showing this axis; but as the investigations, first of Fabbri, afterwards of Sabatier, of Pinard, and more recently of Boissard, show the obstetric pelvis—the dynamic as distinguished from the static pelvis, the soft parts being appended to the bony pelvis, and those which make the pelvic floor, thus forming the entire pelvis—presents a cavity which is not in any respect a curved canal, but rather a cavity chiefly cylindrical, having two walls, anterior and posterior, almost vertical, and at the fundus forming a plane nearly perpendicular to these two walls. The cylinder has its fundus at the coccyx, and an opening upon the anterior wall. Now, laying aside confusing curves, pelvic inclined planes, and speculative synclitisms, the head descends to the pelvic floor in a straight line, then turns at almost a right angle to make its exit at the vulva; in other words, the axis of the birth-canal is at first a line directed backward and downward, and then a line almost perpendicular to it. Hence, until the head reaches the pelvic floor, the fundus of the pelvic cylinder, the traction with the forceps must be downward and backward, and then upward and forward."—Parvin, *Science and Art of Obstetrics*, 627.

Now to this description I entirely demur. The diameters of the head are such that it fills the canal, and if it does so it must compress the soft parts against the bony walls. The soft parts antero-posteriorly are thin, and it does not admit of doubt that the canal, while the head is there, takes its shape and curvature entirely from the curvature of the bony walls. Thus the curvature will vary with the curvature of the sacrum, and while that undoubtedly is first, in general terms, downwards and backwards, it is so to a varying extent, and long before it reaches the level of the coccyx it has begun to turn forwards. Now it is just this delicate perception of the changing direction of the axis which is the prime virtue of the axis-traction forceps, and it is this which enables us to adjust our traction with a nicety impossible by any other means. A properly constructed pair of forceps will show this curvature from the brim to the outlet, and I have demonstrated this to students over and over again.

Thus in a normal pelvis where the powers are defective the axis-traction forceps show us precisely *how* to apply the necessary *vis a fronte* by which such force is most completely economized.

2. *In Justo-minor Pelvis.*—In such a pelvis the function of the instrument is even more obvious. Here we again promote flexion, and draw the head into the brim in the most favourable attitude. And as soon as we have cleared the brim we at once appreciate the benefit of the indicating power of the instrument. A *justo-minor* pelvis has a less backward inclination of curvature than a normal one, and I am convinced that difficulty in delivering in such a case is artifically induced by forgetting this and ignoring the indication of the instrument, and applying the force *too far backward* while the head is passing through the upper third of the cavity. In a case like this the abnormal curvature is "felt" (if I may use the word) by the forceps, and its inclination unmistakably given to the operator. If this is so, the directive value of the instrument is very great, and the saving of undue force in this difficult class of cases must be of immense importance.

3. *With the Head in the Cavity.*—Assuming the head is in the cavity, but not yet on the floor of the pelvis, it is obvious that there is one portion of the canal through which the traction is downwards coincident with the vertical axis of the body, and at this point the traction may be made in the proper axis by a pair

of ordinary straight or curved forceps, the axis of which lies in the centre of the vulva. Theoretically this exists for an infinitesimally short part of the curve, practically it may be considered to do so for an appreciable distance. Now it so happens that this is probably the position of the head at which forceps is most frequently applied, and it may well be that a practitioner employing the axis-traction instrument in such a case may find it no easier to draw the head on to the perineum by it than by the ordinary forceps. Hence he naturally concludes that the former instrument has no advantages. This, as we shall see, is an unjust conclusion. But it should, at the same time, be clearly understood that for a part of the canal from about the middle of the cavity until the head rests firm on the perineum and pelvic floor, the axis-traction instrument, so far as tractive direction is concerned, has little or no advantage over the simple instrument.

But two things must be kept in view in relation to this matter:—(1.) It is not always possible to be sure without the axis-traction instrument that the head *has* reached this level (*i.e.*, the level for which traction is to be in the vertical axis). (2.) When the head has touched the floor the axis of the canal curves quickly forward, and the axis of this curvature can only be determined by the axis-traction instrument. Hence for a head in the cavity the axis-traction forceps are again the more efficient and the safer instrument.

4. *With the Head at the Outlet.*—I am not likely to be challenged when I say that probably the commonest accident with the ordinary forceps in the hands of practitioners, is the rupture of the perineum as the head is clearing the outlet. I presume that with the ordinary forceps this has happened in the hands of every one with any experience. Now it seems to me that this is due to two causes:—

(1.) The mechanism of delivery at the outlet, known as *Extension*, is very imperfectly understood, or I should say is misunderstood by most accoucheurs. It is in most books most erroneously described, and by many teachers improperly taught.

This movement is sometimes represented as being a movement round the occiput as a pivot resting on the pubic arch, while the forehead, face, and chin successively glide over the perineum. But this pivotting movement is only a part of the process, for as soon as the sub-occipito-bregmatic diameter is clear, a gliding movement of the whole head forward begins, so that the occiput and upper part of the face are born at the same moment, and the largest diameter which stretches the perineum is the first which escapes, viz., sub-occipito-bregmatic. On the other hand, were the occiput to remain on the pubis all through, and the delivery to be completed by the pivotting movement only, it is plain that the occipito-mental diameter (the largest in the head) would have to stretch the outlet, which in a rigid or primiparous perineum would inevitably be accompanied by laceration. This, then, it seems to me is the primary cause of the frequency of perineal laceration. The forceps are applied, the occiput is fixed on the arch, and the head is "levered out" round the occiput as a pivot—the sliding movement being totally ignored.

(2.) But even in any case where the mechanism is understood the difficulty of delivery is not removed. In the effort to hold the forceps in the way they must be held in the position of the patient, the blades are apt to slip or rotate on the head, and the points will thus project; and where this is avoided the difficulty of applying the traction in the line of least resistance is complicated further by the effort to combine both the gliding and the pivotting movements.

Now with the axis-traction forceps all difficulty and practically all danger at the outlet disappear. But for this end they must be used still rigorously as axis-traction instruments, and I am convinced that Tarnier and his pupils are to blame for totally misrepresenting the value and use of his instrument at this part of the canal.

A moment's consideration of the nature of the curve at the lower end of the canal will show us that the change of direction is more sudden and more pronounced than anywhere else. Accordingly, it is surely here, if anywhere, that, if there is anything at all in the axis-traction principle, we shall find its most obvious and valuable application. An error of direction in the upper part of the canal is undoubtedly objectionable and to be avoided by all means, but there the tissues are supported by the bony canal, and withstand a great amount of pressure without any apparent serious inconvenience.

But at the outlet the case is very different. The posterior boundary of the outlet consists of soft parts entirely, and the danger they are liable to is shown in the frequency with which they are damaged by ordinary forceps in delivery; and, as I have said, it is here if anywhere that the delicate perception of the line of least resistance which the axis-traction instrument gives is of value. By its means the mechanism of "extension" as it occurs in a normal labour can be reproduced to an absolute nicety, and thereby 9 out of 10 cases of ruptured perineum avoided.

Yet in the face of this fact Tarnier at this point in the operation, the most difficult and the most delicate, the point in which the virtue of the instrument is obvious to anyone who uses it aright, throws aside the axis-traction principle entirely, and as soon as the head begins to extend, grasps the rods and handles together in one hand and delivers as if with the Levret instrument (Fig. 15).

I would very strongly maintain that the safe delivery of the head over the perinæum can be effected by the axis-traction forceps in a way which is impossible by any other means. This efficiency is due to the accuracy with which the ever varying line of traction is indicated by the index of the instrument. If this is scrupulously followed, the complex movement of extension is effected with perfect exactitude; the blade of the forceps can never project beyond the contour of the head, and, as often happens, deal disaster to the perinæum and rectum, and by no possibility can the occipito-mental be dragged through the antero-posterior diameter of the outlet. This demands, I need hardly say, great care and keenness of attention; the movements of the handle must be watched and carefully followed; traction should be carefully graduated, intermittent, with considerable interval between each effort. Besides this, however, it requires a properly constructed instrument, sensitive and light. The very weight of the Tarnier model interferes with its proper use at the perinæum, because the effect produced by the mass of such an instrument is no doubt often greater than the traction required to effect delivery. And this may be one reason why its use at the perinæum may be so little appreciated in the home of its birth.

FIG. 15.—Misuse of Axis-traction Forceps at perinæum (after Poullet, etc.) Complete delivery of head should be effected by means of the traction handle only.

In 1884 Dr Halliday Croom drew attention to its value at the outlet in cases of occipito-posterior, and stated that he had found in these instruments a means of saving the perinæum, which was very notable. I have no doubt his subsequent experience has borne this out, in these the most troublesome of all cases at the outlet, and the result is intelligible on the same principle as applies to anterior cases,—namely, the certainty with which the tractive force can be applied in the most effective direction, the traction being directed only to the advancing of the head, not to the stretching of the walls.

I would urge, then, very strenuously the use of these instruments at the outlet. Properly applied and properly used they will give an admirable account of themselves. I should say that the forceps are applied at the outlet twenty times for once they are used at the brim, and it is a most unfortunate thing that any one should, by misunderstanding their value, get only one-twentieth of the good of them.

I may say, as regards my own experience, that for the ten years I have used these instruments, in cases of all sorts, occipito-posterior, face cases, rigid perinæum, flat pelvis, etc., I have never yet injured the perinæum on any occasion, beyond the slight split in the margin of the mucous membrane, which is inevitable in all first labours, and consequently during that time I have never put a stitch in a perinæum. This result demands patience and care, and an intelligent use of the instrument.

5. *The Axis-traction Forceps in Flat Pelves.*—In June 1888 I read before the Society a paper dealing with the use of the axis-traction forceps at the brim in rickety pelvis. I mentioned a case in

which, with typical rickety mechanism, delivery by the axis-traction forceps was accomplished without difficulty. In the autumn of last year, while in charge of the out-practice of the Maternity Hospital, I saw another case of still greater interest, and equally successful. I was sent for by the Residents to see a patient in her third labour, whom they had failed to deliver. We could get an imperfect account of the previous labours, but one of the children seems to have been born dead with forceps, and the other by embryulcia. When I arrived the woman had been in labour for more than 12 hours. The waters had long escaped, and on examination I found the head in the brim, but not engaged so firmly as to prevent its being pushed up. Both fontanelles could be readily felt. The Residents had attempted to apply forceps, but had failed to get them to lock.

I applied the instruments shown, which had just been finished, taking care to fit the blades over the sinciput and occiput with accuracy. The handles were naturally more apart than usual, but the rods came together and the locking was not difficult. When traction was made, the handles came back to the perinæum, and this, of course, indicated great backward inclination, as one would expect in a rickety pelvis. Traction was continued *with only one hand on the traction-bar*, and after a little I found the head was coming through the brim. As it did so the handles went a little further back, so as to press on the perinæum somewhat, and then the head slipped into the cavity. Very slight traction brought it to the outlet, the passages being dilated and roomy, and without any trouble whatever *the head came readily out in the transverse at the outlet*, no rotation having occurred in the cavity at all. When the head was examined it presented a typical example of rickety moulding, and showed the flattening and shear in a most characteristic fashion. Unfortunately, owing to a mistake, the measurements were not made at the time. On examining the pelvis post-partum, I found the diagonal conjugate to be only 3·25 inches. Taking ½ an inch off this gives a true conjugate of 2·75 inches. The measurement was done with care, and I have no doubt of its accuracy.

Barnes gives 3 inches as the limit at which turning is practicable; others, however, hold 2·75 will permit a living child to pass by turning. But I am not aware that any one has suggested that the forceps could compete with turning down to these limits. Yet a careful consideration of the whole subject, taking into account the theoretical principle involved and my own experience, leads me to believe that a properly constructed pair of axis-traction forceps will deliver a child in a flat pelvis down to the limits which can be dealt with by turning, and with a much greater chance of delivering it alive.

The objections to the use of forceps in flat pelves have been mainly two. The one based on a fallacy, the other sound enough.

The *first*, emphasised by Schroeder, may be stated as follows:—

Owing to the configuration of the flat pelvis the blades can only be applied in a transverse or oblique diameter. This, by compressing the skull antero-posteriorly, was supposed to cause bulging in the transverse diameter, and so force the parietal bones more firmly than ever on to the promontory and pubis.

That this is a fallacy the experiments recorded in the paper referred to proved, for I there showed that a fœtal head can be compressed to the extent of 1½ inch without making the slightest increase in the bi-parietal diameter. This I pointed out was

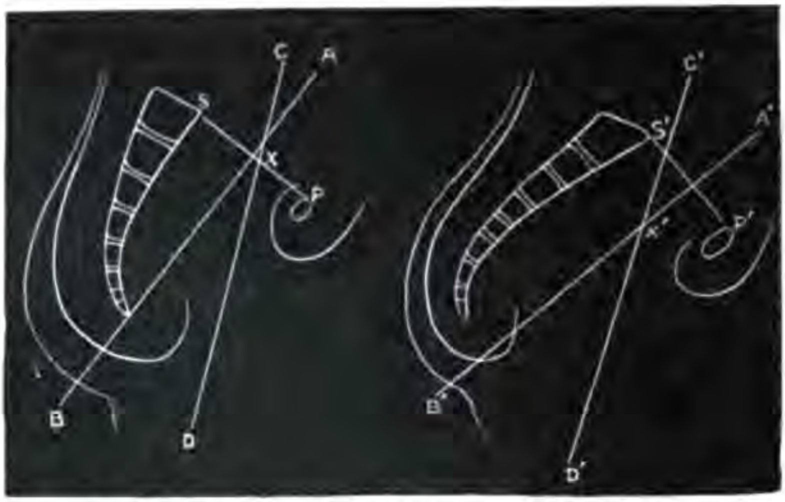
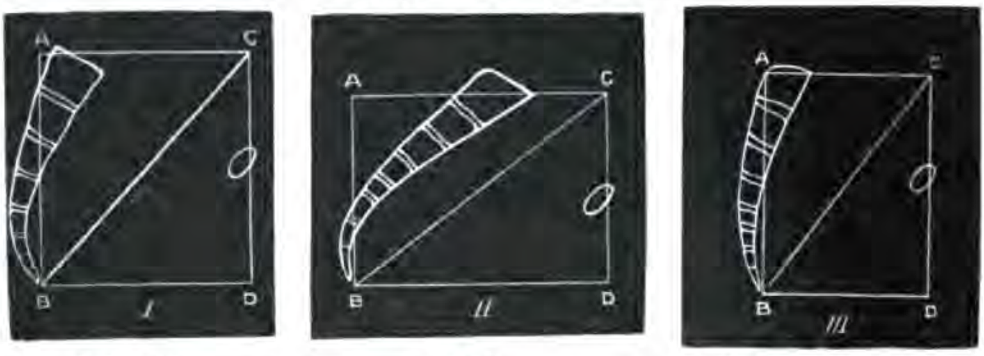


FIG. 16.—Comparison of Axes of Normal and Rickety Pelves.

explained by the fact that the head "telescoped," the frontal and occipital slipping under the parietals, and accommodation for the contents being found in the vertical elongation of the head. Thus it is plain that the application of the forceps to the extremities of the antero-posterior diameter, while easy in a flat pelvis, is in

FIG. 17.—Comparison of Inclination of Axes in



I. Normal. II. Flat. III. Justo-minor pelves.

A B, verticals through coccyx; C D, verticals through symphysis pubes; the diagonals C B, indicate the *relative* inclination of line of traction.

no way objectionable. Further, it should be borne in mind that any attempt to grip the head obliquely, as has been recommended, is objectionable, because it is obvious that this telescoping action cannot be so perfect under oblique pressure.

But the *second* objection to the use of forceps in flat pelves refers to the defect in the line of traction, which, with ordinary forceps, is even more pronounced in flat than in normal pelves.

It is obvious, if we consider the inclination of the axis of the brim in a flat pelvis, that the line of traction with ordinary forceps is even further in front of that axis than in the case of a normal pelvis. The angle at X^1 (Fig. 16) is greater than the angle at X, hence sine X^1, representing the ineffective force (that spent on the pubis) will bear a greater proportion to cos. X^1 than sine X does to cos. X.

This fact can be graphically represented by the following device:—Let I., II., III. (Fig. 17), be respectively vertical mesial sections of normal, rickety, and justo-minor pelves. Draw the perpendiculars A B through the tip of the coccyx, and the perpendiculars C D through the crest of the pubis. Complete the parallelogram by the horizontal lines A C and B D, the former passing through the promontory and the latter through the tip of the coccyx. The parallelograms so constructed give a graphic representation of the cavities of these pelves. They express the proportion between the vertical and horizontal elements. Thus it will be seen that in I. the parallelogram is nearly a square—that is to say, its vertical and horizontal elements are nearly equal. In II. the horizontal element is obviously greater than the vertical, while in III. the vertical preponderates. Now draw the diagonals C B. The angles B C D will measure the *relative* inclination of the axis of the brim in the three forms of pelves, and consequently indicate the special modification necessary for forceps traction in each case. Accordingly, it will be seen that in II. (the rickety pelvis) this inclination backward is greater than I., while in III. (justo-minor) this inclination is less than I.

Now, for a normal pelvis Tarnier estimates that every 30 lbs. of force which tends to depress the head in the proper axis is accompanied by 26 lbs. of force expended on the pubis where traction is made with the ordinary forceps. Accordingly, if we take this estimate as approximately correct, it is obvious that the amount of ineffective as compared with effective force will be greatly increased where we deal with a flat pelvis. In other words, where we attempt to deliver a normal head through a flat pelvis with the ordinary forceps, more of the force applied will be spent in crushing the head on to the pubis than in pulling it along the canal.

With the axis-traction instrument the case is totally different. Practically the whole force is expended as efficient force tending to cause the descent of the head. Then taking the average biparietal as 3½ to 4 inches, there could be little difficulty in dragging it through a 3½ brim—in fact such a head would show little moulding, if any at all. Let us suppose the conjugate is contracted to 3 inches, then even this only assumes an overriding of the parietals to ½ inch, an amount of accommodation which can readily be obtained by compression of the newly born fœtal head without apparent inconvenience. If my assumptions are correct, then it is not difficult to see that a 3-inch conjugate may readily permit the passage of a fœtal head.

But I have as yet assumed that the head is entering with its *bi-parietal plane parallel with the plane* of the brim. Now we know that Naegele's obliquity is of the highest importance in normal rickety mechanism, *i.e.*, the posterior boss is held back by the promontory, while the anterior moulds itself round the symphysis pubis. The manner in which this aids the passage of the head through the brim is obvious, and requires no further discussion here. It would be, however, of very great interest if we could show that this mechanism is in any way favoured by the axis-traction forceps. I have already shown that the special advantage of the curved forceps in occipito-anterior cases is that it does not cause any interference with the relative position of the occiput and sinciput—does not, indeed, interfere with the normal mechanism. This is undoubtedly so when the head is oblique or antero-posterior. But when the head is transverse the case is different.

When the blades of a curved pair of forceps are applied to the sinciput and occiput of a fœtal head lying in the transverse at the brim they will tend to grasp the head somewhat nearer the pubic than the sacral side of the head. When traction is made there will be a greater tendency for the pubic parietal bone to descend, the sacral or posterior boss being held back by the sacrum, round the promontory of which it pivots. In this way Naegele's obliquity will be developed in the process of extraction, and the normal mechanism of such a case copied. That this is so the case recorded seems to prove, for as the head cleared the brim there could be no doubt that the handles curved backwards while traction was being made—a movement which would indicate a certain amount of rotation round the promontory. Such a movement as this will obviously facilitate the escape of the head, and probably diminish the available diameter by another ¼ or ½ inch.

Contrast with the claims here made for the forceps the advantages offered by turning. The special claim made on behalf of turning in flat pelves is that we bring down a diameter—the bi-temporal—which is probably one inch shorter than the bi-parietal. It must, however, be kept in mind that a flat pelvis is seldom so roomy at any one side as to allow of the sliding of the occiput so far from the middle line as to permit the bi-temporal to lie in the conjugate. Probably in most cases we get the head in a position midway between, giving us a diameter of say 2¾ or 3 inches. And as I have pointed out, this is practically obtained by easy moulding under the action of forceps.

But, further, having got the body down and the head thus engaged, we have these difficulties to bear in mind:—1. We can no more exercise traction in the proper axis by the body of the child than we can by the straight forceps, hence much of the force is spent on the pubis. 2. This force is transmitted by the neck of the child, a matter of grave risk to the fœtus. 3. Every moment of delay increases the peril of the fœtus by compression on the cord. 4. The application of supra-pubic pressure (Schatz' method) tends to cause bulging of the bi-parietal diameter, and demands an amount of force out of all proportion to that required by the forceps.

Against this now place the claims of the forceps. 1. Seizure of the head in such a way as to favour Naegele's obliquity. 2. Traction of the head in the proper axis, so that all force applied is effective. 3. A diminution of the diameter by moulding probably equal to the difference between the bi-parietal and available bi-temporal. 4. Safety of child during operation. 5. Avoidance of all intra-uterine manipulation. On these grounds I am inclined to believe that in the management of flat pelves we have in the axis-traction forceps a substitute for turning—a safer and more efficient means of interference.

From the foregoing study of the mechanical principles involved in the axis-traction forceps it is obvious that their efficiency depends largely on the accuracy with which these principles are followed in their construction. The somewhat complex nature of their construction renders it very easy for errors in their details to arise even in the hands of careful makers. This is especially likely to occur where the instruments are turned out in large quantities. While the practised eye can readily detect any essential error in their construction, this is more difficult in the case of those less familiar with the details, and a serious error in the curvature of the rods may readily be overlooked. On this account it is well that a ready means for testing the accuracy of the construction of any instrument should be available. The following method is sufficiently simple, and will enable anyone before using an instrument to assure himself of its proper construction:—

A piece of paper about 18 inches square should be firmly stretched on a drawing board or other smooth surface. A pencil line should be drawn down the centre of the paper. Place the left blade of the forceps on the middle of the paper so that the shank coincides with the line already drawn, the hollow side of the blade being upwards. Trace an outline of the blade on the paper, holding the pencil perfectly vertical in doing so. Mark the point at which the shank joins the curve of the blade; call this point P. Mark the centre of the tip of the blade; call this point Q. Join P Q by a straight line. This will form the chord of the arc which forms the middle of the curve of the blade. Bisect P Q by a line at right angles to it E F. Describe a circle G Q V P H whose centre lies on E F and whose circumference touches Q V P. The arc Q V P lies in the middle of the blade. Now draw a tangent A B to the circle Q V P at the point V. This will be parallel to the chord Q P. Now lay the blade on the paper in its original position, taking care that the points P and Q correspond precisely with their position on the forceps. If the traction-rods are properly constructed the *stud will lie on the line A B when the rod lies close to the shank.*

It will be found that the circle G Q V P H has a radius of about 7 inches; but as it is difficult to obtain forgings which are always identical, this radius may vary somewhat. This variation does not materially affect the efficiency of the instrument provided it is kept within reasonable limits, and the construction given will enable anyone to determine the proper curvature of the rods for any instrument, whatever the curvature of the blades may be.

The Plate at the end of this paper will show accurately how this projection is made.

LITERATURE.

TARNIER.—*Description de deux nouveaux Forceps.* Paris, 1877.

TARNIER.—"Perfectionnement dans la construction et dans l'application du Forceps," *Trans. Internat. Med. Congress.* London, 1881. Vol. iv., p. 239.

In these papers M. Tarnier gives an account of the principles of his invention, and a general account of the construction of the new forceps; but without any explicit detail which would insure the proper proportions of the instrument being secured. The instrument described in the first paper had peculiarities of blades and handles which were abandoned later on, and the instrument described in the second paper approaches closely as to curvature to the model of the ordinary Levret instrument.

SIMPSON, A. R.—"On Axis-traction Forceps," *Trans. Edin. Obstet. Society,* 1879–80, p. 219, and *Edin. Med. Journal,* Sept. and Oct. 1880.

SIMPSON, A. R.—"Again on Axis-traction Forceps," *Trans. Edin. Obstet. Society,* 1882–83, p. 143.

These papers are devoted to an exposition of the axis-traction principles and a description of Prof. Simpson's special adaptation of Tarnier's invention to the J. Y. Simpson instrument, which is modified in various ways.

HERMANN.—*Ueber eine neue Geburtszange zur Extraction des im Beckeneingange stehenden Kindskopfes mit Abbildungen von Th. Hermann,* 1884.

FOULIS.—"On Axis-traction Forceps," *Trans. Edin. Obstet. Society*, 1886–87, p. 189.

Under the class of instruments described by these authors come all instruments in which an additional handle for traction is attached, and in which both hands are used for traction,—the one grasping the application handles, the other the traction handle. For example, the device recommended by some of fixing a blunt hook or a towel in the lock and using this as a tractor along with the handles, is of this class. None of these instruments has any relation to Tarnier's principle, and these are in no sense "axis-traction." They are essentially dangerous instruments in that they give greater power of traction in a faulty direction.

HUBERT.—"Note sur l'équilibre du forceps et du levier," *Mémoires de l'Académie Royale de Belgique*, 1860.

Hubert's instrument is the original of all those with a rigid traction bar, or what amounts to the same thing, with a "perineal curve," such as Aveling's, Reid's, Morales', etc. Their advantages and limitations are discussed in the text.

CROOM, J. HALLIDAY.—"On the advantage of the Axis-traction Forceps in Low Operation," *Brit. Med. Journal*, 1884, vol. ii., p. 1237.

The author discusses the advantage of the instrument in—

1. Occipito-posterior cases in which anterior rotation occurs.
2. Occipito-posterior persistent cases.
3. Saving the perineum.

MURRAY, R. MILNE.—"On the Effects of Compression of the Fœtal Skull, with special reference to Delivery in minor degrees of Flat Pelvis," *Trans. Edin. Obstet. Society*, 1887–88, p. 207.

This paper contains an account of some experiments on the fœtal skull, showing the influence of antero-posterior compression in altering the other diameters, and discusses the delivery of flat pelvis by the axis-traction forceps.

POULLET.—*Des Diverses Espèces de forceps.* Paris, 1883.

This vol. (228 pages) gives an account of the various forms of forceps from those of Chamberlen onwards. It gives also a list of all papers on Tarnier's forceps up to 1883. Since then the literature is of minor interest.

Professor Simpson was sure he expressed the opinion of every Fellow present when he said that the paper which Dr Milne Murray had just read had given them all unqualified pleasure. He himself had been specially interested in all that Dr Murray had to say on the mechanical principles, the construction, and scope of the axis-traction forceps, and in the main agreed with Dr Murray's demonstrations, and found in them, indeed, a confirmation of what he (Professor Simpson) had thought regarding the instrument. The value of it was becoming more and more widely appreciated. Quite recently a work had appeared on Operative Midwifery, by Professor Farabeuf and Dr Varnier of Paris, in which, with new and suggestive illustrations, there was an admirable demonstration of the mode of action of forceps. The last number of the German *Archiv für Gynækologie* contained an interesting paper by Dr Nagel, giving the results of a long series of forceps cases in the polyclinic attached to Professor Gusserow's service in the Charité Hospitàl of Berlin. He (Professor Simpson) was gratified to observe that Dr Nagel, after trial of various kinds of forceps, found that the axis-traction forceps which he had first shown to this Society yielded the most satisfactory results. Dr Nagel had not been able to obtain such marked advantages, as regards the saving of the perineum, as so many of them had found here from the use of axis-traction forceps; but he found that there was no drawback to their use when the head was low in the pelvis, and it was important for the practitioner to familiarize himself with an instrument that would give the best results in the most difficult cases. As regards the application of the forceps at the brim of a flat pelvis, he would observe that, in the course of the years that they had employed axis-traction implements, they had become growingly confident in the safety of their employment. Still there were cases where the grasp was too directly occipito-frontal to be quite so safe to the infant; and in arguing against the operation of turning, Dr Murray had exaggerated the dangers attendant on that procedure. A very valuable part of the paper was that bearing on the construction of the instrument, and Dr Murray had rendered a distinct service in making out the "mechanical projection" which would enable a purchaser of a pair of forceps to see at a glance that he was getting a well-constructed instrument. In making the handles all of metal, Dr Murray was anticipating what would happen in the making of all our obstetric apparatus. It was striking to notice in the Museum of the International Medical Congress at Berlin how all the surgical instruments—scalpels, long needles, and everything—were made entirely of metal. As to the traction rods, he (Professor Simpson) had from the first directed them to be made so as to run parallel to the shanks, and had shown that in this relation of rods and shanks we had the best guide for the proper line of traction.

Dr Barbour had listened with great interest to the paper. He was sorry that he had missed the first part dealing with the physics of the axis-traction forceps, as Dr Milne Murray would handle that question ably. As to the best form of forceps, he preferred Professor Simpson's to Dr Murray's; the sliding lock on the latter was not so simple, and more difficult to keep clean. He thought that we must still regard turning rather than forceps as the mode of delivery in the typical rickety pelvis. It was the more scientific method—that is, the one that followed most closely the natural one. The position of the promontory furrow at one end of the bi-temporal diameter was positive proof that this was the diameter that passed the conjugate of the brim. In a normal pelvis, as Dr Murray had said, there might not be room for the occipital end of the head to slip to one side of the conjugate, but the typical rickety had a longer transverse diameter than a normal pelvis. Turning was only to be done when there was plenty of room in the transverse diameter. He had never seen the child suffer from too strong traction.

Dr Haultain entirely agreed with Dr Murray in regard to the efficacy of the axis-traction forceps in flat pelves. He had had several opportunities of testing their value, and had not yet found them wanting. In two cases especially he had been able to extract a living child where in previous labours turning had failed. He had also had the opportunity, which had been denied to Dr Barbour, of seeing a trunkless head left in utero, having been asked by a brother practitioner to assist in its removal. This was comparatively easily accomplished after the head was gripped—by axis-traction. He believed that Professor Simpson was right in stating that in some cases death or injury to the fœtus might result from the effects of compression; but as an argument for turning against forceps he could not support it, as he believed the number of fœtal deaths from compression of the cord after turning in flat pelves would greatly outnumber those destroyed by compression. He must congratulate Dr Murray in having demonstrated the action of the axis-traction in such an effective and scientific manner, as it would allow him at least to attempt to deliver in all cases of flat pelves with forceps more conscientiously than he had previously done.

Dr Thomas Wood said Dr Murray had presented to the Society and the profession in general the most complete form of axis-traction forceps which had yet been constructed, and for this, as well as the physical principles which he had so clearly laid down regarding the forceps, he was to be congratulated. At the same time, however, he wished to point out that whether they got axis-traction with this instrument or not depended very considerably upon the knowledge and skill of the operator, namely, as to whether he applied the forceps to the fœtal head in such a way that the axis of the blades exactly corresponded with the axis of that part of the pelvic canal in which the fœtal head was lying. Ideal application of the axis-traction forceps he considered was where the fœtal head was grasped by the forceps in such a manner that the axis which cut the smallest plane of the head at right angles, the axis of the blades of the forceps, and the axis of the pelvic canal, all coincided. Wherever they had the forceps applied in such a way that the axis of the canal and the axis of the blades were at an angle to each other, or lay in front or behind each other, then they did not get axis-traction at all, at least not until they had altered the position of the head and brought the canal axis and the forceps axis to coincide. Dr

Murray had shown that the forceps could be applied to the anterior or posterior portion of the head so as to correct its position—that is to say, when the occiput was delayed or too high up, they grasped the head more towards the occiput, in such a way that the forceps axis would be towards the occipital side of the pelvic axis; thus they brought down the occiput. This, of course, was not axis-traction but leverage; here there was no harm done, but good. But take this case again, where the occiput was too high up, the forceps, say from want of proper care, were applied with their axis on the sincipital side of the axis of the canal; if traction be now applied you have the already abnormal position aggravated, because you are bringing into the pelvic canal a plane of the fœtal head having a larger circumference, and by continuing you will have the forceps ultimately slipping off the head, but not until you have brought about a considerable alteration of position for the worse.

Dr Fred. W. Mann had seen several cases of labour in flat pelves. He was distinctly impressed with the advantages of the axis-traction forceps. He had not seen cases in time to be able to turn. While doing a locum for a friend in a large practice, and having been up every night during that week, he got a case of labour in a flat pelvis where the head was immovably fixed in the brim; he, wishing to demonstrate the advantages of the axis-traction forceps to his friend, and the ease with which they could be applied anywhere in the pelvis or above it, sent for him. Dr Mann pulled the child through, the grasp of the forceps being on the transverse diameter of the child's head. The head did not rotate, but was born transversely, and the child alive, the mother's diagonal conjugate being 3¼ inches. He could testify to the safety of the forceps in such cases both to the mother and child, having had at least over twenty such cases. He also said that the axis-traction forceps in occipito-posterior cases were quite as good as the straight forceps, provided the men using them did what they were taught by the Edinburgh School of Midwifery, *i.e.*, to use the application handles as indicators only when pulling, and to follow them with the traction rods. He in several cases had noticed, when the axis-traction forceps were applied above the brim, that the indicator was in the centre of the vulva; he pulled in that direction, knowing it was the wrong direction to pull, but, following the above rule, things always came right. He did not know the reason then why the application handles should be in the centre of the vulva, but had got a reason for it now.

Dr Church thought that there was less risk to the child in turning than in applying the traction forceps—that with the forceps the child's head might be grasped by forehead and occiput, and dangerous compression and injury to the skull result. He did not admit that the child's head was so soft, and that its parts did so easily overlap with impunity, as Dr Murray maintained. He thought that delivery might be accomplished more easily by means of forceps, but that there was more danger to the brain of the child, the signs of brain lesion not showing themselves, perhaps, at the time, but maybe months or even years afterwards, in the form of hemiplegia or other paralysis. Dr Church had seen such cases applying at hospital for advice.

Dr Murray replied.