is evidently 67.5°, which is near enough for all practical purposes to the angle of the fissure of Rolando. The side A B is then applied to the middle line of the head, the point A being placed half an inch behind the midpoint between the glabella and the inion, when the line A E will correspond to the fissure of Rolando.

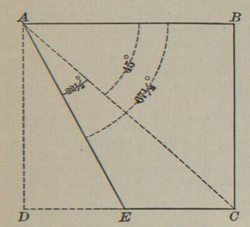

FIG. 1017.—Chiene's Method of Locating the Fissure of Rolando.

But it must be remembered that however exact our cerebral localization may be, there are exceptional cases that set at naught all our present knowledge on this subject. Thus Cunningham reports a case of subarachnoid cyst extending from the fissure of Rolando to the occipital lobe with neither motor nor sensory disturbance, and Bramwell reports a case of sarcoma of the dura destroying the greater part of the motor centre without any paralysis. These and a number of other such cases should make us careful not to be too dogmatic until we learn much more.

Percussion of the Skull.—Here, perhaps, as well as elsewhere, may be noted a point to which Macewen has called attention, viz., that percussion of the skull may afford valuable evidence not only of the condition of its contents, and, as I have pointed out, of that of the skull itself, but also, as I have observed in one case, of the condition of the overlying tissues.

Macewen does not state the character of the percussion note, but presumably it is that, when an abscess or tumor exists, there will be a local, increased dulness on percussion, with a lower tone. He states that it has been verified post mortem, and that it will probably be of especial value in early life in the diagnosis of tumors of the cerebellum. In a case of hydrocephalus I have observed a markedly increased dulness of one side on percussion, and the autopsy showed that the ventricular distention was far more marked on this side.

In simple fracture of the skull, hydrocephalus, and large tumors, the "cracked-pot" sound described on page 421 of this paper may be of service, and I would urge that it be tested and reported on in future cases.

In a case of syphilitic necrosis of the skull above the left ear, with a Jacksonian epilepsy in the left arm and leg, and therefore a presumable lesion (gumma?) on the right side of the brain, I have tested the percussion note. Over the necrosed bone the tissues were somewhat thickened, but not to any excessive degree. The percussion note was so much duller on the left side, half-way between the sagittal suture and the ear, that two of my assistants with their backs turned to the patient correctly stated which side was percussed, and the same difference was noted as between the same site and the forehead well above the frontal sinus. In a paper published in 1884, I have pointed out the similar value of percussion in the so-called abscess in the frontal sinus and the antrum.

GENERAL TECHNIQUE OF OPERATIONS ON THE BRAIN.—This has been carefully formulated by Horsley. In a few minor points I have added to it from my own personal experience, as well as from that of others.

I. *Shaving the Head.*—This is not only important for the operation, but should always precede a definite diagnosis, and, in fact, be one of the means of making it. So important do I regard this that I should consider no diagnosis as assured, and no operation warranted, that had not been preceded by shaving. The unexpected and the unknown scars found have surprised me in several cases. Besides this, no reliable mapping on the head of the fissures and convolutions can otherwise be made. These should always be marked on the skull by an aniline pencil.

II. *Antiseptic Preparation of the Patient.*—The day before the operation the patient's head should again be shaved, scrubbed by a mail-brush with soap and water, next with ether, and then be covered with a wet sublimate dressing (1:2,000), retained in place by a bandage till the time of operation. Formerly I used, as Horsley advises, a solution of 1 to 1,000, but I have found that the recently shaved scalp is so tender that pustulation was often caused by it. This scrubbing must be gentle, but thorough. The operation room should be uncarpeted and should contain only necessary furniture, the walls and ceiling should be carefully wiped the day before, and all the woodwork and furniture scrubbed with carbolic solution. Aseptic gauze sponges should be used. The instruments may be disinfected either by boiling for fifteen minutes, or by lying for an equal length of time in a carbolic solution (1 to 20), and then transferred to boiled water sufficiently cooled to permit of their being handled. The head should be washed with soap and water, ether, and sublimate solution, a second time just before the operation. The hands, and especially the finger nails, of the operator and of every one of the assistants should be most carefully cleaned and then disinfected.

III. *Anæsthetic.*—Horsley specially advises the use of chloroform, but I have often used ether and found no reason to regret it. Horsley cautions us that when the dura is opened there is a special sensitiveness to the action of an anæsthetic (chloroform only?), and that special care should therefore be used not to give too much.

As a preliminary Horsley advises that a quarter of a grain of morphine be injected under the skin from a half-

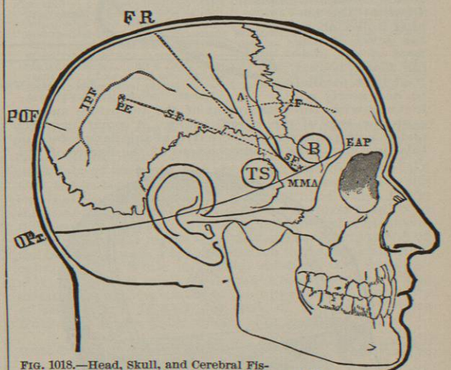

FIG. 1018.—Head, Skull, and Cerebral Fissures (adapted from Marshall, by Hare). OPr, occipital protuberance; EAP, external angular process; SF, Sylvian fissure; A, its ascending limb; FR, fissure of Rolando; PE, parietal eminence; MMA, middle meningeal artery; TS, tip of temporo-sphenoidal lobe; B, Broca's convolution; IF, inferior frontal sulcus; POF, parieto-occipital fissure; IPF, intraparietal sulcus. The pterion is the region where three sutures meet; those bounding the great wing of the sphenoid where it joins the frontal, parietal, and temporal bones.

hour to an hour before the operation, both because a smaller quantity of anæsthetic will be required, and also because it produces contraction of the arterioles, and consequently diminishes hemorrhage. As Nancrede has pointed out, however, the use of opium, at least in cases in which a small definite cortical centre is to be removed and but little hemorrhage is anticipated, is not advisable. Horsley states that it is dangerous to operate upon patients under the influence of drugs, and especially the bromide of potassium; why, I do not know; but I should be inclined to follow so high an authority.

IV. *Marking the Bone.*—This can be done in two ways: 1. The site of the scar or other lesion is easily marked by making a small incision down to the bone and then marking it by an aniline pencil as done by Weir; or, better, I think, as I have proposed, by nicking the bone by a gouge. To mark the Rolandic and other fissures of the brain, the same method may be employed by means of two or more small nicks. These nicks may also be useful in other ways. In my first case (tumor), as I was not able to replace the button of bone, I utilized the nick to fix accurately the location of the tumor. There was a scar, the situation of which was exactly determined by measurements. A nick on the button of bone was made at the site of the scar. After the operation the button of bone was fitted to the tumor, and the dimensions of the tumor measured from the nick. These measurements were afterward transferred to another skull, upon which the site of the scar was accurately fixed, and upon which, also, the fissures of the brain had been marked. I was thus able to locate, with great accuracy, the position of the tumor. 2. Another method of marking the fissures (especially the Rolandic) is by drawing them on the scalp with an aniline pencil, and prolonging the lines above and below the limits of the intended flap. When the flap is raised all the other external landmarks are practically lost; but a nick in the bone, or an imaginary line adjoining the aniline lines of the Rolandic fissure beyond the limits of the flap, will give us this important landmark.

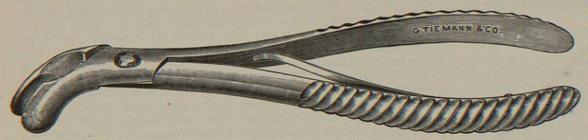

FIG. 1019.—Hopkins' Rongeur Forceps, as Modified by Weir.

V. *Access to the Brain.*—Instead of the old crucial incision Horsley has recommended a large horseshoe-shaped flap, which will usually be about three inches or more in diameter. This incision must be carried vertically down to the skull, and must be so made, first, as to favor drainage in the supine position; secondly, its base should be so placed as to retain the most favorable blood supply to the flap. Horsley has recommended that the periosteum be not raised with the flap, but reflected by a later crucial incision. I have, however, always reflected the periosteum with the flap, and have found no ill results. It is a cardinal principle in the new cerebral surgery that both the flap in the scalp and the opening in the bone shall be ample. The mode of dealing with the bone will be mentioned later; but let it once for all be stated that a large opening in the bone has been amply proved to be no more dangerous than a small one, and an immense advantage can be gained in locating the fissures and the convolutions (and therefore the lesions), and, so to speak, in the amount of "elbow-room" for operative procedure. This is of the greatest possible service. Jonnesco and Doyen have gone so far as to reflect nearly the whole side of the skull (hemicraniotomy). As a rule this is a needlessly large opening and certainly increases the danger.

FIG. 1020.—Pyle's Chisel, as Modified by Keen.

Different methods may be adopted for making the opening in the bone. A large trephine, one and one-half, two, or even two and one-half inches in diameter, may be used. If the smallest of these sizes be used, it may necessitate the removal of two adjacent buttons, and even then the opening may have to be enlarged in any given direction for access to the lesion. This is best done by the ordinary rongeur forceps, or by Hopkins' modification of them. These forceps have been further modified (and I think with advantage) by Weir, by making the bend at right angles to the handles of the forceps instead of in their plane (Fig. 1019).

Another method is one that Mr. Horsley has used, and which has the advantage of abridging the time required for the operation. He makes a one-inch opening with a trephine, and by this determines the thickness of the skull. He then outlines the piece of bone to be removed, by Bonwill's surgical engine, cutting almost through the bone. Complete division of the bone is then effected by stout bone forceps. Devilbiss' forceps are also very useful.

The German surgeons frequently use the chisel and hammer. In most of my recent operations I have used this method and have found no evil consequences from their use. Pyle chisels, as modified by myself, I have found the most useful (Fig. 1020). The thick handles add greatly to the convenience of their use.

Oteoplastic Resection.—In 1889 Wagner, following an earlier suggestion of Wolff, proposed to make a temporary osteoplastic resection by chiselling loose the piece of bone to be removed, except at one portion where it was fractured and turned back using the scalp as a hinge. The scalp is incised down to the bone, the flap not being loosened from the bone. By mallet and chisel the bone is then nearly cut through at every point, the separation being completed by an osteotome, excepting at its base. It is then lifted by means of elevators, the base being fractured, a window, so to speak, being opened by turning back the flap (Fig. 1021). By this means access can be had to a very large area of the brain cortex; one of even three, four, or five inches has been thus exposed. When the operation is terminated the opening is closed by replacing the flap, which is sutured in place as usual. In chiselling such a piece loose, it is best to chisel it obliquely, so that the opening in the inner table will be a little smaller than that in the outer, the inner table thus forming a shelf on which the flap rests. The base of the flap which serves as a hinge should always be in that part of the flap having the largest blood supply.

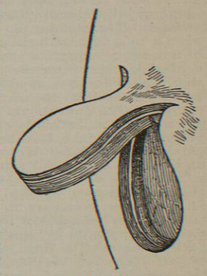

FIG. 1021.

The surgical engine with a special drill, an electrical motor with a saw, and the Gigli wire saw have been also used in place of the chisel.

"Trephining," in the remainder of this paper, will be used in the sense of opening the skull to obtain access to its interior, irrespective of whether the opening is made by the trephine, the chisel, or any other means.

Of course, in trephining for abscess only a three-fourth-inch trephine would be necessary, and the opening can be enlarged, if necessary, by the rongeur forceps. For tapping the ventricles a half-inch opening is ample. Von Bergmann has declared himself opposed to operative interference with a cerebral tumor which would require a large opening in the bone, on account of the probable

consequent œdema. The best answer to this is that success has practically followed operations in which large openings have been made and no œdema has followed. Horsley has thus successfully removed a tumor of four and a half ounces, and I have done the same in a case of a tumor weighing over three. Bramann has successfully removed a tumor weighing nine ounces, the largest on record (*Centralbl. f. Chir.*, 1892, Beilage, p. 66). Indeed, in some cases pre-existing œdema has been relieved.

It is quite surprising how far beyond the limit of the opening in the bone and dura we can feel and see. The brain allows gentle pressure very readily. A finger can be inserted for nearly an inch all round the opening, and the eye can reach as far if the brain be gently depressed by any flat instrument.

Before enlarging the opening the dura mater must be separated from the bone. This can be done with a bent probe, but the best instrument is one devised by Horsley (Fig. 1002). By it also the under surface of the surrounding bone can be examined for any inequalities, etc.

The dura, as a rule, should be opened. Unless this is done important information may be lost, and the case be improperly treated. Occasionally it may be allowed to remain intact, when, for instance, a sufficient lesion has been discovered. But it is a rule, with rare exceptions, that, if we trephine at all, the *brain itself* should be examined. The opening in the dura should not be by a crucial incision (except in case of a small opening for abscess of the brain or draining the ventricles), but by a horse-shoe-shaped incision at about a quarter of an inch away from the margin of the bony opening. The dura should first be lifted by a tenaculum and slightly opened by a scalpel, and the incision then be completed by a pair of blunt-pointed curved scissors. The dura should be carefully lifted by forceps so as not to wound the veins beneath, and the same caution applies to the scissors. Should it be necessary to cut across the trunk or any branches of the meningeal arteries, they should be secured by ligatures passed through the dura mater by a small curved Hagedorn needle, and tied before the vessel is cut across, the dura being well lifted meantime, lest the needle wound the large veins in the brain. When the operation is terminated, if the dura has not been removed, it should be replaced and secured by catgut.

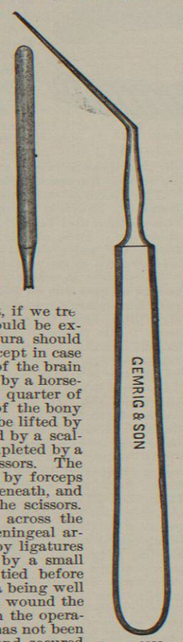

FIG. 1022.—Horsley's Instrument, to Separate the Dura from the Skull.

VI. *Hemorrhage.*—Hemorrhage from the scalp will be very free. To a large extent it can be prevented in many cases by the use of the narrow band furnished with Esmarch's bandage, as has been suggested by Dr. M. Allen Starr. Hæmostatic forceps, however, can with safety grasp the entire thickness of the scalp and quickly control any large vessels. Such as need it, of course, should be ligated at the end of the operation. The control of hemorrhage from the vessels of the brain itself, is one of the most difficult of all the operative questions. I have already alluded to the use of morphine. I have also used a solution of cocaine applied directly to the brain. I have also suggested the use of antipyrin, which has been employed by Park with advantage. Such solutions, together with the corks and the bottles, should be sterilized. These applications have certainly proved advantageous in checking hemorrhage from the smaller vessels, nor could I see any harm resulting from them when I have used them. The cocaine should be a ten-per-cent. solution. Another means is boiling water cooled to 115° or 120° F. This I have used very liberally and have found no disadvantage from the comparatively high temperature. Pressure is another means which can be constantly and successfully applied by sponges, or by iodoform or other gauze.

But, after all, the chief reliance is to be placed on ligatures of catgut. They should not be chromicized, but are best prepared after the Jefferson method * by bichloride of palladium. The method of applying them is very important. While the larger arteries in the brain can be ligated in the usual way, the veins, which are very large, very full, and very fragile, are a much more troublesome source of hemorrhage, and require much more delicate manipulation. The greatest gentleness must be used during traction; and in tying, the traction on the two ends of the ligature must be exactly even or the vessel will be torn. In addition, the knot must be drawn only tightly enough to stop the hemorrhage, for if drawn too tightly it will easily cut through the fragile vessel. Weir has suggested in some cases the application of clamps to the vessels for twenty-four hours; very exceptionally they may be used, especially to the dura. Of course they must be included in the dressing.

It is occasionally necessary to trephine very near, or even over, one of the great sinuses of the brain, and in doing so it might easily be wounded. The sinus, however, may be avoided if due care be used. The trephine should be applied far enough from the sinus to be in a region of absolute safety. The opening can be enlarged later toward, or even over, the sinus with safety. In a recent case I recognized when I was near the lateral sinus by feeling the bony groove in which it is lodged by my finger introduced through the trephine opening. I could then separate the dura and sinus from the bone and could have trephined safely over the sinus, had it been necessary. In addition to this we may have to deal with a primary wound of a sinus itself. If the opening in the sinus is small, lateral suture of the sinus may be practised. If large and it cannot be closed by sutures, clamps may be used with advantage.

Pressure by a tampon of iodoform or other gauze has controlled it in a number of instances. In some cases the sinus has been tied by two ligatures, one in front and one behind, thus cutting off all possible hemorrhage, and the sinus excised as by von Bergmann and Küster. Barr has even suggested that in cases of thrombosis of the lateral sinus we may purposely open it after ligation, clean out the clot and remove this portion of the sinus. Care should be taken that no air enters the sinus lest sudden death should follow, as in Volkmann's case. In the same volume a series of nine experiments are reported on dogs by Genzmer, in which there was aspiration of air in six. (See also Senn's experiments.)

VII. *Treatment of the Brain.*—The first practical point to notice, after the dura is opened and hemorrhage controlled, is whether the brain *bulges* into the trephine opening. If it does so, it indicates a pathological increase of the intracranial pressure, a fact of the highest importance, since it will indicate either a tumor, abscess, blood clot, or dropsy of the ventricles. Bulging of the dura before opening it is, of course, equally significant.

Next, the *color* of the brain should be observed. A yellow tinge or lividity will probably indicate a tumor beneath the cortex. If the brain tissue be the seat of an old laceration its color will be altered, usually to a dirty yellowish brown. Next, the condition of the vessels and of the perivascular lymphatics must be observed, and particular notice should be taken whether there are yellow-white patches on them that may indicate any old mischief. Sometimes the membranes and convolutions will be densely matted into a yellowish cicatrix. In a number of cases I have seen *œdema of the membranes* sometimes

* Annals of Surgery, January, 1898; Journal of Nervous and Mental Disease, 1894, xxi., p. 486.

so great as to obscure the sulci and convolutions to a marked extent. Precisely what is its significance, how far it is normal and how far pathological, I do not yet know. Nicking or snipping the membrane allows the serum to escape, and the sulci and convolutions to be recognized.

Next, the *density* of the brain must be appreciated by the touch. If there be an abscess or dropsy of the ventricles the elastic tension will be increased, but, at least in dropsy, it will be very soft. If there be a large tumor the brain substance will be more resistant and dense than normal except in the case of soft sarcomata, etc. But it must be remembered that a small cerebral tumor at any distance beneath the cortex can scarcely be detected by this means. Should any hardness be detected, the brain substance must be incised and careful search instituted by the finger for the tumor or other pathological condition. If the finger be used it should be the little finger by preference, and great gentleness should be employed, or serious laceration of the brain substance will be produced. If abscess or dropsy be suspected the brain may be explored by a needle, knife, or grooved director. (For their comparative value, see page 414.) Wright, after trephining over the occipital lobe, even thrust a trocar through the tentorium down into the cerebellum and evacuated an abscess—a procedure I should not employ; trephining over the cerebellum itself would have been safer and better.

Next, the presence or absence of *pulsation* in the brain is to be noted. If a large tumor, abscess, or cyst exist it will be absent, but if a small tumor, cyst, or abscess be separated from the surface by any considerable layer of normal brain tissue, pulsation may be present. Altered brain tissue from old lacerations, etc., will generally pulsate.

In incising the brain, the knife should be carried down vertically into the corona radiata in such a manner as to avoid damage to the fibres coming from adjacent portions of the cortex, and the incision should run as nearly as possible parallel with the cerebral vessels which are "terminal."

Should the brain tissue be abnormal, the whole abnormal portion must be removed. It is important in doing this to remember that, while we should guard against producing any needless paralysis by removing healthy brain tissue, yet it is of prime importance that *all* of the diseased portion should be removed. If there be a cortical tumor (unless it is encapsulated or otherwise definitely limited), the necessity of removing a portion of adjacent and apparently healthy brain tissue, so as to get beyond the limits of infiltration, is of the greatest importance. If the tumor be subcortical, it can be sought for by the finger with great gentleness, and be removed either by a sharp spoon or other similar means, together with a suitable adjacent zone of healthy brain tissue. In all this removal of tissue adjacent to the tumor we can cut much more freely antero-posteriorly than vertically upward or downward. In the vertical direction we encroach far more quickly upon adjacent additional centres than we do in the antero-posterior direction.

VIII. *Recognition of the Brain Centre Sought for.*—In certain cases of Jacksonian epilepsy the object sought for is the removal of the centre whence the discharging lesion starts. In this case it will be necessary to recognize such centres by definite methods. In some cases the membranes and the convolutions are so matted together, and the brain substance so altered, that it will be impossible to recognize the sulci and the convolutions. But in these cases it is scarcely necessary to do so, inasmuch as all the damaged tissue should be removed, and, as before stated, we must even encroach to some degree upon apparently healthy brain tissue. In other cases, however, it is important and also possible to recognize the individual sulci and the convolutions, and to determine the precise part of the brain that is the seat of the discharging lesion, and therefore to be removed. The prolonged aniline lines on the undisturbed portion of the scalp, indicating the position of the fissure of Rolando, or the reapplication of the cyrtometer will here assist us very materially.

The determination of the brain centre by electricity has now been done in many cases most satisfactorily and without damage to the brain. The earliest four cases were those of Horsley, Keen, Deaver and Lloyd, and Nancrede. This is best accomplished by means of an ordinary faradic

FIG. 1023.—The Author's Cerebral Electrode.

battery. In order more handily to use this means of diagnosis, I have had made a little rubber handle with two insulated points, the stems of which, being flexible, can be bent toward each other or separated as far as desired (Fig. 1023).

A very important point in this relation is stated by Horsley as the result of his experiments on animals. The cortex of the brain soon loses its excitability for electrical stimuli when bathed with antiseptic solutions. In any such case, therefore, it is desirable that the search for such cortical centres, by means of electrical stimuli, should be done *immediately* after the opening of the dura, and *before* any antiseptics have been applied. Usually none are now used. When once recognized, I have suggested, in order to prevent the need for repeated and possibly injurious applications of electricity, that the desired centre be marked by an aniline pencil or a nick. If the centre is to be removed the latter would do no harm.

IX. *Drainage.*—Drainage of the brain should be conducted on precisely the same principle as drainage for other parts of the body. Usually it may be entirely dispensed with. If it is used, however, it must be dispensed with as soon as possible. Generally I employ a gauze wick and remove it at the end of twenty-four hours. If not employed there is usually a considerable bulging of the flap during the first few days after the operation. This bulging, if it does not become too great, is not to be interfered with. If, however, it is more than a moderate bulging showing a considerable collection of wound fluids, a stitch may be cut and the flap gently and slightly opened. This will give egress to the retained fluids and the opening may be kept patent for twenty-four hours by a very small bit of gauze inserted for about half an inch. Primary union will follow the removal of this gauze.

In cases of abscess, gunshot wounds, hemorrhage, etc., or in cases in which there is danger of infection, the drainage must be more prolonged, and is best accomplished by rubber tubing. For the method of drainage in these conditions the reader is referred to other portions of this paper under the headings mentioned.

X. *Replacement of the Bone.*—Mr. Macewen first showed the possibility of replacing the bone by mincing it up into small pieces and spreading it over the surface of the reunited dura. Clark, of Glasgow, was the first, I believe, to replace the entire trephine button with success. In the case of replacement the utmost care, however, must be given to the button from the moment it is removed to the time of its replacement. The instant that it is removed it should be placed in a cup containing a warm solution of bichloride (1 to 2,000), or warm salt solution, 0.7 per cent. This cup should be placed in a large basin in which lies a thermometer, and hot water should be poured into the outer basin from time to time to keep the temperature always between 105° and 100° F. It should be the duty of one assistant to attend to nothing else but to the water in this basin. All small fragments are also placed in this cup, and when the dura has been sutured the large discs of bone may be replaced, together with a suitable number of the small fragments bitten away by the rongeur forceps. If there be more than one large button, the triangular spur or spurs between the trephine holes should not be removed unless it is absolutely neces-

sary in order to get more room, as they assist materially in keeping the buttons in their proper places. Should the membrane be removed, the bone cannot be thus replaced. In one case I successfully adopted the following expedient: I bored the centre-pin hole completely through the bone, and at the margin of the disc made another hole, also by the centre pin of the trephine. The two ends of

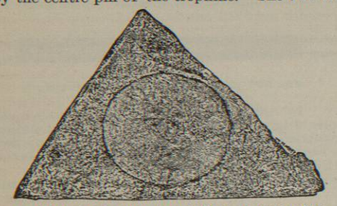

FIG. 1024.—Replaced Button of Bone. Inner surface.

a chromic catgut ligature were passed through these openings, and by needles these two ends were passed through the scalp and tied on the outside. The union to the scalp was complete, and the aperture in the skull was almost entirely closed by the callus. If the opening, after removing the disc of bone, has been enlarged by the rongeur forceps, the small fragments may be scattered closely together over the dura.

XI. *Substitute for the Dura.*—In three cases in which the dura was necessarily removed, I have made an efficient new dura by stripping off a large piece of the pericranium, trimming it to fit the opening and then fixing it in place (with the osteogenetic surface outward) by a few sutures. Bone chips may then be sprinkled over the surface freely. These have united and formed a firm skull. Figs. 1024 and 1025, in the so far unique case of Burrell, show how complete the union may be after replacement of a trephine button. In case the bone is not replaced it will be well for the patient to wear a skull cap into which is sewed a metal plate somewhat larger than the opening, as a protection against blows and falls. If a drain tube has to be placed under the bone, a piece should be bitten out of its edge by the rongeur forceps to allow for the passage of the tube.

XII. *Closure and Later Treatment of the Wound.*—Hemorrhage having been checked, the dura sutured as described on page 408, and the bone replaced with provision for drainage if deemed useful, the scalp should now be replaced and secured with sutures. An abundant dressing is to be applied and retained in place by suitable bandages. The dressing will most probably be saturated with blood and serum at the end of a few hours. If so, the wound should be redressed. At the end of twenty-four hours the wound should always be redressed, when, as already directed, the drainage is to be removed, or slight drainage provided by a bit of gauze if the wound fluids necessitate the slight opening of the scalp wound. The next dressing should not be done until the wound fluids have saturated the dressing to its margin. By the fifth day, it is my rule then to redress the wound for the purpose of removing any stitches that may be no longer needed. In operations on the brain in which the bulging above referred to has produced some tension on the stitches, it is best not to remove them too early; but usually all of them may be taken out by the seventh or eighth day, and some of them by the fifth. If by the fifth day primary union has been secured, a mere protective dressing may be applied. In a few days this may be dispensed with, but the patient, on account of his shaven head, should wear a skull cap, or some other means of protection against taking cold.

XIII. *After-Treatment.*—If the case be not one with active inflammation, and if union by first intention has been secured, the patient should be well within a week or ten days, without an elevation of temperature much above 100° F., and possibly not even up to that point. The bowels and the diet should receive the ordinary care.

One thing is of the greatest moment after such operations: no excitement, study, business, household cares, or mental worry should be permitted for several weeks, or, better, for several months, after the operation.

XIV. *Secondary Operations.*—A number of these have been done. Mr. Horsley has referred to some in his paper. Nancrede has reported one, and Stokes another by Franks, and I have done several. The membranes will commonly be found to be quite adherent to each other and to the brain tissue, and if it be necessary to dissect them off the latter, it is almost inevitable that some portion of the outer layer of the cortex will be removed along with them, producing paresis in the centres thus encroached upon; hence it should be done with the greatest gentleness and care. After removal of a motor centre there is, of course, entire paralysis of the part supplied by this centre; and the pressure caused by the blood clot which accumulates and the later cell proliferation is apt to cause widespread paralysis, amounting even to a hemiplegia. After some weeks this invariably disappears to a greater or lesser extent, leaving, however, the affected muscles, it may be, somewhat paretic. The cicatricial tissue between the brain and the bone very likely will be quite vascular, and, possibly, traversed by large veins. Should the dura not have been opened at the first operation, it will still be adherent to the brain itself, and probably covered by a layer of granulation and cicatricial tissue, which must be dealt with according to the needs of each case.

XV. *The Limits of Operative Interference with the Brain.*—Over twenty years ago I perforated the squamous bone and passed a probe between the dura and along the petrous bone to a depth of two inches, in a search for an abscess. I found no pus, but the search did neither good nor harm. Weir has proposed, in a case of aural disease with subsequent cerebral mischief, in a similar manner to lift the dura to a point corresponding to the roof of the tympanum; and if need be, in suppurative meningitis of the middle fossa, to open the dura and drain the fossa. He has well likened the petrous bone to the appendix vermiformis, as a focus of inflammation followed by suppurative processes in the dura or arachnoid, either local or general. It is followed, therefore, by external pachymeningitis and extra-dural abscess, internal suppurative meningitis, or cerebral or cerebellar

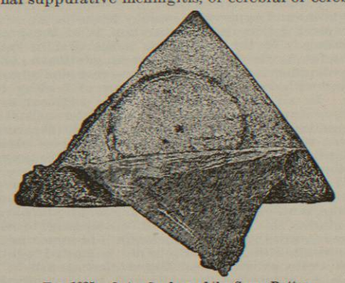

FIG. 1025.—Outer Surface of the Same Button.

abscess, all of which he suggests may be similarly relieved by operation. The same excellent surgeon has shown (and I have verified the procedures partly on the living subject and partly on the cadaver) that the cerebellum can be lifted sufficiently to obtain a view as far as to the foramen magnum; the same foramen can be reached by the finger on the inside, and from the outside by both the eye and the finger; the longitudinal and lateral sinuses

can be safely uncovered and separated from the skull; and the frontal lobe can be lifted far enough to expose the anterior clinoid processes.

Horsley has reached an exostosis of the orbit almost at the optic foramen, and has stated that the tumor of the auditory nerve, reported to the Neurological Society of London by Dr. Sharkey, could have been removed by incision of the tentorium and ligature of the lateral sinus.

Other cases, referred to in this paper and elsewhere, show that the sinuses may be tied and exsected; a very large part of the surface of the skull, up to even the size of the palm, or even more, may be taken out; large tumors, up to over nine ounces, may be successfully removed, and considerable areas of brain tissue may be cut away with safety and advantage.

A large portion of the base of the brain can be explored by the finger, the eye, and the probe or director, and the substance of the brain can be punctured almost with impunity, repeatedly and to a depth of two inches and more, without leaving any injurious trace behind.

I have shown also that the lateral ventricles can be safely reached. In many cases, especially since my paper was published, the ventricles have been tapped with success. Even a wound involving them is not necessarily fatal.

MENINGOCELE, ENCEPHALOCELE, AND HYDRENCEPHALOCELE.—For the more detailed account of symptoms and physical signs of these diseases, see the article entitled *Brain: Cephalocele* in the present volume. In this article I shall consider them only briefly and from the surgical point of view.

Meningocele, encephalocele, and hydrencephalocele are allied malformations of the brain which are fortunately not common.

1. MENINGOCELE consists in the protrusion of the membranes of the brain through an aperture in the bones of the skull, the sac formed by the membranes being distended to a greater or lesser extent by fluid which is extra-cerebral.

2. ENCEPHALOCELE consists in the protrusion of a portion of the brain itself, as well as of the membranes, usually with a smaller amount of fluid within them, the fluid again being external to the brain substance.

3. HYDRENCEPHALOCELE consists in the protrusion of the brain substance itself as well as of the membranes, but in this case the interior of the mass communicates directly with the ventricles, and is often filled with a large amount of the ventricular fluid, so large in some cases that the layer of brain substance enclosing the fluid is reduced to a very thin film.

All three forms of the disease arise in intra-uterine life, and are therefore congenital. The most frequent is unfortunately the gravest form—viz., hydrencephalocele—and the least frequent is meningocele. As a rule, they are apt to be fatal early in life. Their commonest situation is, first, in the median line, especially in the occipital region; next, in the fronto-nasal region, and lastly, at the sides of the skull or about the base. Of 93 cases collected by Houel, 68 were occipital, 16 fronto-nasal, and 9 at the sides and base.

Diagnosis.—They have been mistaken for abscesses, nævi, sebaceous cysts, etc. The following points of diagnosis will generally enable the surgeon to reach a proper conclusion:

All of them are congenital, commonly median, and especially occipital in position. Meningocele is usually cystic in its feel, is translucent, fluctuates, rarely pulsates, is more or less pedunculated, generally becomes tense in forced expiration and is easily reducible. Encephalocele is usually small, is opaque, does not fluctuate, pulsates distinctly, has a wide base, becomes more tense in forced expiration, and symptoms of pressure are produced on attempting to reduce it. Hydrencephalocele is generally large, is lobulated, is partially translucent, fluctuates distinctly, pulsates but rarely, is usually pedunculated, is made only slightly more tense in forced expiration, and is not reducible.

All three forms are apt to be combined with other deformities, and paralysis often accompanies hydrencephalocele.

Treatment.—As a rule, hydrencephalocele is not amenable to treatment. The child fortunately dies early. The other two forms hold out more hope, especially if they are small. Sometimes an encephalocele by retrograde development may be changed into a meningocele, and occasionally by gradual concentric ossification, resembling that of the fontanelles, the bony aperture is lessened and may even close. The intracranial communication with the interior of the sac may be narrowed and finally obliterated, thus partially or completely effecting a spontaneous cure. Until the late improvements in cerebral surgery, nothing was usually recommended in the way of treatment, certainly not unless there was danger of rupture. A number of successful cases of excision, however, have been recently reported, and, unless the size of the tumor or the condition of the patient forbid, this should be attempted, of course with all the antiseptic care bestowed on other brain operations. Enough scalp should be preserved to make sufficient flaps to close the opening. If operation be felt inadvisable, electrolysis may be used as a substitute. Pressure and the injection of Morton's fluid (iodine, gr. x.; potassium iodide, gr. xxx.; glycerin, ʒ i.) may be tried, but with little prospect of benefit.

INTRACRANIAL ABSCESS.—*Causes.*—Nearly one-half of the cases of abscess of the brain arise from a suppurative process in the ear. Occasionally they arise from an acute inflammation of the ear; but much more frequently they are a sequel of chronic ear disease. Occasionally they will follow even a few weeks after suppuration, but they are far more commonly a sequel years after scarlet fever, or some other exanthem, has set up a discharge from the ear. The situation of such abscesses is most frequently in the temporo-sphenoidal lobe.

Barr, in 76 cases of cerebral abscess following disease of the ear, found 55 in the temporo-sphenoidal lobe, 13 in the cerebellum, 4 in both the cerebrum and cerebellum, 2 in the pons, and 1 in the peduncle. When situated in the temporo-sphenoidal lobe they are not necessarily directly in contact with the petrous bone, but may be separated from it by even an inch of apparently healthy brain tissue. They reach the cerebellum usually by the track of the lateral sinus, in which very often thrombosis occurs. The mastoid cells are very frequently, but not always, involved. The discharge is almost always fetid.

The next most frequent cause is injury. Frequently this injury has not been very severe, but even a small scalp wound, if it becomes septic, may involve the bone, the veins, or the lymphatics, and then the encephalon. Moreover, if recovery apparently takes place, the patient is by no means safe, as a number of instances are on record in which several weeks or months, and in some instances even a number of years, have elapsed between the infliction of the injury and the development of the abscess. A most remarkable case of late development of abscess, and of its correct localization, is given by Mr. Damer Harrisson in the *British Medical Journal*, April 21, 1888. A boy, aged *fifteen*, had received a severe blow on the *left* side of the head when *four or five years of age*. No severe symptoms followed the wound, but nine or ten years later, for about a year before his admission, twitching and flexion of the wrist, biceps, and deltoid had been observed. Eight days before his admission he had received a blow on the *right* side of the head from a pair of tongs. Three days after this accident a convulsion on the *right* side of the body suddenly set in, beginning in the arm, then spreading to the face and leg, and followed by paralysis of the *right* side of the body. Repeated convulsions followed his admission. Mr. Harrisson trephined the boy, not at the site of the last, but at the cicatrix of the *first*, injury, and eventually evacuated four drachms of fetid pus, and the boy made an uninterrupted recovery. Macewen (*loc. cit.*) reports a remarkable case in which an acute abscess developed later in the periphery of an old encysted abscess. After evacuating several ounces of pus, the old abscess ap-