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3,457,922

STEREOTAXIC SURGICAL INSTRUMENT AND METHOD

Filed Dec. 13, 1966

4 Sheets-Sheet 2

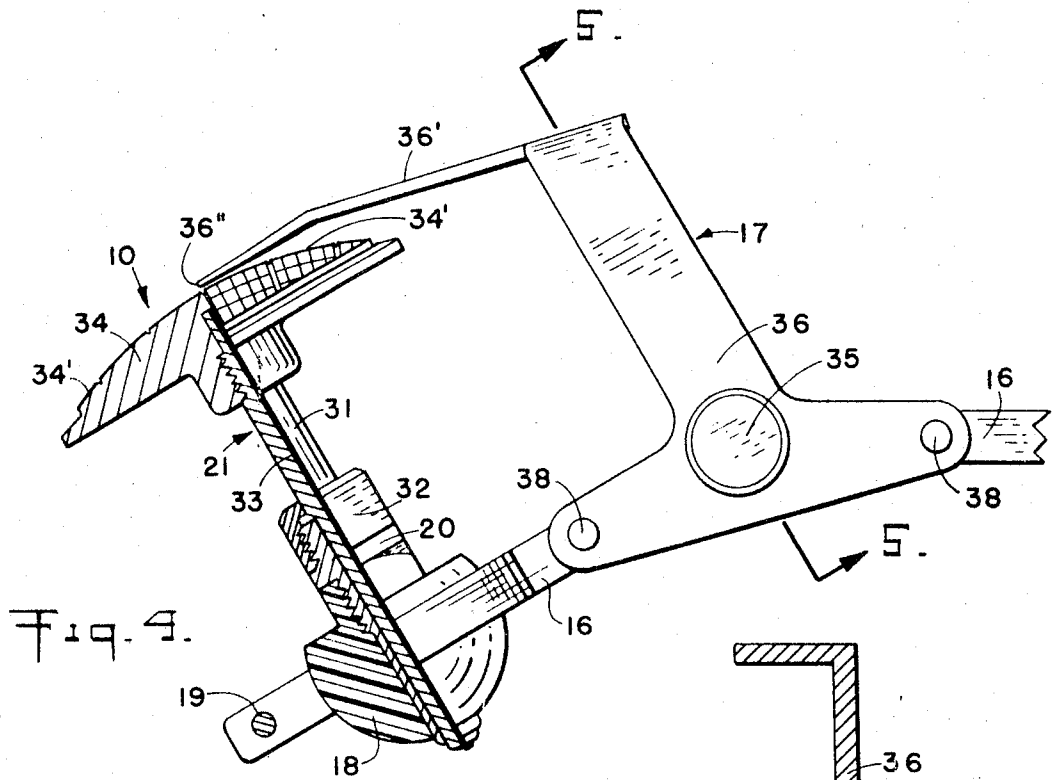


Fig. 4.

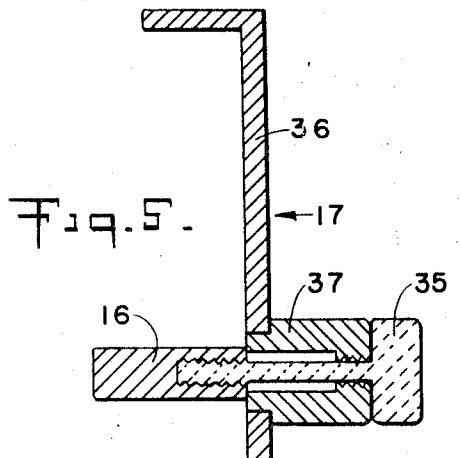


Fig. 5.

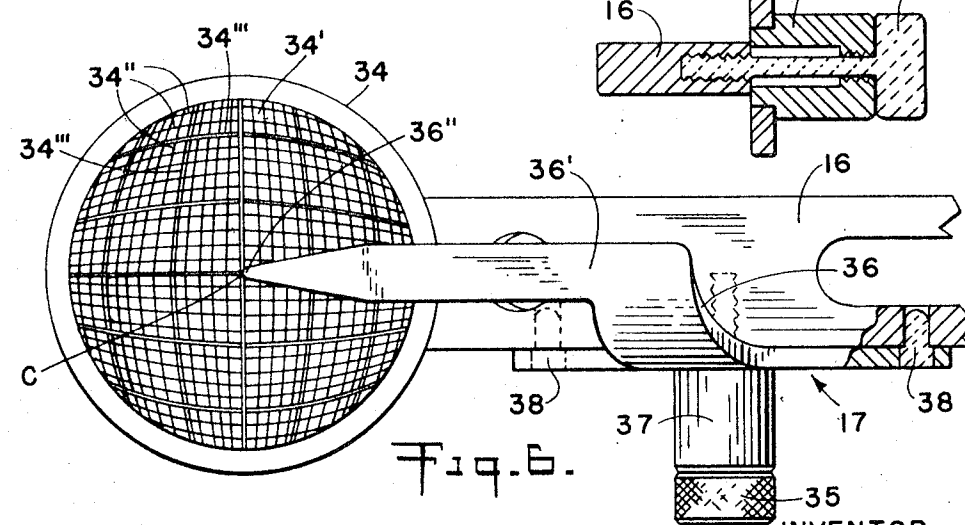


Fig. 6.

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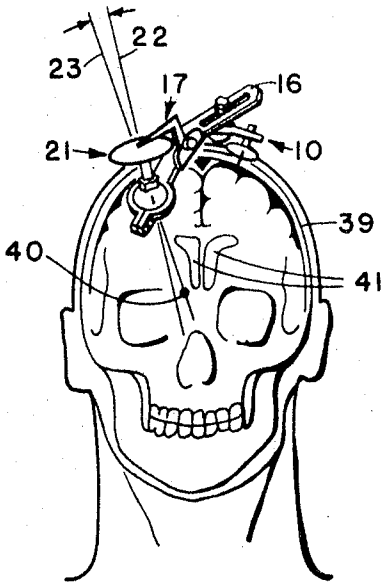


Fig. 7.

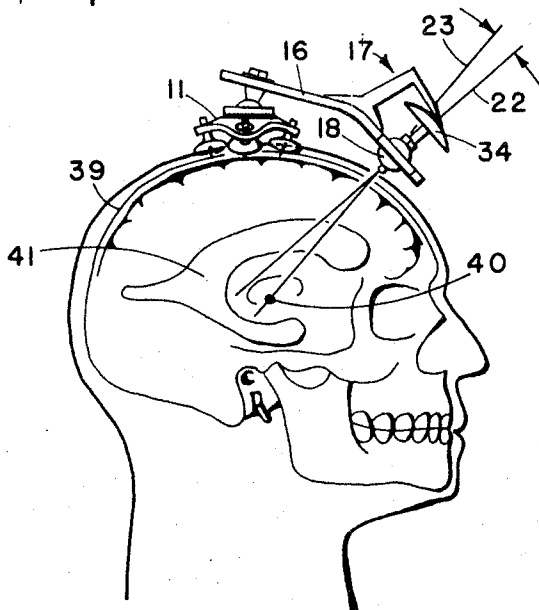


Fig. 8.

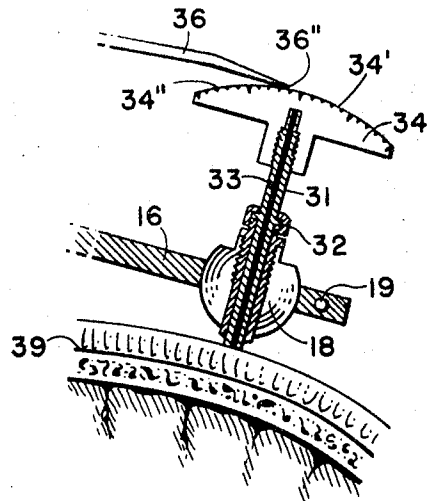


Fig. 9.

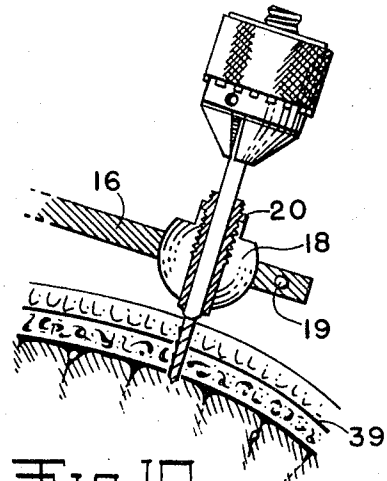


Fig. 10.

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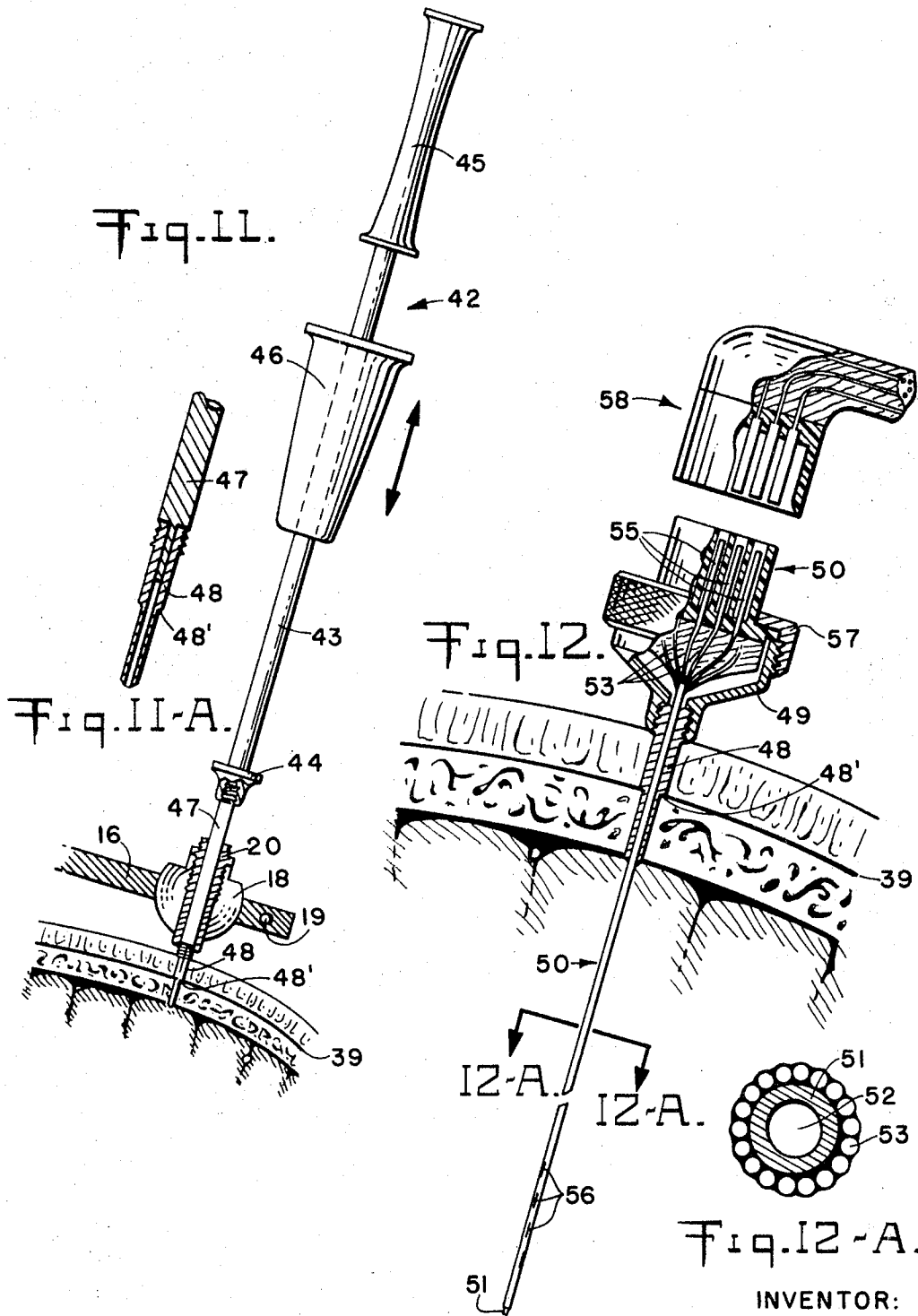
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**STEREOTAXIC SURGICAL INSTRUMENT  
 AND METHOD**

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2 Claims

**ABSTRACT OF THE DISCLOSURE**

A stereotaxic surgical instrument having a base element of low profile adapted to be secured to the skull by a rapid process of nailing including an arm having one end adjustably securable to the base including a surgical guiding means pivotally secured adjacent the opposite end thereof for guiding a surgical instrument in which the surgical guide means is provided with an aperture there-through extending in a general direction perpendicular to the surface of the skull wherein the axis of the aperture through the pivotable means may be oriented from various adjusted locations with one or more surgical targets within the skull cavity without relocating the base element on the skull.

The present invention relates to a new instrument and method of stereotaxic surgery and implantation of brain electrodes or probes.

In the past, several stereotaxic techniques and instruments have been developed for study and treatment of certain disorders of the brain and associated structures within the head. For such uses the instruments must be capable of permitting accurate placement of various diagnostic and surgical devices. Most such instruments are awkward, expensive and bulky. Further, their use has been complicated by difficulty in attachment, the presence of index scales, complex protractors or rectangular measuring systems requiring careful manipulation and the use of certain correction factors found to vary in many patients. Even with the simpler instruments more recently developed, holes up to one inch in diameter must be placed through the scalp and skull in order to attach the instrument base. Specific anatomical structures are localized within the brain by the X-ray visualization of air or certain organic iodine compounds placed into the major fluid cavities of the brain, the ventricular system. From these visualized landmarks the sites of proposed electrode or probe implantations are determined by measurement and calculation. Such measurements and calculations are generally difficult or tedious not only because of the complexity of the instruments, but also because of distortions and enlargements produced by the X-ray beam.

Further, while such instruments are capable of accurate placement of brain devices or probes for temporary or acute use, they are not generally designed nor usable for the placement of devices to be left in for a prolonged period. Stereotaxic instruments generally permit implantation to occur from or through only limited areas of the head in order to avoid certain critical structures of the brain.

It is a primary object of this invention to provide an improved and simplified positioning instrument for implantation of brain electrodes, probes and surgical devices.

Another object is to provide precise and convenient universal adjustment of the instrument.

Still another object of the present invention is to provide a rapid, simple and firm attachment of the supporting base of the instrument to the skull. This same is performed without the need for holes to be placed through the scalp

and bone. In that external contours of skulls show variation among patients, the supporting base is adaptable to those contours of all human skulls.

A further object of the present invention is to provide a freely movable locating-guiding assembly that is remotely attached to the supporting base which is firmly attached to the skull.

Still another object of the present invention is to provide accurate positioning of the implement prior to drilling of the bone, opening the head or otherwise penetrating the skull and brain.

A still further object of the present invention is to provide an instrument for implantation of a brain electrode or probe which permits the point of entry and path into the brain to be adjusted prior to implantation thus avoiding engagement with critical areas thereof. By the use of X-rays during positioning, the path of the drill hole is made accurately and the end of the electrode or probe can thus be positioned in a desired location. In that the locator assembly lies in the X-ray beam it is therefore subject to the same circumstances as the skull; thus no special correction for X-ray distortion or magnification is needed.

Ancillary to the preceding object, it is a further object of the present invention to provide a probe anchoring device which may be firmly and accurately placed in the skull. Said anchoring device can be guided through the locating-guiding assembly of the stereotaxic instrument and driven into place utilizing a special hammer developed for this use.

The above and other objects and advantages of the present invention will become apparent in the following descriptions and drawings, wherein:

FIG. 1 is a side perspective view of the instrument constructed according to and embodying the present invention;

FIG. 2 is a top plan fragmentary view of the attachment device;

FIG. 3 is an enlarged sectional view taken along line 3—3 in FIG. 2;

FIG. 4 is an enlarged side fragmentary view of the protractor-pointer assembly partly in section and partly in elevation;

FIG. 5 is a sectional view taken along line 5—5 in FIG. 4;

FIG. 6 is a top plan fragmentary view of the protractor-pointer assembly;

FIG. 7 is a diagrammatic front elevation of the instrument applied to a skull;

FIG. 8 is a diagrammatic right-hand side elevation of the instrument shown in FIG. 7;

FIG. 9 is an enlarged fragmentary sectional view of the protractor-pointer assembly in place on a skull;

FIG. 10 is a fragmentary sectional view as shown in FIG. 9, the scalp and skull shown being drilled;

FIG. 11 is a fragmentary sectional view as shown in FIG. 9, a sliding weight hammer shown in use to drive a pin into the skull;

FIG. 11-A is an enlarged sectional view of the driver tip and pin; and

FIG. 12 is an enlarged fragmentary sectional view showing a brain probe assembly attached to the pin, wherewith an electrical connector assembly and an enlarged sectional view of the brain probe are also shown; and

FIG. 12-A is a sectional view taken along the line 12-A of FIG. 12.

Referring now to the drawings, particularly FIGS. 1 and 2, reference numeral 10 generally designates the present instrument which includes a tripod base 11 having three foot-plate assemblies 12, and a centrally located,

freely movable, compressible ball 13 that can be locked in any position by a clamping ring 14 having a surface complementary thereto. Through the threaded center of this ball 13 is placed a bolt 15 which may be tightened against an extension arm 16 thus holding same in some desired position. On one side of the extension arm 16 is a removable pointer assembly 17 including a base portion 36, an outwardly extended portion 36' and a point 36''. Near the distal end of the extension arm 16 is a spherically surfaced concavity which defines a coupling socket into which is placed a second freely movable, compressible ball 18. This ball 18 and the central ball 13 are formed of a steam autoclavable, X-ray transparent plastic such as polycarbonate or polyphenylene oxide or the like. Said distal ball 18 rotates in a complementary surface of the outer end of the extension arm 16 and is locked in position by tightening the set screw 19 pinching the ball between the confronting faces of the jaw members 16' and 16''. Threaded into the axial bore of the distal ball 18 is a removable hollow guide bolt 20 onto which is shown attached a spherical protractor assembly 21. The upper surface 34' of this protractor 34, in near contact with the tip of the pointer 36'', is accurately engraved to indicate angular changes from position 22 to a new position 23 (see FIG. 1).

Referring to FIG. 3 it can be seen that the foot-plate assembly 12 consists of a freely movable, drilled single-ball bearing 24 whose race 25 has been pressed into the tripod base 11. Pressed into the ball 24 is a foot-plate 26. Through the center of same is placed a removable cranial nail 27 having a threaded upper end 27' and a pointed lower end 27''. The central ball 13 is clamped in desired position by the clamping ring 14 by the three set screws 28 placed equidistant around said clamping ring 14. The central bolt 15 compresses a thrust washer 29 against the extension arm 16 and against a spacer 30 thence against the central ball 13.

Referring now to FIGURES 4 through 6, reference numeral 17 refers generally to the pointer assembly and reference numeral 21 refers generally to the spherical protractor assembly. The demountable protractor assembly 21 is provided with a shaft 31 made of X-ray translucent aluminum down the center of same is poured a lead core 33 being opaque to X-rays. Said shaft 31 is held into place on the bolt 20 of the distal ball 18 by a captive nut 32. The protractor proper 34 is firmly screwed to the shaft 31 and is provided with outer curved surface. With 34' the curved outer surface is provided with grid grooves or lines 34'', the distal ball 18 in a position with its axial shaft 31 perpendicular to the plane of the extension arm, the point C on the surface of the protractor 34 indicates a central location for the protractor assembly or neutral zero position as shown in FIGS. 4 and 6. Angular displacements of the ball about its axis from this neutral zero position are indicated by the grid grooves or lines as previously described. The said grid grooves or lines are placed each 2 degrees with heavier grooves at 10 degree spacing. The member 34 of the protractor assembly is made of an X-ray transparent plastic similar to that of the central and distal balls 13 and 18. All grid grooves are filled with a cured mixture of white lead and epoxy plastic. These grooves are thereby X-ray opaque. The grooves, being established in reference to the center of rotation of the distal ball 18 exhibit a great circle curvature.

The pointer assembly 17 is demountable from the extension arm 16 by means of a captive screw 35 maintained to the pointer arm 36 by a permanently pressed on spacer 37. Two indexing pins 38 are permanently pressed into the pointer arm 36 base and mate into corresponding holes in the extension arm 16 thus establishing a temporary rigid attachment to same.

Referring now in particular to FIGS. 7 through 11, the operation of the instrument is as follows:

The instrument is placed upon the head 39 at a pre-

determined location and in turn each tripod foot-plate assembly 12 is anchored to the skull by the driving of a cranial nail 48 or screw or suitable holding element. The cranial nail 27 may be screwed into the end of the captive hammer 42 to be so driven. When firmly attached to the head, the tripod base 11 is rigid with respect to the skull. Set screws 28 and 19 and central bolt 15 are made slack so that the positioning of the extension arm 16 and the distal ball 18 is freely selectable for any point over the surface of the head 39. The protractor assembly 21 is attached into the guide bolt 20 within the distal ball 18 and made fast by tightening the captive nut 32 provided. The pointer assembly 17 is then attached to the extension arm 16 and made fast utilizing the captive screw 35 and indexing pins 38. A first approximation path 22 of the final desired path 23 to the brain target 40 is made and all set screws 19 and 28 are tightened such that no motions of the present instrument are now permitted save a sliding friction movement of the distal ball 18 and protractor assembly 21.

The major reference cross lines on the spherical surface of the protractor 34 are adjusted to lie exactly parallel and perpendicular to the front-to-back center line of the skull. Adequate X-ray contrast medium is instilled into the brain cavities or ventricles 41 and the proposed target site 40 is exactly determined based on requirements of the operative case.

A carefully positioned front-to-back, or anterior-posterior X-ray film is taken as shown diagrammatically in FIG. 7. In a similar manner same is performed for a lateral film as in FIG. 8. Close examination of said films will disclose the correct path 23 to be taken. A line is drawn upon the surface of the X-ray film extending from the target site outward through the center of the distal ball 18 and beyond thence through the protractor 34. The central lead core 33 of the protractor shaft 31 and individual lead-filled surface grooves 34'' of the protractor 34 are clearly visible on the X-ray film as shown diagrammatically in FIG. 9, thus permitting an accurate angular correction to be determined for both anterior-posterior and lateral planes. The protractor assembly 21 and distal ball 18 alone are carefully moved so as to correspond to the desired path 23 to the brain target 40. Following this, recheck or confirmatory X-ray films may be taken in the two planes. The set screw 19 holding the distal ball 18 is now firmly tightened. No further movements of the instrument 10 relative to the head 39 may now be permitted. Both the pointer assembly 17 and protractor assembly 21 are now removed.

As is shown diagrammatically in FIG. 10, a drill is passed through the guide bolt 20 and thence penetrates scalp and bone of the head 39 in the desired path 23.

Referring now to FIG. 11, a captive hammer is generally referred to by the numeral 42 and comprises a shaft 43 onto one end at which is affixed a stop piece 44 having a threaded hole therein. On the opposite end of said shaft 43 is a grasping handle 45. A freely sliding weight 46 may thus be slid axially along the shaft 43 to engage or strike the stop piece 44 or the face of the handle 45. In the use described herein a pin inserter 47 is screwed into the stop piece 44. The distal end of this inserter 47 is so fabricated to pass into the core hold of the cranial pin 48 and thus made to drive said pin through the guide bolt 20 axially into the hold previously drilled into the skull 39. A diametric step 48' in the cranial pin 48 stops it at a desired length into the bone of the skull 39.

In that the cranial pin 48 has been positioned in the desired path 23 to the brain target 40, the entire instrument 10 may be moved elsewhere upon the head or removed entirely. If so desired the present instrument may be utilized for temporary or acute implantation so that no cranial pin 48 need be placed.

Referring now to FIG. 12 a brain probe is referred to generally by the numeral 50 and its mating electrical

connector socket by the numeral 58. Said probe 50 consists of a central tube 51 having a hollow core 52 and around said tube are suitably cemented a plurality of fine wires 53 previously insulated for their entire length. Said wires 53 are attached to the end of a suitable electrical connector 55 comprising one of same for each wire used in the probe. This assembly is then encapsulated thus insulating the terminations between wires 53 and connectors 55. After fabrication of the probe device a suitable contact 56 is established at a singular, selected location by removing the insulation from the wire at that point. Said probe 50 has been previously disclosed and is not presented as a part of the present invention.

The probe or other such device is maintained on the head for prolonged implantation thusly: onto the threaded end of the cranial pin 48 is screwed a retaining cup 49, into same is then placed the probe 50 or other such device. Same is held firmly in place and is prevented from movement by a locking ring 57 whose inner surfaces are suitably disposed to seal the probe 50 against the retaining cup 49. Said probe 50 is of sufficient length to reach the brain target 40. An electrical connector socket assembly 58 may be mated with the probe at such time as diagnostic studies are to be performed.

The captive hammer 42 is used both to drive and remove the cranial nails 27 and the cranial pins 48. Same may be implanted with or without the use of a pin inserter 47. A rapid sliding of the weight 46 transmits its force axially into or away from the implanted piece depending on the direction of slide and end struck.

It will be appreciated that there is herewith illustrated and described an instrument which may be easily attached to the skull, permitting exact determinations of paths to be taken for implantation of devices for temporary or prolonged study or treatment of selected targets within the brain utilizing landmarks determined by standard X-ray film.

Variations and modifications may be made without departing from the spirit of this presentation of a preferred embodiment of the present invention.

I claim:

1. A stereotaxic instrument for use with an X-ray machine to locate a target area within a skull cavity having a base adapted to be fixed to the skull and supporting thereon an adjustable pivot means including means for fixing the position of the pivot means relative to the base comprising in combination:

- (a) an elongated arm having an end portion releasably fixedly to said pivot and longitudinally adjustable relative to said pivot, and means for locking the arm at selected positions;
- (b) means on said arm positioned outwardly from said first pivot means for engaging a second pivot means, and means for fixing the position of the second pivot means relative to the arm;
- (c) the second pivot means having a guideway associated therewith;
- (d) an X-ray transparent removable protractor assembly including a stem constructed of X-ray transparent material adapted to have one end slidably engageable and removable with the said guideway of the second pivotable member and a disk-like member fixed to the opposite end of the stem, the outer surface of the disk-like member being provided with grid lines of X-ray photographic material;
- (e) an X-ray photographic material extending along said grid lines and along said stem;
- (f) an opaque stationary pointer affixed to the said

arm and extending over the grid surface of the disk and in close proximity thereto;

whereby the position of the pointer on the grid surface may be recorded on an X-ray picture along with the angle of the stem in its relation to the target area in the skull cavity.

2. A method of determining the direction and course of a brain probe toward a target area within a skull cavity, from outside the skull, in which an adjustable, fixable support including a fixed pointer is utilized to support a pivotable and fixable holding member having a guideway associated therewith for a directional indicating means for indicating the path of the probe, wherein the directional indicator consists of an X-ray transparent removable protractor assembly including a stem constructed of X-ray transparent material having a photographic longitudinal line extending therealong adapted to have one end engagable with the guideway of the holding member and a disk-like member having an outer surface provided with grid lines thereon corresponding to the angle of the protractor relative to the center line thereof and fixed to the opposite end of the stem, wherein said grid lines are X-ray photographic, comprising the steps:

- (a) securing the support to the skull;
- (b) fixing the holder for the protractor assembly at a predetermined point over the outer surface of the skull;
- (c) inserting the stem of the protractor assembly into the guideway of the holder;
- (d) aligning the pointer with a predetermined pair of intersecting grids;
- (e) making an X-ray film of the entire assembly, showing both protractor and desired point within the skull cavity;
- (f) extending the photographic line of the stem on the film to a point indicating the inward portion of the skull cavity;
- (g) extending a line on the film through the pivot point of the protractor assembly holding means and the target area;
- (h) determining the angle between the two lines extending outwardly from the holding means, noting the points where the lines extend through the grid marks as shown on the X-ray film;
- (i) readjusting the protractor assembly by using the grid lines formed on the disk to represent the number of degrees between the inverging lines on the film;
- (j) making a verification X-ray film;
- (k) removing the protractor assembly from the holder guideway;
- (l) inserting a drill tool within said guideway in the holder and drilling an opening in the skull along the axis of the said guideway of the holder;
- (m) removing said drill and inserting a tool along the said guideway having a probe guide element detachably secured thereto, forcing the said probe guide element into said skull opening along the axis of the guideway, detaching said tool, inserting said probe and extending the same beyond the said probe guide element into the skull cavity and toward the target area.

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