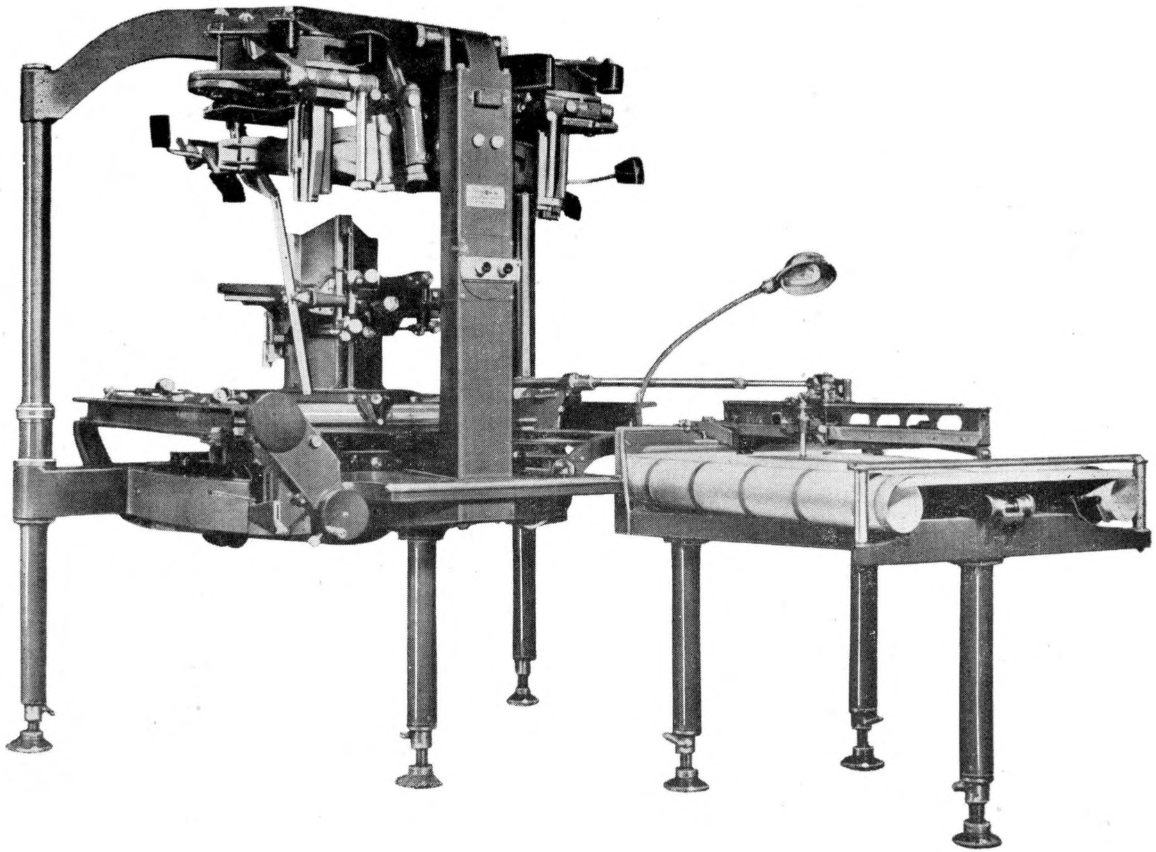

The Santoni Stereocartograph, Model IV.

THE SANTONI STEREOCARTOGRAPH, MODEL IV

(see : Advertisement)

BASIC PRINCIPLES OF THE INSTRUMENT

A restitution apparatus consists of an instrument using which reconstruction of the shape of an object may be achieved by means of two photographs of the object concerned taken from two different points apart from each other and situated at suitable distances from the object.

The line joining the two points from which the photographs are taken (centre of sight) is the *base*. The latter should be reproduced in the restitution apparatus in the same proportion (scale) as that in which the shape of the object is to be reconstructed. At the extremities of the *base* of this instrument (b, fig. 1) are mounted two cases (C_1 C_2) representing the cameras with which the photographs have been taken, or the single camera in its two positions. The two photographs (L_1 L_2) are inserted in these cases at a distance from the centres of sight (V_1 V_2) equal to the principal focal length (f) of the camera with which the photographs have been taken. Moreover, the angular position of each photograph with reference to the base of the restitution instrument (b) should reproduce the position in which the exposure was made. The foregoing conditions imply that all the couples of homologous rays (projections of the two images of the same point of the object) will intersect within the space of the restitution apparatus and that all these intersections forming a whole (Q, P, ...) will give rise to a model of the same object, called *Optical model*. These intersections are invisible even in instruments in which the projection is made by optical procedure (i.e. instruments for which lenses are fitted into the centres of projection (V_1 V_2) and where the photogrammes are lighted from behind); to give actual shape to these intersections, a screen having the shape of the object must be provided, it being precisely this shape the restitution of which is sought for. Practically, and even when continuity is effected from one point to another, the reconstruction is operated point by point, i.e. considering two visual rays at the same time. It is in this way that for simplified optical projection instruments a small screen (S) is used, fitted with a central index movable along the reference plane of the apparatus and also in altitude, in other words movable along the three orthogonal directions (X Y Z).

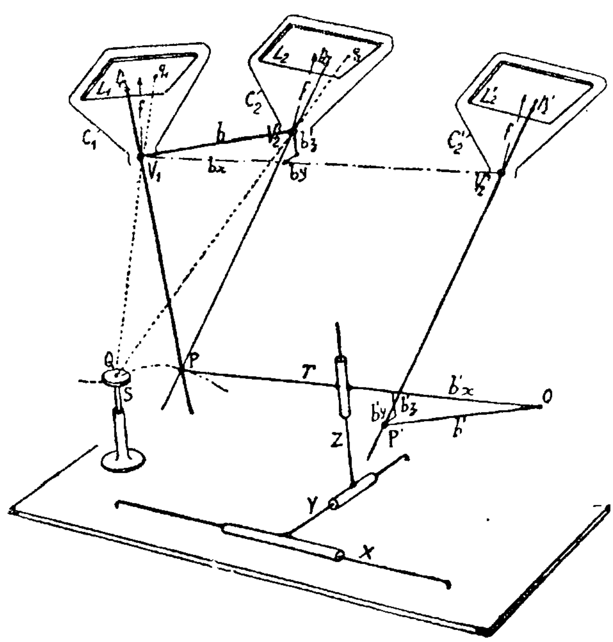

FIG. 1
Diagram of the Santoni Stereocartograph.

The impossibility of realising the reconstruction shape of the object in any way other than by successive points, means that the projection can be carried out by mechanical means as well as by optical means. For this purpose, in each centre of projection (V_1 V_2) may be fitted a pivoted driving rod representing in turn the projecting ray p_1 V_1 P — p_2 V_2 P. It is necessary that a connecting joint, movable in the X Y Z directions so as to represent in turn the reproduced point P of the optical model, should unite the two controlling rods.

The practical results obtained justify the assertion of the greater advantages of the mechanical projection when compared with the optical projection. Suitable optical devices by means of which the extremity of the controlling rod is represented by an index mark, enables the coincidence of the extremities of the rods inside the projection chambers with the images p_1 and p_2 of the selected point P, to be checked.

These optical devices, as in modern technique, allow the corresponding points of the two photogrammes to be observed simultaneously, by means of the stereoscopic sight.

Naturally it is not easy to realise the material intersection of two control-rods and for this reason, in nearly all apparatus of this kind, the parallelogram V_2 V'_2 P' P is added to the theoretical intersecting triangle V_1 V_2 P; this parallelogram materially transfers the control-rod V_2 P in V'_2 P'. In general two gimbals carrying two cylinders for the relative motion of the driving rods are placed at the points P and P' so as to make the distances V_1 P and V'_2 P', vary freely.

Either P or P' may be considered as the intersecting point. The rod T which carries the coupling gimbals of the control-rods is called the *basic span* (*pont de la base*). In fact, as the projection centres V_1 V'_2 generally remain in a set position, the *base* is necessarily introduced, on the span, in the opposite direction (b') from the point of departure (O) and in relation to its components b' X, b'Y, b'Z.

The *basic span* T, mounted on carriers and rails, generally graduated, is movable along three orthogonal directions X Y Z. During its movements it is necessary that the span should keep its proper orientation with the greatest possible exactitude; respect of this condition is necessary in order that the two driving-rods may act as if their intersection were an actual fact.

The Santoni Model IV Stereocartograph (like preceding models) is constructed according to the principles of mechanical projection. A special appliance permits of this projection being operated, taking into account the distortion introduced by the objective of the camera with which the photographs have been taken.

DESCRIPTION OF THE APPARATUS

1. Projection chambers and optical observation system.

In restitution apparatus based on mechanical projection, collimation (focusing) for the various points of the photogramme may be obtained by means of an optical system consisting of lenses and prisms, in which at least one lens and one prism follow the focusing movement, remaining connected during their motion with a plane parallel to the photogramme, and communicating with the terminal of the driving-rod so that they may be directed by the latter in its polar movement.

The use of this appliance necessitates the realisation — and afterwards the strict fulfilment — of particular adjustment conditions. In fact, the optical system has variable length and is partly mobile even during the operation of restitution. It is that adopted by Santoni in Stereocartograph Model III and subsequently by other constructors.

A different system — that adopted in Stereocartograph Model IV — allows each photogramme to move in its proper plane, with reference to the terminal element of the optical observation system, while maintaining its initial orientation. This motion is always governed by the polar movement of the driving-rod.

As the optical system remains set in each of its component parts during the restitution, the adjustment conditions required by this device are much reduced compared with those required by the preceding device.

A special arrangement for obtaining the perfect equilibrium of the moving organs and an optical system of extreme simplicity has been conceived for the optical-mechanical realisation of Model IV, a diagram of which is given in fig. 2.

The control-rods consist of rectilinear part A_1 (A_2 etc.) and the curved part B_1 on the side of photogramme L_1 and carrying the small sliding rod C_1 which is situated in the prolongation of the axis of A_1. The control-rod may pivot around the primary axis M at the same time as its supporting bracket D_1, and may also pivot, with relation to D_1 around the secondary axis N_1 which is situated on the same plane as M; consequently it may be turned around the point V_1 which represents the centre of projection.

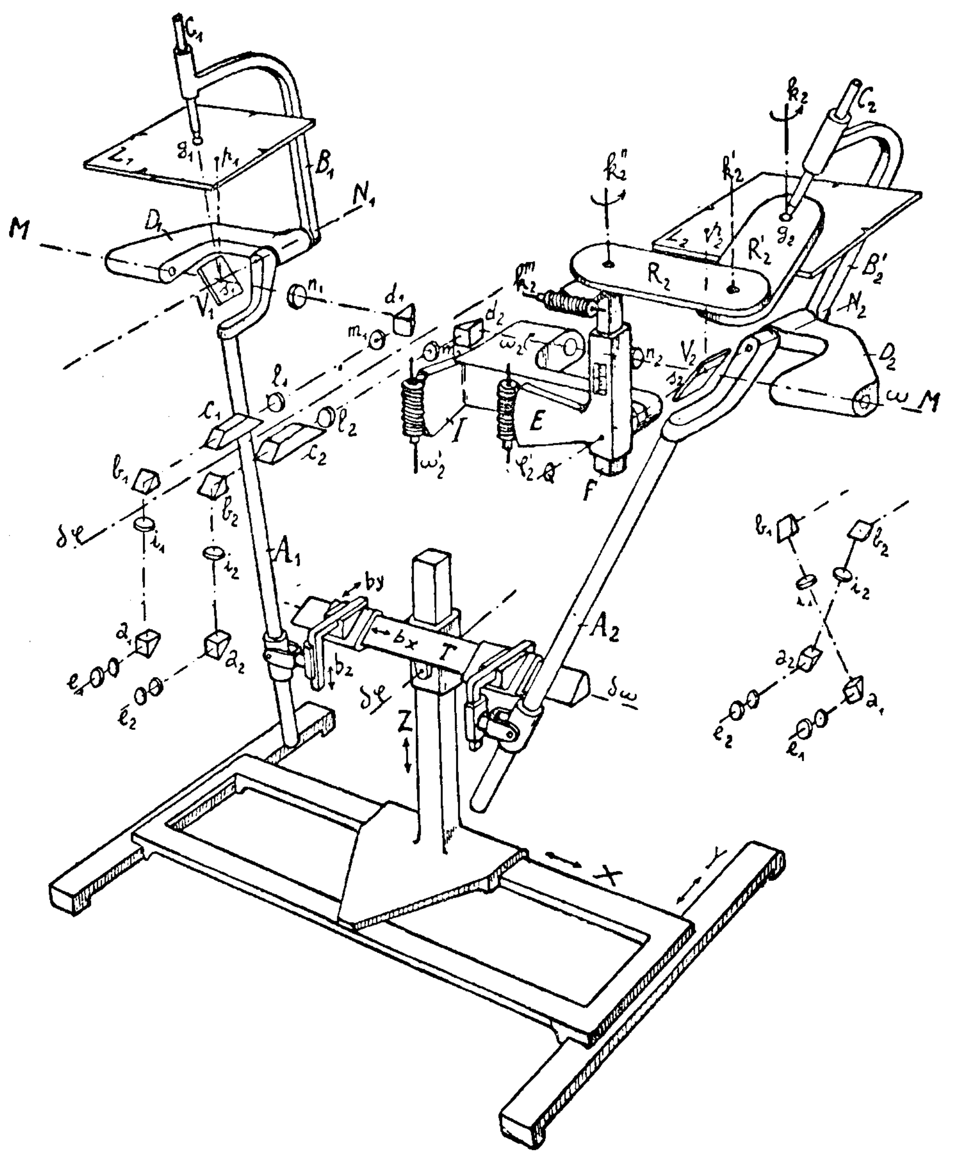

FIG. 2
Optical-mechanical system of the Santoni Stereocartograph, Model IV.

The collimation axis of the optical system traverses point V_1; this collimation axis is deviated by means of mirror s_1 along the perpendicular s_1 p_1 to the plane of the photo-plate. The mirror s_1 as well as all the other parts of the optical system, remains set during the restitution. The photo-plate is maintained by its own appropriate parts adapted for free displacement along its proper plane while retaining its initial orientation. The lower extremity of the small sliding rod C_1 is connected to the photogramme (or, more exactly, to its support) by means of a spherical joint g_1; consequently, any rotation movement of the control-rod around V_1 causes a displacement of the photogramme in its proper plane.

If the photogramme is set up after 180° revolution with reference to the tip axis (which would correspond to the negative position) the control-rod takes the direction of the visual ray corresponding to point p_1 (any point of the photogramme brought progressively in correspondence with the optical axis V_1 p_1, i.e. collimated). In fact, as a result of the 180° revolution of the photogramme and of its translocation g_1 p_1, the joint g_1 finally occupies the position where p_1 would have been placed, in normal conditions, corresponding to the negative image. Especially, if the axis of the driving-rod is fitted along the axis of the projection chamber V_1 p_1, the joint g_1 coincides with p_1 and consequently with the principal point.

Through the eyepieces e_1 e_2 collimation may be effected simultaneously on two photogrammes by means of stereoscopic sight. This result is reached in the following way: the image of point p_1 (and part of its surrounding) forms itself in correspondence with collimation index m_1 through the medium of mirror s_1, of the lens n_1 and of the prism d_1; and by means of lens l_1, of the prism e_1 (Amici prism) of prism b_1, lens i^1 and prism a_1, the image of the photogramme and of the index-mark m are translocated in the plane of eyepiece e_1.

The left-hand side and the right-hand side of the optical tracks are of equal length except that the stroke a_1 e_1 is several centimetres shorter than the corresponding stroke a_2 e_2 while the stroke l_1 b_1 is longer than l_2 b_2 by the same quantity. Resulting from this contrivance, the crossing of the optical tracks is rendered possible, as may be ascertained from the right-hand side of fig. 2. The object of this crossing is the maintenance of each photogramme in a set position in the joining-up operations relating to *aerial triangulation.*

To accomplish this procedure, the carriage of the base permits the setting of the component b_x either in an inner or outer direction (additional component) and consequently, on the latter assumption, the control-rods finally diverge.

Shown to the right in fig. 2 is a diagram of the mechanical parts carrying the photogramme. These parts consist of an arm I which can be made to rotate around the primary axis M (ω rotation) and which supports the arm E; the latter in turn may be made to rotate around the axis Q (φ rotation). Arm E carries part F. Case R_2 carries case R'_2 and rotates around axis k''_2 of F_1; R'_2 rotates around axis k'_2.

A spherical joint provides for the connection through g_2 of the lower extremity of the small rod C_2 with R'_2; so that when the control-rod A_2 C_2 turns around V_2, the spherical joint g_2 remains connected to a plane perpendicular to the axes k''_2 k'_1. To avoid overloading the illustration, the carrier of the photogramme is not shown, being identified with the photogramme L_2 itself. This plate-holder may be made to rotate around axis K_2.

The orientation of the photogramme is maintained during the operation of translocation by a system of pulleys having the same axes as k_2 k'_2 and k''_2 and steel tapes situated inside cases R_2 R'_2.

The rotation of L_2 is controlled by means of a sector connected to the pulley of axis k''_2, by means of the tangent screw k'''_2 for the purpose of introducing tip (k).

The steel-tape system simply serves to suppress any play of the axes of rotation of the pulleys (mounted on spheres). Following this fact the degree of accuracy reached in the transmission of tip and in its maintenance is particularly high.

Further, the parallelism of axes k''_2 and k'_2 (which may if necessary be checked and adjusted) guarantees the rigorous definition of a plane passing through joint g_2. Finally, a perfect balance of the weights in motion is ensured by a system of counter-weights not reproduced on fig. 2 but appearing on photo-plate No. 3.

The focal length may be varied by using the sliding movement, governed by a graduated scale, of part F with reference to part E.

This mechanical change of focal length is completed by the optical focusing of the image of the photogramme onto the index-mark m_2, obtained by sliding the lens n_2 (or n_1) along axis M_1, this movement being directly controlled through the corresponding eyepiece e_2 (or e_1).

Mirror s_2 is entirely in relation with rotation ω of arm I, since the latter carries it. The image is *automatically* kept oriented in the eyepieces by means of a differential connection of the rotation of the carrying arm I with the Amici prism C_2 giving a rotation of $1/2\ \omega$ to the latter. Rotations φ are transmitted, after reduction by one-half, to the mirror S_2 by part E. Under the above conditions the optical axis S_2 p_2 accomplishes the same rotation as the photo-plate carrier. No connection with the Amici prism is provided for because the rotation φ does not modify the orientation of the image.

2. **Distortion corrector.**

As in previous models, Model IV includes the Santoni distortion corrector. It is known that this corrector is based on the automatic variation of the restitution focal length according to the variation of the angle between the control-rod and the axis of the photographic perspective, following the same law as that which determines distortion effect in the camera.

For this operation the lower cap of the spherical joint g is mobile and may be replaced by a small tempered-steel cam. A counteracting spring serves to maintain this cam against a small sphere fixed to the plate-holder. When the contact point between the cam and the sphere is changed, the centre point is lowered or raised in consequence. In this way the joint is displaced along a revolution surface during the translocation of the photogramme and no longer along a plane; the axis of the revolution surface coincides with the axis of the projection chamber (V_1 p_1 or V_2 p_2). The establishment of this cam entails no difficulty even for those who have to use the instrument. By its use either the average correction for several objectives, or separate corrections for each objective, may be performed.

3. **Base carriage and relative controls.**

The base carriage consists of the horizontal bar T of prismatic section, along which two secondary carriages intended to introduce the component of the base, b x, may be shifted. In their turn the two secondary carriages carry other carriages, which may be moved horizontally but in direction perpendicular to the two supporting carriages, intended to introduce the component b y. Finally, each of the last series of carriers carries the vertical carriage b z which is fitted with the gimbals coupling to the control-rod concerned.

In the first place by an arrangement of this kind the effect of base b x is divided in two halves and consequently the balance of the movable weights on span r is maintained. The operations relating to aerial triangulation are facilitated through the fact that the other movements (b y and b z) are duplicated.

All carriages are fitted with scales and with micrometric screws.

The bar T is located on a movable carriage along a vertical column according to Z direction; this column in turn rests upon the principal carriage movable in X direction along two parallel rails which are movable with the bracket supporting them, along the two rails Y. Finally the latter rest on the base-plate of the apparatus.

A pantograph arrangement directly manœuvred by the right hand of the operator governs synthetically the X Y motions.

The handle of the pantograph is indicated on the illustration by the letter V; the Z movement is governed by a micrometric screw, manœuvred by the operator's left hand, acting on a wheel. The elevation of the point stereoscopically collimated is read on a meter located near Z, at the same time as the transmission of the movements X Y to a drawing-table placed at the right-hand side of the operator permits the planimetric position of the same point to be plotted on the plotting-sheet. The pantograph device, the use of which does not require any special training, greatly facilitates the plotting of continuous lines whether it is a case of topographic detail such as walls, roads, buildings, or of elevation contours.

4. **System of absolute orientation of the model.**

Once formed, the optical model free from parallax and adjusted to a selected scale, is absolutely oriented by means of an additional rotation d ω of the arm I effected by the same controls ω and by a general rotation of the span carrying the two chambers around axis d φ of fig. 2. One of the important characteristics of the instrument consists in the fact that even the basic span is provided with micrometric parts by means of which it may be made to undergo the same rotations d ω and d φ as are introduced on the span carrying the chambers. This eliminates all calculation inherent in the variation of the components b x, b y, b z, which are functions of the absolute orientation of the model.

5. **Drawing table and transmissions.**

The drawing table is fitted with a carriage movable in X direction, supporting a rail along which the pencil carrier slides. Cogwheels and toothed racks control the displacements of the two carriers. Compared with systems based on the use of screws, this device possesses the advantage of reduction of the angular speed of the transmission parts and more particularly the suppression in the instrument of all lubricated parts such as screws exposed to dust.

The pantograph control of the apparatus is rendered very light and especially sensitive by means of a special transmission part between the carriage of the apparatus and the drawing table, constructed according to the above-described principle. By the use of all those special devices it was hoped to produce an instrument that would no longer engage both hands and a foot of the operator in a long and tiring sequence of movements but that might prove a *real drawing instrument* with which the more delicate part of the task might be wholly reserved for the right hand of the operator.

Owing to the proximity of the plotting table, the operator may follow the work point by point, come back easily and quickly onto any point in the field of the model, checking at the beginning from the origin of the drawing—which is very useful at every stage of the work—and finally may complete personally the drawing so far as the numbered indication for elevation and the figurative part is concerned, by direct reference to the model.

As a result, an assistant operator can be dispensed with, although the pencil carrier is fitted with 2 pencils at opposite corners of the slide y.

6. Restitution field.

The plate-holders are suitable for any size below 20 × 20 centimetres. The focal length may be varied continuously from 10 to 21 centimetres. The ω rotation for the plate-holder assemblage is largely greater than 90° and therefore renders it possible to pass with continuity from nadir sights to land sights including in both cases the additional tilt.

It may be seen, then, that the Stereocartograph Model IV no longer necessitates the inversion of Y Z connections between the carriage, the control-rods and the drawing table. This instrument permits above all the restitution of oblique photographs whatever the angle ω may be—whether the photographs are used singly or coupled with nadir chambers—while permitting the restitution of nadir photographs made with large-angle cameras. Now this latter possibility is practically obligatory because of mechanical considerations in large-area surveys.

In conclusion, the facility of optical reversion without reversing the images makes the use of Model IV very easy for aerial triangulation operations.

NOTES

1 IT IS VERY IMPORTANT THAT PROJECTOR IS INSTALLED WITH THE 'FORE & AFT' NAMEPLATE, ON THE FORE AND AFT LINE, AND ALSO WITH THE ARROW OF THE OUTBOARD NAMEPLATE POINTING OUTBOARD THIS SHOULD BRING THE PET COCK TO THE HIGHER SIDE OF TANK IF SLOPING (SEE SKETCH 'A')

2 IT IS IMPORTANT THAT THE PROJECTOR BE FITTED HORIZONTALLY WHATEVER THE RISE OF THE SHELL PLATING THIS IS ACCOMPLISHED BY SELECTING THE APPROPRIATE FIXING HOLES IN THE TRUNNION, AFTER MEASURING THE SLOPE IN INCHES VERTICAL, PER FOOT HORIZONTAL

3 ITEMS MARKED THUS * ARE SUPPLIED WITH PROJECTOR ASSEMBLY

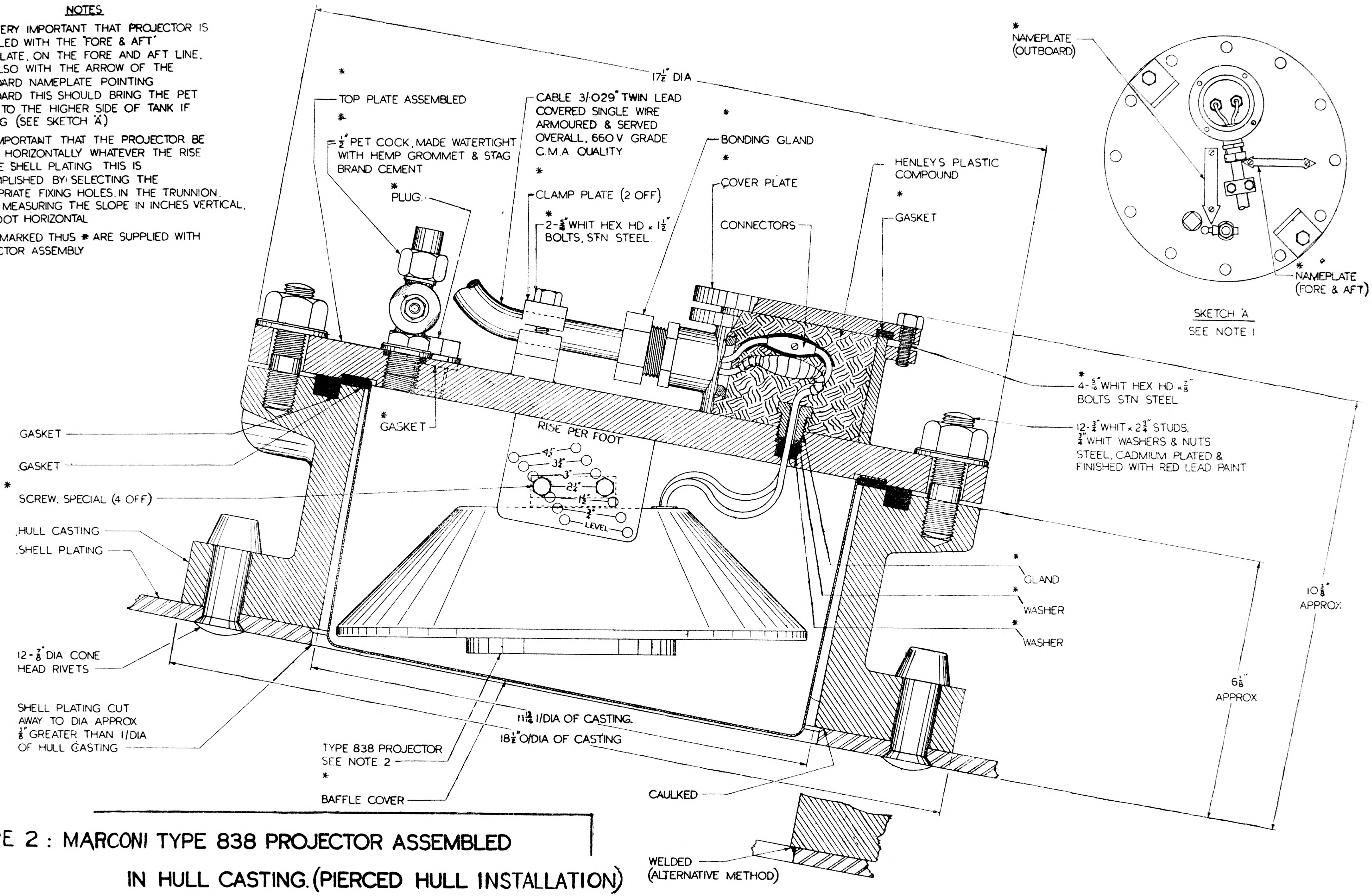

FIGURE 2 : MARCONI TYPE 838 PROJECTOR ASSEMBLED IN HULL CASTING. (PIERCED HULL INSTALLATION)