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RAE Report No. E.A.228/1

Report No. E.A.228/1

September, 1944

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

Structural features of 'Big Ben' A-4

- by -

The Staff of S.M.E. Department

1. Introduction and Summary

From examination of the wreckage available, it has been possible to identify the following parts of the structure:-

(a) the warhead
(b) the radio compartment
(c) the fuel tanks and the surrounding shell structure
(d) the combustion chamber, auxiliary power unit and their supporting structure
(e) the venturi
(f) the stabilizing fins and external control vanes
(g) the shell structure at the rear end
(h) the internal control vanes

A description of the available parts of the structure is given, and also the conjectural information deduced from these parts and their relation to other parts of the structure.

The reconstructed layout, of which the major part is deduced and cannot be definitely established, is shown in fig.A. It will be noted that some of the information has been obtained from captured drawings.

2. External structure

Four distinct types of construction of the external shell have been identified; they have been distinguished by the following names:-

(a) light construction
(b) medium construction
(c) heavy construction
(d) detachable panel construction

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There is no evidence to contradict the reasonable assumption that transverse sections of the projectile are circular.

2(a) Light construction

Description (see figs.1 and 2.)

This type of construction is formed from sheet 0.025 inches thick, which is reinforced by means of longitudinal stringers, A, rolled from steel sheet 0.021 inches thick; these stringers are of semi-circular "top-hat" section and are spot-welded to the skin by their flanges. This covering is supported on

circular formers, B, of "top-hat" section, and is attached by means of spot-welding of the skin to the top of the "top-hat"; the formers have equally spaced cut-outs around the circumference for the continuous stringers. The formers are rolled from steel sheet and appear to be built-up from four quadrants which are butt-welded at their ends; most of them are 0.068 inches thick, but one former, which is almost complete is 0.0835 inches thick. The dimensions and spacings of these members are shown in fig.2.

On those formers of which parts are available, the stringer pitch varies from 6.44 to 5.09 inches. Except for end panels the former spacing is 17.75 inches, and there are parts of at least 6 different formers.

On four of these formers, the butt-welded joint is reinforced by a strap, which is spot-welded to the flanges of the "top-hat". Opposite these reinforcedjoints, there are sheet steel gussets, C, welded to the sides of the formers, which support ribs projecting outwards radially from the shell. These ribs appear to be of similar dimensions and appearance to those in the fins.

Deductions

(i) That there are 32 stringers around the circumference of the shell, as the formers appear to be made up of four quadrants.

(ii) That this shell is on a tapered portion of the projectile, as the stringer pitch varies on pieces of six formers available.

(iii) As this type of construction appears to be a fairing and not a heavy load bearing structure, it is presumed to enclose the venturi and the engine bay, where the loads are carried by a braced framework of steel tubes. There is evidence of this light construction on the end frame to which the steel tubular engine mounting is welded.

(iv) The maximum diameter on this part of the construction, deduced from the pieces available, is just under 66 inches at the end frame at the front end of the engine bay.

2(b) Medium construction

Description (see figures 3 and 4)

This type of construction is formed from steel sheet 0.025 inches thick which is reinforced by means of longitudinal stringers of two types, viz. a light semi-circular "top-hat" section, A, rolled from 0.047 inches thick steel sheet and a heavy "top-hat" section, B, rolled from 0.040 inches thick steel sheet; the dimensions and spacings of these stringers are shown in fig.4. The light stringers are spot-welded to the skin by their flanges and the heavy stringers are attached to the skin by their flanges with rivets, countersunk on the outside. This covering is supported by intercostal frame members, C, which are presumed to form circular rings; they are of ordinary "top-hat" section rolled from steel sheet 0.047 inches thick. The stringer pitch shows a distinct taper in one portion of the structure, and the stringers themselves are continuous. The intercostal frame members are attached to the skin by their flanges with rivets countersunk on the outside. They are made partially continuous over the stringers by means of short steel straps riveted to the tops of the "top-hat"

intercostals, or by sheet steel fittings, which also give some support and stiffness to the sides of the intercostals; these fittings are spot-welded to the top and sides of the frame members. The frame spacing is about 13.5 inches.

No attachment fittings, either internal or external, have been found on this part of the structure.

Deductions

(i) From considerations of symmetry and positive evidence from the end frames it is assumed that the whole circumference of this type of construction was built-up from 32 stringers, with 3 light stringers between 2 heavy stringers.

(ii) From evidence deduced from angle end frames adjacent to the radio compartment at the forward end and adjacent to the engine bay at the aft end, it is assumed that this medium type of construction occurs at both ends of the fuel tank bay. The nature of the structure visualised is that of two ends to the tank bay, consisting of a few feet length of complete shell of the medium construction, in which the forward end of the front tank and the aft end of the rear tank are housed.

2(c) Heavy construction

Description (see figures 5, 6, 7 and 8).

This type of construction is formed from steel sheet 0.025 inches thick which is reinforced by means of continuous longitudinal stringers of two types, viz. a light semi-circular "top-hat" section, B, rolled from 0.040 inches thick steel sheet; and a heavy "top-hat" section, A, rolled from 0.040 inches thick steel sheet; the dimensions and spacings of these stringers are shown in fig.7. The light stringers are spot-welded to the skin by their flanges and over part of their length the heavy stringers are attached to the skin by their flanges with rivets, countersunk on the outside; the exception to this riveting is where provision is made for access panels. This covering is supported by intercostal frame members, D, which are presumed to form circular rings; they are of "top-hat" cross-section, rolled from steel sheet 0.047 inches thick, and attached to the skin by their flanges with countersunk rivets. The intercostal frames are made partially continuous over the stringers by means of the same steel sheet fittings as are used on the medium structure. The frame spacing is about 17.75 inches.

The circumference of this heavy construction is divided into apparently four panels to provide a convenient method for building the shell structure around the tanks. Each panel consists of 3 heavy "top-hat" stringers as described above with light "top-hat" stringers each side of them; the edges of the panel are reinforced by "top-hat" stringers, F, of the heavy type attached by one flange to the outer skin with countersunk rivets. The outer side of these edge stringers is flanged on one edge and not flanged on the other. The panels can thus be joined by placing the unflanged edge of one panel on the flanged edge of the adjacent panel. Steel reinforcing strips are placed on the outside leg of each "top-hat" stringer and the panels are then bolted together. The opening is finally faired in by means of a cover strip, G, attached to the inner flanges of the edge stringers by means of bolts and anchor stop nuts.

At the longitudinal joints between these panels, supports for the fuel tanks are provided, A in fig.8. They are formed from thick steel sheet stampings, which are bolted between the edge stringers of adjacent panels. The internal projection, to which the light alloy tank support is pinned, is slotted to allow for longitudinal and radial expansion of the tanks. The tank supports available are of two different types; one type for support near the ends and the other for support of the main body of the tanks. As shown in fig.8 the latter consists of a light alloy casting to which is riveted a light alloy doubling plate, which is spot welded to the tank itself; one of the support brackets is slightly smaller than the others, presumably for accommodation in the tapered portion of the forward tank. The end tank supports are similar light alloy castings which are supported on the end frames by tension members at the forward end and compression members at the aft end.

The number and location of the tank supports cannot be established.

Deductions

(i) On the assumption that there are four panels forming the circumference of the shell around the tanks, the maximum diameter that can be found is about 66 inches.

(ii) The form of joint between the medium and heavy types of structure has not been established.

2(d) Detachable panel construction

Description (see figure 9)

For ease of access the shell around the radio compartment is built up from four detachable panels which are supported by four heavy longitudinal load-bearing members equally spaced around the circumference (see fig.22) and by an angle frame at the aft end and presumably at the forward end of the compartment.

Only small pieces of these panels are available, but the nature of the construction is visualised to be that shown in fig.9. The longitudinal edge members are of Z-section steel sheet, 0.040 inches thick. The skin between these edges is stiffened by "top-hat" members rolled from 0.032 inches thick steel sheet and Z-section members rolled from steel sheet 0.021 inches thick; all the attachments of skin to the stiffeners and edge members are spot-welds. The panels are fastened to the heavy longitudinal members and to the end frames by bolts and anchor stop nuts.

2(e) End frames and transport joints

Description (see figures 10 and 20).

Parts of several different types of angle end frame have been identified as follows:-

(i) Two pieces of a transport joint, consisting of two rolled steel angles bolted back to back. One angle, 1.75" x 1.2", is clearly an end frame for the radio compartment; it has portions of the

detachable panel attached to its periphery and also a small part of the end fitting of one of the main longitudinal members of the radio compartment. Insulation in the form of a wooden strip is provided along its circumferential leg. The complementary angle, 1.75" x 1.2", has a small portion of the medium construction shell attached to it.

(ii) Four pieces of the angle front end frame to the engine bay; it is a 2.1" x 1.5" rolled steel section, with the circumferential leg inside the outside surface (see fig.10). To this frame are bolted the tubular longitudinal and cross-bracing members of the engine mounting. Except for a sawcut, this frame appears to be complete.

On one of the four pieces, there is a second rolled steel angle of 2.0" x 1.6" section, bolted so that its circumferential leg is on the outside surface. There is evidence from the marks on the circumferential leg that there has been medium construction shell attached to this frame. There are also fittings, which provide end support for the fuel tank, bolted to the radial leg of the angle.

(iii) Five pieces of 1.5" x 1.5" rolled steel angle which form part of an end frame for the light construction. The type and spacing of the attachment bolts on this frame are the same as those on the frame just described in paragraph (ii). It is therefore assumed that this frame is bolted to that supporting the engine mounting so that its circumferential leg is outside. The form of the whole transport joint is therefore shown in fig.20.

Deductions

(i) On the assumption of 32 stringers in the medium construction the external diameter of the end frame at the aft end of the radio compartment is 57 inches; this dimension checks with an assumed symmetry of bolt-holes in the frame. The diameter of the projectile, calculated from the captured "Normandy" trolley at the forward support is 57.5 inches. It therefore seems reasonable to assume that this frame is the strong support at the forward trolley. A further check on the diameter of this frame is provided by calculation from the measured length, taper and forward end diameter of the radio compartment.

(ii) Assuming 1/16" for the saw-cut, the external diameter of the end frame at the forward end of the engine bay is nearly 66 inches. This dimension checks with an assumed symmetry of bolt-holes, and also with the assumption of 32 stringers in the medium construction. This joint is probably the strong support at the aft trolley, corresponding to the 67.5 inches diameter calculated from the "Normandy" trolley.

3. Warhead

(a) Description (see figures 18 and 19)

The warhead was found in a number of fractured parts, which could be separated into the following parts:-

(i) the outer skin, of 0.25" steel sheet
(ii) a large end-plate, of 0.4" steel sheet, and
(iii) a small fuse cap, which appears to be an end fitting.

By matching the fractures, the outer skin was reconstructed as shown in fig.19. The layout of these pieces suggests that the warhead was a truncated cone, terminating at its small end in the fuse cap, E, where the fractured edges match. The skin was joined longitudinally by a weld, B, 69" long, and at the larger end, the edge of the outer skin at A had been welded externally. The large end plate as shown in fig.18 is not complete, but on what was considered to be the outside there are four chamfered bosses, A, unequally spaced around the circumference, a plug, B, with a coarse internal thread and a blank end facing inwards, a hole for a gaine tube, C, and a circular flange, dished outwards, with five equally spaced tapped holes, D. On its periphery there is an internal weld which could not be matched with the external weld around the periphery of the outer skin.

The toal weight of the warhead casing and end plate available is 275 lb.

(b) Deductions (see figure 21)

By straightening out the dished flange of the large end plate it appears that there were 6 tapped holes in the flange. On the same radial lines as these holes, near the outer circumference, there are some small plug welds.

From this evidence it was deduced that the end plate was flat and nearly 35" diameter. The location of the end fittings was visualised to be that shown in fig.21. The small end was approximately 6" diameter and the overall length was then calculated to be 67½".

As it appeared to be impossible to match the welded edges on the outer skin and on the end plate, it is suggested that some fitting similar to that shown in fig.21, was welded to both. A ring of this type would be convenient for supporting the four strong external members of the radio compartment and for attaching an external shell to the warhead. The outside diameter of 38" corresponds to that measured at the front end of the radio compartment.

On these measurements the capacity of the warhead is 15.4 cu.ft.

The attachments to the chamfered bosses may have provided shearing strength when the projectile was in the horizontal position.

4. Radio compartment

Description (see figure 22).

The radio compartment consists of a truncated cone, divided into four equal compartments by means of radial plywood sheets, which are supported at the centre by means of four steel angles bolted back to back, and at the external edges by means of built-up members, as shown in fig.22. These members are adapted to receive the detachable panels described in paragraph 2(d).

At the aft end of the compartment, the four external members are attached by means of sheet steel brackets to the angle end frame as described in paragraph 2(e). No support for similar brackets at the forward end has been recovered, though a similar angle ring has been assumed to provide this support.

The length of the radio compartment from the centres of these end frames is 4' 7½". The external diameter at the front end is about 38", and from the taper, which can be measured, the diameter at the rear end is about 57".

Owing to the small amount of the plywood division walls available, it was not possible to establish the locations of all the radio mountings, of which many pieces were found.

5. Fuel tanks

Description (see figure 23).

There is a considerable quantity of light alloy sheet and fittings, which indicates that there are two tanks. From the nature of the dyes used, it is believed that one is a liquid oxygen tank and the other an alcohol tank.

From the evidence given by some larger pieces of skin which were beaten out, the skin on the sides is 0.040 inches thick and is reinforced circumferentially by Z-section stringers internally spot-welded to the skin; the circumferential legs are 1.0" wide and the radial leg 2.25" deep; these stringers occur in pairs as shown in fig.23. Each section of tank has a longitudinal seam weld, and the sections are joined by circumferential seam welds arranged so that the longitudinal welds are staggered. The tanks are supported by the brackets described in paragraph 2(c), so that there are four supports, equally spaced, round the circumference; the number and longitudinal spacing of the supports cannot be established. The ends of the tanks are of light alloy sheet, 0.080 inches thick.

The aniline dye indicates that the alcohol tank was forward of the oxygen tank. The pumps which supply the engine are situated aft of the oxygen tank, so that the alcohol has to be carried by pipe through the oxygen tank. Several portions of this light alloy pipe were found, 6 inches in diameter, with a larger pipe of nearly 10 inches diameter round it, so that an insulation gap could be provided between the alcohol and the liquid oxygen.

Provision for expansion of the tanks themselves is made at the tank supports, and for the outlet pipes by means of copper bellows attached to the pump inlets. Between the long pipe through the oxygen tank and the alcohol tank outlet, there is some form of joint, of which the exact nature cannot be established, but it probably counteracts any local differential expansion.

Each tank is provided with a manhole in one end, the manhole cover, 17.25" diameter, being bolted to a cast light alloy ring which is seam welded into the end of the tank.

No individual lengths for the two tanks can be established, but from considerations of fuel consumption and pump capacity it is believed that they are of approximately equal volume. A probable overall length is 20' 2", the distance between the end frames at the trolley supports.

It is reasonable to suppose that over most of their length, the tanks are 66" - 7" = 59" external diameter, allowing for the depths of the tank supports, although there is insufficient evidence to confirm this.

6. Engine mounting

Description (see figures 10 and 11).

The engine and engine accessory mounting essentially consists of a braced framework of steel tubes. The pieces were too distorted and incomplete to reconstruct the bay accurately, but a general impression of the structure which was visualised is shown in fig.10. The main members are the four longitudinal steel tubes, F, which are 2.125" external diameter and 0.065" thick. These are welded at the forward end to small fittings which are bolted to the end frame, D. At the rear end, they are attached to the venturi through the universal joints, A; a large detail of this joint is shown in fig.11. The transverse frames, C and G, divide the bay into three compartments; they consist of smaller diameter steel tubes welded to the longerons. Diagonal bracing of the types shown at E and H provide additional support for concentrated loads. The brackets, B, provide support for the unit comprising the two pumps for alcohol and oxygen and the turbine.

The best available evidence indicates that this bay is 7' 2" long.

7. Venturi

Description (see figure 12).

The venturi, as shown in fig.12, consists of a double-walled, steel plate, seam-welded chamber; it is 57.25" long, 37.25" diameter at its forward end, 29.25" diameter at its aft end and it has a throat diameter of 15.625", 25.5" aft of its forward face, all diameters being internal. Alcohol is circulated as a coolant in the space between the two walls. There are two circumferential expansion joints in the outer skin, approximately semi-circular in cross-section. There are four circumferential rings of equally spaced holes forming fuel jets into the chamber itself; three of these rings are forward of the throat, and one aft of the throat. The actual jet face is bolted on to the venturi as shown at A in fig.12. The rear 8" of the venturi has no coolant circulating around it but insulation is provided by means of glass wool which is retained by a steel sheet outer skin. To provide insulation and opportunity for differential expansion between the aft end of the venturi and the light alloy channel which is bolted to it, a joint consisting of two overlapping skins, probably filled with glass wool, is formed on the rear edge of the venturi.

Attachment of the structure supporting the internal control vanes is made by means of four lugs shown at B in fig.12. These are

constructed so as to form an expansion joint between the venturi and the fin structure.

8. Stabilizing fins

Description (see figures 15 and 16)

For stabilization, four fins at right angles are provided at the rear end of the projectile. Considerable disintegration of these surfaces had occurred, but the main members of one fin are shown in fig.15. The main longitudinal member A is a steel sheet channel which is supported by pressed steel sheet ribs, which run radially outwards from the formers of the "light" shell construction covering the engine bay and venturi (see C in fig.1). To its front end, another channel, B, is welded, forming the strong member in the fin leading edge. This leading edge slopes at just over 30° to the longitudinal axis. The skin covering is 0.025 inches thick and is stiffened by means of longitudinal stringers of flat "top-hat" cross-section. All the attachment joints are formed by spot-welding. Beyond both leading edge and longitudinal channel members, there is a sharply pointed fairing, stiffened by small triangular riblets; the height and width of this fairing increase gradually from the front to the rear end.

In line with the rear face of the venturi, a strong steel channel, D, is bolted to the cast light alloy channel ring which is attached to the venturi; this channel, D, provides strong support for the longitudinal fin member, A, at its aft end. A diagonal brace, E, is attached both to D and A. On the rear face of the diagonal brace, E, there are the remains of some insulating board, which are attached to the brace by means of bolts and anchor stop nuts; this board may be associated with some form of aerial. There are also two steel ties from D to the triangular casting which supports the internal control vanes.

Small external control vanes, I, are provided at the rear outer ends of the four fins.

The overall length of the fins is about 13' 0", and the overall diameter at the rear end is about 11' 8".

9. Control surfaces

Description (see figures 13, 14 and 17).

Two sets of four control surfaces are provided,

(1) internal control vanes, and
(2) external control vanes.

The four internal vanes (D in fig.13) equally spaced round the circumference, project into the jet at the rear end of the venturi; they are made of refractory material which appears to be mainly graphite, and are both heat-resisting and heat-insulating. The heavy bearing is further insulated by means of a circular steel plate, 0.26" thick, which is bolted to the heavy steel backing plate for the vanes themselves. At the rear end, this backing plate has bolted to it a shaped projection, which probably acts as a locating pin.

The two roller bearings are supported in a triangularly shaped light alloy casting which is itself bolted to the light alloy cast channel ring on the rear end of the venturi (see fig.17).

The movement of each vane is controlled by a hydraulic servo unit, A, (driven by a small electric motor) through the agency of two links, B and C. The servo units are mounted on brackets which are supported on the forward face of the channel ring.

The four external vanes (B in fig.14) are located at the rear outer ends of the four stabilizing fins. They are in exactly the same planes as the four internal vanes. The vanes are of normal symmetrical aerofoil section, of 16" chord and 3" maximum thickness. The inner portion is supported on a torque shaft, about 6" long, and the outer portion probably tapers off to a point giving an overall width of approximately 12". The ribs are of pressed steel sheet and the skin 0.026" thick steel sheet, is spot welded to the rib flanges.

The torque shaft is splined at its inner end to receive a 270°, 8" diameter sprocket. From this a chain drive is presumed to run to a 3" diameter sprocket which is splined on a heavy torque shaft, (H in fig.15). Two of these torque shafts are longer than the other two; the longer ones carry a claw fitting at their inner ends, whilst the shorter ones carry a gear wheel.

One of the control arms B in fig.13 bears an extension on the forward side of the servo unit control shaft centre-line. This extension supports a pin, which from measurement, appears to engage with the claw fitting described in the last paragraph. It therefore seems probable that at least one pair of the external vanes is connected to one pair of the internal vanes; both controls move in the same sense. No connection can be established between the second pairs.

It has been established that the longer torque shafts, with claw fittings, are diametrically opposite, and so, therefore, are the shorter shafts fitted with gear wheels.

10. Assembly

It has been established that the structure can be broken down into the following components:-

1. the radio compartment and warhead.
2. the fuel tank bay.
3. the engine and engine accessory bay.
4. the venturi.
5. the "light construction" shell and fin structure.
6. the tail unit and internal control vanes.

It is also possible that there is some form of transport joint between the warhead and the radio compartment.

The "heavy" construction shell is assembled around the fuel tanks in the manner indicated in paragraph 2(c) and figures 5, 6, 7 and 8. The front and rear ends of the tank bay are believed to be the circular angle frames, which form strong points where the empty structure rests on the trolleys, provided for its transport after complete assembly.

The joint with the radio compartment end angle frame is shown in fig.20; access to the bolts being obtained through the detachable panels of the radio compartment. The joint with the engine bay end angle frame is also shown in fig.20, access being provided easily through the braced framework before the external shell is in place. The "light" tapered shell and the stabilising fins can be assembled over the rear end, after the venturi is attached to the engine mounting through the four universal joints. The detail at the transport joint is shown in fig.20; access for a spanner is provided in the gap between the two angles for tightening up the large hexagonal nuts.

The tail unit is bolted to the heavy radial fin members in line with the rear face of the venturi and is located on the four lugs, B, in fig.12.

11. Estimate of structure weight

The following estimate of the weight has been made:

Structure and tanks		
Shell	1,750 lb.	
Fins, control surfaces and operating mechanism	1,150	
Engine mounting	250	
Tanks, pipes and mountings	300	
10% allowance for fittings, etc.	350	3,800 lb.
Power unit		
Turbine, pumps and auxiliary fuel tank	450	
Venturi, and burner unit	1,000	1,450
Equipment		
Radio	300	
Wooden structure for radio	400	
Air bottles	100	
Wiring	50	
Sundries	50	
6% allowance on power unit and equipment	150	1,050
		6,300

Estimated total weight (less fuel and warhead) = 6,300 lb.

This weight is based on the following estimated division of the total length

Nose fairing	11½"
Warhead	5' 7"
Radio compartment	4' 7½"
Fuel tanks	20' 2"
Engine and accessories	7' 2"
Venturi	5' 0"
Tail unit	2' 4"
Total length	45'10"

The centre of gravity empty is between 45% and 50% aft of the nose.

12. Estimated strength of structure

The strengths of various parts of the structure were calculated as follows:-

1. Heavy shell construction

(a) Load taken by structure when skin buckles: 57.5 tons compression.

(b) Load taken by structure at failure: 225 tons compression.

2. Medium shell construction

(a) Load taken by structure when skin buckles: 49.5 tons compression.

(b) Load taken by structure at failure: 190 tons compression.

3. Light shell construction

(a) Load taken by structure when skin buckles: 27.5 tons compression.

(b) Load taken by structure at failure: 100 tons compression.

4. The failing strength of the heavy structure in pure bending is 3,750 tons. in.

5. The compressive failing load of each of the four longitudinal members in the engine and engine accessories mounting is 10 tons.

6. The compressive failing load of each of the four fin posts is 4.5 tons.

7. The failing strength of each of the radial fin channel members in line with the rear end of the venturi, in pure bending, is 32.5 tons.in. at a point 37.25 inches from the longitudinal axis of the projectile. This is the section at which this member is weakest.

These figures have been calculated on an assumed shell diameter of 66 inches.

List of illustrations

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" 3	"Medium" construction shell.	Neg. No. 56034
" 4	"Medium" construction details.	E.A.D. No. 83
" 5	"Heavy" construction shell (inside).	Neg. No. 56035
" 6	"Heavy" construction shell (outside).	" " 56036
" 7	"Heavy" construction details.	E.A.D. No. 84
" 8	Tank supports.	Neg.No. 56037
" 9	Detachable panel construction.	E.A.D. No. 85
" 10	Mounting and end frame for engine and accessories.	Neg. No. 56039
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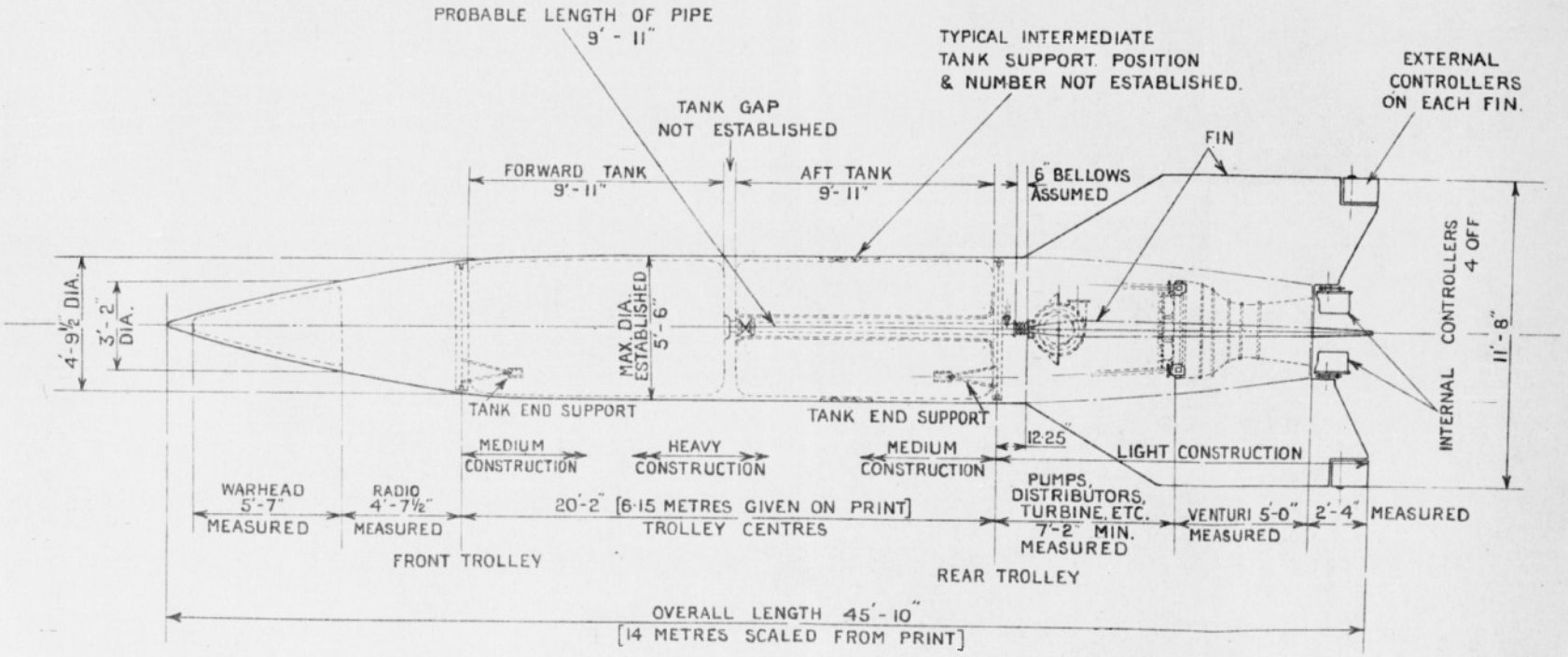
FIG. A



ROCKET — GENERAL ARRANGEMENT

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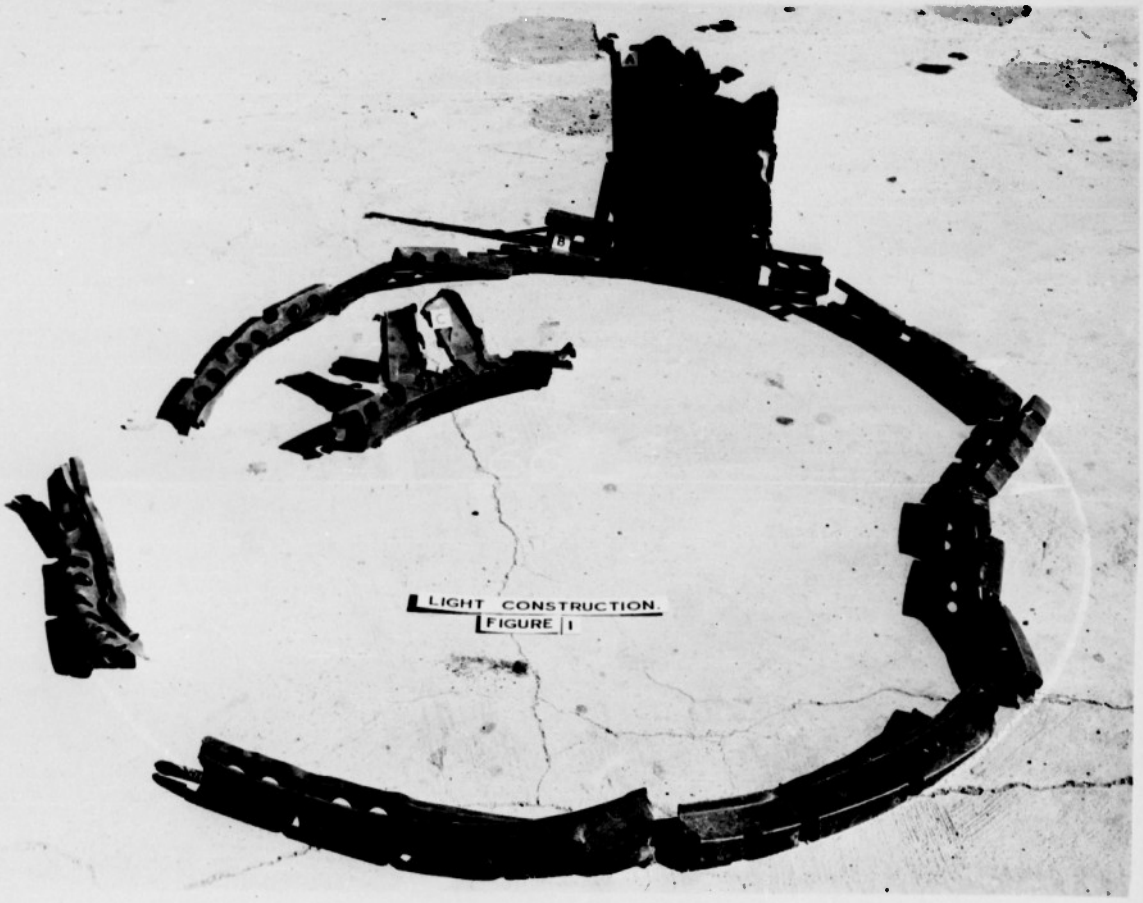
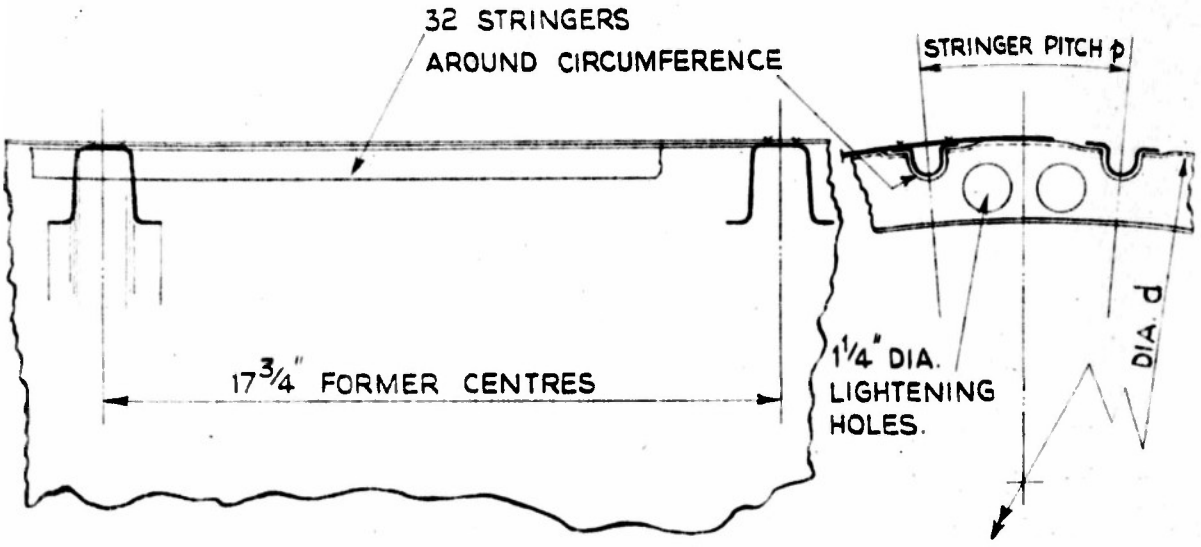
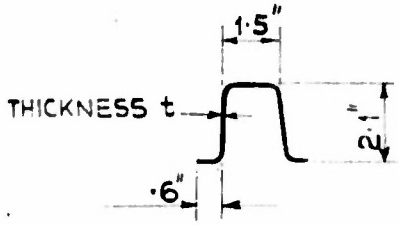


LIGHT CONSTRUCTION.
FIGURE 1

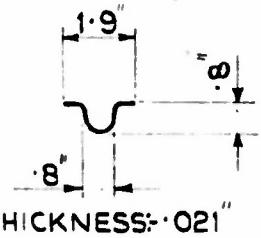


PART LONGITUDINAL SECTION

PART TRANSVERSE SECTN



FORMER B



STRINGER A

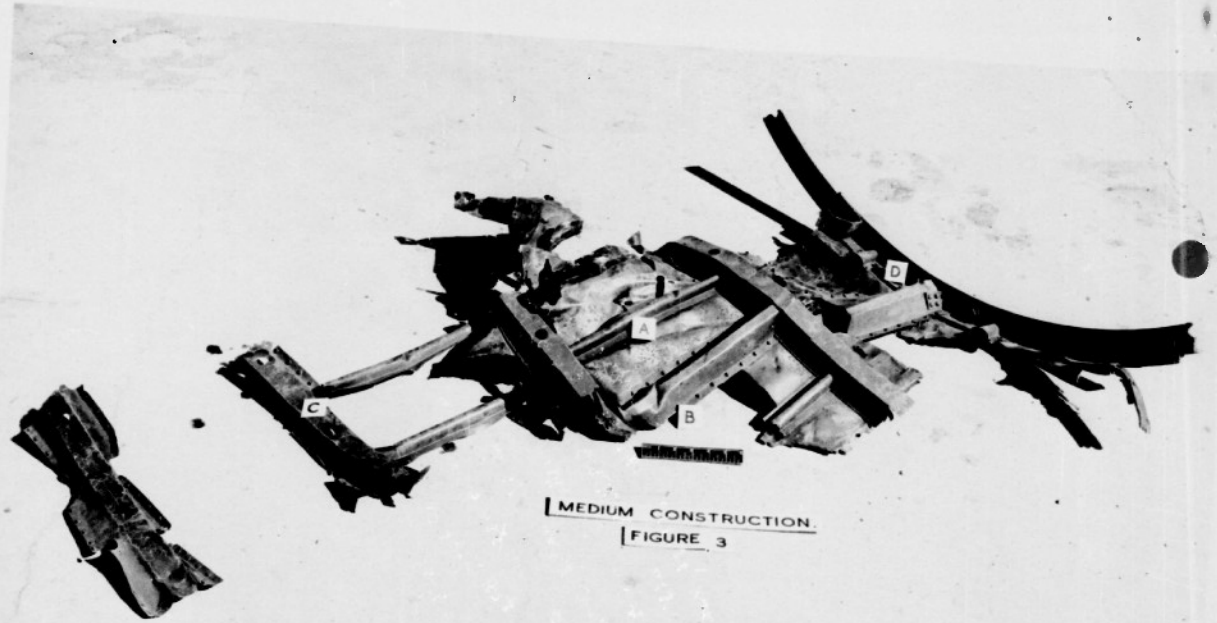
SKIN THICKNESS:- ·025"

STRINGER PITCH p	6 7/16"	6 5/16"	6 1/16"	5 13/16"	5 7/16"	5 1/16"
OUTSIDE DIA. d	65·6"	64·33	61·8"	59·25"	55·4"	51·6"
FORMER THICKNESS t	·0835"	·068	·068"	·068"	·068"	·068"

SKIN SPOT-WELDED TO STRINGERS & TOP OF TOP-HAT FORMERS.
TOP-HAT FORMERS IN 4 QUADRANTS, BUTT-WELDED.

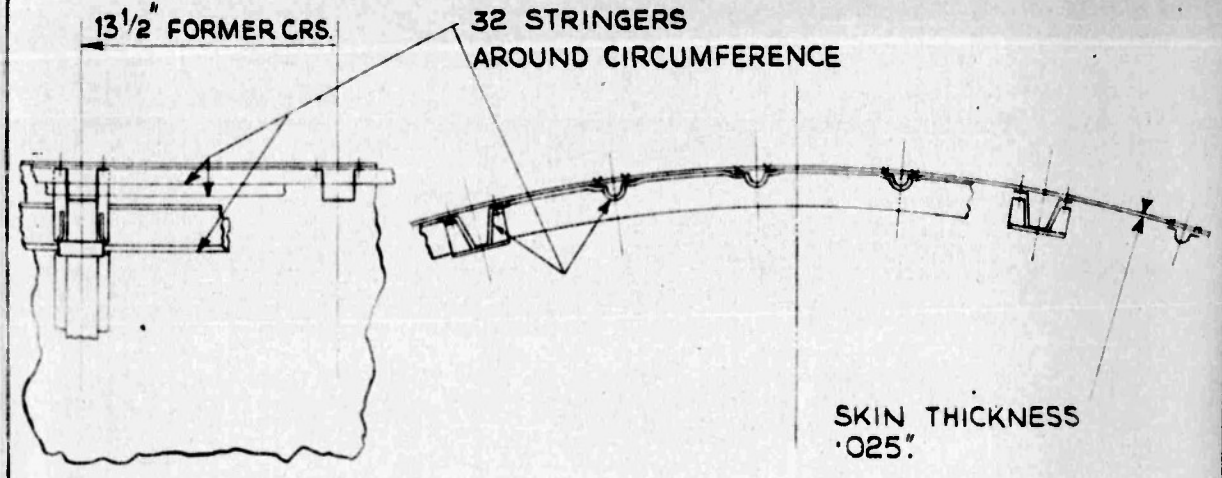
FORMERS BELOW (& INCL.) 61·8" DIA. HAVE REINFORCING STRAPS AT BUTT-WELDS & SUPPORT BRACKETS FOR MEMBERS RUNNING RADIALLY FROM OUTSIDE OF FORMERS.

LIGHT CONSTRUCTION

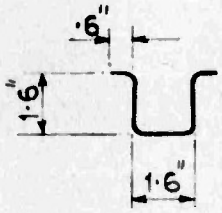


MEDIUM CONSTRUCTION.
FIGURE 3

FIG. 4

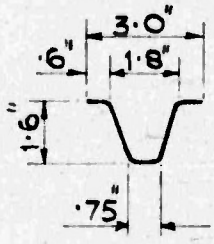


PART LONGITUDINAL SECTION. PART TRANSVERSE SECTION



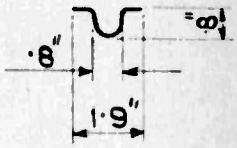
THICKNESS: ·047"

FORMER C



THICKNESS: ·040"

HEAVY STRINGER B

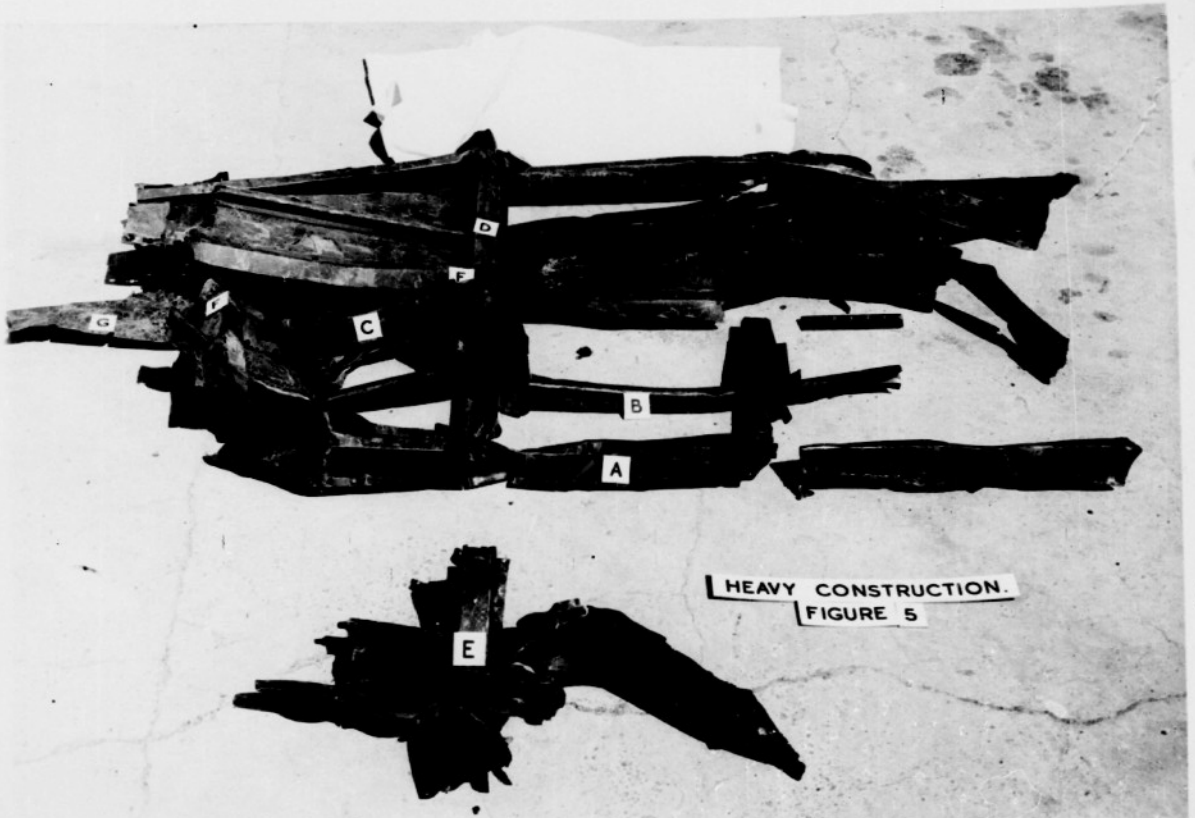


THICKNESS: ·047"

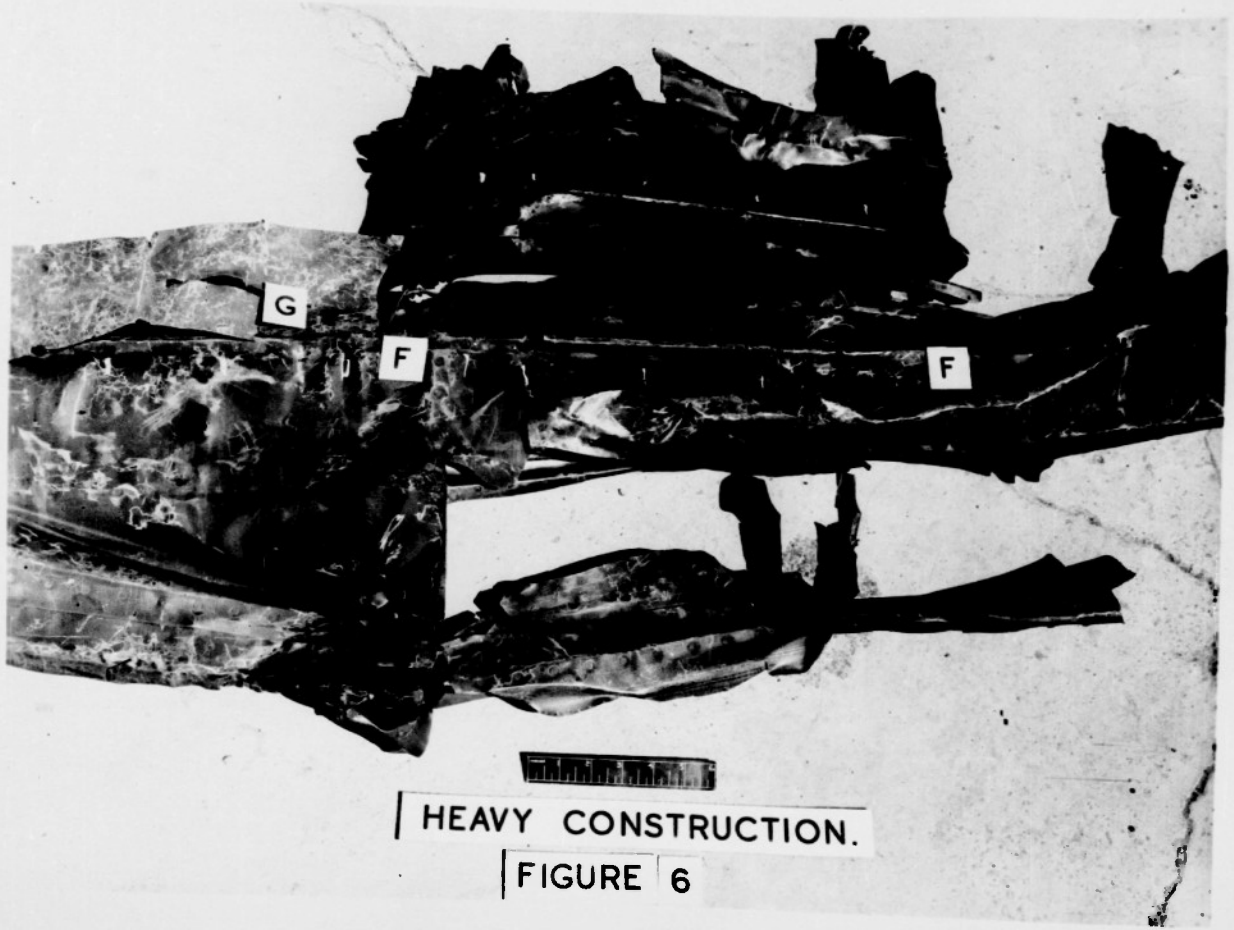
LIGHT STRINGER A

SKIN SPOT-WELDED TO LIGHT STRINGERS.
SKIN RIVETED TO HEAVY STRINGERS & FORMERS.

MEDIUM CONSTRUCTION



HEAVY CONSTRUCTION.
FIGURE 5



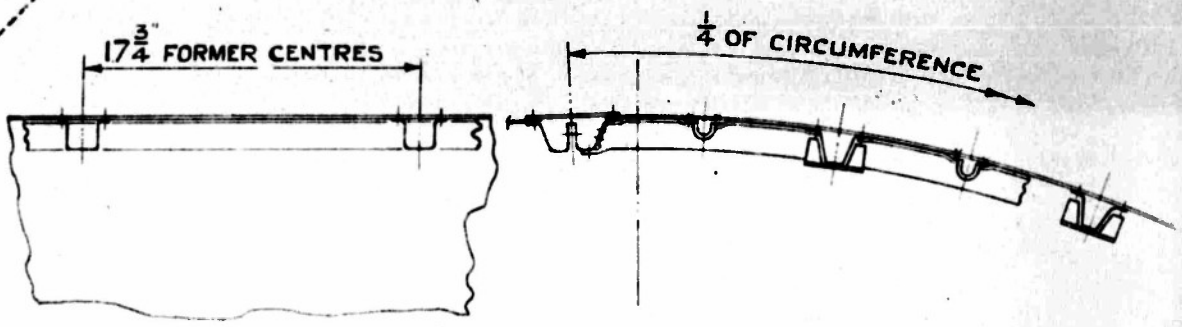
HEAVY CONSTRUCTION.

FIGURE 6

Nº E.A.D. 84
DR
TR 29-5-44
CH
APP

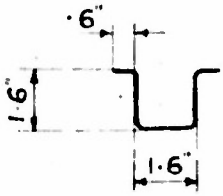
REPORT Nº E.A.228/1.

FIG 7.



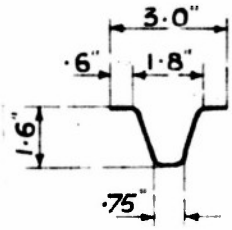
PART LONGITUDINAL SECTION.

PART TRANSVERSE SECTION.



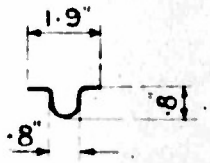
THICKNESS ·047"

FORMER D.



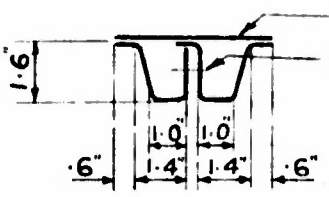
THICKNESS ·040"

HEAVY STRINGER A.



THICKNESS ·040"

LIGHT STRINGER B.

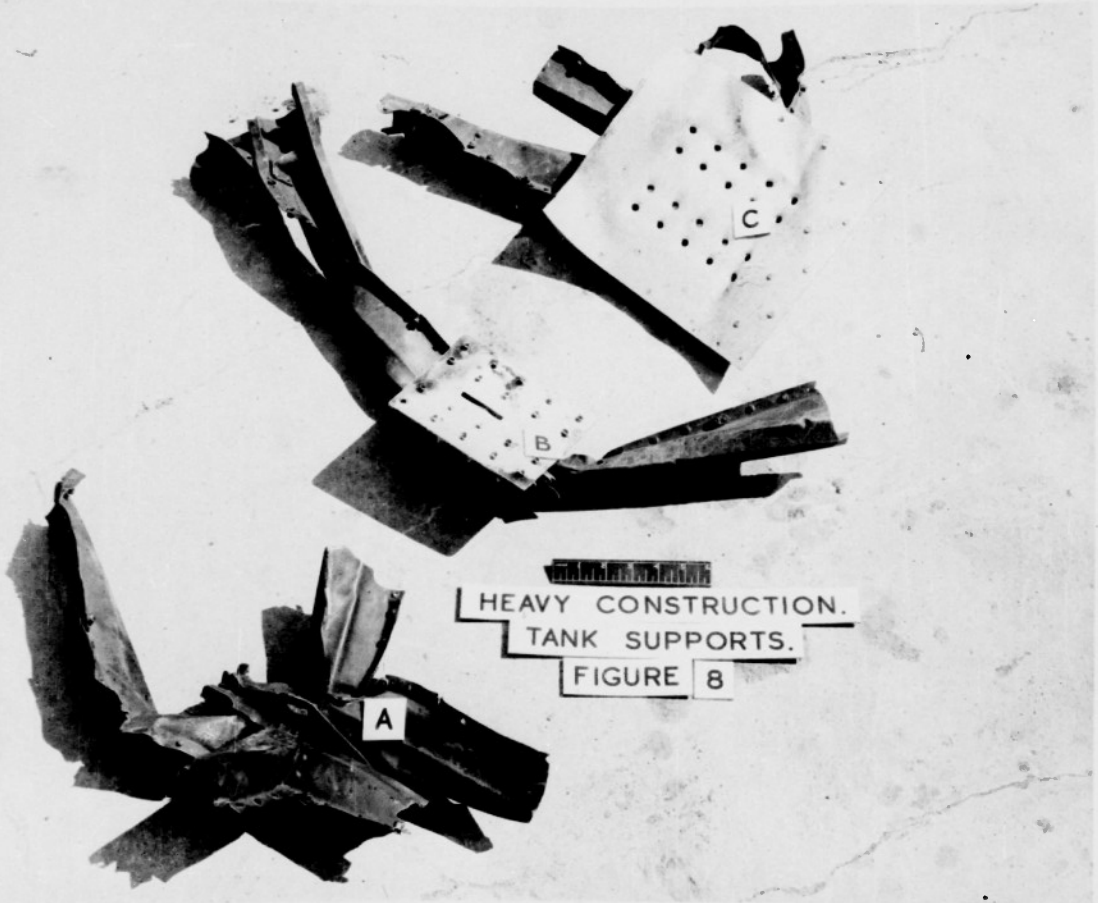


THICKNESS ·048"

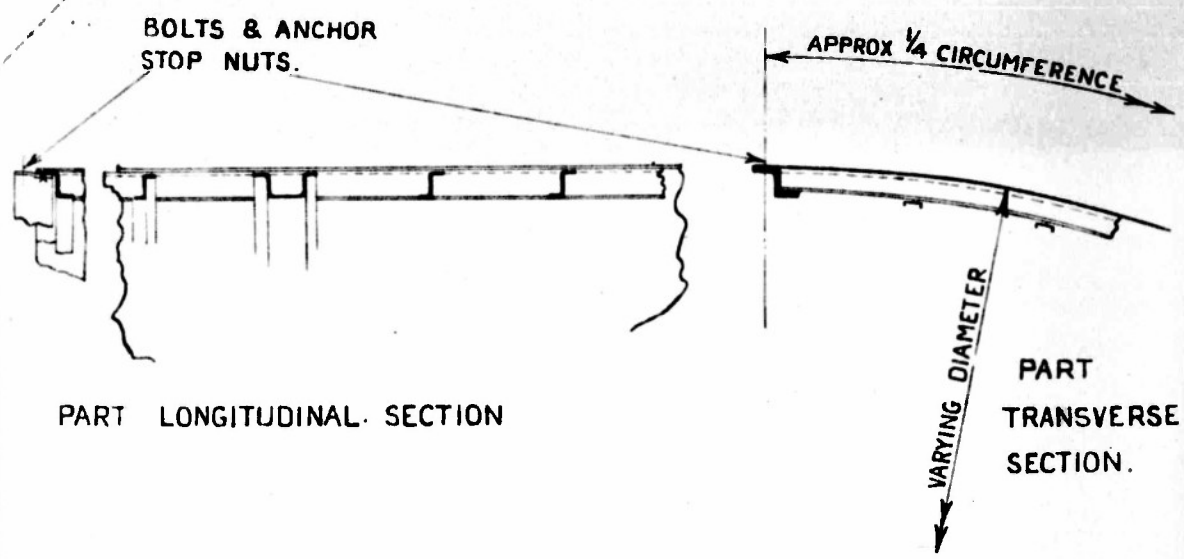
EDGE STRINGERS F.

SKIN SPOT-WELDED TO LIGHT STRINGERS
SKIN RIVETED TO HEAVY STRINGERS & FORMERS.
SKIN RIVETED TO OUTER FLANGES OF EDGE STRINGERS ONLY.
COVER STRIP IS ATTACHED BY BOLTS & ANCHOR STOP NUTS
TO OUTER FLANGES OF EDGE STRINGERS.

HEAVY CONSTRUCTION

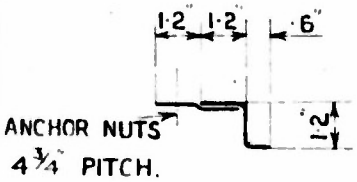


HEAVY CONSTRUCTION.
TANK SUPPORTS.
FIGURE 8

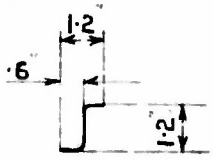


PART LONGITUDINAL SECTION

PART TRANSVERSE SECTION.

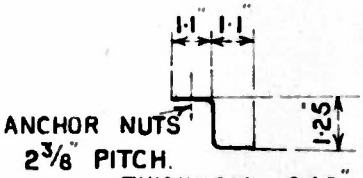


TRANSVERSE EDGE MEMBER.



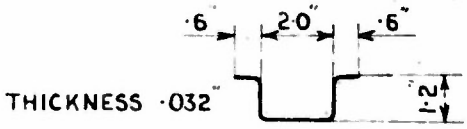
THICKNESS ·021"

LIGHT STRINGER.

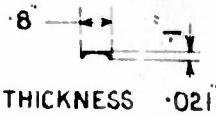


THICKNESS ·040"

LONGITUDINAL EDGE MEMBER.



FORMER

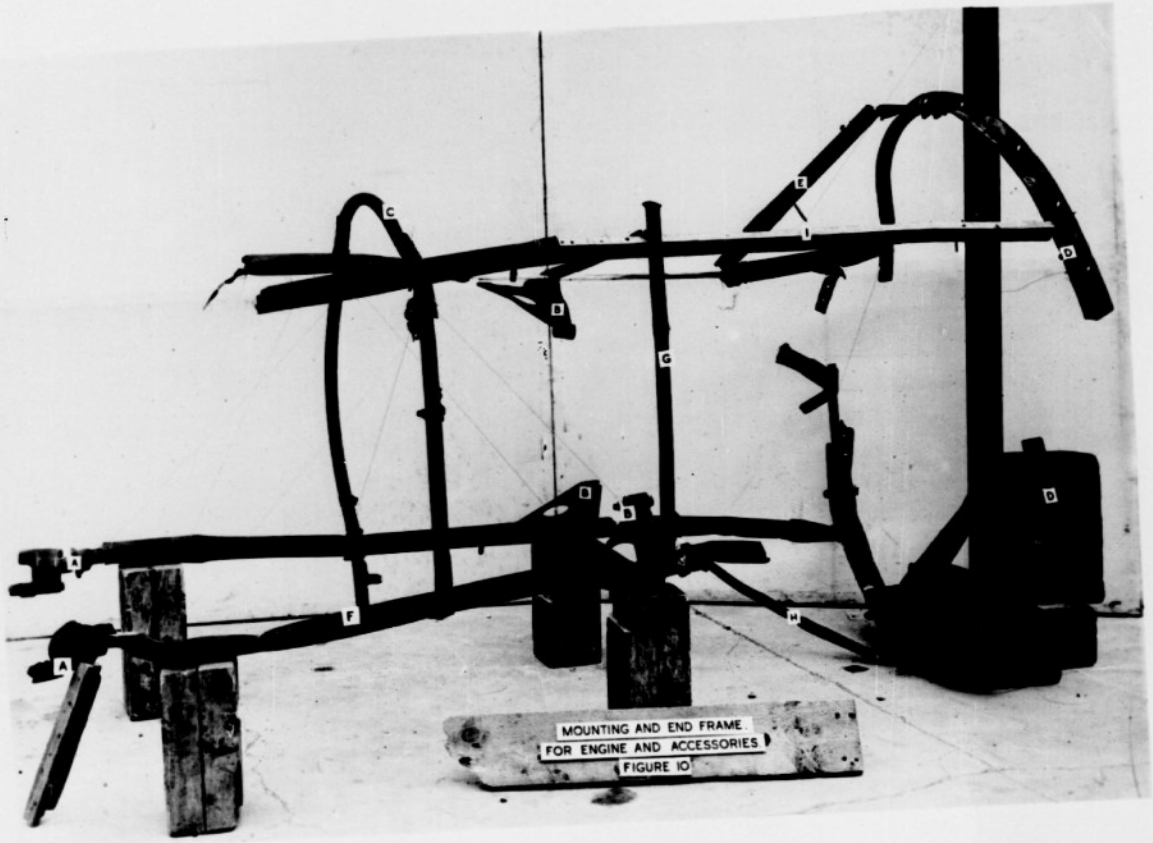


THICKNESS ·021"

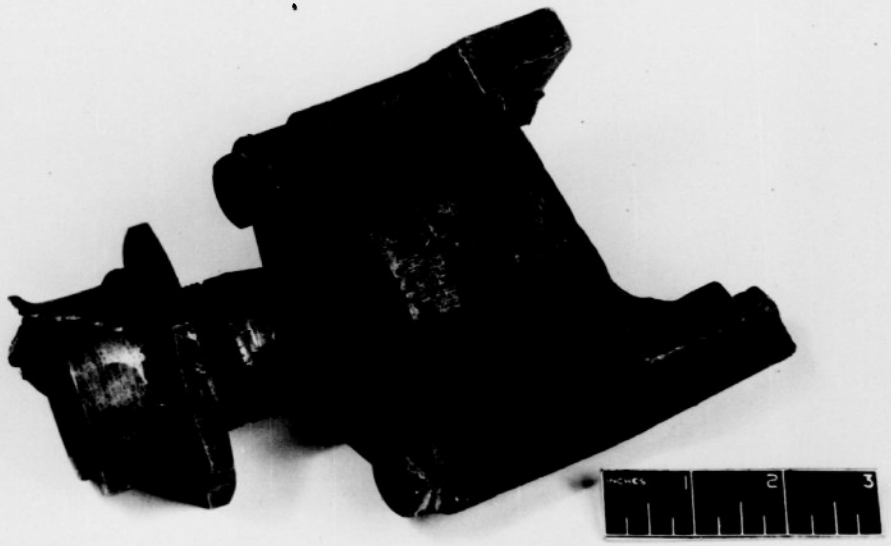
TIE

SKIN SPOT-WELDED TO LONGITUDINAL EDGE MEMBER FORMERS & LIGHT STRINGERS.

DETACHABLE PANEL CONSTRUCTION

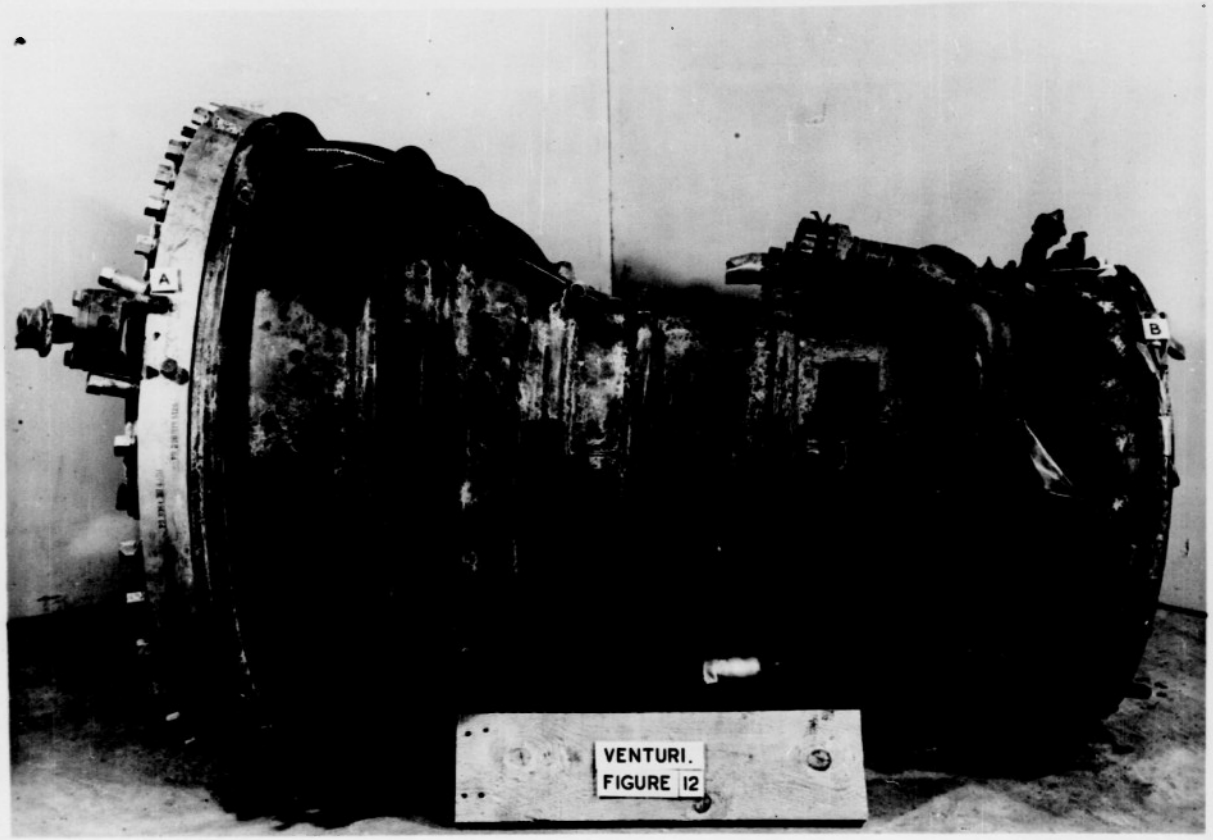


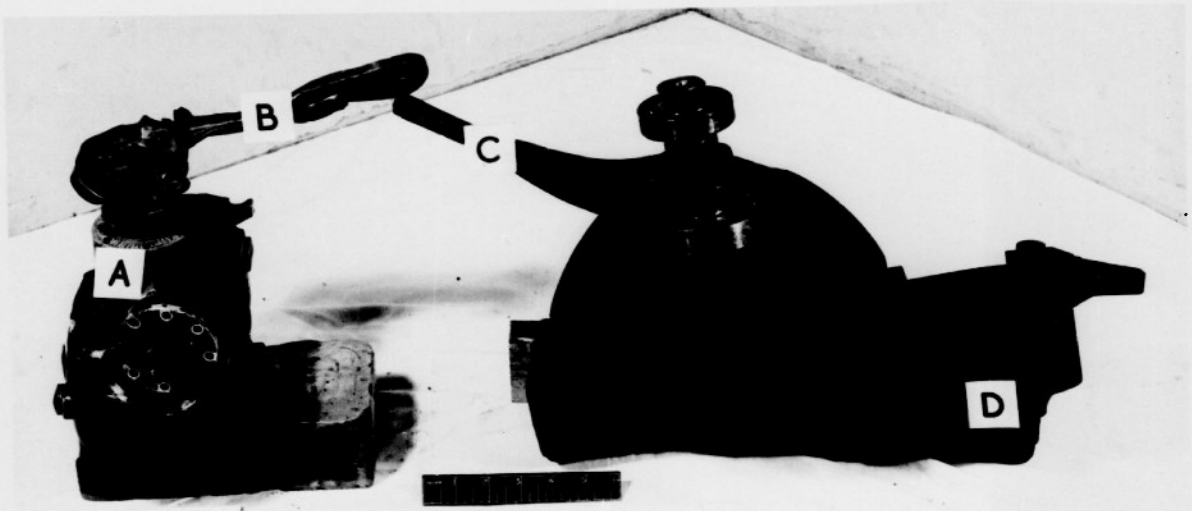
MOUNTING AND END FRAME
FOR ENGINE AND ACCESSORIES
FIGURE 10



UNIVERSAL JOINT.

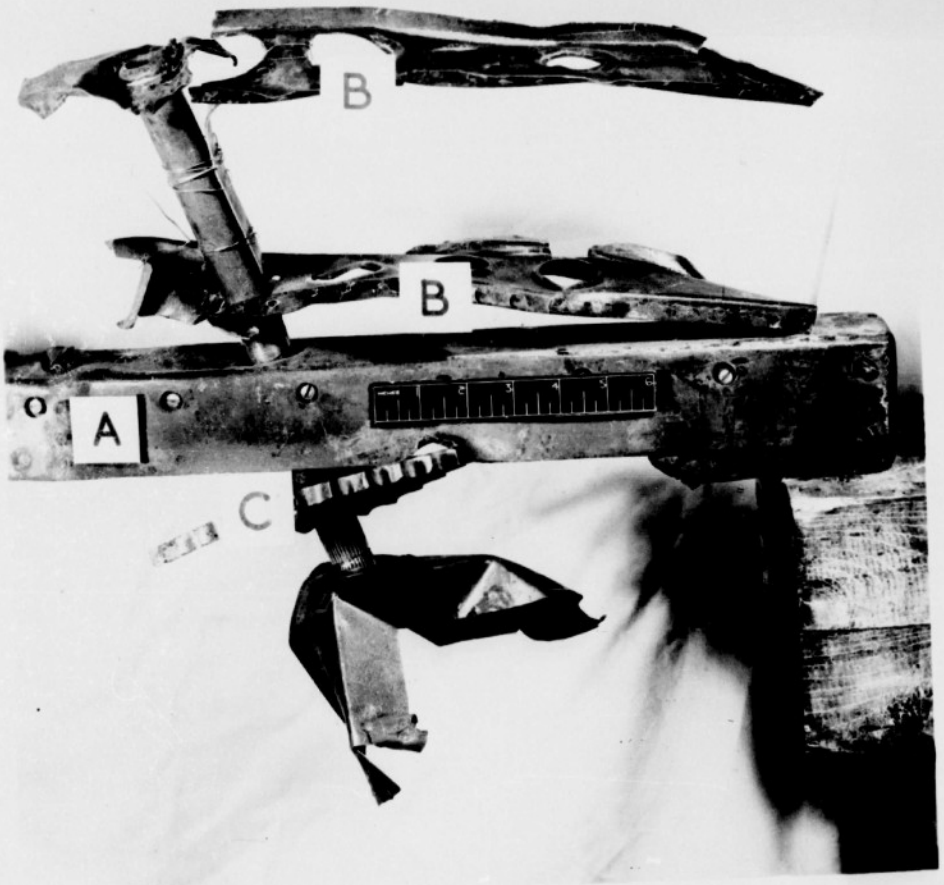
FIGURE 11


A
B
VENTURI.
FIGURE 12



CONTROL VANE. 1

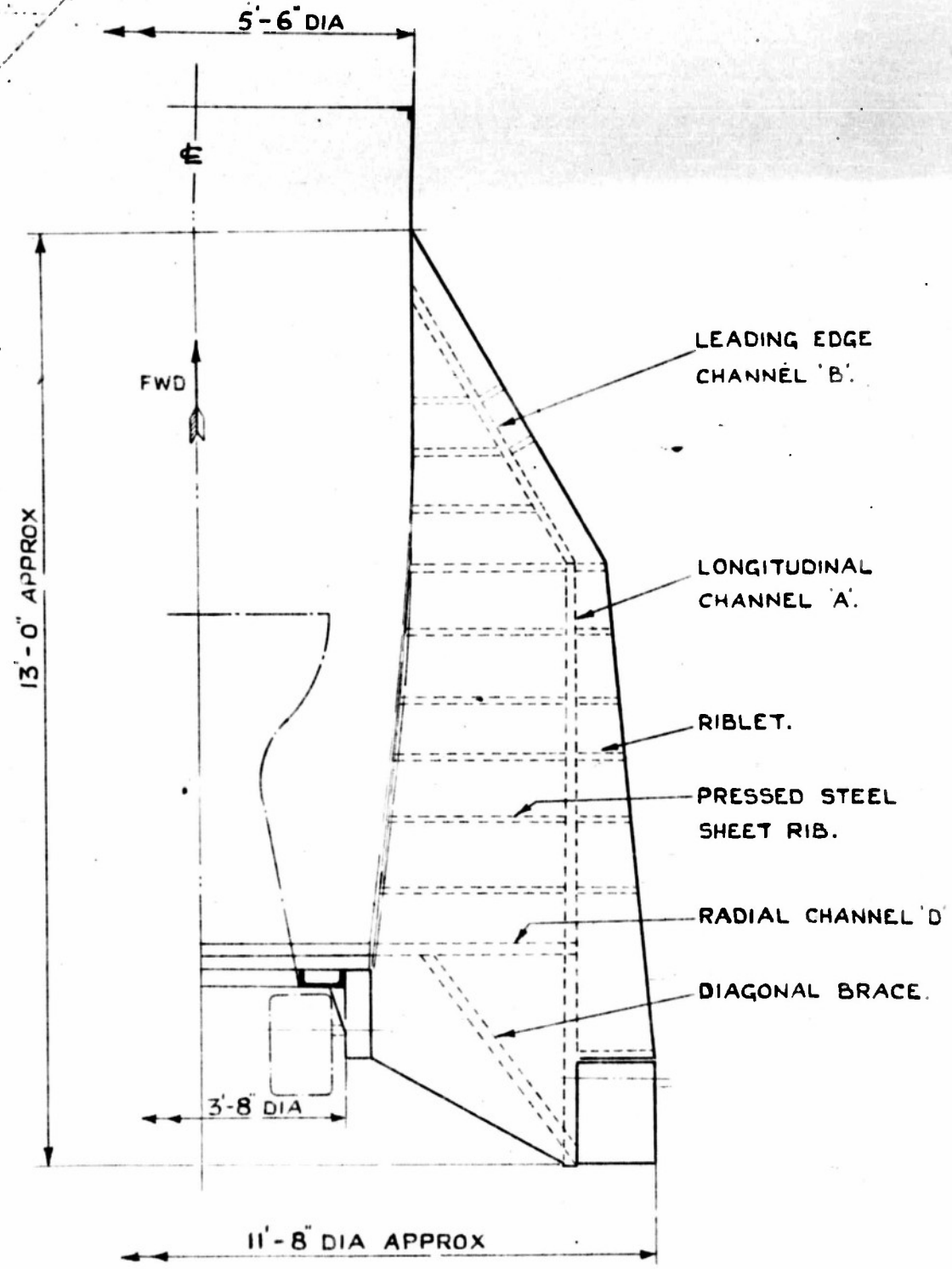
FIGURE 13



CONTROL VANE. 2

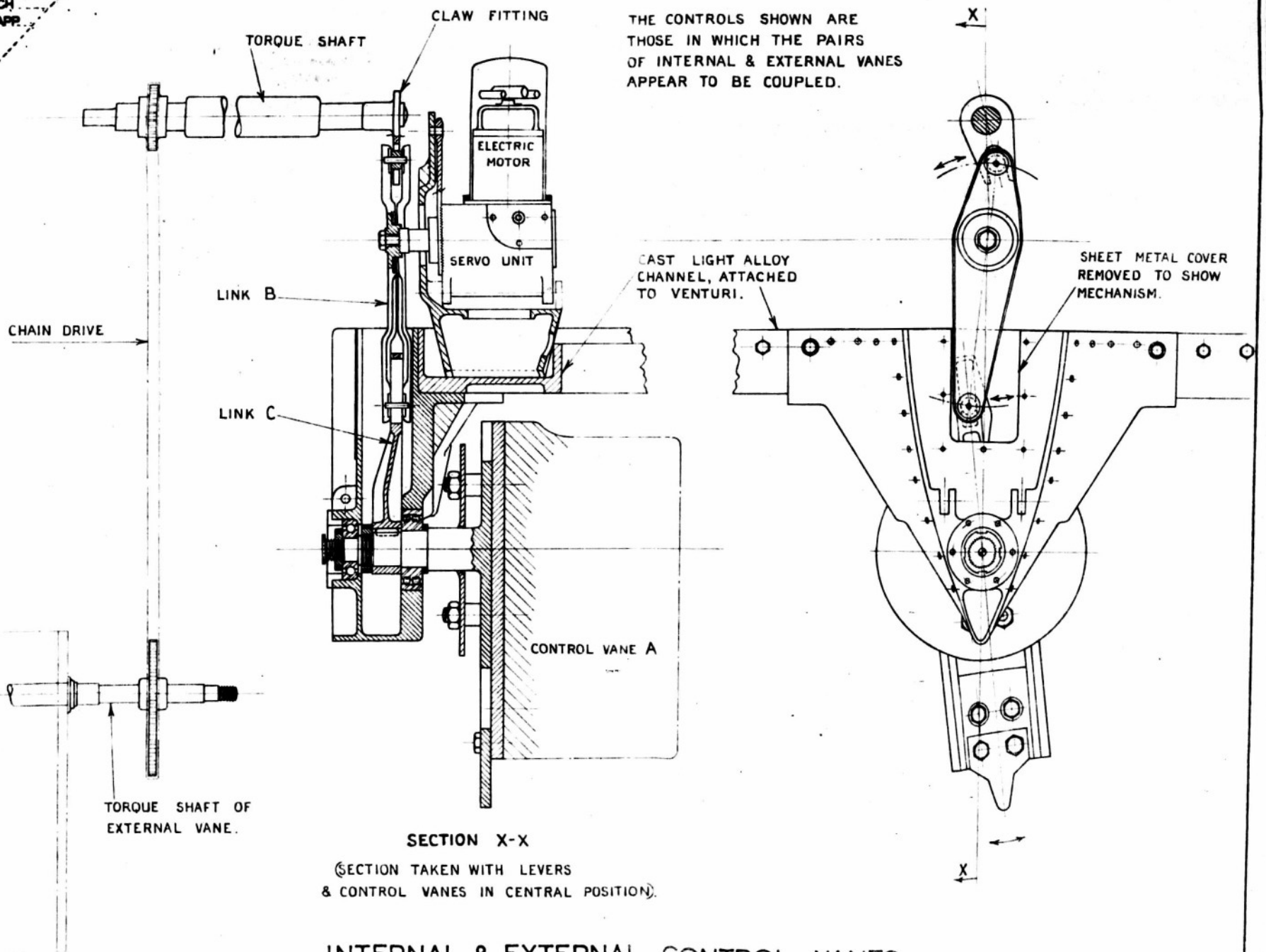
FIGURE 14


FIN & CONTROL SURFACE
FEET



DIAGRAMMATIC LAYOUT OF FIN.

STABILIZING FIN.



SECTION X-X

(SECTION TAKEN WITH LEVERS & CONTROL VANES IN CENTRAL POSITION).

INTERNAL & EXTERNAL CONTROL VANES


C
B
D
A
E
WAR
HEAD

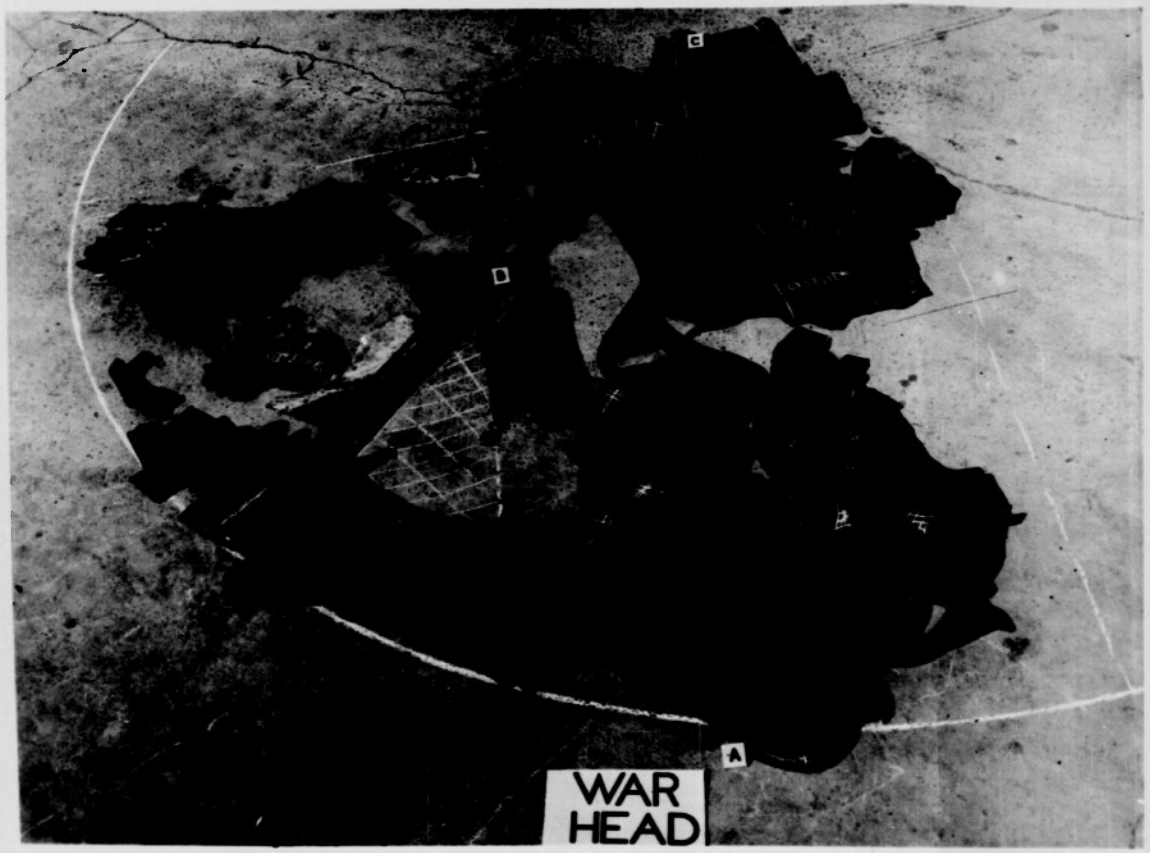
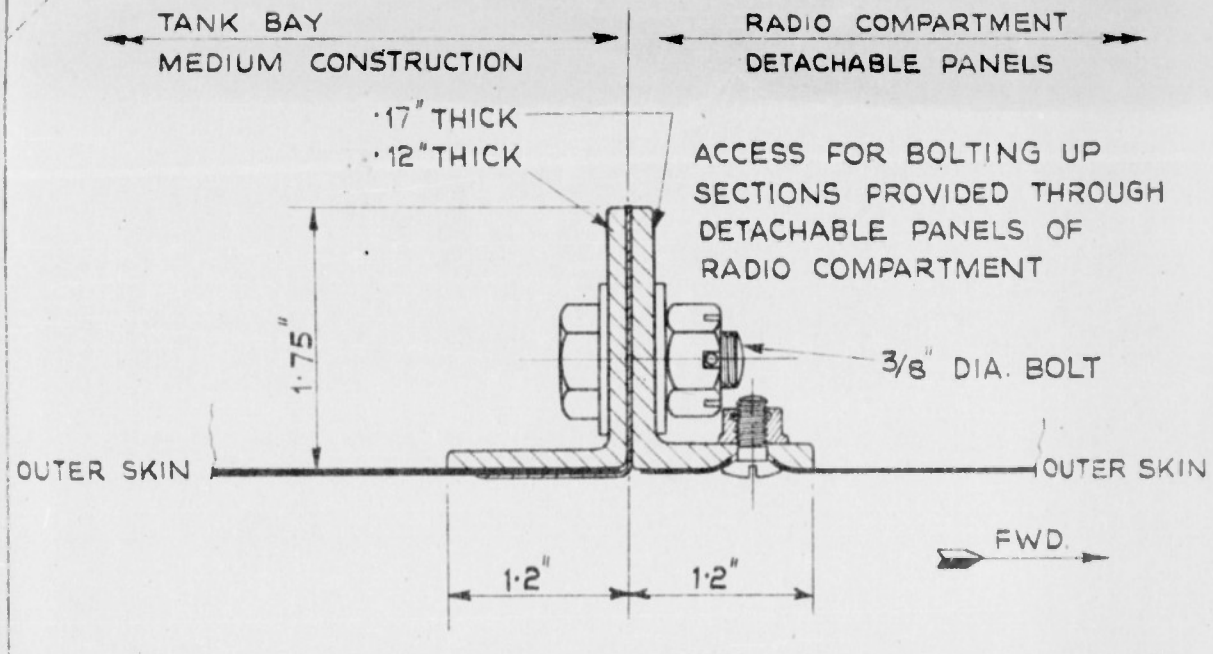
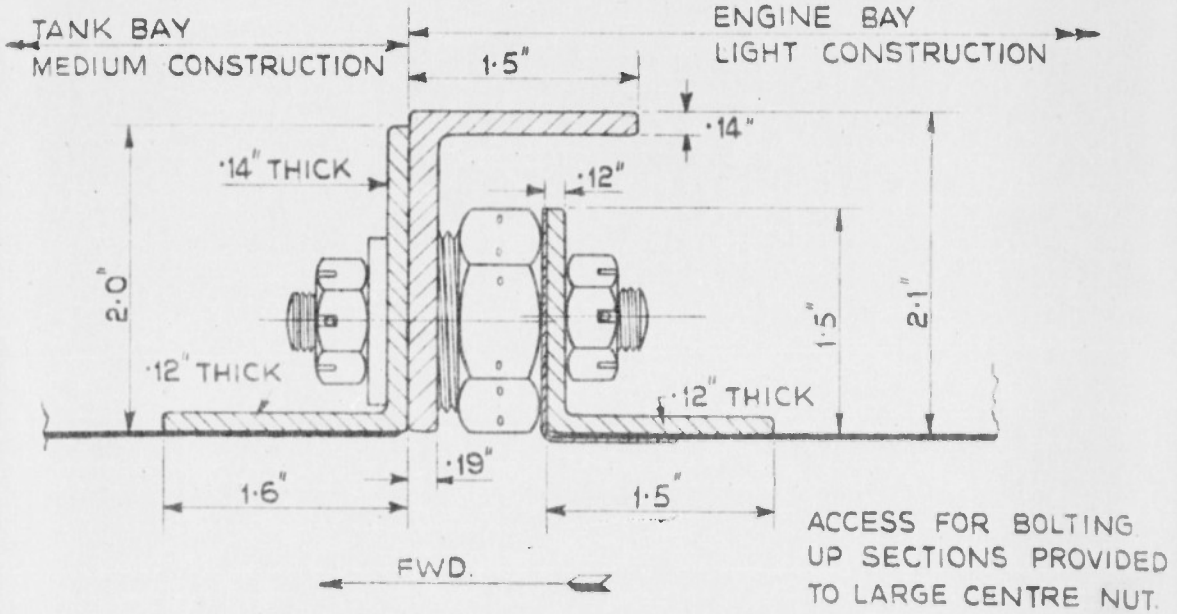

G
D
A
WAR
HEAD

FIG. 20



DETAIL OF TRANSPORT JOINT
BETWEEN TANK BAY & RADIO COMPARTMENT.



DETAIL OF TRANSPORT JOINT
BETWEEN TANK BAY & ENGINE BAY.

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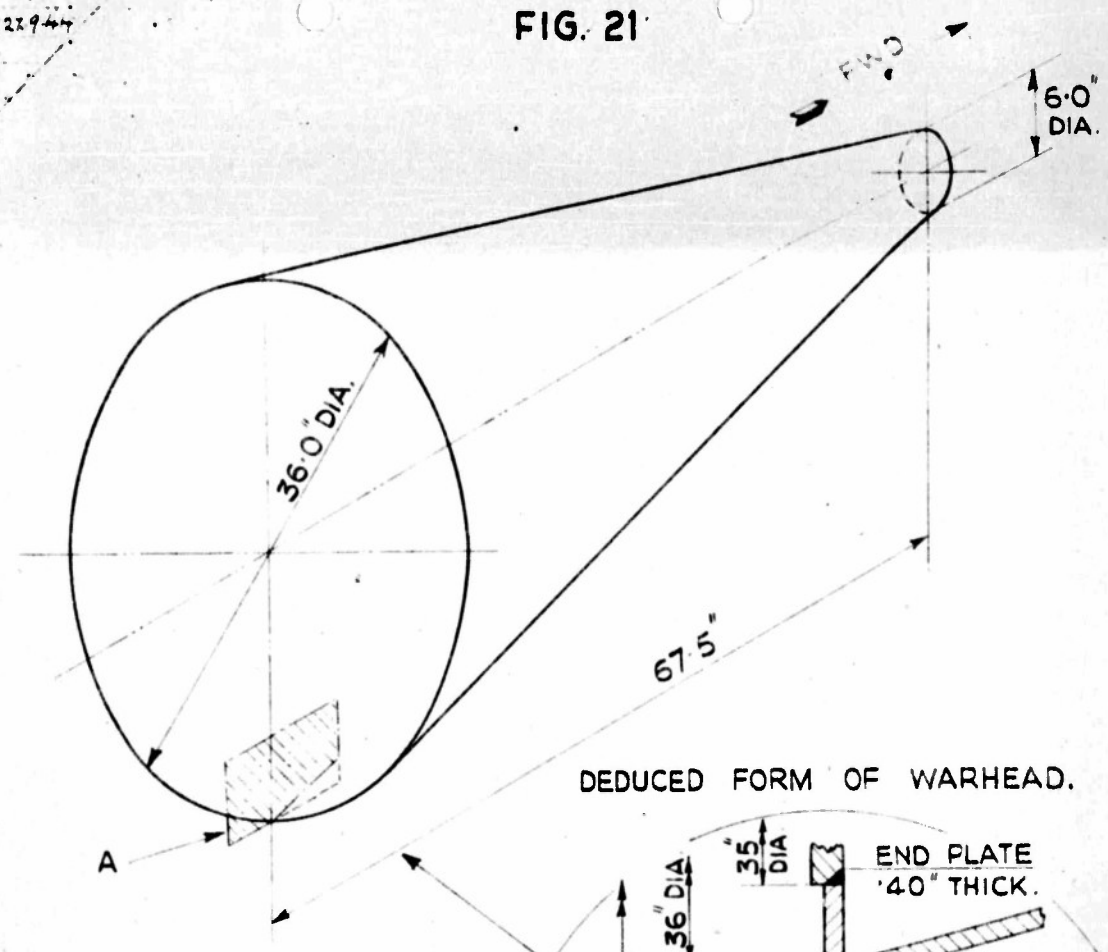
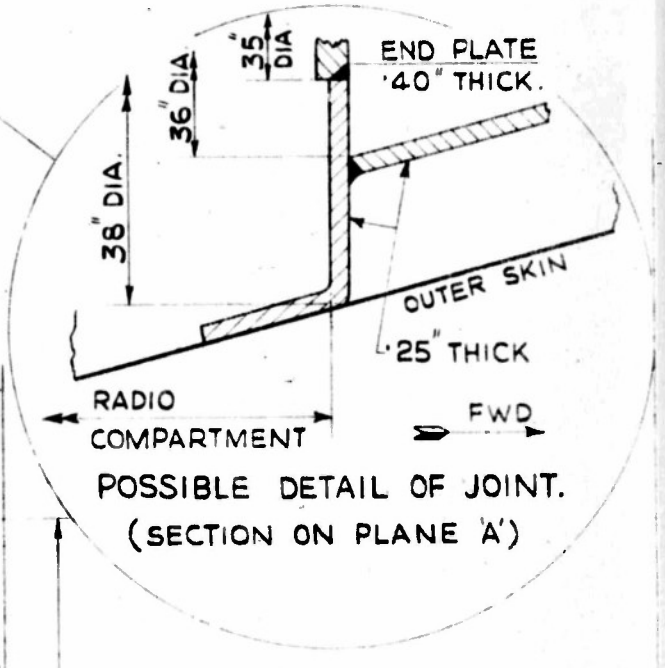
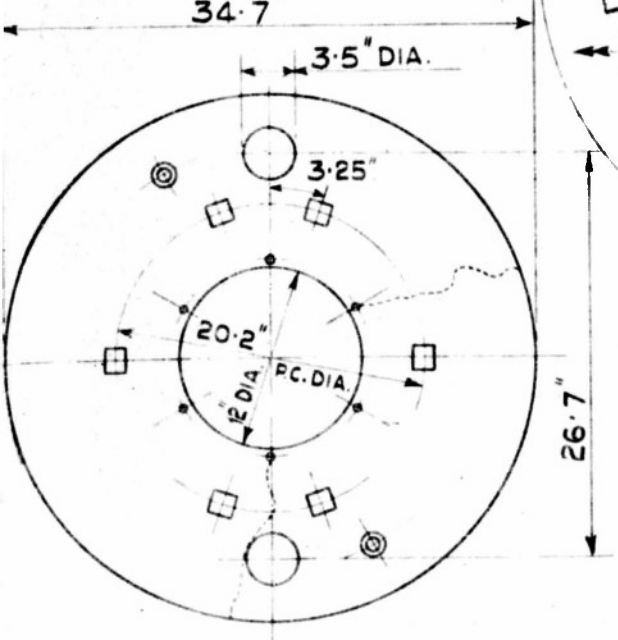
FIG. 21



DEDUCED FORM OF WARHEAD.



POSSIBLE DETAIL OF JOINT.
(SECTION ON PLANE 'A')



DEDUCED FORM
OF END PLATE.

RECONSTRUCTION OF WARHEAD

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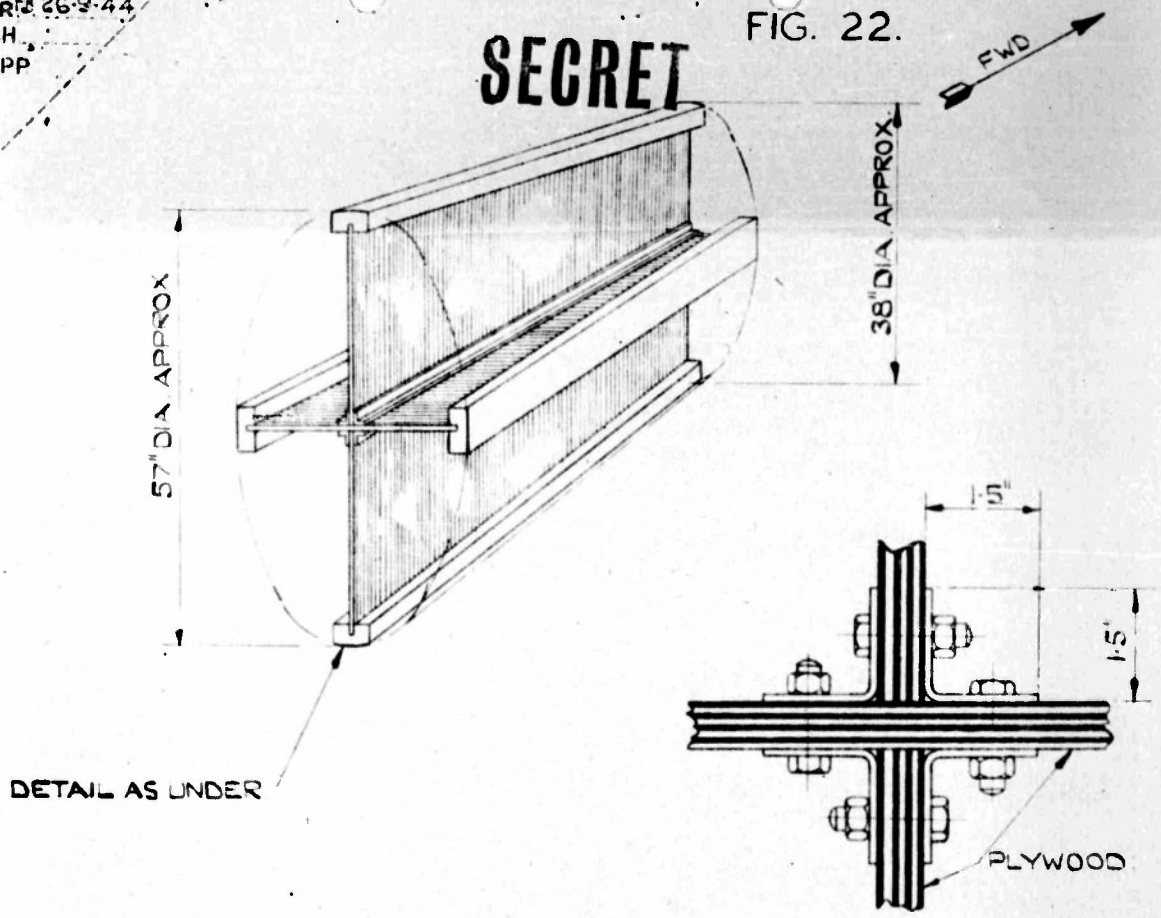
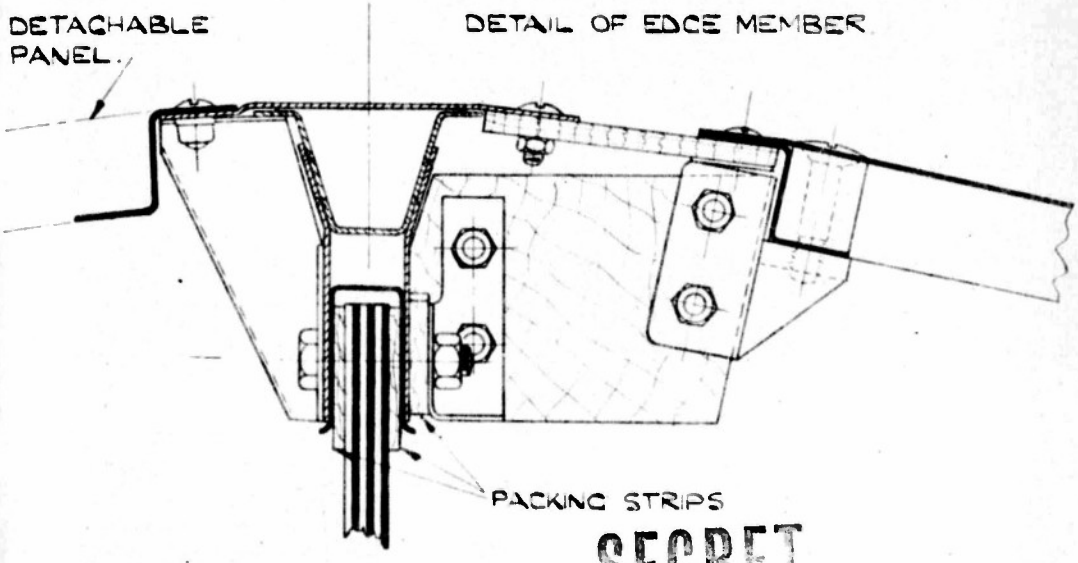
FIG. 22.

SECRET



DETAIL OF CENTRE MEMBER



DETAIL OF EDCE MEMBER

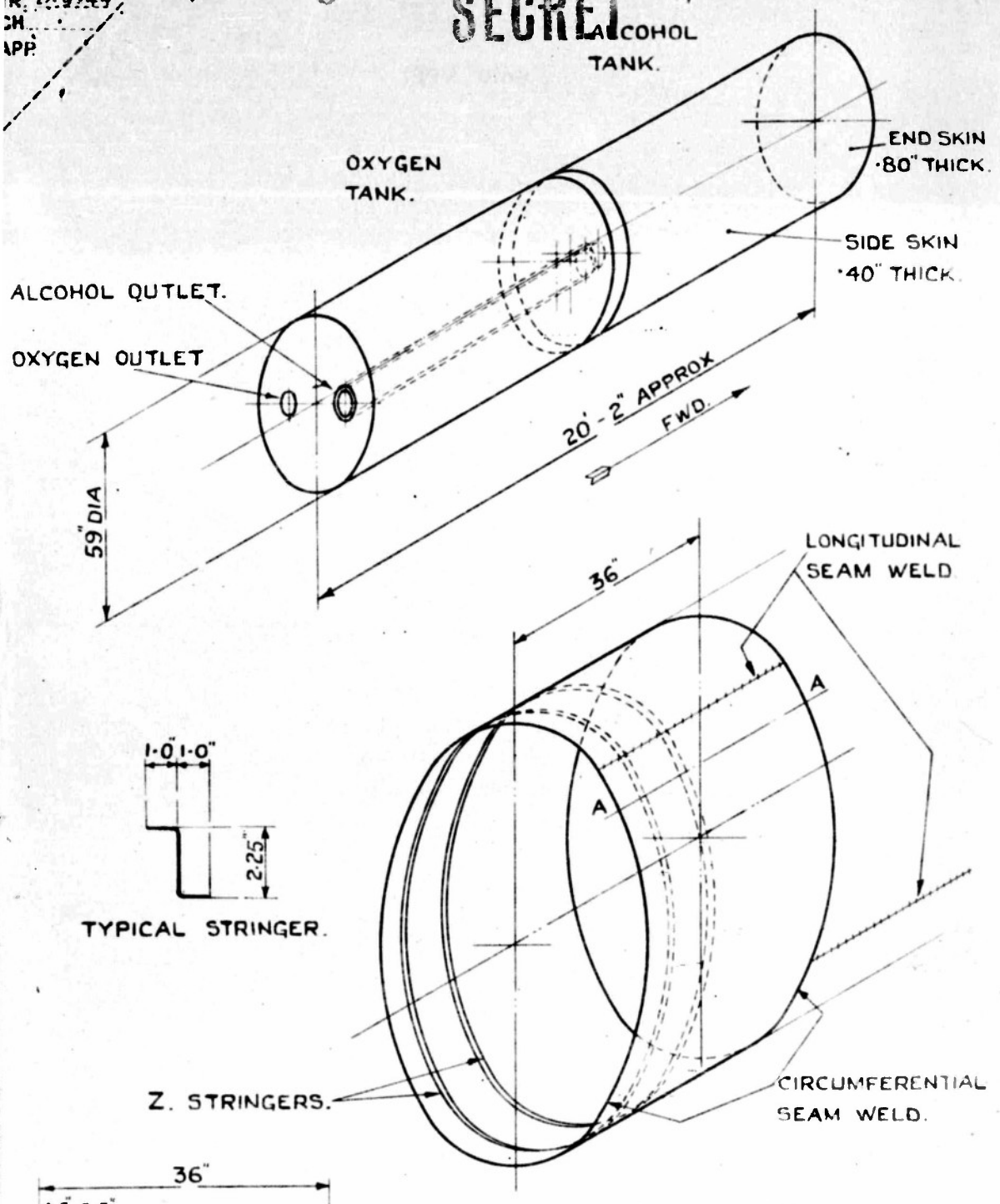
SECRET

RADIO COMPARTMENT

V-38818

FIG 23

SECRET



TYPICAL SECTION OF TANK.

LONGITUDINAL SECTION A.A.

FUEL TANKS.

SECRET

V-30818

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AUTHOR(S):

OA: Royal Aircraft Establishment, Farnborough

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