THE AVRO ARROW

To Doug & Donette
with my best
regards

A BOOK BY

Tom Dugelby

THOMAS B DUGELBY

CHAPTER 5

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INTRODUCTION.

Perhaps the best introduction to the theory of the Cooke-Craigie system of tooling is to refer to an article entitled "Production of an All-Weather Long Range Jet Fighter", written in 1953 by R.K. Anderson who was the Assistant Industrial Engineering Manager, Aircraft Division for Avro Aircraft.

"At the close of World War II, defence planners accurately estimated the requirements that would be necessary in 1954 and as a result they are getting the CF-100 long-range jet interceptor which has the speed, maximum altitude, fuel capacity, radar facilities and fire power to intercept and destroy any known bomber in existence today. The time from conception through design, development and quantity production, though normal for the aircraft industry world-wide, was a long 5 years. We can say accurately that it takes about five years for aircraft manufacturers in any country to produce aircraft in quantity from the beginning of design.

Past practice has been a development production cycle that began with the hand building of experimental prototypes, flight testing and then tooling for quantity production. The initial stage in this cycle, the hand building of prototypes, required that engineering design releases be only sufficient to enable first class aircraft workers to make parts strictly by hand methods, cutting and fitting on a trial and error basis. This results in an aircraft that may be a thing of beauty and may perform remarkably, but one that cannot be duplicated part for part. Further there will never be a desire to duplicate such an airplane part by part simply because parts were not developed with any thought as to ease of tooling and producing. This results in having to release a complete new set of detailed dimensioned drawings before processing, tool design and tool manufacture can be done. Then it becomes possible to manufacture detail parts in quantity and proceed with the business of making airplanes.

About five years after the original thinking started, usable production aircraft began to be delivered. By this time the aircraft is obsolete, and so are those that have been planned for the next year and the next. It becomes evident that we must find a way to reduce that five years as much as possible.

After careful study of statistics on the development and manufacture of aircraft over the past 15 years, the following plan has been evolved. It is now thought possible because of our present engineering abilities and research equipment, to design an initial flight article that is extremely close to the specifications developed by wind tunnel work. In other words design engineering will make a complete release the first time with all details fully dimensioned.

The time lapse for so doing is little greater than would eventually have been necessary for a full production release but saves the time needed for a prototype release. What has been accomplished.? All parts and assemblies can now be planned for production. Tool designs for production can be started immediately. These are production tools which would have to be made later anyway but can now be ready to be used in making the first parts of the prototype. In the past, convenience tools were made by the skilled workers and generally afterwards scrapped. Assembly jigs can be designed and built that will take no longer than would have been necessary for a prototype but, again, these are production jigs that will not have to be scrapped or rebuilt. Interchangeability media can be incorporated from the beginning. Of course, only one set of tools will be needed at this stage. Further, only those tools that are economically feasible for making a few parts will be built, but those parts that are machined by non-production methods will still be made accurately to detailed dimensions. Sub-assemblies that later will be tooled are now incorporated in main jigs. It is now possible to make several prototypes that are alike and that are the same as future production models except for those changes that are incorporated as a result of thorough testing. In other words, revisions that are a result of research and testing are the only changes that would have to be made under any system, but those changes that would have occurred due to the difference of method of manufacture are eliminated.

All changes must be carefully recorded in the form of concurrent detail drawings. Tool drawings must be kept abreast of the changes and tools reworked or rebuilt as necessary. The elapsed time will be no longer or very little longer than with the old method, but since all engineering details, all production planning and processing papers, all tool designs and some actual tools have been kept current, production in quantity can start immediately and can accelerate rapidly as the remainder of the tools plus duplicate tooling and convenience tooling are completed. Approximately two years of elapsed time have been saved.

Now, let us consider the cost of such a program. Much to the surprise of most proponents of this theory, the saving in cost can be enormous. It has been determined that except in very unusual cases no greater than 25% scrap loss has occurred in past programs. This sounds like a lot but the loss is at a point in production where it is the cheapest. Sheet metal tools and sheet metal parts are the greatest affected. The cost of these items when compared to the cost of the same items under the old system, is negligible, and the wrong or spoiled parts because of hand methods, are practically eliminated. Further, expensive castings and forgings are not involved since nearly all parts of this nature must necessarily be machined from raw stock in the beginning. The real saving in cost is in the lower labor cost of producing the first several production models. The cost of the first production aircraft will be reduced to the point where the cost will now be in the general area of 15 to 20 man hours per pound where 25 to 40 is more normal under previous methods. Take this difference over 20 tons of airframe and a considerable saving has resulted."

The Avro Arrow was designed as a "Weapons System", -in other words, a totally integrated system in which every factor affecting combat performance was to be coupled with every other item at the earliest possible stage of design. This meant that the airframe, engine(s), avionics, armament, test and support equipment, trainers, tools, trials etc, were all designed as a package. During the design of the airframe, Production Planning had to keep pace. Planning is the vital part of producing the aircraft -how to split it up into components, how to locate each detail part of each component and in what sequence they were to be assembled. At the same time, the Interchangeability Control Points have to be established, incorporated into the Jig References, and located in the Jigs, in preparation in preparation for receiving the parts and Flow Charts incorporating all of this had to be prepared.

A selection of component drawings, flow charts, loft drawings, jig and jig reference drawings is offered in order to give an insight into the difficulties and complexities facing the designers, planners, tool designers and production personnel in producing the Arrow.

One fact that was not, and still is not known to many people, is that a lot of the design work was carried out by Sub-Contractors, in some cases in the United States. At least one wind tunnel model was designed and produced by Cornell Aeronautical Laboratories in Buffalo, New York, and quite a lot of the Tool Design was carried out by Sub-Contractors, for instance;

1. Aero Detroit. 2. Aero Car. 3. Krumm-Young. 4. Miller-Naismith.

These companies were responsible for the design of the large assembly jigs and in some cases, the jig references. Avro Tool Design of course, designed the rest - the machining fixtures, press tools, drill jigs, etc, and kept them updated with changes. This was done as a matter of expediency, cost, time and experience. The American firms had more experience in the design and construction of large welded constructions.

Some of these designs are re-produced here so that as we progress through the descriptions of the manufacturing processes, the reader can refer to them for explanation.

APPLICATION OF THE THEORY TO CF-105 TOOLING POLICY.

On May 2/55, Harvey R Smith, Vice President - Manufacturing at Avro, issued a memorandum stating the tooling policy for the CF-105 and at the same time, cleared up wrong impressions that were circulating not only at Avro, but with the DDP and the RCAF as well. This concerned "Phase 1 and Phase 2 tooling". This policy was created at the time when Avro was considering the proper ways and means of producing the first several airplanes only, and assuming that there would be a sizable time gap between the first several and subsequent production airplanes.

In his memo, Smith outlined that, if the Company were to build a few airplanes with some time between each one, then the policy of "Phase 1 and phase 2" would hold, as doubtless there would be many modifications to the airframe which in turn would necessitate changes to the tooling, and therefore the tooling would have been of a different nature than that required for mass production. It must be remembered that the aircraft had not been ordered in large quantities at first, hence the reason for "Phase 1 and phase 2". However, with the order for up to 40 aircraft, this definition became superfluous and "hard" production type tooling was designed and built.

The CF-105 airplane was fully recognized by all to be an extremely advanced type of airplane that required very careful co-ordination of tooling in order that everything fitted together at the final assembly stage in perfect order.

With this in mind, the goal was to incorporate full interchangeability from aircraft number one. To achieve this, every part had to be carefully scrutinized by Production Planning, tools designed to control this and full use made of the Master Models in the construction of dies, jigs etc., for the manufacture of complex exterior sheet metal parts.

For these purposes, the "Cooke-Cragie" system was adopted. This system, in which "hard", or production type tooling is used from the outset, eliminates the need for a hand-built prototype, (which had been done prior to the CF-105), and that subsequent aircraft could be supplied in short order.

To this end, let us take a look at typical examples of tooling and its applications on the CF-105.

BASIC REQUIREMENTS.

Two basic factors had to be considered in the preparation of the tooling program for the CF-105.

(a) It was recognized that this aircraft was of an extremely advanced type performance-wise, and meant that a very high degree of envelope accuracy and surface smoothness were mandatory to ensure aerodynamic efficiency.

To summerize, Avro's approach was to provide only that necessary and simple tooling for difficult operations; where interchangeability control was required; or where the extensive set-up involved would jeopardize the required production rate.

THE MASTER MODELS.

As noted in the Design part of this treatise, the basic lines of the aircraft were determined after extensive wind tunnel testing and the application of AREA RULE. These lines were then drawn to the INSIDE SKIN line to a very high degree of accuracy and were then used to control the construction of full scale master models. These master models served two purposes: first, they proved the lines by the act of splining in the templates and, secondly, by filling in each model three-dimensionally to the correct skin profile, they provided an accurate pattern for the manufacture of production tooling. To begin with, all the drawings, or lofts, were drawn on thin glass-cloth, this material having flexibility, durability and excellent dimensional stability. Master Control Templates, or MCT's, were then prepared by exposing photo-sensitized dural sheet of .051 in. thickness against the glass cloth drawing, (a photographic contact print). Templates too large to be reproduced from a single loft drawing (the limit was 16ft x 4ft. 6in.), were built up from sections spliced together with butt-joints. Symmetrical patterns were formed by printing from both sides of a half-loft-drawing, matching the axis of symmetry.

Two MCT's were produced, one of which was retained in the template library and the other built into the master model concerned. The master models were each built up on a surface table, upon which was mounted a vertical steel column with a true square section to provide four faces from which to work. On these faces, the MCT's were positioned by an optical transit, or columator, and clamped, doweled and secured. When all the templates had been proven as to their being in their correct positions, tie-rods were pushed through holes about an inch in from the edge of each template, and the spaces between the templates were wrapped with brass or bronze mesh. Kish Epoxy 203 or 407, a low cost plastic with an asbestos filler was then applied over the mesh and to about 1/8in. below the finished surface. The final contour was then completed by applying a finishing coat of 418T splining resin which was then splined to the templates. The resulting surface was then checked for accuracy and adjusted if required, and the model was then completed with the addition of station, trim and butt-joint lines.

After each model was completed, it was checked to see if there were any corrections to be made to the original glass-cloth lofts. Direct casts could then be taken from these models and stretch-form or drop-hammer tooling could then be made, the dies generally being made from KIRKSITE, with about 1/8in. facing of cast Epoxy. Fibre-glass drill and router jigs could be cast directly from the model and upon completion, the aircraft parts that they made could be re-applied to the master models for checking.

(b) In order to provide the most safe and efficient use of the aircraft in Service Handling, a high degree of interchangeability was desirable.

These two basic requirements created the necessity for Avro's "Master Model Program" for envelope control, and the "Interchangeability Tooling Program" for interchangeability control. The main approach to "detail" and "sub-assembly" tooling, was dictated largely by economy, however the final assembly fixtures had full provision for maintaining the requisite interchangeability points in their proper relative positions.

ENGINEERING INFORMATION FOR THE TOOLING PROGRAM.

MASTER LINES GLASS CLOTHS.

As soon as the "envelope" or shape of the aircraft was defined, full scale layouts of the "master lines" were drawn on glass cloth. These master lines glass cloths were reproduced onto other glass cloth sheets for the purpose of filling in the actual structural details in the area concerned. These were the Assembly Glass Cloths and were merely the full scale master lines glass cloths repeated exactly, plus the inside envelope details. In addition, Basic Geometry Drawings were supplied by Engineering to define interchangeability locations.
Master Lines Glass Cloth reproductions on metal were used for the "envelope" tooling control. The assembly glass cloth was the basis for part manufacture and associated tooling.

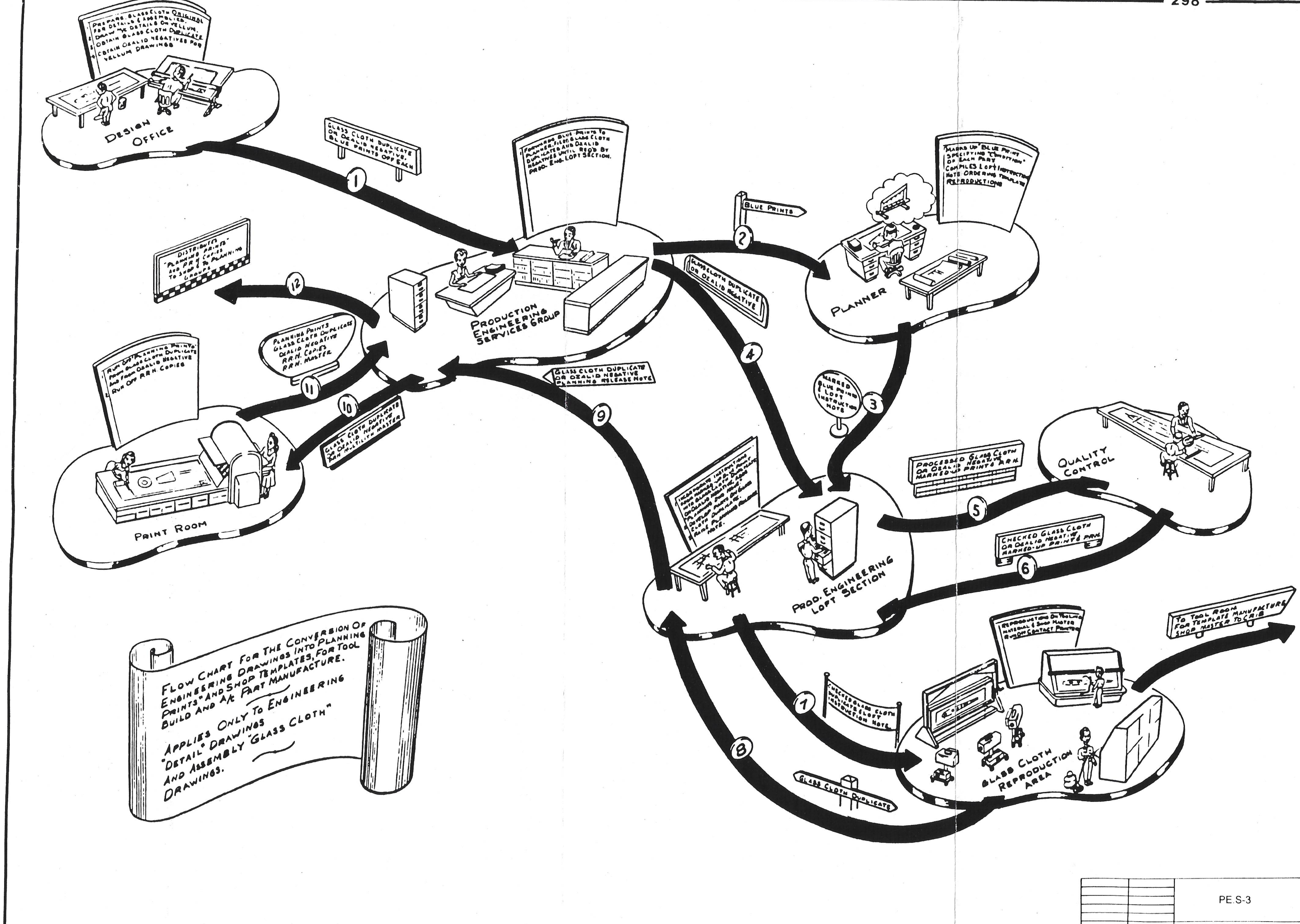
TOOLING FOR MACHINED PARTS.

The following illustrations show three typical machined parts together with the required tooling. The basic policy at Avro with regard to these and similar other parts, was to provide the minimum number of tools, consistent with the quality required for the particular parts in question.

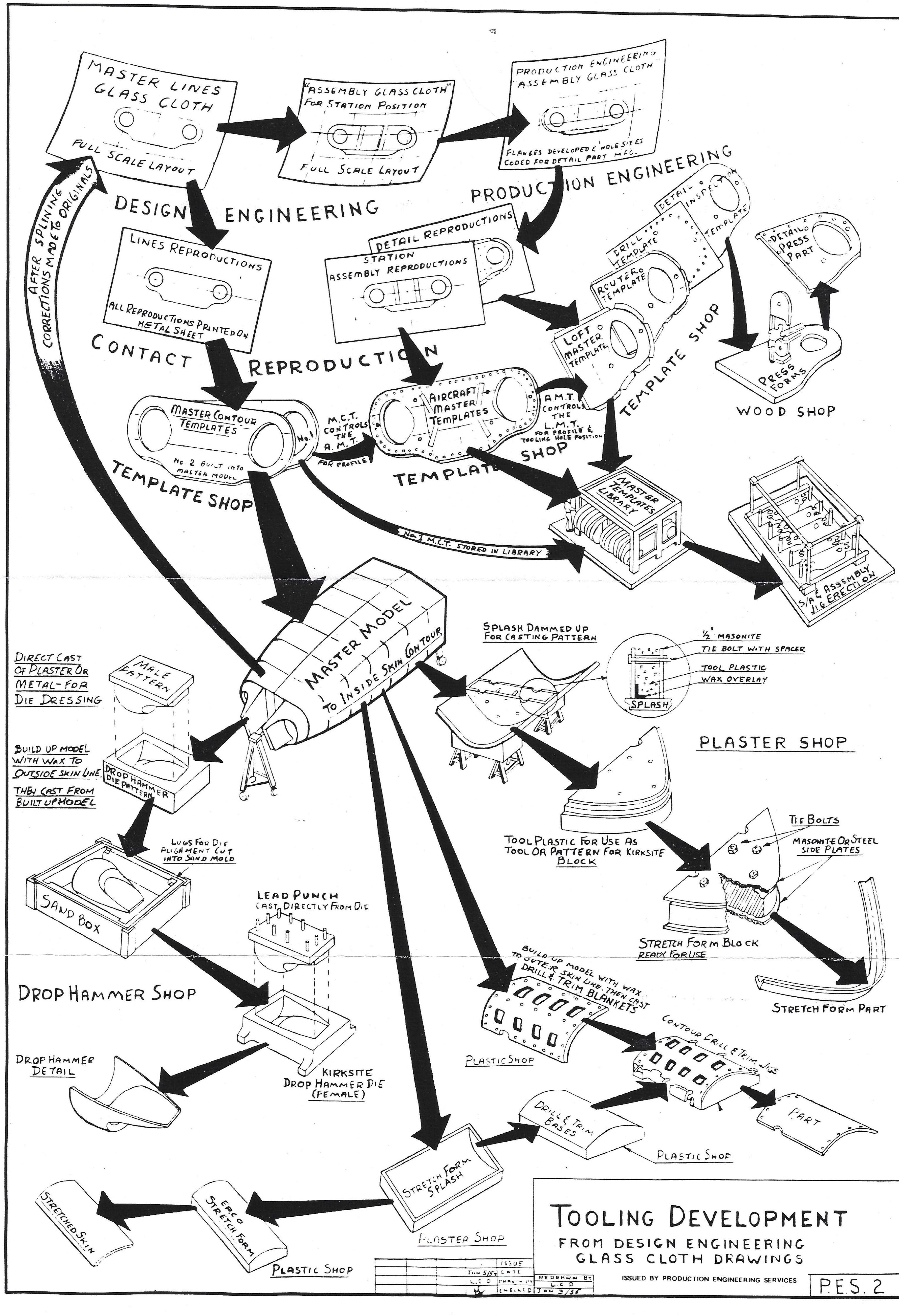
(1). An example of a part which was made without special tools, using only the standard equipment available in the shops.

(2). An example of a more complex part and the simple type of fixtures provided to maintain the necessary dimensional control.

(3). An example of a part where interchangeability was required. This required the use of a slightly more complex drill jig to ensure matching of the hole pattern with the mating part. The remainder of the operations are performed with the simple tool shown, and standard set-ups on existing equipment.



Design Office
1. Prepare Glass Cloth Original for Details & Assemblies. Draw A/C Details on Vellum.
2. Obtain Glass Cloth Duplicate
3. Obtain Ozalid Negatives for
4. Obtain Ozalid Vellum Drawings
Glass Cloth Duplicate or Ozalid Negative. Blue Prints off Each
1
Production Engineering Services Group
1. Forwards Blue Prints to Planner, Files Glass Cloth Duplicates and Ozalid Negatives until Req'd by Prod. Eng. Loft Section.
2
Blue Prints
Planner
Marks up "Blue Print" Specifying "Condition" of Each Part
Compiles Loft Instruction Note Ordering Template Reproductions
Glass Cloth Duplicate or Ozalid Negative
4
Marked Blue Print & Loft Instruction Note
3
Distributes "Planning Prints" and P.R.N. Copies to Shop & to Planning Groups
12
Planning Prints
Glass Cloth Duplicate
Glass Cloth Negative
Ozalid Negative
P.R.N. Copies
P.R.N. Master
11
1. Run off "Planning Prints" from Glass Cloth Duplicate and from Ozalid Negative
2. Run off P.R.N. Copies
10
Glass Cloth Duplicate or Ozalid Negative P.R.N. Multilith Master
Print Room
Glass Cloth Duplicate or Ozalid Negative Planning Release Note
9
Prod. Engineering Loft Section
Processed Glass Cloth or Ozalid Negative P.R.N. Marked-up Prints
5
Quality Control
Checked Glass Cloth or Ozalid Negative P.R.N. Marked-up Prints
6
7
Checked Glass Cloth Duplicate & Loft Instruction Note
8
Glass Cloth Duplicate
Reproductions on Tooling Material & Shop Master Run on Contact Printer
Glass Cloth Reproduction Area
To Tool Room for Template Manufacture Shop Master to Crib
Flow Chart for the Conversion of Engineering Drawings into Planning Prints and Shop Templates, for Tool Build and A/C Part Manufacture.
Applies Only to Engineering "Detail" Drawings and Assembly "Glass Cloth" Drawings.
PE.S-3

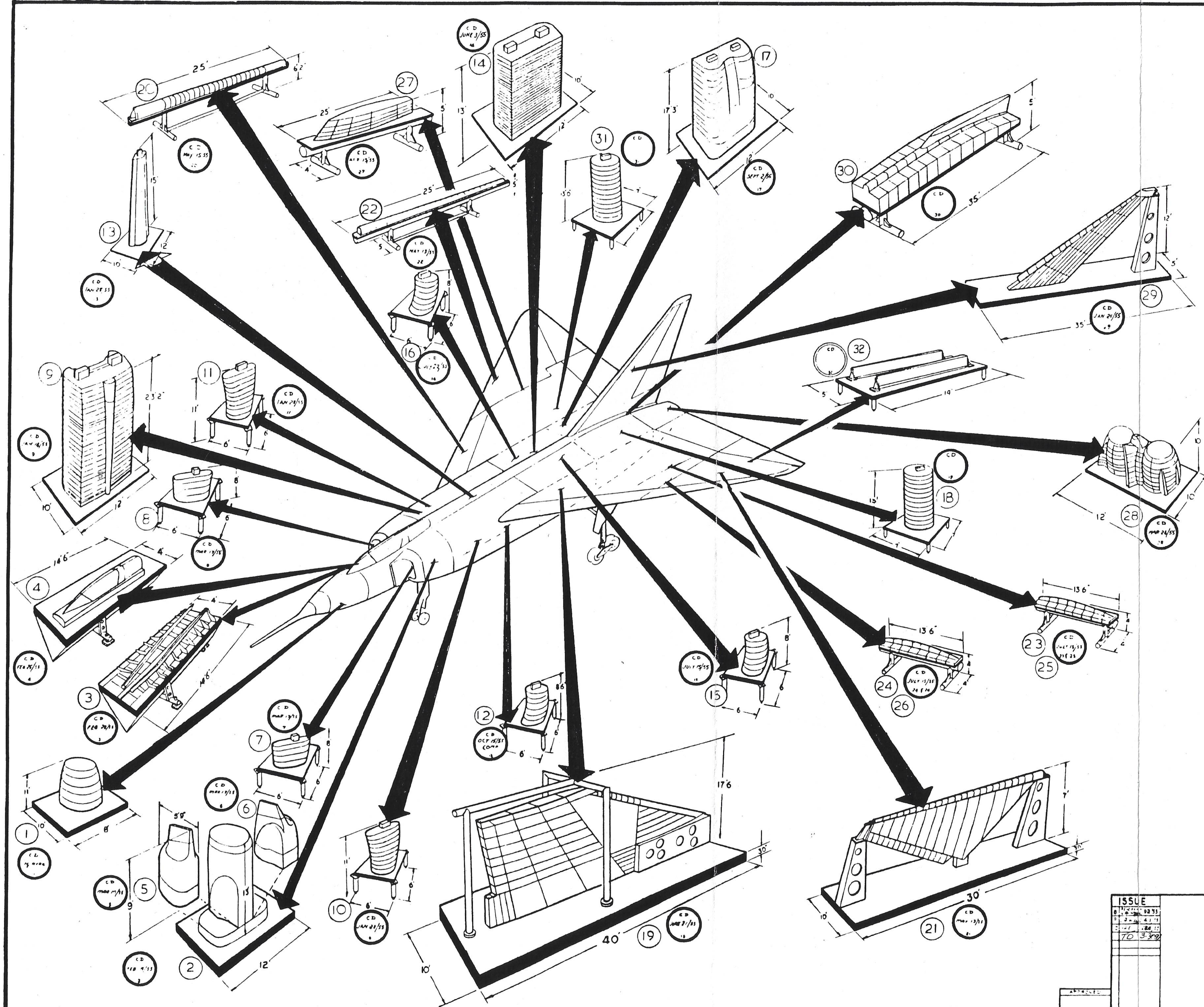


TOOLING DEVELOPMENT

FROM DESIGN ENGINEERING GLASS CLOTH DRAWINGS

ISSUED BY PRODUCTION ENGINEERING SERVICES

P.E.S. 2



	COMPONENT DESCRIPTION	COMPONENT TOOL
1	RADAR NOSE	7-1051-1-MM1
2	FUSELAGE NOSE	7-1052-1-MM1
3	TOP DECKING	7-1052-1-MM2
4	WINDSHIELD CANOPIES & FAIRINGS	7-1053-1-MM1
5	AIR INTAKE L.H.	7-1055-1-MM1
6	AIR INTAKE R.H.	7-1055-2-MM1
7	LEAD IN AIR DUCT	7-1055-1-MM2
8	LEAD IN AIR DUCT	7-1055-2-MM2
9	CENTRE FUSELAGE	7-1054-1-MM1
10	CENTRE FUSELAGE AIR DUCT FWD L.H.	7-1054-5-MM1
11	CENTRE FUSELAGE AIR DUCT FWD R.H.	7-1054-6-MM1
12	CENTRE FUSELAGE AIR DUCT AFT LH&RH	7-1054-3-MM2
13	CENTRE FUSELAGE TANK PORTION	7-1054-9-MM1
14	DUCT BAY	7-1056-2-MM1
15	DUCT L.H.	7-1056-11-MM1
16	DUCT R.H.	7-1056-12-MM1
17	ENGINE BAY. OUTSIDE SKIN	7-1058-3-MM1
18	ENGINE BAY DUCT. L.H.	7-1058-1-MM2
19	INNER WING. L.H. & L.E.	7- 1062-3-MM1
20	I/W LEADING EDGE R.H.	7-1062-6-MM1
21	OUTER WING L.H. & L.E.	7-1064-1-MM1
22	O/W LEADING EDGE. R.H.	7-1065-1-MM1
23	I/W & O/W JOINT FAIRING. L.H. TOP	7-1062-3-MM2
24	I/W & O/W JOINT FAIRING. L.H. BOTTOM	7-1062-3-MM3
25	I/W & O/W JOINT FAIRING. R.H. TOP	7-1062-4-MM2
26	I/W & O/W JOINT FAIRING. R.H. BOTTOM	7-1062-4-MM3
27	I/W & O/W TRANSPORT JOINT. R.H.	7-1062-4-MM1
28	REAR FUSELAGE	7-1059-1-MM1
29	FIN	7-1083-1-MM1
30	WING FIN FAIRING	7-1062-1-MM7
31	ENGINE BAY DUCT. R.H.	7-1058-1-MM3
32	AILERON CONTROL BOX. L.H.	7-1064-5-MM1
	AILERON CONTROL BOX. R.H.	7-1065-6-MM1

ISSUE

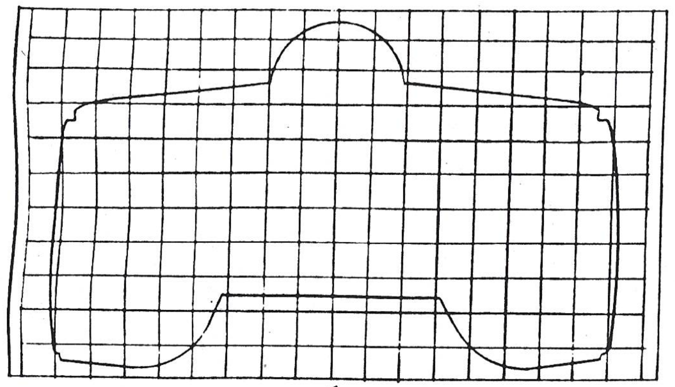
C-105
MASTER MODELS

4300-PE-6

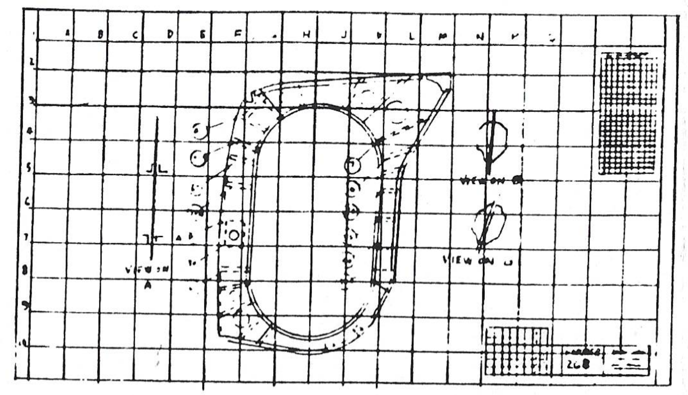
Master Gauges

APPLICATION OF LOFTS TO MASTER MODELS.

MASTER LINES GLASS CLOTH OF STA 268.



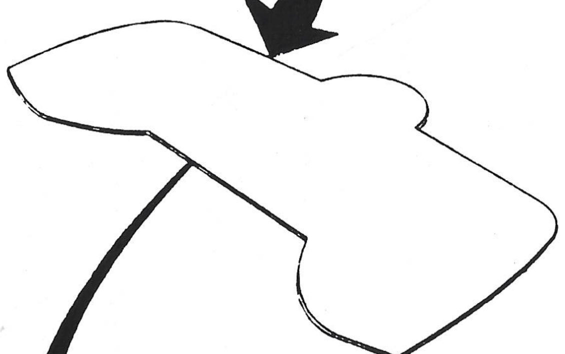
ASSEMBLY GLASS CLOTH OF STA 268.



MASTER LINES GLASS CLOTH IS CONTACT PRINTED ONTO TEMPLATE MATERIAL.

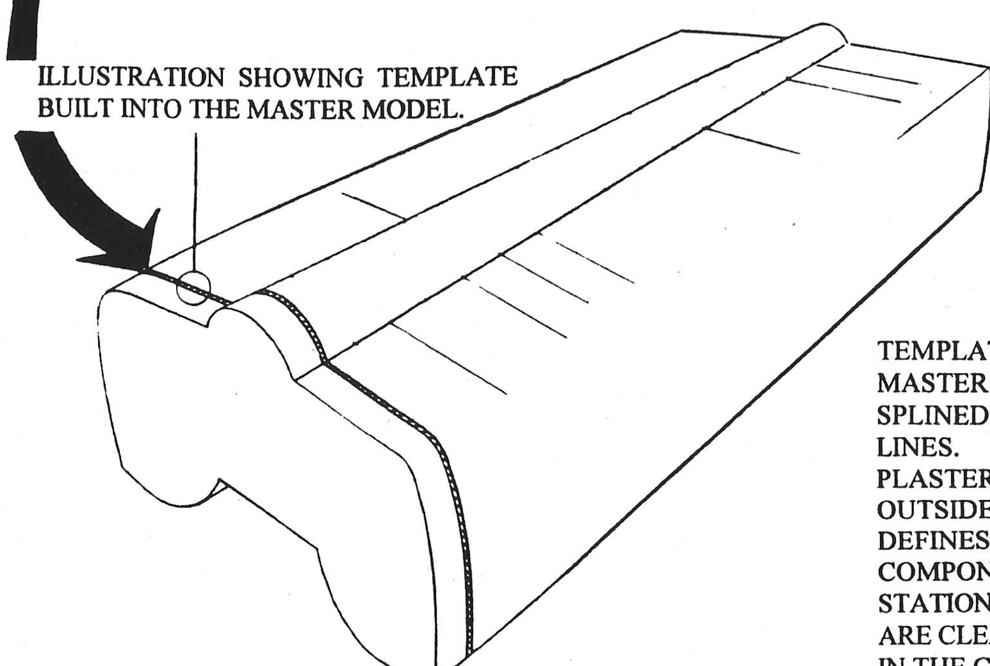
"MASTER LINES GLASS CLOTH" AFTER HAVING BEEN PRINTED TO PROVIDE MCT'S FOR THE MASTER MODEL IS CONVERTED INTO AN "ASSEMBLY GLASS CLOTH" BY DRAWING IN THE STRUCTURE DETAILS IN FULL SCALE.

PROFILE SHOWN ON THIS DRAWING IS IDENTICAL WITH THAT OF THE MASTER MODEL.



MASTER CONTOUR TEMPLATE (MCT),FOR STA.268 MADE FROM THE CONTACT PRINT.

ILLUSTRATION SHOWING TEMPLATE BUILT INTO THE MASTER MODEL.



TEMPLATES ARE MOUNTED ON THE MASTER MODEL FRAMEWORK AND SPLINED IN TO PROVE THE MASTER LINES. FRAMEWORK IS THEN PLASTERED IN TO FORM THE MODEL. OUTSIDE SURFACE OF THE MODEL DEFINES THE "ENVELOPE" OF THE COMPONENT. ALL DATUM LINES, STATION LINES AND SKIN TRIM LINES ARE CLEARLY SHOWN ON THE MODEL IN THE CORRECT POSITIONS.

USE OF MASTER MODELS IN TOOLING.

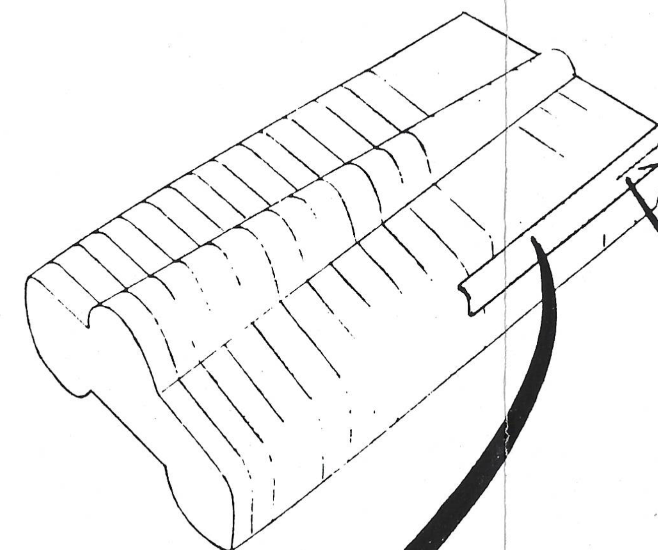
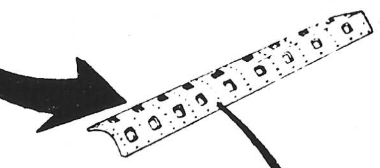
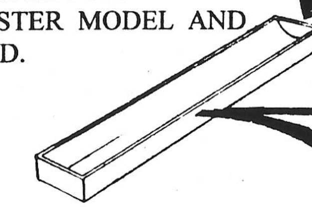


ILLUSTRATION OF CENTRE FUSELAGE MASTER MODEL POINTING UP A SKIN PANEL FOR STRETCH FORMING.

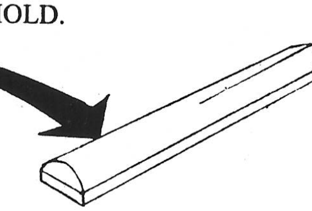
DRILL AND TRIM BLANKET BUILT UP FROM MASTER MODEL.



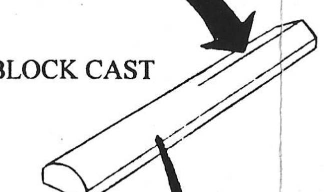
SPLASH AND STRETCH FORM BLOCK TAKEN FROM MASTER MODEL AND MADE INTO A MOLD.



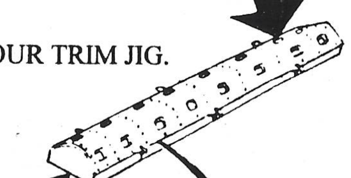
DRILL AND TRIM BASE CAST INTO THE MOLD.



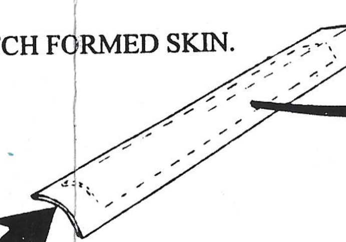
PLASTIC STRETCH FORM BLOCK CAST INTO THE MOLD.



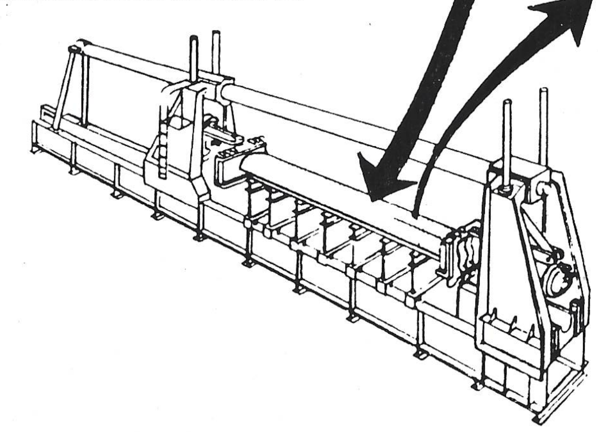
DRILL AND CONTOUR TRIM JIG.



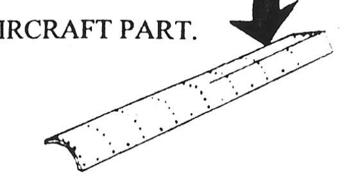
STRETCH FORMED SKIN.



STRETCH FORMED SKIN.. SKIN BEING STRETCH FORMED ON THE AVRO STRETCH FORM MACHINE.

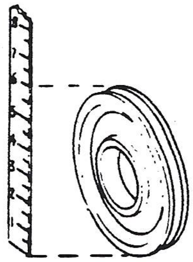


FINISHED AIRCRAFT PART.

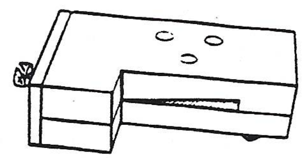
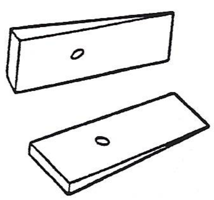
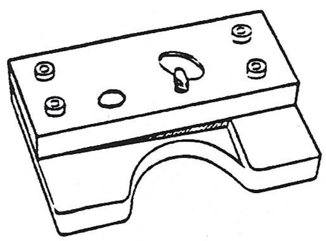
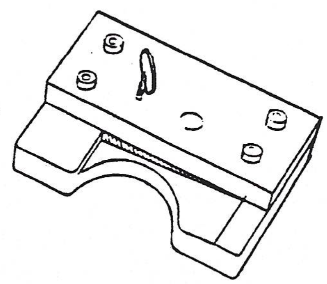


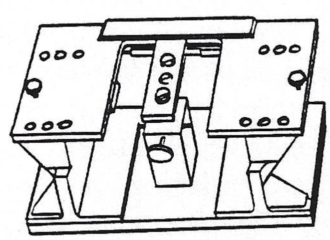
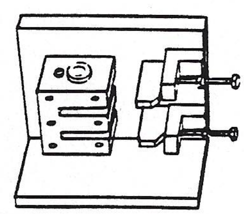
MACHINED PARTS WITH AND WITHOUT FIXTURES.

1. TYPICAL MACHINED ITEM MADE FROM BAR STOCK WITHOUT SPECIAL TOOLING.

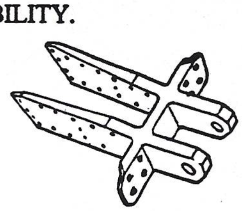
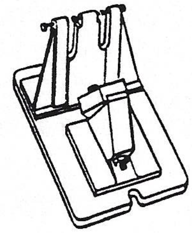
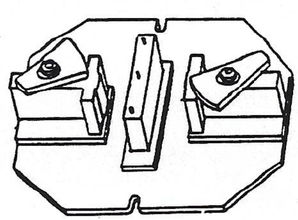
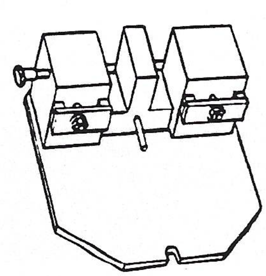


2. TYPICAL MACHINED ITEM MADE FROM BAR STOCK WITH ONLY THE ESSENTIAL TOOLING;- THE PART IS HANDED BY THE DEGREE OF TAPER.

3. COMPLEX PART MADE FROM BAR STOCK. THIS PART REQUIRES THE USE OF MORE COMPLEX TOOLING TO ENSURE THE NECESSARY INTER-CHANGEABILITY.

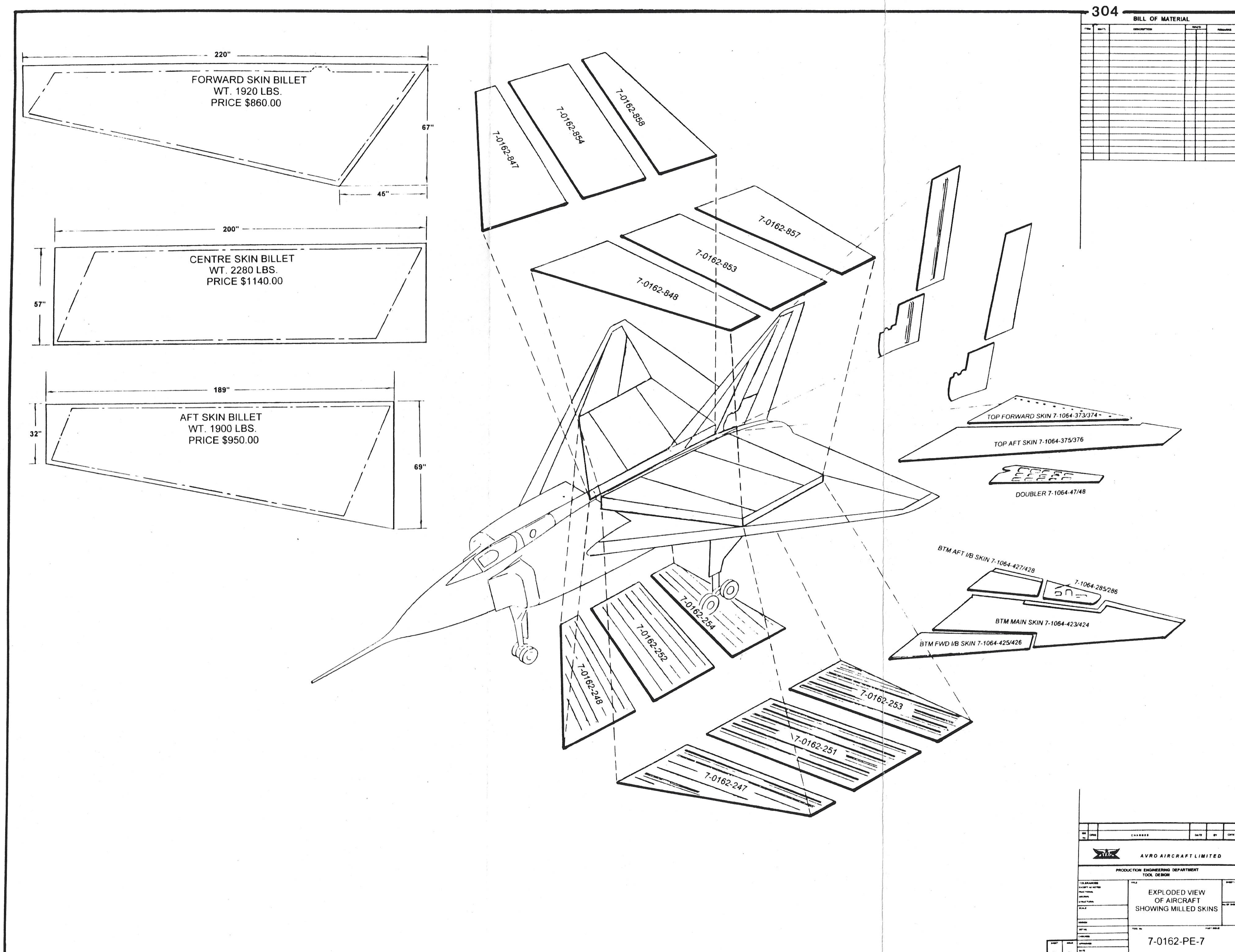
WING SKINS.

In a paper entitled "Machining Approach To Aircraft Production", Harold Young, Avro's Production Engineering Manager, stated "very early in the design scheme stages, it was determined that integrally stiffened skins and completely machined structural members were necessary in order to meet the design requirements". Investigations were conducted both in the United States and the United Kingdom, where several Companies had learned to their cost, that unless the plates were stress-relieved before machining, disastrous distortions could result. It was established that a stretch of some 2% was required. At the time, the size limit for stretching was 140 sq.ins. cross section with a plate thickness of 3" requiring a stretch pull of 6,000,000 lbs.

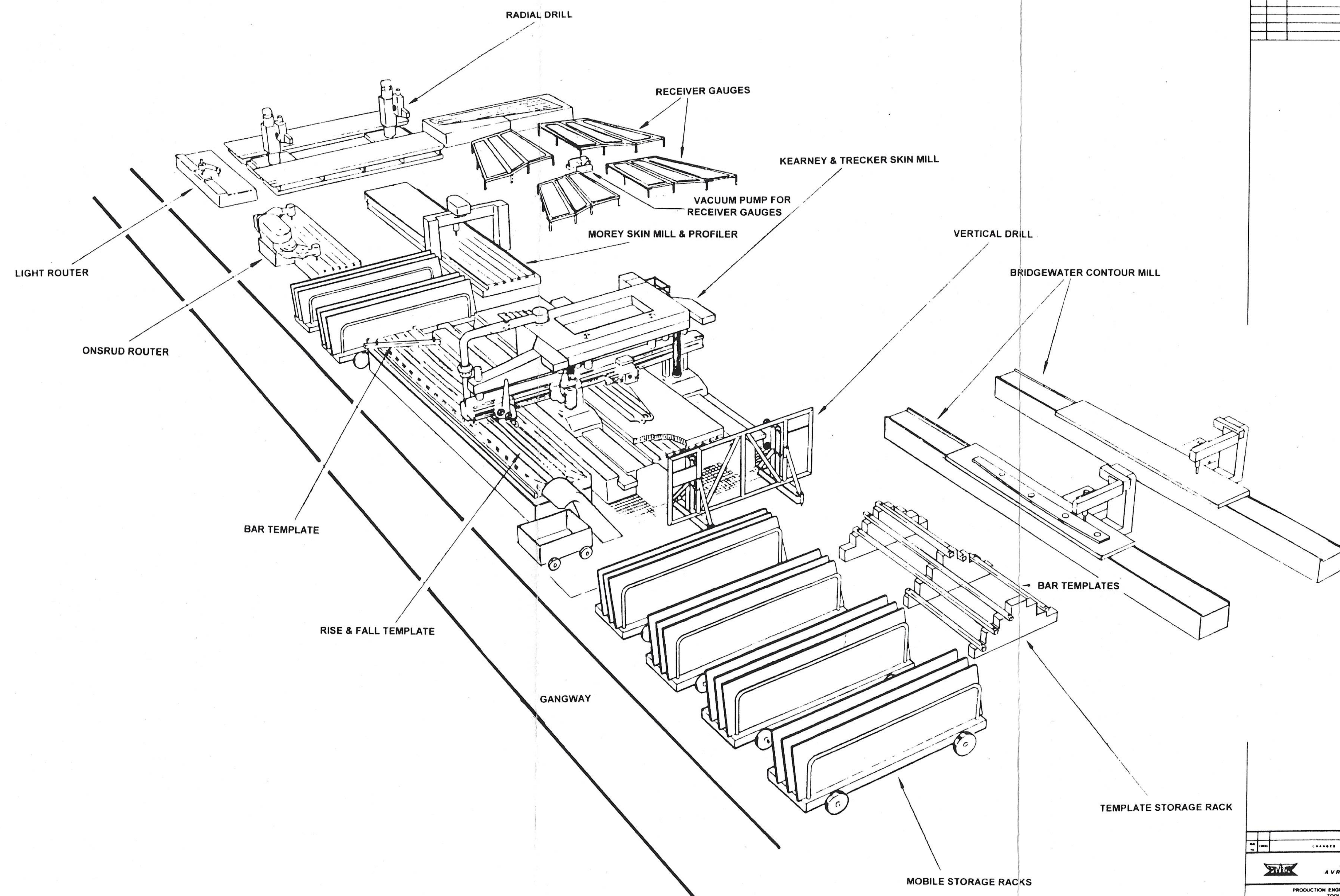
Typical of the machines used at Avro to machine the wing skins was a 200-ton Kearney and Trecker skin mill, which was the biggest one made by that Company. It was made to Avro specifications, and although it cost Kearney and Trecker over $1,000,000, Avro was charged only $350,000 as the Milwaukee company hoped to recover from additional sales of $600,000 each.

The work table of this machine, was 28ft.x9ft. although extra sections could be added. In order to maximize floor space, the table was stationary and the cutters mounted on a movable over- head gantry. The basic gantry speed was 30ins./min., but on a straight through cut with the rise and fall tracer control, a feed of 100 ins./min. was possible, whilst for conventional milling the speed could have risen to 160 ins./min., and 240 ins./min. was adopted for rapid traverse without cutting.

The work pieces were retained by a vacuum chuck built into the table which was pivoted on a vertical axis to allow for the milling of tapered webs. Machining was conducted on a direct copying basis from a template, mounted on an adjacent table, across which moved a stylus with an 8oz. contact pressure; the stylus readings were transmitted to an electronic centre which released the desired pattern to the 70-ton cutter head. This head comprised horizontal and vertical heads, one rated at 50 HP at 1,800 rpm, and the other at 100 HP at 3,600 rpm.; both heads could tilt up to 5 degrees. It was quite an experience to watch this mill at work. A typical slab of high-strength light alloy weighing some 2,280 lbs. was positioned on the table and secured by the vacuum chuck. Using a 10 in. diameter cutter at 3,600 rpm, and employing rise and fall tracing for thickness variation, as the Arrow wing skins were tapered, it was possible to maintain a feed of 100 in./min. on a cut 1 1/2 ins. deep and 2 1/2 ins. wide, with a resulting metal removal of 375 cu.ins./min. The coolant system provided a flood flow of over 62 gallons/min. in order to maintain correct tool temperatures. Finally, and upon completion of the machining, a finished wing skin weighing some 290 lbs. was removed from the table.


BILL OF MATERIAL
220"
FORWARD SKIN BILLET
WT. 1920 LBS.
PRICE $860.00
67"
46"
200"
CENTRE SKIN BILLET
WT. 2280 LBS.
PRICE $1140.00
57"
189"
AFT SKIN BILLET
WT. 1900 LBS.
PRICE $950.00
32"
69"
7-0162-847
7-0162-854
7-0162-858
7-0162-857
7-0162-853
7-0162-848
TOP FORWARD SKIN 7-1064-373/374
TOP AFT SKIN 7-1064-375/376
DOUBLER 7-1064-47/48
BTM AFT I/B SKIN 7-1064-427/428
7-1064-285/286
BTM MAIN SKIN 7-1064-423/424
BTM FWD I/B SKIN 7-1064-425/426
7-0162-254
7-0162-252
7-0162-248
7-0162-253
7-0162-251
7-0162-247
CHANGES
DATE
BY
CHK'D
AVRO AIRCRAFT LIMITED
PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN
TOLERANCES
EXCEPT AS NOTED
FRACTIONAL
DECIMAL
STRUCTURAL
SCALE
DETAIL
CHECKED
APPROVED
DATE
TITLE
EXPLODED VIEW
OF AIRCRAFT
SHOWING MILLED SKINS
TOOL No.
7-0162-PE-7

BILL OF MATERIAL



AVRO AIRCRAFT LIMITED

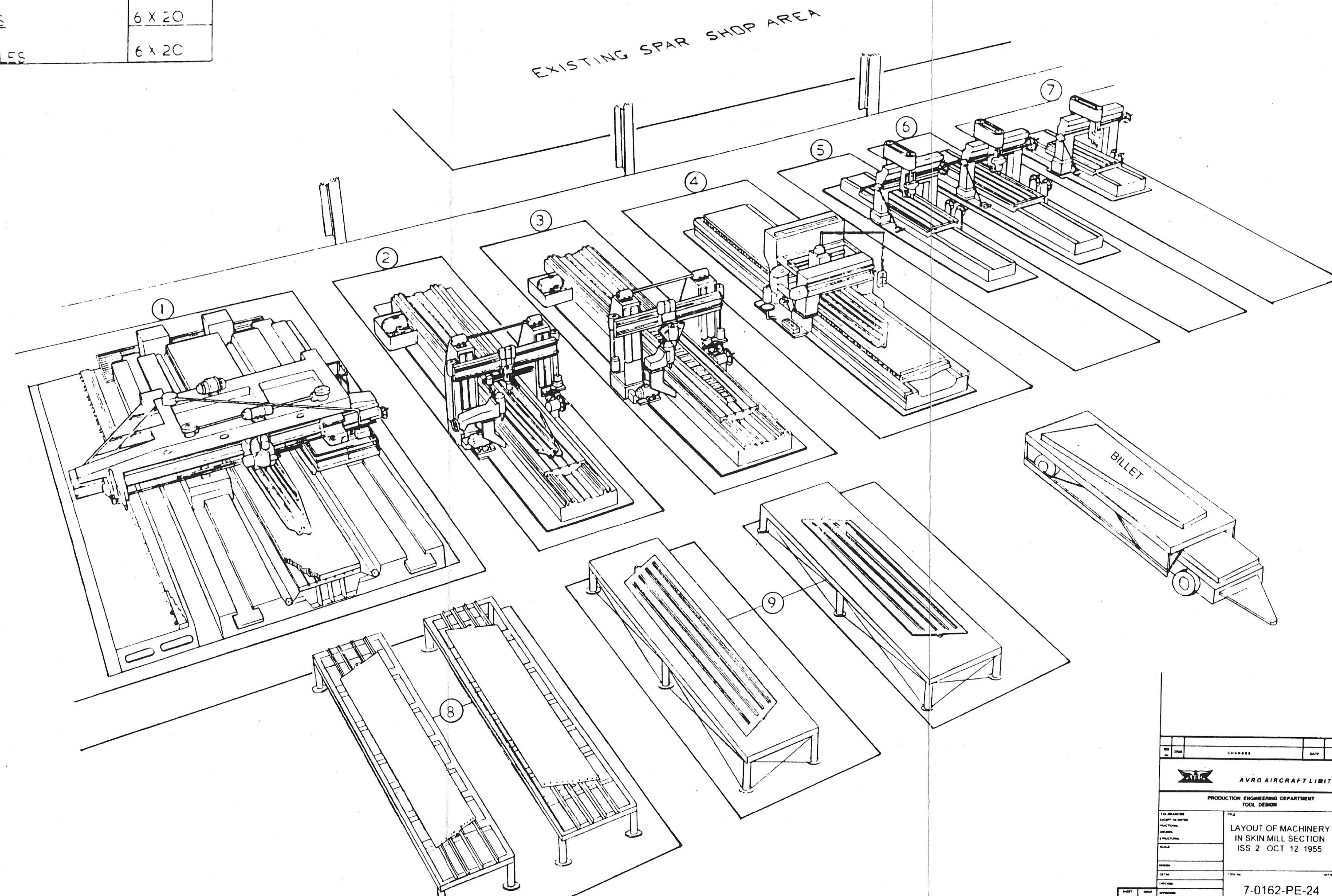
PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN

LAYOUT OF MACHINERY
IN SKIN MILL SECTION
ISS 2 OCT 12 1955

7-0162-PE-24

BILL OF MATERIAL

		TABLE SIZE
1	KEARNEY & TRECKER SKIN MILL	28 X 9
2	MOREY 50M SKIN MILL	6 X 20
3	MOREY 50M PROFILE MILL	6 X 20
4	ONSRUD INVO-MILL	6 X 20
5	MOREY 50M PROFILE MILL	4 X 8
6	MOREY 50V PROFILE MILL	4 X 8
7	MOREY 40M PROFILE MILL	3 X 4
8	WORK TABLES	6 X 20
9	SURFACE TABLES	6 X 20



CHANGES | DATE | BY | CHK'D

AVRO AIRCRAFT LIMITED

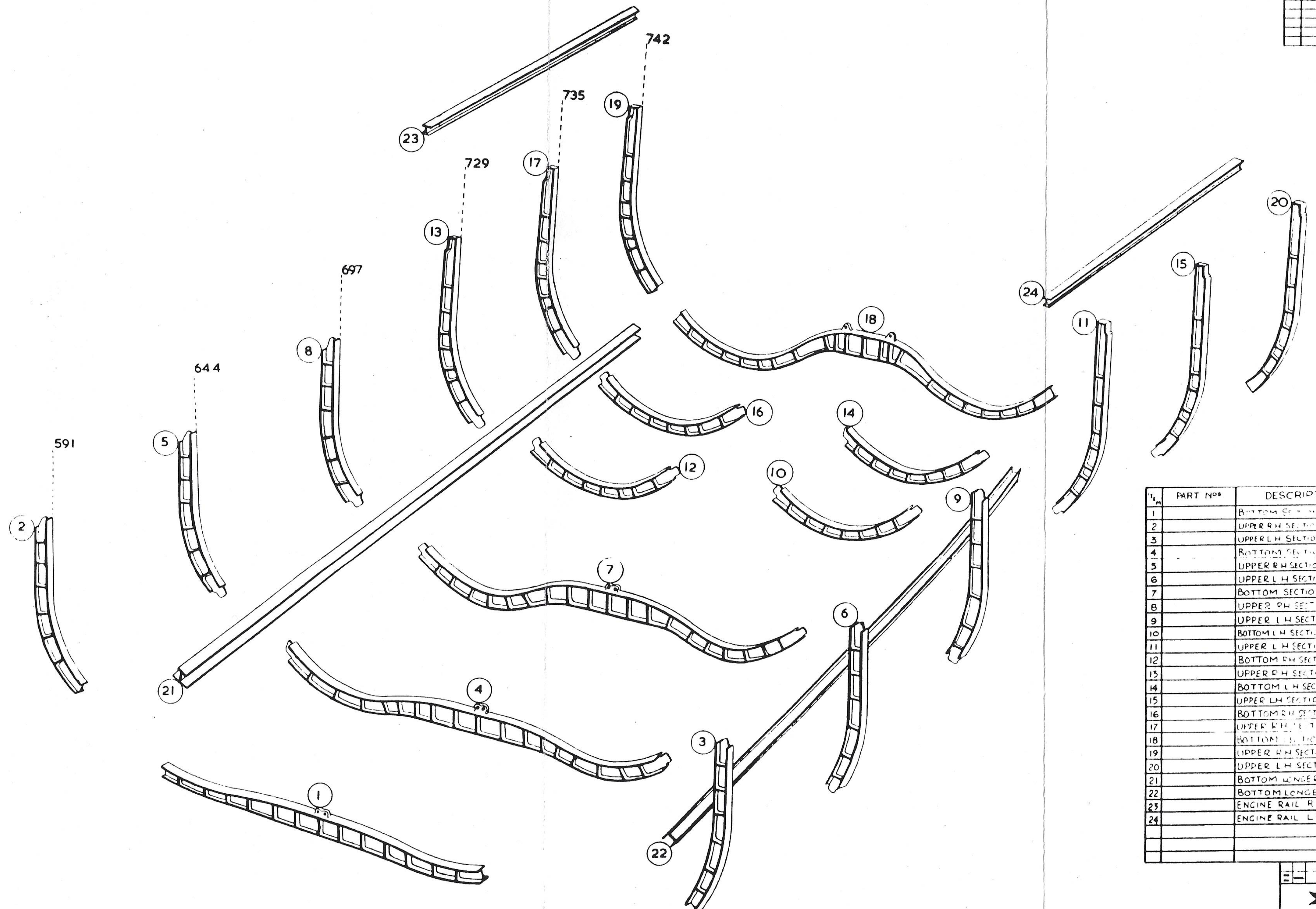
PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN

TOLERANCES EXCEPT AS NOTED
FRACTIONAL
DECIMAL
STRUCTURAL
SCALE

LAYOUT OF MACHINERY
IN SKIN MILL SECTION
ISS 2 OCT 12 1955

7-0162-PE-24

BILL OF MATERIAL



ITEM	PART Nos	DESCRIPTION	TOOL ... DATE ESSENTIAL	TOOL ... DATE COMPLETE	PART COMPLETION
1		BOTTOM SECTION 591			
2		UPPER R H SECTION 591			
3		UPPER L H SECTION 591			
4		BOTTOM SECTION 644			
5		UPPER R H SECTION 644			
6		UPPER L H SECTION 644			
7		BOTTOM SECTION 697			
8		UPPER RH SECTION 697			
9		UPPER L H SECTION 697			
10		BOTTOM L H SECTION 729			
11		UPPER L H SECTION 729			
12		BOTTOM RH SECTION 729			
13		UPPER R H SECTION 729			
14		BOTTOM L H SECTION 735			
15		UPPER LH SECTION 735			
16		BOTTOM R H SECTION 735			
17		UPPER R H SECTION 735			
18		BOTTOM SECTION 742			
19		UPPER R H SECTION 742			
20		UPPER L H SECTION 742			
21		BOTTOM LONGERON RH			
22		BOTTOM LONGERON LH			
23		ENGINE RAIL RH			
24		ENGINE RAIL LH			

AVRO AIRCRAFT LIMITED

PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN

DIFFICULT MAJOR
MACHINE PARTS
ENGINE BAY MK II

DATE MARCH 57

PS - 13 PE 58 - 003

Additional mills were added to this one as follows:-

1. Morey 50M Skin Mill. Table size 6ft.x20ft.

2. Morey 50M Profile Mill. Table size 6ft.x20ft.

3. Onsrud Invo-Mill. Table size 6ft.x20ft.

4. Morey 50M Profile Mill. Table size 4ft.x8ft. - 2 Installed.

5. Morey 40M Profile Mill. Table size 3ft.x4ft.

6. In addition, work and surface tables were also provided.

FORGINGS.

The use of dies to forge parts for the Arrow were held to a minimum due not only to their cost, but the relatively small quantities required. Therefore, hand forging was employed for most parts. Most of the early experience with hand forgings was achieved with 75S and 14S high-strength light alloy, but distortion with machining was prevalent and it became necessary to machine initially to within .125 ins. to .25 ins. above the finished size and then heat treat before finish machining. A new alloy was developed, the 79S which was received in the T8E13 condition which required no heat treatment after machining. Tests conducted on the new material indicated that heavier cuts could be taken and still preserve the distortion-free qualities. At the time however, the 79S alloy was restricted to hand forgings with two parallel sides not more than 6 ins. apart and with a maximum cross section of 72 sq.ins.

PRESS-WORK.

Another new tool which Avro purchased for the Arrow, was a rubber press of advanced design, which, at the time was probably the largest in the world. It was designed to Avro specifications by Siempelkamp of Krefeld, Germany, and could exert a total force of 15,000 tons on a pad measuring 120ins.x60ins.x12ins. Unusual features of the design were that the main frame was constructed from metal laminations in groups of six, each lamination weighing 10 tons, and that the 19 in. working stroke was applied from below with the loading table being forced upwards into the pad.

JIGS AND FIXTURES.

Jigs ranged from bench drill jigs to plate type assembly jigs to large and small floor mounted assembly jigs. The manufacture of these tools ranged from alloy plate or magnesium tooling plate jigs to both welded tubular and angle frames coupled with cast sections for some of the larger assembly jigs. In all cases concerning assembly jigs, the jig references were used to control the interchangeability control points so that each aircraft component produced on its jig would mate with the adjoining component. It can readily be appreciated that strict control had to be applied in order that each component would mate with adjoining components.

APPLICATION OF INTERCHANGEABILITY CONTROL - JIG REFERENCES.

JIG REFERENCES.

Jig references are tools used to set-up assembly jigs at those points where interchangeability control is required, to ensure that mating components built in their respective assembly jigs will go together accurately when married up. When marrying up two components, it is essential that the overall alignment is correct and that at the point of joining:

(a) The mating surfaces butt smoothly.

(b) The holes for the attachment bolts line up.

(c) The skin line flows smoothly across.

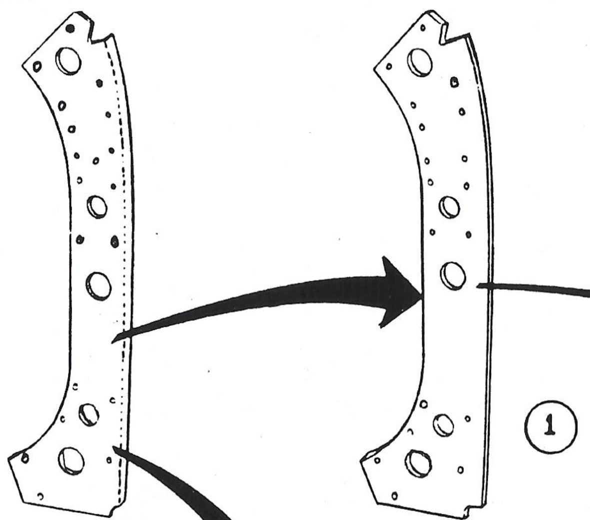
(d) The skin gap is within the required tolerance.

While this is of importance in the assembly line, it is of even greater importance from the servicing standpoint when a damaged component has to be replaced, particularly where the work has to be done outside the plant without adequate facilities.

A jig reference, is in effect a master component or more specifically a replica of those points of the component that must be controlled to ensure interchangeability. The jig reference is applied to the component assembly jig to position the jig locators accurately on the jig frame. The jig reference is then removed and the assembly jig is ready for use. The jig reference is built to the master dimensions stated on the basic geometry drawings and any profiles are obtained from the master lines glass cloth. To control interchangeability at the joint between two components, two jig references are built, one for each side of the joint. The two jig references are first matched together to ensure that each is the counterpart of the other, then each is applied to its corresponding component assembly jig. In a simple joint where two ends of the adjacent components are identical, then only one jig reference is required. The jig reference has three uses;

(1) To set-up the component assembly jig.

TOOLS FOR DRILLING, ROUTING AND FORMING.



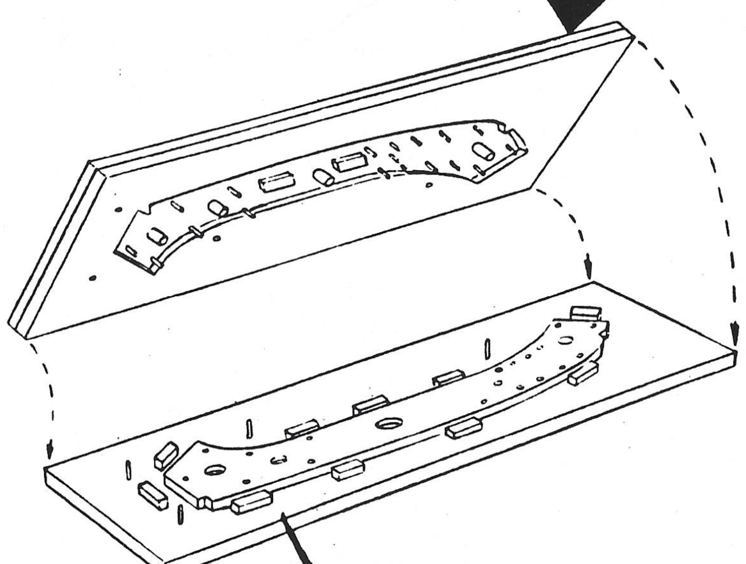
FINISHED WEB.

DRILL AND ROUT TEMPLATE CUT FROM METAL REPRODUCTION OF THE ASSEMBLY GLASS CLOTH.

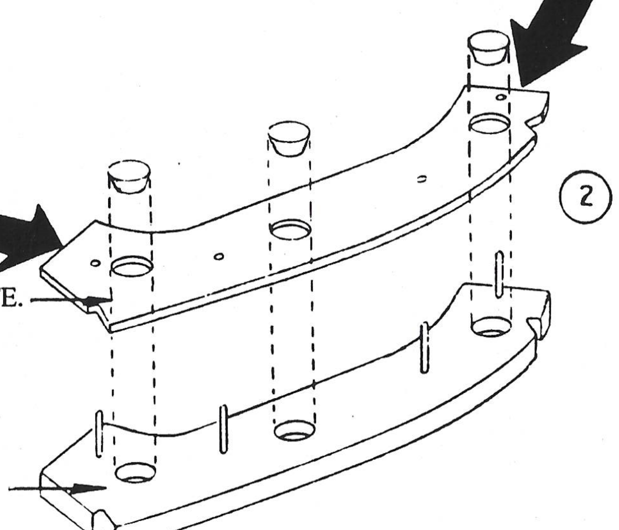
TWO SIMPLE TOOLS ARE REQUIRED TO MAKE THIS PART;-

1. TEMPLATE FOR DRILLING THE HOLES AND ROUTING THE PART TO CORRECT PROFILE.

2. FORM BLOCK FOR FORMING THE FLANGES ON A RUBBER PRESS.



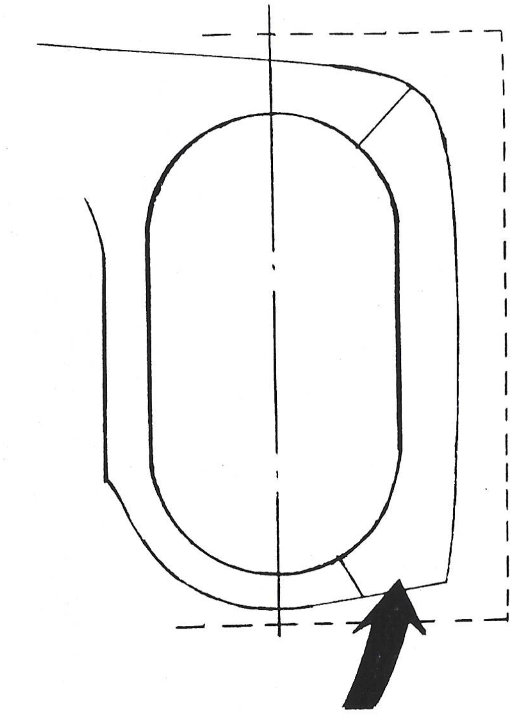
FOR A HIGH PRODUCTION RUN, THE DRILL AND ROUT TEMPLATE COULD BE REPLACED BY A KIRKSITE TEMPLATE DIE FOR BLANKING AND PIERCING.

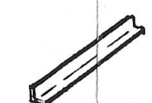


SUB-ASSEMBLY

SECTION OF ASSEMBLY GLASS CLOTH FOR STATION 268.

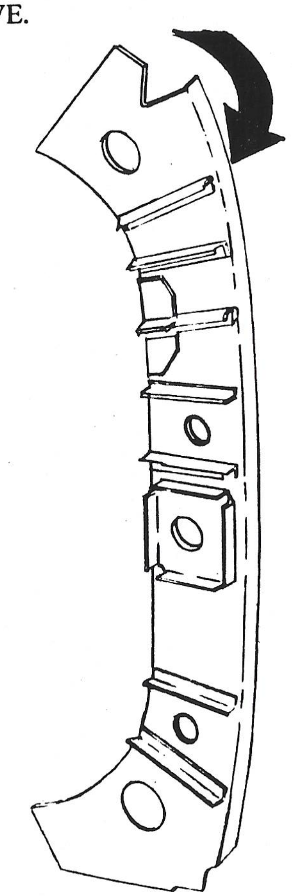
NOTE:- THE OUTSIDE CONTOUR IS AN EXACT DUPLICATE OF THE MASTER MODEL AT THIS STATION.

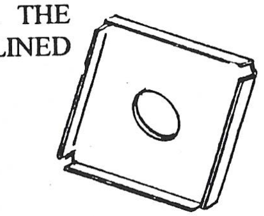




STIFFENER ANGLE.
NO TOOLS REQUIRED - MADE FROM STANDARD ANGLE SECTION CUT TO LENGTH AND DRILLED FROM A METAL REPRODUCTION FOR THIS AREA OF THE ASSEMBLY GLASS CLOTH.

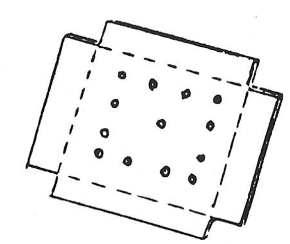
FINISHED SUB-ASSEMBLY FOR THE AREA OF FORMER 268 OUTLINED ABOVE.



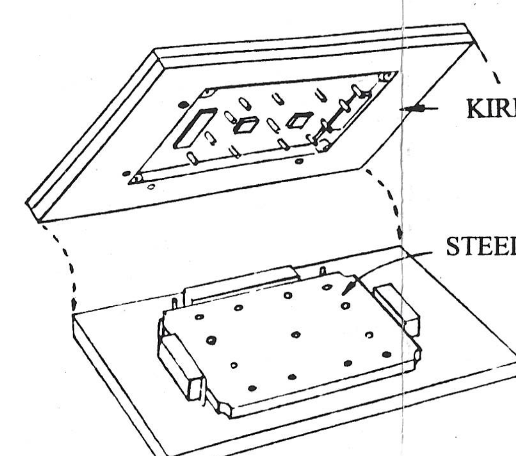


REINFORCING PLATE

TO PRODUCE THIS DETAIL ONE TOOL ONLY IS REQUIRED. A SIMPLE FLAT TEMPLATE CUT FROM A METAL REPRODUCTION OF THE ASSEMBLY GLASS CLOTH. MATERIAL FOR PART IS SHEARED TO SIZE AND DRILLED FROM TEMPLATE. THE HOLE IS PIERCED AND FLANGED BY STANDARD TOOLS.



TEMPLATE.



FOR A HIGH PRODUCTION RUN THE TEMPLATE WOULD BE REPLACED BY A KIRKSITE TEMPLATE DIE FOR BLANKING AND PIERCING.

TOOLING FOR ASSEMBLIES.

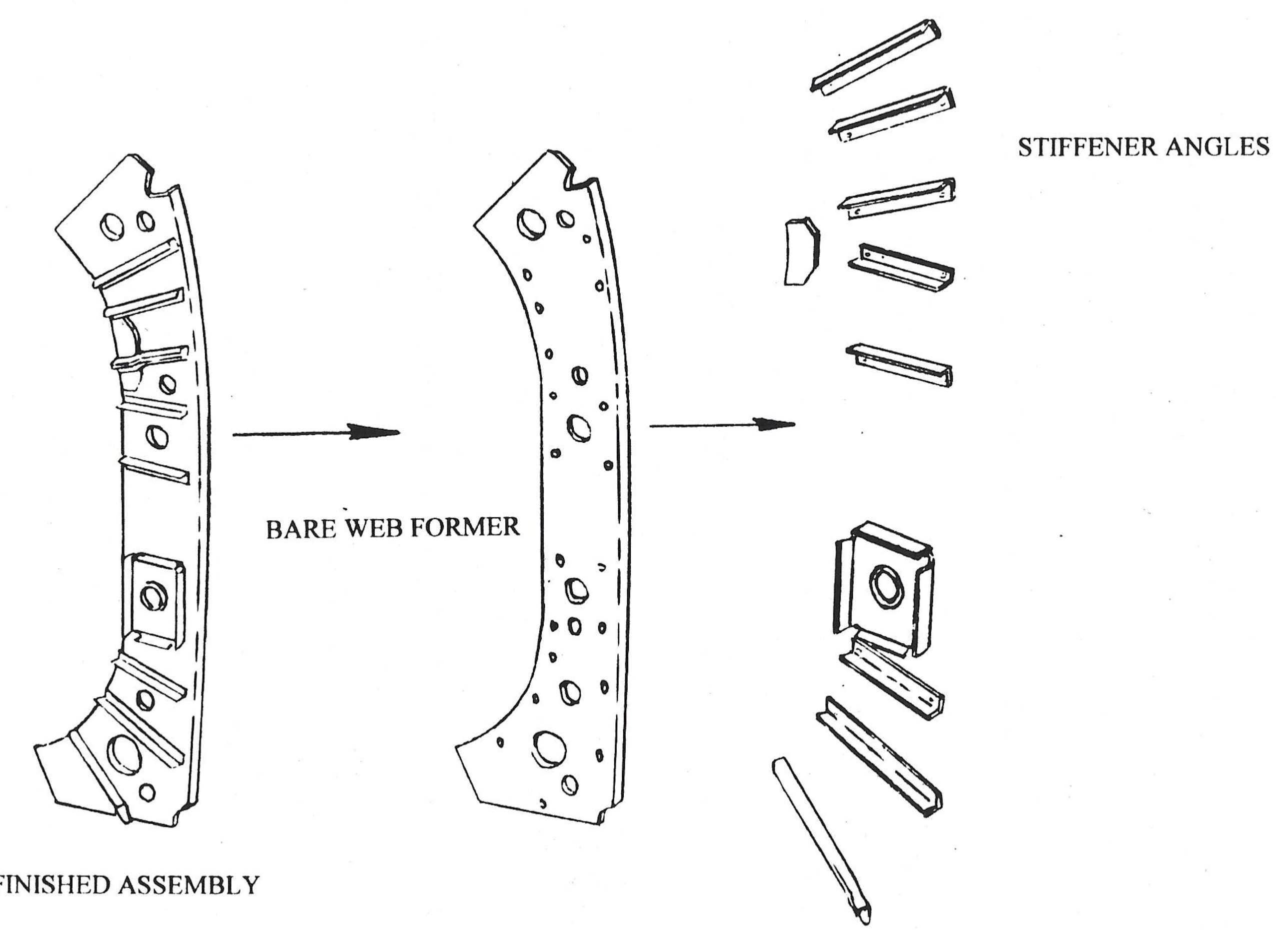
AVRO'S APPROACH TO ASSEMBLY TOOLING IS BASED ON ECONOMY, CONSISTENT WITH ADEQUATE CONTROL OF ESSENTIAL POINTS SUCH AS INTERCHANGEABILITY POINTS, SKIN CONTOUR AND MAJOR PICK-UP POINTS.

THE QUALITY OF ASSEMBLY JIGS REQUIRED IS HELD TO A STRICT MINIMUM IN LINE WITH THIS POLICY. SUB-ASSEMBLY JIGS ARE NOT ORDERED WHEREVER THE WORK CAN BE INCLUDED IN THE NEXT STAGE. IN ADDITION, THE ASSEMBLY JIGS THAT ARE ORDERED, WHILE BEING OF A PRODUCTION TYPE, HAVE ONLY THE ESSENTIAL LOCATORS AND PICK-UPS PUT ON AT THIS TIME. LATER, WHEN PRODUCTION WARRANTS, ADDITIONAL LOCATORS ETC., MAY BE ADDED.

FOLLOWING ARE EXAMPLES OF THIS TOOLING POLICY:-

SIMPLE SUB-ASSEMBLY - ASSEMBLY JIG NOT REQUIRED

THE DETAILS ARE PRE - DRILLED AND ASSEMBLED IN THE SAME FASHION AS A MECCANO SET.



FINISHED ASSEMBLY

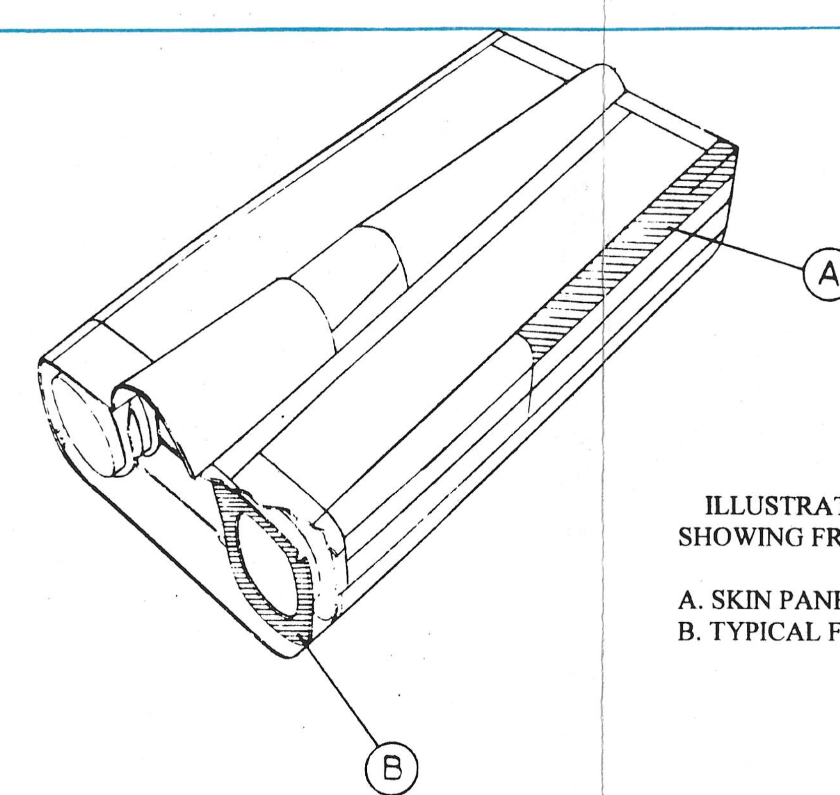
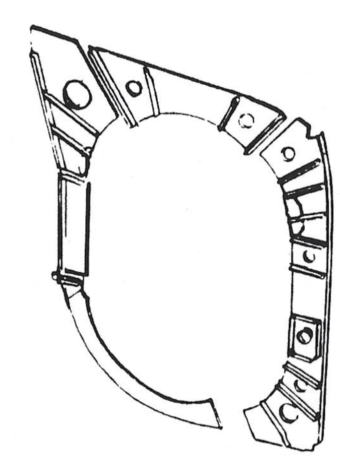
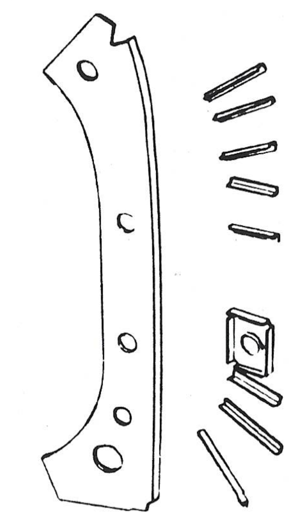


ILLUSTRATION OF CENTRE FUSELAGE SHOWING FRAMEWORK AND POINTING OUT:-

A. SKIN PANEL FOR STRETCH FORMING.
B. TYPICAL FORMER AT STA. 268.



EXPLODED VIEW OF STA. 268.

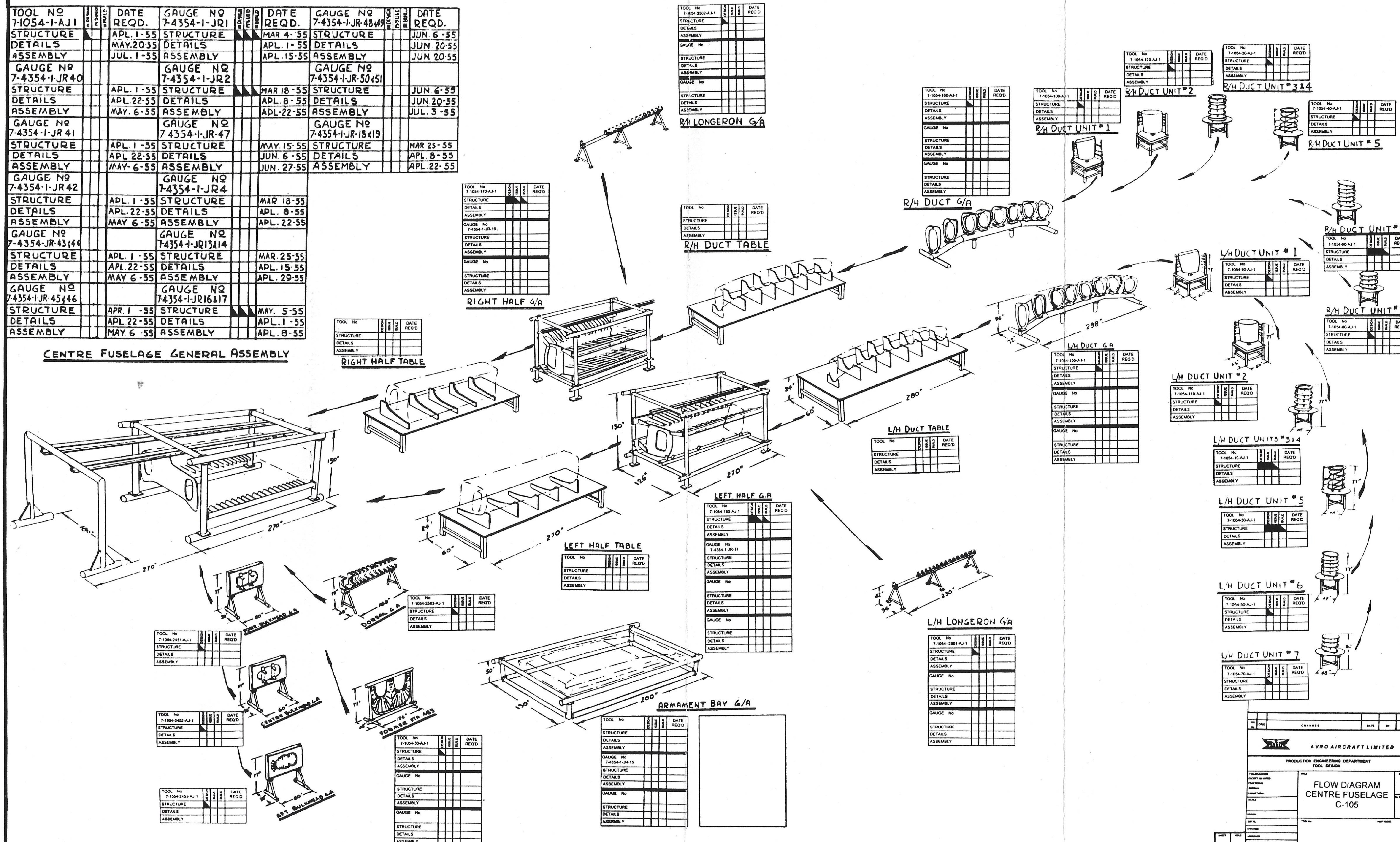


EXPLODED VIEW OF SUB-ASSEMBLY FOR FORMER 268.

ILLUSTRATION OF CENTRE FUSELAGE STRUCTURE SHOWING A TYPICAL FORMED SKIN PANEL AND A TYPICAL HALF FORMER.

TOOL Nº 7-1054-1-AJ1				DATE REQD.	GAUGE Nº 7-4354-1-JR1				DATE REQD.	GAUGE Nº 7-4354-1-JR-48&49				DATE REQD.
STRUCTURE				APL. 1-55	STRUCTURE				MAR 4-55	STRUCTURE				JUN. 6-55
DETAILS				MAY. 20-55	DETAILS				APL. 1-55	DETAILS				JUN 20-55
ASSEMBLY				JUL. 1-55	ASSEMBLY				APL. 15-55	ASSEMBLY				JUN 20-55
GAUGE Nº 7-4354-1-JR40					GAUGE Nº 7-4354-1-JR2					GAUGE Nº 7-4354-1-JR-50&51				
STRUCTURE				APL. 1-55	STRUCTURE				MAR 18-55	STRUCTURE				JUN. 6-55
DETAILS				APL. 22-55	DETAILS				APL. 8-55	DETAILS				JUN. 20-55
ASSEMBLY				MAY. 6-55	ASSEMBLY				APL-22-55	ASSEMBLY				JUL. 3-55
GAUGE Nº 7-4354-1-JR 41					GAUGE Nº 7-4354-1-JR-47					GAUGE Nº 7-4354-1-JR-18&19				
STRUCTURE				APL. 1-55	STRUCTURE				MAY. 15-55	STRUCTURE				MAR 25-55
DETAILS				APL 22-55	DETAILS				JUN. 6-55	DETAILS				APL. 8-55
ASSEMBLY				MAY-6-55	ASSEMBLY				JUN. 27-55	ASSEMBLY				APL 22-55
GAUGE Nº 7-4354-1-JR 42					GAUGE Nº 7-4354-1-JR4									
STRUCTURE				APL. 1-55	STRUCTURE				MAR 18-55					
DETAILS				APL. 22-55	DETAILS				APL. 8-55					
ASSEMBLY				MAY 6-55	ASSEMBLY				APL. 22-55					
GAUGE Nº 7-4354-JR-43&44					GAUGE Nº 7-4354-1-JR13&14									
STRUCTURE				APL. 1-55	STRUCTURE				MAR. 25-55					
DETAILS				APL. 22-55	DETAILS				APL. 15-55					
ASSEMBLY				MAY 6-55	ASSEMBLY				APL. 29-55					
GAUGE Nº 7-4354-1-JR-45&46					GAUGE Nº 7-4354-1-JR16&17									
STRUCTURE				APR. 1-55	STRUCTURE				MAY. 5-55					
DETAILS				APL. 22-55	DETAILS				APL. 1-55					
ASSEMBLY				MAY 6-55	ASSEMBLY				APL. 8-55					

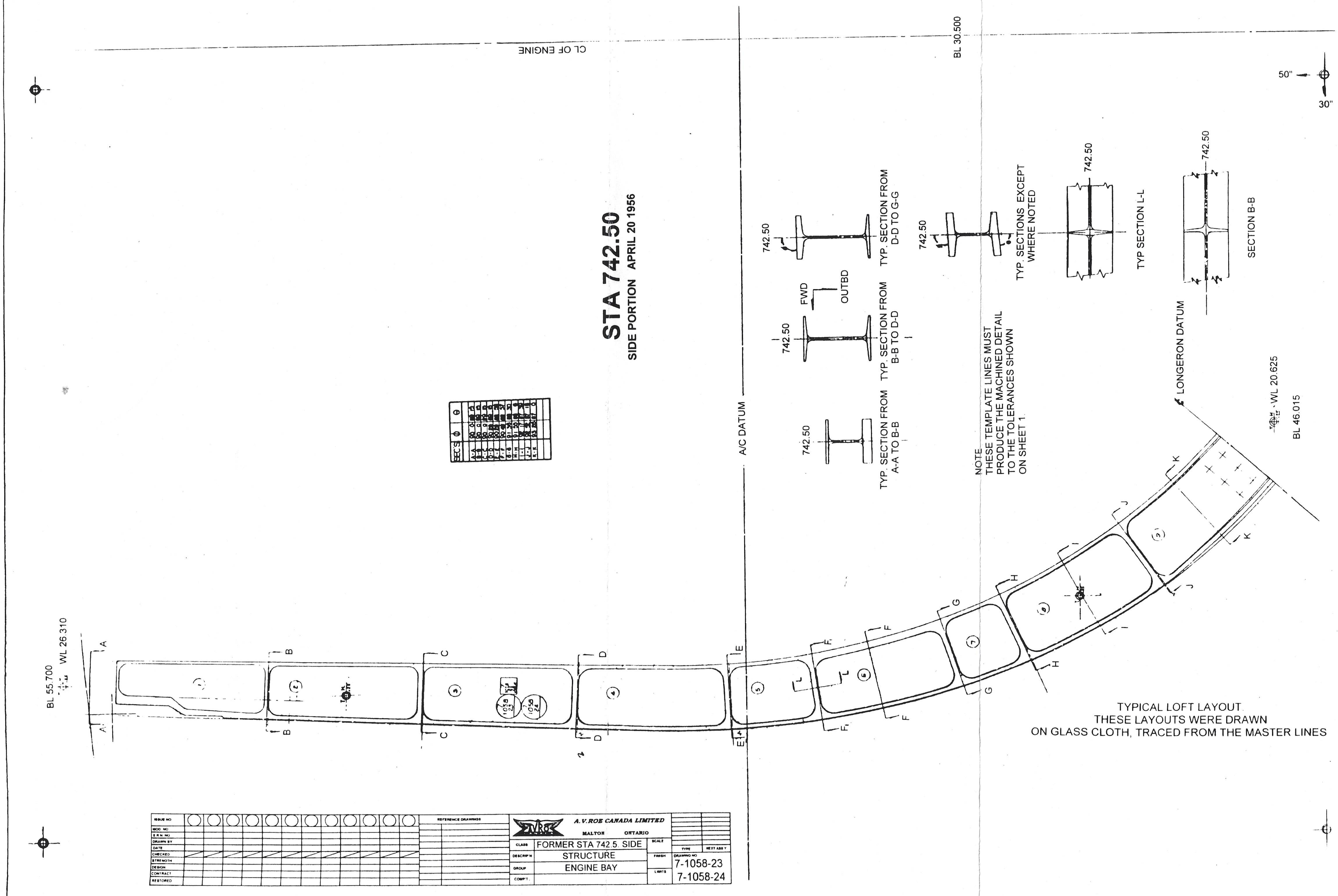
CENTRE FUSELAGE GENERAL ASSEMBLY



AVRO AIRCRAFT LIMITED

PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN

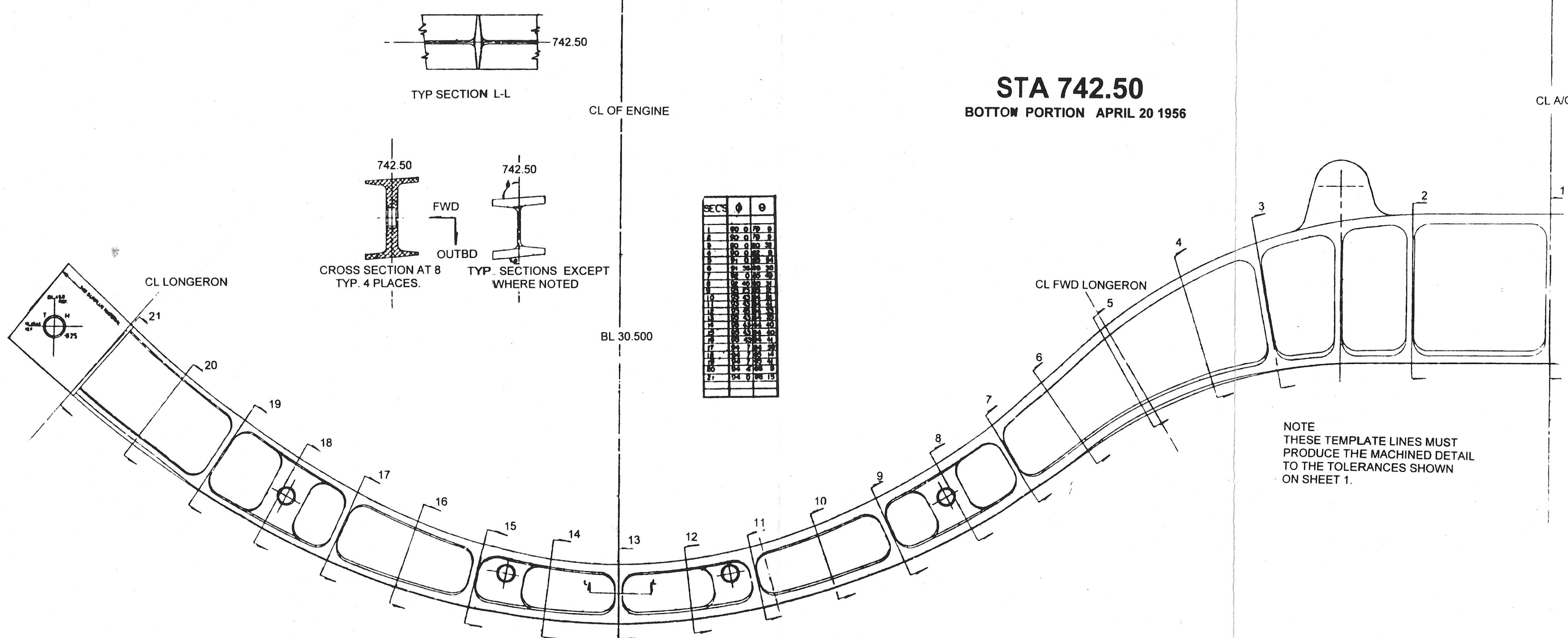
FLOW DIAGRAM
CENTRE FUSELAGE
C-105



TYPICAL LOFT LAYOUT.
THESE LAYOUTS WERE DRAWN
ON GLASS CLOTH, TRACED FROM THE MASTER LINES

STA 742.50

BOTTOM PORTION APRIL 20 1956



SECS	φ	θ
1	80 0	70 0
2	80 0	70 0
3	80 0	80 30
4	80 0	[illegible]
5	[illegible]	[illegible]
6	[illegible] 30	[illegible] 30
7	[illegible] 0	[illegible]
8	[illegible]	[illegible]
9	[illegible]	[illegible]
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14	[illegible]	[illegible]
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16	[illegible]	[illegible]
17	[illegible] 7	[illegible]
18	[illegible] 7	[illegible]
19	[illegible] 7	[illegible]
20	[illegible] 4	[illegible]
21	94 0	[illegible] 15

NOTE
THESE TEMPLATE LINES MUST PRODUCE THE MACHINED DETAIL TO THE TOLERANCES SHOWN ON SHEET 1.

TYPICAL LOFT LAYOUT
THESE LAYOUTS WERE DRAWN ON GLASS CLOTH, TRACED FROM THE MASTER LINES

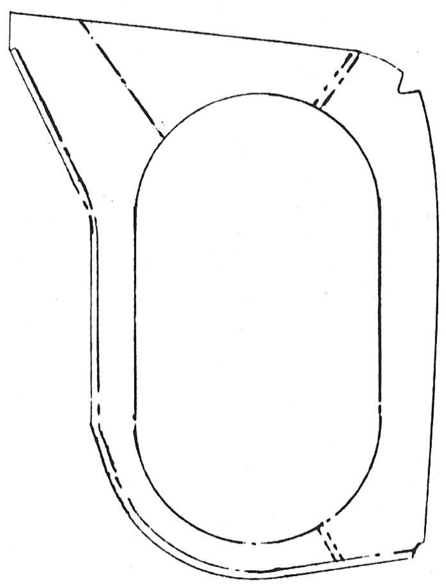
ISSUE NO	
MOD NO	
DRAWN BY	
DATE	
CHECKED	
STRENGTH	
DESIGN	
CONTRACT	
RESTORED	TD

REFERENCE DRAWINGS

A.V. ROE CANADA LIMITED
MALTON ONTARIO

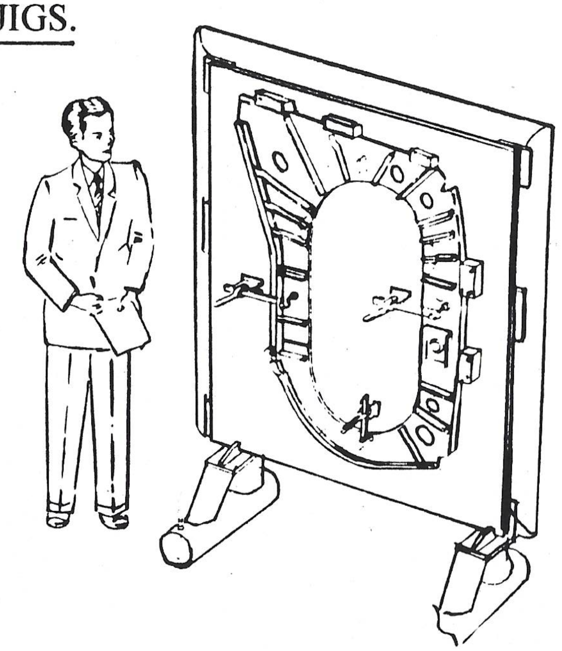
CLASS	FORMER STA 742.5 BTM.	SCALE	
DESCRIPTION	STRUCTURE		DRAWING NO
GROUP	ENGINE BAY		7-1058-29

ASSEMBLY JIGS.

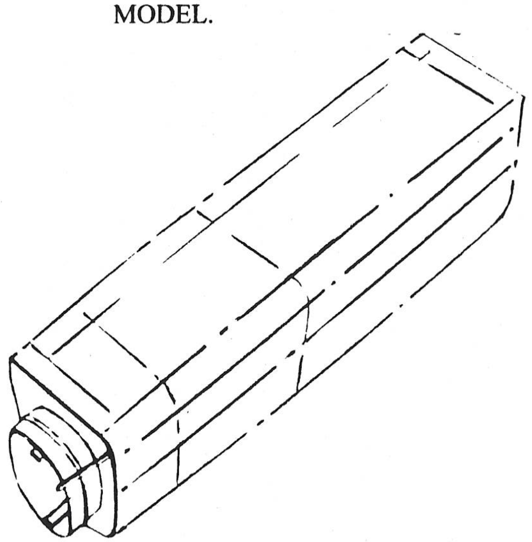


BARE FORMER AT STA. 268

FOR THIS ASSEMBLY A JIG IS REQUIRED TO ENSURE THE CORRECT POSITION OF EACH PART IN RELATION TO THE OUTSIDE CONTOUR, WHICH IS CRITICAL AS IT PICKS UP THE SKIN. THE JIG IS BUILT FROM THE ASSEMBLY GLASS CLOTH WHOSE LINES ARE THOSE OF THE MASTER MODEL.

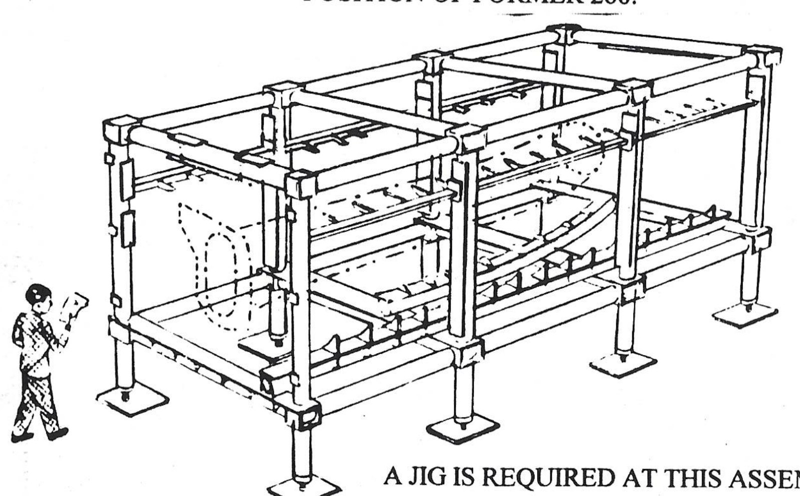


ASSEMBLY JIG.
THE THREE SUB-ASSEMBLIES ARE LOADED INTO THE JIG, DRILLED AND SERVICE BOLTED TOGETHER. WHEN THE ASSEMBLY IS FITTED INTO THE NEXT STAGE, THE THREE PORTIONS ARE UN-BOLTED TO FIT AROUND THE AIR DUCT.
THE JIG CONTROLS THE OUTSIDE CONTOUR OF THE ASSEMBLY.



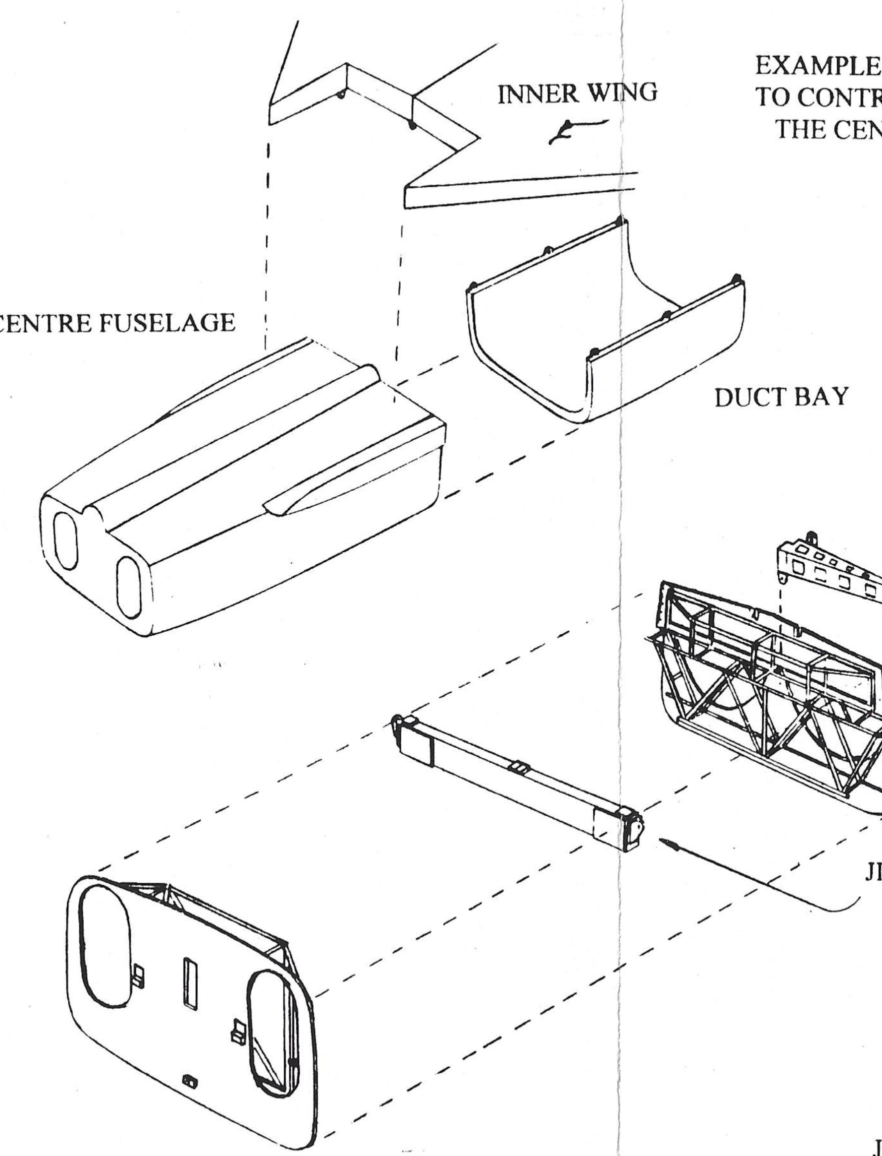
LEFT-HAND SECTION OF THE CENTRE FUSELAGE.

ASSEMBLY JIG.
SHOWING IN DOTTED LINE, THE OUTLINE OF THE ASSEMBLY AND THE POSITION OF FORMER 268.



A JIG IS REQUIRED AT THIS ASSEMBLY STAGE TO ACCURATELY POSITION THE STRUCTURE PORTIONS OF THE CENTRE FUSELAGE LEFT HAND SECTION TO ENSURE THAT THE SKINNING MAINTAINS THE ENVELOPE ESTABLISHED BY THE MASTER MODEL.

EXAMPLE OF APPLICATION OF JIG REFERENCES TO CONTROL INTERCHANGEABILITY BETWEEN THE CENTRE FUSELAGE - INNER WING AND THE DUCT BAY.

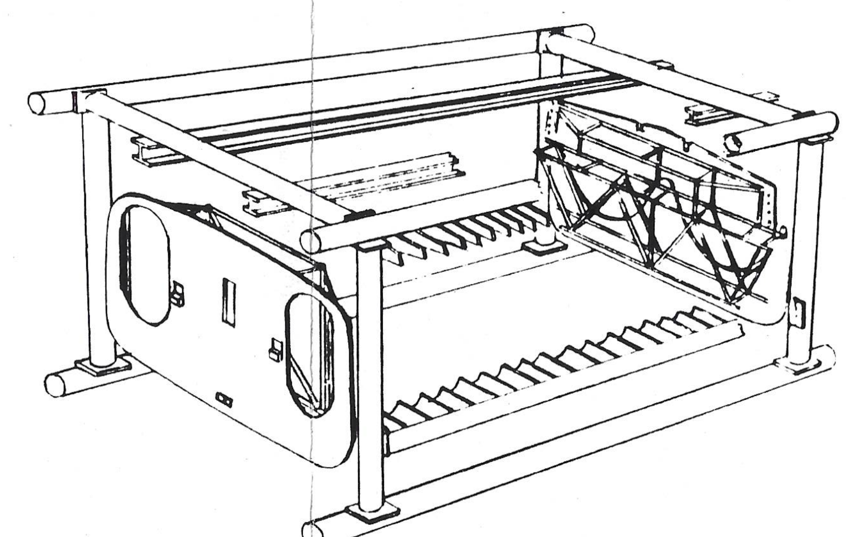


CO-ORDINATION OF INNER WING JIG REFERENCE TO CENTRE FUSELAGE JIG REFERENCE AT STA. 485 AND STA 483.

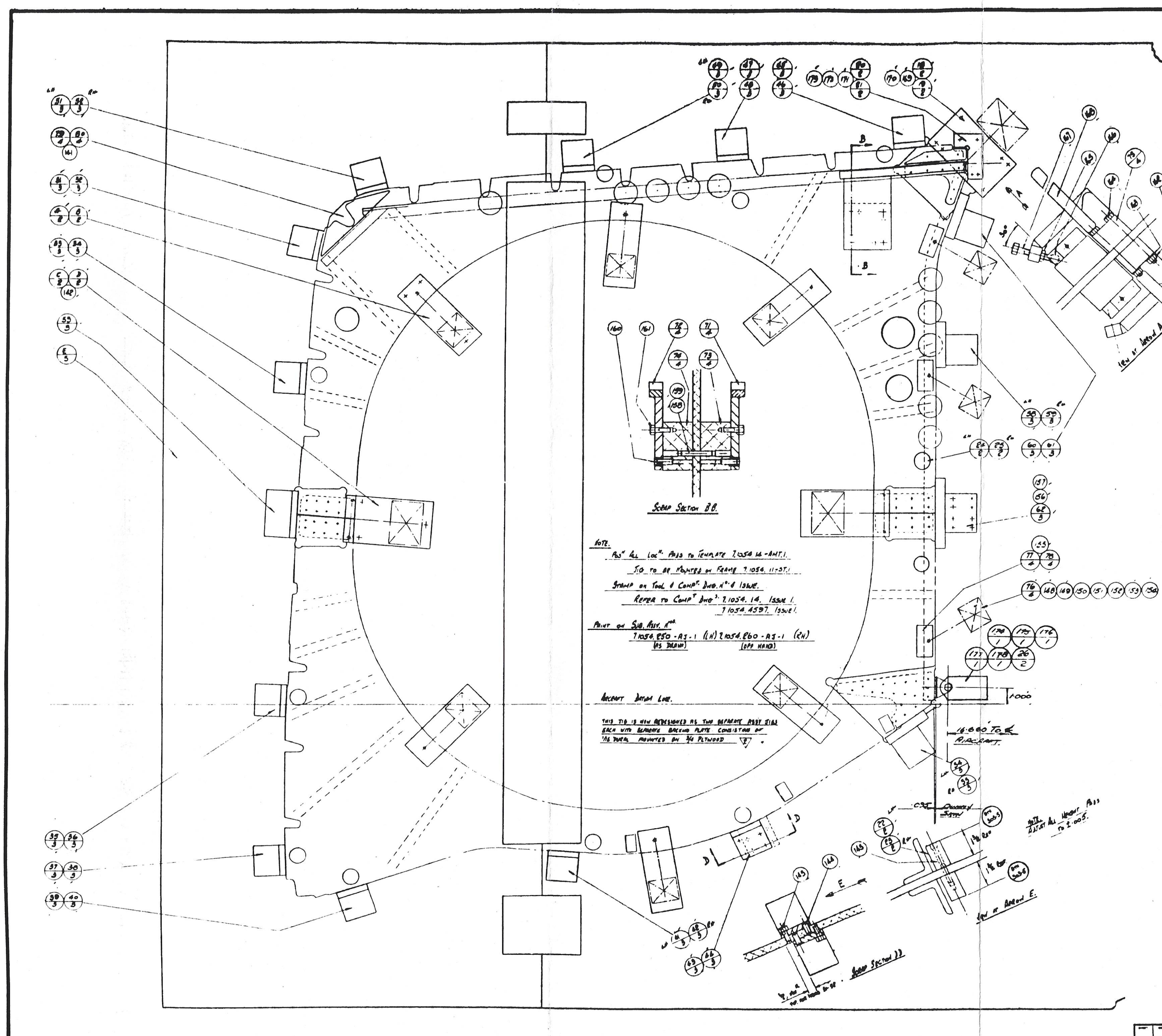
DUMMY FORMER CHECKED TO THE MASTER LINES TEMPLATE. THIS CONTROLS THE OUTER CONTOUR, DUCT POSITIONS AND LONGERON LOCATIONS.

JIG REFERENCE.

CO-ORDINATION OF BOTH DUMMY FORMER AND JIG REFERENCE TO THE MAJOR ASSEMBLY CENTRE FUSELAGE JIG.



BILL OF MATERIAL



ISS No.	ORDER	CHANGES	DATE	BY	CHK'D

AVRO AIRCRAFT LIMITED

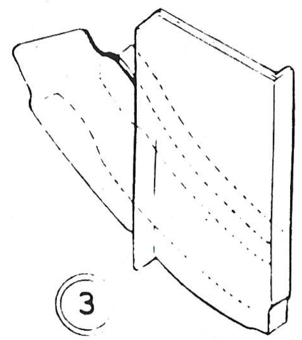
PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN

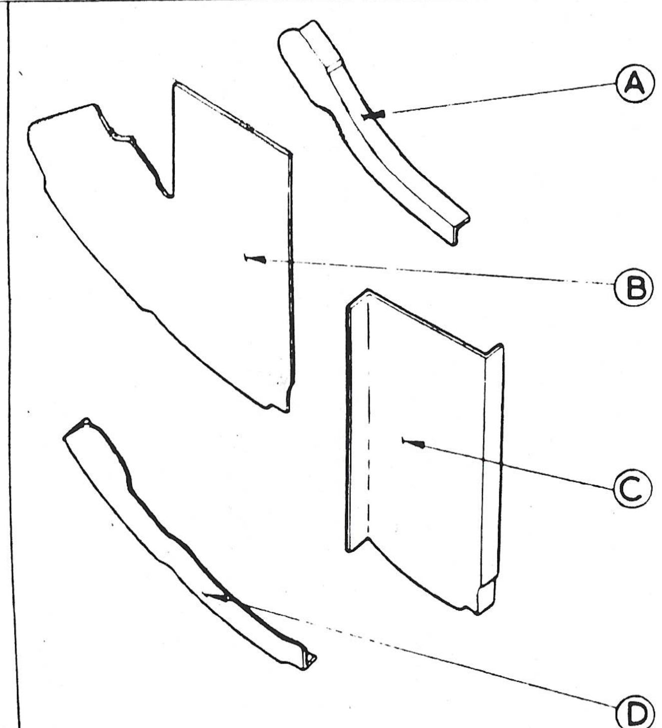
TITLE: FRAME ASSEMBLY JIG STA.303.5

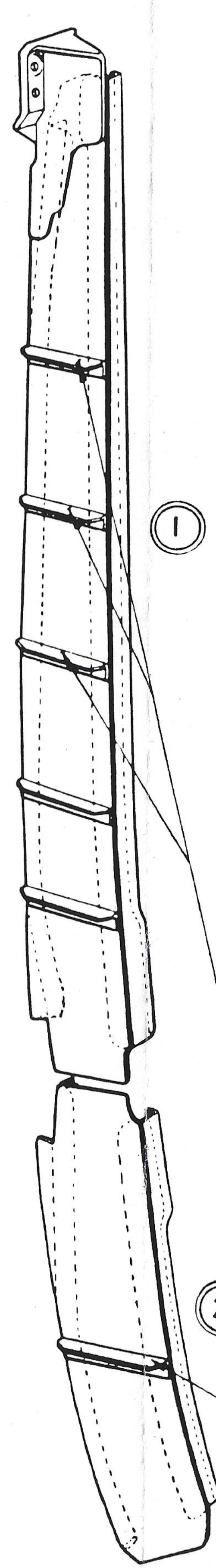
SHEET No. 1 — No. OF SHEETS 5

TOOL No. 7-1054-250-AJ-1

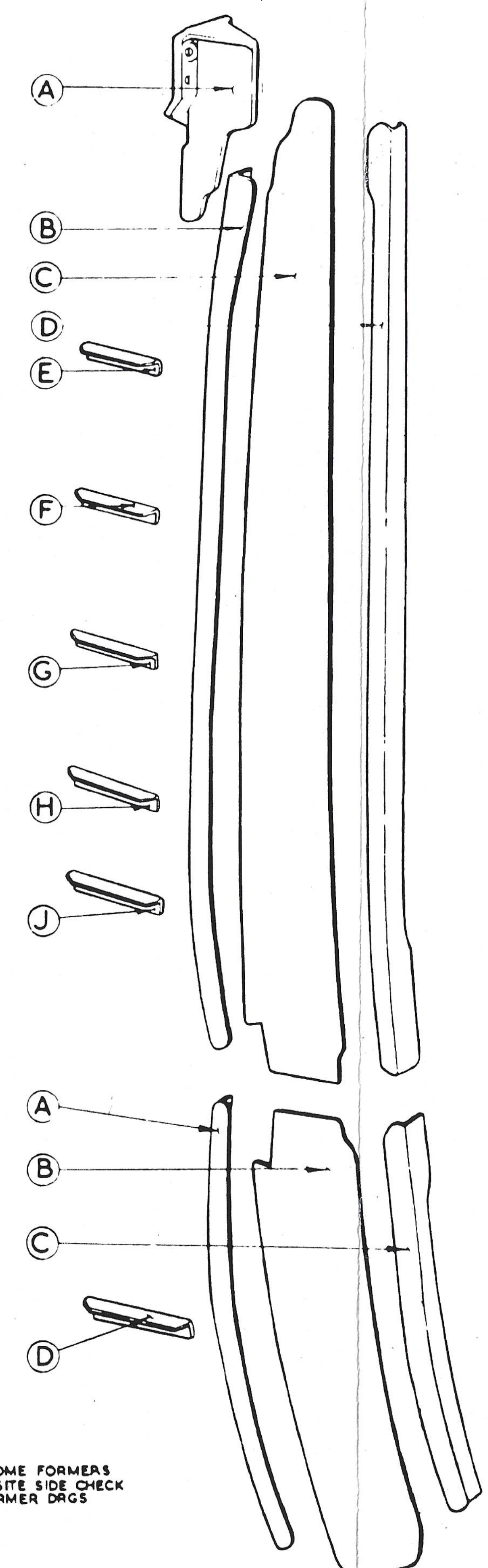
STA	S/A	S/A NUMBERS		DESIGN DWGS	A	B	C	D	E	F	G	H	J
489.90	1	7-1058	110	7-1056 171-172	355	301	295	303	337	341	343	345	-
		.	120	.	356	302	295	304	337	341	343	345	-
	2	.	130	.	305	297	307	2141	-	-	-	-	-
		.	140	.	306	297	308	2141	-	-	-	-	-
	3	.	150	173 174	1737	1733	1731	1755	-	-	-	-	-
		.	160	.	1738	1733	1752	1756	-	-	-	-	-
494.80	1	.	170	175 176	355	365	361	367	337	341	343	345	-
		.	180	.	356	366	361	368	337	341	343	345	-
	2	.	190	.	371	362	373	2143	-	-	-	-	-
		.	200	.	372	363	374	2143	-	-	-	-	-
	3	.	210	177 178	1755	1751	1747	1753	-	-	-	-	-
		.	220	.	1756	1751	1748	1754	-	-	-	-	-
499.70	1	.	230	181 182	355	385	381	387	2085	2091	2087	2095	-
		.	240	.	356	386	381	388	2085	2091	2087	2095	-
	2	.	250	.	393	387	391	2093	-	-	-	-	-
		.	260	.	394	388	392	2094	-	-	-	-	-
	3	.	270	183 184	1773	1767	1765	1771	-	-	-	-	-
		.	280	.	1774	1767	1766	1772	-	-	-	-	-
504.60	1	.	290	185 186	355	415	411	417	337	341	2135	345	346
		.	300	.	356	416	411	418	337	341	2136	345	346
	2	.	310	.	421	413	423	2137	-	-	-	-	-
		.	320	.	422	413	424	2138	-	-	-	-	-
	3	.	330	187 188	1791	1785	1783	1787	-	-	-	-	-
		.	340	.	1792	1785	1784	1788	-	-	-	-	-
509.50	1	.	350	191 192	355	441	455	483	338	341	349	345	346
		.	360	.	356	442	455	485	338	341	343	345	346
	2	.	370	.	495	437	487	2141					
		.	380	.	496	437	488	2141					
	3	.	390	193 194	1807	1802	1804	1801					
		.	400	.	1808	1803	1804	1802					
514.40	1	.	410	195 196	355	505	501	507	338	341	343	345	346
		.	420	.	356	506	501	508	338	341	343	345	346
	2	.	430	.	511	503	513	2142	-	-	-	-	-
		.	440	.	512	503	514	2142	-	-	-	-	-
	3	.	450	197 198	1822	1821	1817	1825	-	-	-	-	-
		.	460	.	1826	1821	1818	1824	-	-	-	-	-
519.30	1	.	470	201 202	355	531	525	533	337	341	345	345	347
		.	480	.	356	532	525	534	337	341	345	345	347
	2	.	490	.	535	527	537	2142			-	-	-
		.	500	.	536	527	538	2142				-	-
	3	.	510	203 204	1841	1837	1835	1843		-	-	-	-
		.	520	.	1842	1837	1836	1844		-	-	-	-
524.20	1	.	530	205 206	2347	555	551	557	2127	2131	2133	344	348
		.	540	.	2348	556	551	558	2128	2132	2134	344	348
	2	.	550	.	561	552	563	2145	-	-	-	-	-
		.	560	.	562	553	564	2145	-	-	-	-	-
	3	.	570	207 208	1861	1855	1853	1857	-	-	-	-	-
		.	580	.	1862	1855	1854	1858	-	-	-	-	-
529.10	1	.	590	211 212	2347	581	575	583	2127	2131	2133	344	347
		.	600	.	2348	582	575	584	2126	2132	2134	344	347
	2	.	610	.	585	577	587	2142	-	-	-	-	-
		.	620	.	586	577	588	2142	-	-	-	-	-
	3	.	630	213 214	1703	1697	1695	1701	-	-	-	-	-
		.	640	.	1704	1697	1696	1702	-	-	-	-	-
534.0	1	.	650	215 216	2347	605	601	607	136	339	341	344	347
		.	660	.	2348	606	601	608	136	339	341	344	347
	2	.	670	.	611	603	613	2144	-	-	-	-	-
		.	680	.	612	603	614	2144	-	-	-	-	-
	3	.	690	217 218	1721	1715	1713	1717	-	-	-	-	-
		.	700	.	1722	1715	1714	1718	-	-	-	-	-







NOTE ANGLES ON SOME FORMERS ARE ON OPPOSITE SIDE CHECK INDIVIDUAL FORMER DRGS



BILL OF MATERIAL

ITEM	MAT'L	DESCRIPTION	REQ'D	REMARKS

ISS No	ORIG	CHANGES	DATE	BY	CHK'D

AVRO AIRCRAFT LIMITED

PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN

TOLERANCES EXCEPT AS NOTED
FRACTIONAL
DECIMAL
STRUCTURAL
SCALE

TITLE
FORMER SUB-ASSEMBLIES
STA. 489.9 TO 534.0

SHEET No
No OF SHEETS

DESIGN
DETAIL
CHECKED
APPROVED
DATE

TOOL No
7-0156-PE-7

PART ISSUE

SHEET No 2

BILL OF MATERIAL

INTERCHANGEABILITY TOOL ISSUE

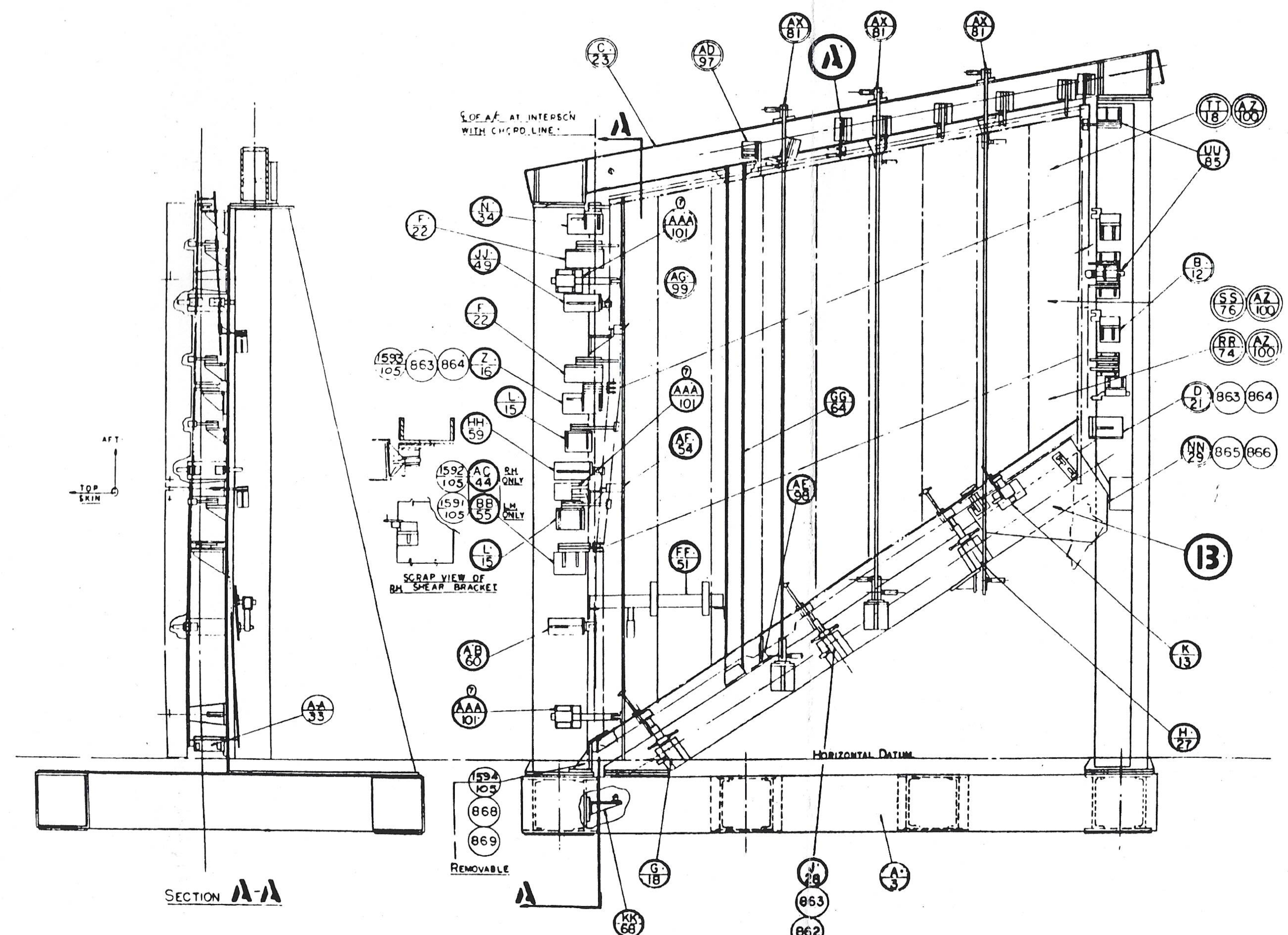
ISS	CHANGE	DATE	BY	CHKD
A	SKIN TRIM LOCATORS R/S ITEMS 594-595 SHT.50. SHT.72 ALTD PICTORIALLY. TRIM LINE CUT BACK .250 TO SUIT FEELER ITEM 867 SHT.1.	21-2-57	T.B.D	

CO-ORDINATION LIST

SHT.40-----OPTICAL CO-ORD RIB 1.---7-4362-3/4-JR-3
SHT.41-----MAIN UNDERCARRIAGE.--7-4362-3/4-JR-6
SHT.37-----7-4362-11-MP-1-2-3-4--------R/S TO T/E INNER WING
SHT.67-----RIB 10-----------------------------7-4362-3/4-JR-2
SHT.72-----REAR SPAR--------------------7-4362-3/4-JR-5
SHT.52-----7-4364-543-MP-1---------------REAR SPAR. I/W TO O/W
SHT.61-----7-4362-130-MP-1---------------RIB 10 TO REAR SPAR

TEMPLATES REQUIRED

7-1062-3-MCT-278/9	7-1062-253/4-LMT-1&2
7-1062-3-MCT-280	7-1062-847/8-LMT-1&2
7-1062-6281-DRT-1	7-1062-853/4-LMT-1&2
7-1062-3027-DRT-1	7-1062-857/8-LMT-1&2
7-1062-7-MCT-1	7-1062-847/8-DT
7-1062-7-AMT-1	7-1062-853/4-DT
7-1062-247/8-LMT-1&2	7-1062-857/8-DT
7-1062-251/2-LMT-1&2	7-1062-887-LMT-1
	7-1062-893-LMT-1



INTERCHANGEABILITY CONTROL POINTS

A — REAR SPAR TO ELEVATOR CONTROL BOX ATTACHMENT ANGLE HOLE PATTERN. SKIN TRIM. INNER WING TO OUTER WING REAR SPAR.

13 — MAIN U/C PIVOT. OUTER DOOR HINGE U/C JACK P/U.

ISS	CHG	CHANGES	DATE	BY	CHK'D

AVRO AIRCRAFT LIMITED

PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN

TITLE: ASSEMBLY JIG INNER WING INTEGRAL TANK ASSEMBLY

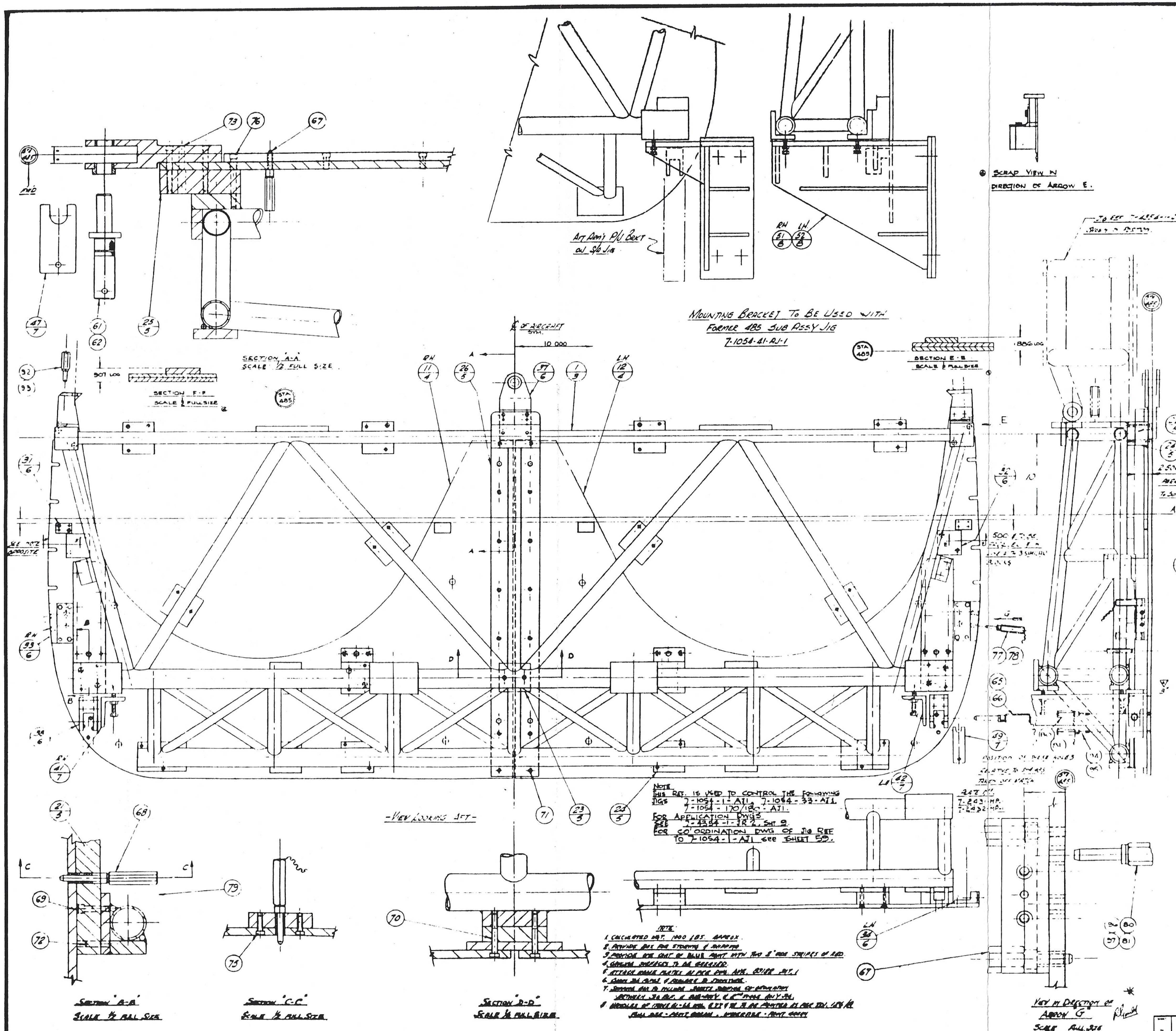
SHEET No. 1 — No. OF SHEETS 106

SCALE 1/16

DATE 20-2-57

TOOL No. 7-1062-7-AJ-1
7-1062-8-AJ-1

BILL OF MATERIAL



ISS No	DWG	CHANGES	DATE	BY	CHK'D

AVRO AIRCRAFT LIMITED

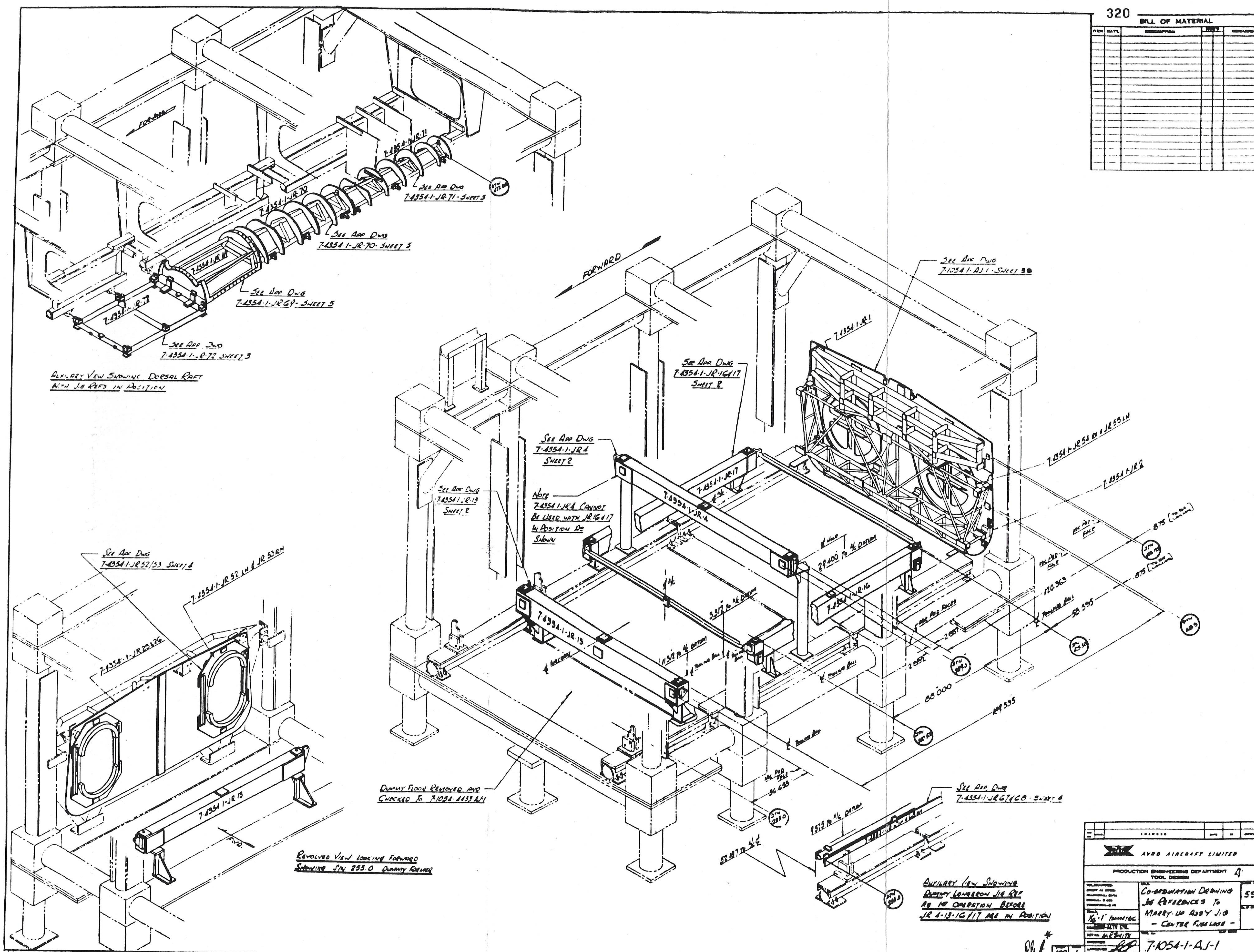
PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN

TOLERANCES EXCEPT AS NOTED: FRACTIONAL, DECIMAL, STRUCTURAL

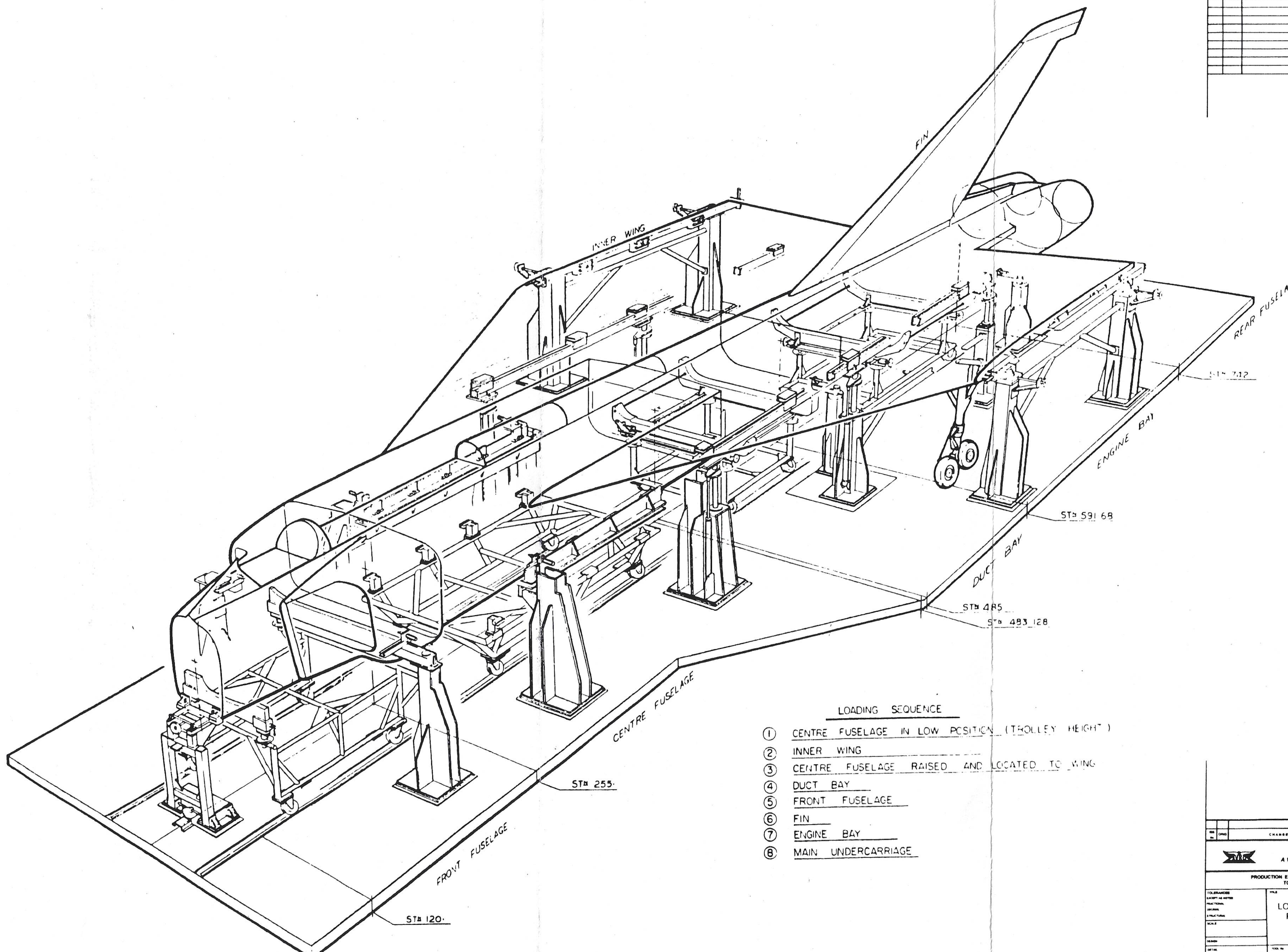
SCALE · DESIGN · DETAIL · CHECKED · APPROVED · DATE

TITLE: JIG REFERENCE STATION 485 0 CENTRE FUSELAGE

TOOL No: 7-4354-1-JR-1


BILL OF MATERIAL
FORWARD
See App Dwg 7-4354-1-JR-71-Sheet 5
See App Dwg 7-4354-1-JR-70-Sheet 5
See App Dwg 7-4354-1-JR69-Sheet 5
See App Dwg 7-4354-1-R-72 Sheet 3
Auxiliary View Showing Dorsal Raft With Jig Refs in Position
See App Dwg 7-1054-1-AJ-1-Sheet 5
See App Dwg 7-4354-1-JR-16/17 Sheet 2
See App Dwg 7-4354-1-JR-4 Sheet 2
See App Dwg 7-4354-1-JR-13 Sheet 2
Note 7-4354-1-JR-4 Cannot Be Used with JR16/17 In Position As Shown
See App Dwg 7-4354-1-JR52/53 Sheet 4
Dummy Floor Removed and Checked To 7-1054-1433 RH
Revolved View Looking Forward Showing Stn 255.0 Dummy Frames
See App Dwg 7-4354-1-JR67/68-Sheet 4
Auxiliary View Showing Dummy Longeron Jig Ref As 1st Operation Before JR 4-13-16/17 Are In Position
AVRO AIRCRAFT LIMITED
PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN
Co-ordination Drawing Jig References To Marry-up Assy Jig - Center Fuselage -
59
7-1054-1-AJ-1

BILL OF MATERIAL



LOADING SEQUENCE

1. CENTRE FUSELAGE IN LOW POSITION (TROLLEY HEIGHT)
2. INNER WING
3. CENTRE FUSELAGE RAISED AND LOCATED TO WING
4. DUCT BAY
5. FRONT FUSELAGE
6. FIN
7. ENGINE BAY
8. MAIN UNDERCARRIAGE

AVRO AIRCRAFT LIMITED

PRODUCTION ENGINEERING DEPARTMENT
TOOL DESIGN

LOADING SEQUENCE
FINAL ASSEMBLY
FIXTURE

7-4200-PE-1

(2) For the periodic inspection of these jigs to check that the control is maintained.

(3) To set-up duplicate jigs at the plant or at the plant of a sub-contractor.

Jig references are used to provide for setting up component assembly jigs to pick up important items of equipment, for example, undercarriage legs, mountings for various types of armament, radar chassis, supports for major flying control items and all parts requiring interchangeability for servicing etc.

Where the hole pattern in two mating machined parts must match to tight limits and the parts are drilled separately, a simple form of jig reference termed a match plate is used to control the respective drill jig.

RESTORING THE DRAWINGS.

The drawings illustrated in this section, have been restored from blue-prints of the period that to say the least, were incapable of being reproduced in their original state. Particular attention has been afforded to the drawing itself, but in many cases, the Bill of Material column was beyond hope for restoration. Instead, a new column has been added solely in the interests of eye appeal. The Author wishes to express that it is his wish that a complete cross-section of tooling drawings has been presented and that the reader will have no problem in understanding the material presented.