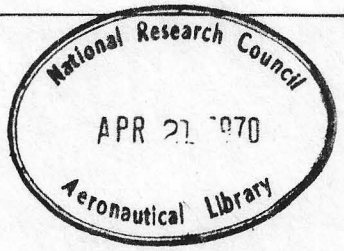

MEMORANDUM TO ALL CONCERNED May 2, 1955

FROM: HARVEY R. SMITH, VICE PRESIDENT - MANUFACTURING

170517

SUBJECT: TOOLING AND MANUFACTURING POLICY FOR BUILDING CF-105 COMPONENT TEST SECTIONS AND FIRST AND SUBSEQUENT AIRPLANES

Relative to many discussions on this subject, and with full understanding of the views of DDP and RCAF, the CF-105 program has been reviewed in fine detail with the following men:

H. F. Young	Chief Production Engineer
T. Bragg	Ass't Chief Production Engineer
W. Hack	Chief Tool Engineer
W. H. Riggs	Production Shop Manager
S. L. Wilson	Industrial Engineering Manager
R. Whittington	Tool Room Superintendent

To preface the tooling and Manufacturing policy covering each phase of this program, I feel it necessary to call attention to the original basic tooling and manufacturing policy, which was established for the CF-105 program last year. That policy was established at a time when we were considering the proper ways and means of producing the first several airplanes only, and assuming that there would be a sizeable gap between the first several and subsequent production airplanes. Consequently, this policy gave rise to the terms "Phase 1 and Phase 2 Tooling". It has occured to me many times that the terms "Phase 1 and Phase 2 Tooling" have been misunderstood by members of our organization, and subsequently by members of DDP and RCAF, consequently it seems necessary to put this matter straight at this time.

If we were to build several CF-105 airplanes only, and then allow a sizeable number of months to elapse before resuming additional production then the policy which developed into the terms "Phase 1 and Phase 2 Tooling" would still be in effect, as established at that time. However, when considering that more than several airplanes must be built and following each other in close sequence, then the terms "Phase 1 and Phase 2 Tooling" become entirely superfluous, and the use of these

terms should be discontinued at once by all parties concerned. It appears, the original misunderstanding on this subject came as a result of the Engineering Department's recommendation that approximately eleven airplanes should be built as quickly as possible, in order that all phases of design and development be proven simultaneously. This recommendation of the Engineering Department was concurred, by all members of this company, the RCAF, and DDP. However, it has since become apparent that all parties concerned, must have assumed that "Phase 1 Tooling" would suffice for the building of more than the first several airplanes, as long as the rate remained at approximately one (1) per month. This is not correct, and it would be dangerous for this thinking to continue any longer. To date, no harm has resulted from this slight misunderstanding, to this company, the RCAF or DDP, consequently no great concern should result from these preface statements.

Facts relative to the CF-105 program, as they appear to me, and as concurred by the men listed above, are as follows:

> To fulfill the requirements established by Avro Aircraft Limited, which was, and still is, in agreement with RCAF, DDP and all members of this company, we must produce the first eleven (11) airplanes at a rate of approximately one (1) per month. To so produce these airplanes, it is necessary to follow our original tooling and manufacturing policy, generally within its entirety, which for all purposes can be construed as meaning a combination of "Phase 1 and Phase 2 Tooling". However, at this point, I ask that all references to "Phase 1 and Phase 2 Tooling" be discontinued, inasmuch as I believe further misunderstanding on this subject could result in extreme embarrassment.

If the statements contained in the paragraph above are understood, and agreeable to all concerned, it then appears that the policy which has resulted from our comprehensive considerations is proper and in order.

The philosophy which has been adopted, covering our approach to the CF-105 airplane tooling and manufacturing phases is as follows:

The CF-105 airplane is fully recognized by all concerned to be an extremely advanced type of airplane. The role which this airplane may be called upon to fill is of major importance to Avro Aircraft Limited, the RCAF, and DDP. With full realization of this fact, but also bearing in mind the position of the customer, regarding <u>expenditures consistent with necessity</u>, the philosophy covering our approach has been, and continues to

be, one which is "predicated on producing the best possible product for the purpose intended, consistent with good management of funds, labor, tooling, material, etc."

This philosophy can also be termed, "one which at all times is concurrent with the state of the art, and altho striving for the accuracy which is mandatory, we do not exceed in quantity, the number of tools, machinery, and material needed, to satisfactorily perform our commitment".

In addition, the evaluation of tooling, methods, rates of production etc., which is to be described in more detail within the policy description of each phase, is based on certain fundamental factors, such as:

(a) Avro Aircraft Limited's complete understanding of the desire of the customer, that the product be tooled properly and efficiently, for the rate of production presently contemplated, which is, at a rate not to exceed one (1) per month. However, at all times we are aware that this rate may be increased. Consequently, our planning, processing, tool design, and tool work orders will be in such condition that, should the rate be increased, the time necessary to so increase will be equal to the time required to build, and put into production those tools, machines, etc., necessary in increased quantities. While it is not possible to definitize to the exact day, how much time would be needed as lead time to provide for an increase, unless the rates of production are known, it can be assumed that:

(b) if the completed airplane rate was at this date increased to several airplanes per month, then it automatically means the building of additional tools, and procurement of materials would have to be put in process as of this date.

(c) if the rate were to be increased, to five (5) per month (from the presently planned rate of one (1) airplane per month,) after approximately ten (10) or twelve (12) are completed, the decision to do so, and action on additional tooling, machinery, and material would have to be in effect approximately fifteen (15) months, previous to the date of the completion of the first additional airplanes.

(d) if the rate were to be increased to one (1) airplane per working day, by means of a normal accelerated rate, (after ten (10) or twelve (12) are completed at a rate of one (1) per month) the decision to do so, and

action on additional tooling, machinery, and material, would have to be in effect, approximately twenty seven (27) months previous to the accelerated peak being reached.

CF-105 BASIC MANUFACTURING POLICY AND PROCEDURE FOR BUILDING COMPONENT TEST SECTIONS AND SUBSEQUENT AIRPLANES

Through the efforts of Engineering and Manufacturing, to avoid and delete, where possible, duplication of efforts throughout the tooling program, we have established that our first release of drawings will be productionized, and in detail, to the greatest degree attainable. In keeping with this thought, selected Supervisors, Process Planners, etc. from the Production Engineering Department will advise and assist their counterparts in the Design Engineering Department throughout the design, drafting, and detail phases preceding scheduled drawing release, to the strictest extent possible. These joint efforts of Design Engineering and Production Engineering will be established and correlated in keeping with distinct sections, and/or components of the airplane. By so doing, these two groups can, and will assure better understanding by Production Engineering of the Designer's problems, and equally important will allow Process, Planning, Tooling and Production problems to be recognized and allowed for, previous to the scheduled release of drawings to Manufacturing.

Therefore, Production Engineering will proceed with their portion of this program in keeping with certain fundamental principles as follows:

1. Interchangeability

The selection of interchangeable components, sections and/or parts of the airplane will be established by Production Engineering during the design period in collaboration with the Design Engineering, and Inspection Departments. Our goal will be to plan for, and achieve, interchangeability to the greatest degree effective airplane number 1. This, of course, is in direct contrast to previous programs throughout the industry whereby various size groups of first production airplanes were completed before interchangeability was achieved. We feel very strongly that concentrated efforts during the Production Design program will allow for this seemingly optimistic view.

In event conditions beyond our control prevent interchangeability on some part, or parts, of the first airplanes, we will submit a request for waiver on that particular part, or parts. It is therefore necessary, and in fact mandatory, that this company and RCAF continue in close harmony

on this subject, and that no parties concerned let "red tape" and/or formalities interfere. We will need much help and understanding on the part of the customer.

Recently, we have been advised by RCAF that number one CF-105 and subsequent, will be in accordance to Mil Spec 1-8500A (ASG). In addition, we have been notified by letter to the effect that "interchangeability is mandatory, beginning with the first CF-105 airplane". Consequently, inasmuch as this company and the RCAF appear to be in agreement concerning the "interchangeability aspects" then it becomes axiomatic that the tooling for the CF-105 airplane must be, "of a quality consistent with interchangeable parts".

2. Die Models

It is our plan to continue with the construction of full size (inside of metal) master models, which will represent each distinct component of the airplane. These master models will be produced in our Tool Room. The master models will be correlated with all outside lines as established by the Drawing Office, and will be altered or corrected accordingly with any lines change. Material used for the construction of these master models will vary depending on the component and/or section of components in question. Certain models will be produced from plastic, others from mahogany, some from plaster, etc. By producing these models in advance of manufacture of form dies, trim templates, etc., we will avoid countless changes to parts and tooling which otherwise can not be avoided, and could only be accomplished by trial and error methods during production of the first airplane. A further desirable feature which results from the early production of master models, is that it allows the designer to view his two-dimension efforts in full scale, so that lines may be altered for compatability, previous to tooling, parts, etc., being improperly made.

In addition, during all phases of tools, dies, router and trim forms, drill templates and assembly fixtures, these three dimension and full size master models will provide an exact replica of the lines, shapes, contours and surfaces which must be produced as accurately as possible in metal. The construction of these models in advance of tooling and manufacture of parts, will provide for Design Engineering, Production Engineering, Production and Inspection personnel the best possible means of proceeding with the CF-105 airplane program with confidence. While these master models can not be expected to eliminate all discrepancies and resulting confusion, they will, without question, eliminate the great majority of misfits, misalignments, etc., which otherwise could only be found during the actual construction of numerous airplanes. Obviously, this latter method always occurs after tooling and parts are on hand, and cannot be tolerated on the CF-105 program.

3. Process Planning

Production Engineering will proceed with the complete planning breakdown of the airplane through each component, sub-component, sub-assembly, detail parts, equipment, etc., to the extent, that as scheduled drawing releases from the Design Engineering Department are completed, the airplane will be fully planned, and operation sheets established for the most efficient production, consistent with the program involved. Included in this complete planning program will be all inspection call-outs, establishment of function operations to be performed in factory, and those required during flight test operations. These items will be established by Production Engineering in close collaboration with Inspection Department and Design Engineering.

This principle of planning within the Production Engineering Department will be predicated on the understanding that as the first preproduction airplane is completed, operation sheets, methods, manufacturing sequence, etc., is correct and current. Should a given part, sub-assembly or component require alteration due to rig tests results, first flight etc., Production Engineering will then be able to provide for the changes which may arise, and will not be in the questionable position of not being completely in control of the situation.

4. Gauges

In conjunction with Items 2 and 3 above, all gauges necessary to assure interchangeability of components, and proper setting and checking of assembly fixtures will be completely planned, designed, and built in advance of the completion of parts and/or assembly fixtures.

5. Tool Design

The Tool Design Section of Production Engineering will complete all tool design necessary for the production of all detail parts, sub-assemblies, major assemblies, components, final aircraft, flight tests, etc., in parallel with the Process Planning as outlined in Item 3 above. This tool design effort will also be predicated on achieving the most efficient production methods, consistent with modern aviation type tooling methods, and in keeping with the numbers of airplanes likely to be required, and consistent with the interchangeability requirements as outlined.

6. Tooling Work Orders

Subsequent to the completion of Process Planning, Operation Sheet, and Tool Design of each detailed part, sub-assembly, major assembly, component and final aircraft, a tool work order complete with estimated labor hours, material, etc., will be written, recorded, and available for issuance. Tool work orders will be issued to the Tool Room in accordance with a detailed and priority sequenced index schedule. This detailed schedule will be prepared from the Master Plan.

RELEASE OF MODELS, GAUGES, TOOLS, FIXTURES, EQUIPMENT, ETC. BY TOOL WORK ORDERS TO THE TOOL ROOM

As explained previously, all Process Planning, Tool Design, Tooling Work Orders will have been accomplished in sequence with the scheduled release of productionized, and detailed drawings from the Design Engineering Department. The release of tooling work orders for build, as outlined for production of the test components and subsequent production airplanes is as follows:

a) Master Models to be released by tool work order and completed as rapidly as possible.

b) Gauges All gauging to be released by tool work order in accordance with priority schedule, but in all cases ahead of detail and assembly tooling.

c) Tools for Sheet Metal Parts to be released by tool work order, for all such parts, in accordance with the priority sequence schedule. These tools for sheet metal parts will not be temporary in any sense, and will suffice for a reasonable production run, consistent with modern aircraft tooling practices. This is not to be misconstrued as elaborate tooling, such as would be considered for several thousand airplanes, or automotive type tooling.

d) Tools for Detailed Machined Parts will be released by tool work order for the first test components and several preproduction airplanes. As stated above, all planning, tool design, and work orders will have been completed for these particular tools. However, it is understood that, due to shortages of tool lead time, development of forgings, castings, etc., it appears necessary to obtain the first several machined sets of parts by tool room methods, while these tools are being built. Obviously, this must be a general policy, and not restrictive in any sense. Due to time and availability of proper castings and forgings, lead time for suitable tooling, etc., it appears necessary for us to make by tool room methods the first several sets of machined parts for the first several airplanes. However, this is strictly due to the reasons stated. This is not good practice and it is uneconomical in every sense, regardless of changes in design, which may and probably will occur during the beginning of this program. It must be remembered that making machined parts by tool room methods and "hogging" intricate parts out of blocks of metal is extremely costly and will not generally provide for the interchangeable requirements. Also by the time several sets of parts have been produced in this manner, the cost incurred will generally be equal to having built the necessary fixtures in the first place. Consequently, while we are possibly justified in making the first several sets by tool room methods, we would not be justified in allowing this excessive practice to continue any longer then is absolutely necessary.

Therefore, during the period we are making the first several sets by tool room methods, I feel we must release and build the necessary machine tool fixtures to provide for the subsequent sets contemplated and again keeping consistent with the rates of production as established by the customer. However, on this subject, the type of fixture necessary for 4, 11, 30 or 200 airplanes is equal to accepted "aircraft type tooling" and does not consider utilization of large quantity aircraft, or automotive type, progressive tooling.

e) Sub-Assembly Fixtures Sub-Assembly fixtures will, as noted, have been fully planned, tool designs and tool work orders prepared as a normal course of the tooling planning operation. The release to the tool room to build sub-assembly fixtures will be confined to those sub-assembly fixtures which are necessary to accomplish good workmanlike sub-assemblies and to ensure proper interchangeability and so forth. These sub-assembly fixtures will only be ordered in quantity to sustain approximately one (1) airplane per month. The multitude of "ease of use" type of sub-assembly fixtures, which become very necessary when increased quantities of airplanes are desired, will not be ordered at this time, but will be developed during the production of the first eleven airplanes and subsequent, should it be deemed they will be needed.

f) Major Assembly Fixtures Major assembly fixtures, having been completely planned and designed, will be released by tool work order to the tool room for completion and used in accordance with the schedule. These releases will include all fixtures necessary to ensure that each major component is properly built and will allow for the desired final assembly of the airplane. The number of each of these fixtures, to be built during this period, will generally be confined to one (1) each. Consequently, if accelerated numbers of airplanes are desired subsequent to the first eleven airplanes, additional amounts of these major fixtures will be necessary. It is to be noted that these major assembly fixtures as described, will be production type fixtures and not in any sense temporary tooling. However, this is not to be misconstrued as meaning high production aircraft, or automotive type tooling.

g) Equipment Equipment for use in sub-assembly, major assembly, final line operations, and flight test operations will have been fully planned, designed and tool orders prepared. However, for the first eleven airplanes, only a strict minimum of these items will be constructed. Items in this category can be better recognized as, testing units for electrics, hydraulics, pressurization, generators, etc., etc.

h) Production Control Production Control will continue, through their presently devised systems, to receive from the Industrial Engineering Department, master schedules from which they will be guided in preparing the detailed work order release dates for production parts. The work orders issued by Production Control to the Shops will be, as at present, the operation sheets as prepared by Production Engineering in accordance with priority sequence planning.

i) Production Production of detailed sheet metal parts and/or machined parts for the first release will be, in the broad sense, performed by production employees on production machines. However, it will be our policy to place the full responsibility, for producing proper and acceptable parts, on the Production Engineering Department during the first release of parts needed for the first eleven airplanes and/or test components. The number of pieces to be released by the work order will be equal to the total required by adding the number of components to be built, plus one or possibly two spare pieces. It is imperative that all tool proving be completed during the manufacturing of these first parts. As sub-assembly, major assembly, component assembly, equipping and final line operations begin, the Production Departments will assign selected supervisors and production employees to perform this work. However, the full responsibility for the proper sequence of build-up, compatability of parts within assemblies, assembly fixtures, equipment, etc., will be borne by the Chief Production Engineer during the construction of the first several airplanes. This is being established very firmly, in order to assure to the greatest extent, that all planning, tool design, tool work orders, parts work orders, parts make, component assembly, and completion of the first airplanes, are in accordance with design drawings, and completely covered by production operation sheets which are accurate and current at all times.

SUMMARY

The development of the CF-105 from its conception through the first several flying articles and subsequent airplanes, can be described in condensed form as follows:

1. Our plan to utilize throughout our product design, and detail drawing stage, every possible method of determining, previous to the first issue, all equipment, piping and wiring positions and to clarify interferences, etc., will result in far smaller amount of corrections necessary during the tooling and first production phase, and I believe will hasten the first airplanes, rather than delay.

   While it is fully recognized by all concerned that perfection in this field may never be complete, nevertheless, our concentrated efforts towards perfection, can only result in greatly reducing the ever present problem in this industry, provided, all concerned enter into this program wholeheartedly to the fullest extent.

2. By carefully and properly processing and planning each individual part, sub-assembly, component, and completed product during and concurrent with the design effort,

we can best assure ourselves that the multitude of unsatisfactory conditions are corrected on paper, before tools and parts are improperly produced. We are also aware that during the rig testing of components, and flight testing of the first airplanes, changes may become necessary which were impossible to forecast during the program as outlined previously. Should instances of this type arise, the facilities at our disposal, and the potential ability within each function of the Avro Aircraft Limited will be able to efficiently cope with these changes far more readily than would otherwise be the case. In addition, at any point during this program, this company and its customer will be better able to forecast the expenditure necessary and availability of production articles, if so desired.

In conclusion, it is mandatory that all department heads, supervisors and affected personnel maintain a clear understanding of this policy and are at all times aware of the customer's desire that we do not expend funds unnecessarily during the start of this program, until the product is proven entirely satisfactory and/or the customer can more readily determine quantities, and rates of production consistent with his needs. It is also mandatory that all department heads, supervisors and affected personnel remain equally aware of the necessity of proceeding with this program in a manner which will, to the greatest extent, ensure that the CF-105 airplane is produced as accurately to the design as possible. In event any interested person is not fully conversant with the meanings and details of this policy, it will be his responsibility to immediately ask for clarification from his supervisor.

Harvey R. Smith

HARVEY R. SMITH
VICE PRESIDENT - MANUFACTURING

HRS/bw

TOOLING AND MANUFACTURING POLICY

CF-105

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BASIC REQUIREMENTS UNDERLYING THE TOOLING PROGRAM

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

1. The fact that this aircraft is of an extremely advanced type performancewise, means that a high degree of "envelope" accuracy and surface smoothness are mandatory to ensure aerodynamic efficiency.

2. In order to provide the most efficient use of the aircraft in Service Handling, a high degree of interchangeability is desirable.

These two basic requirements create the necessity for our "Master Model Program" for envelope control, and our "Interchangeability Tooling Program" for Interchangeability control.

Our approach to "Detail" and "Sub-Assembly" tooling is dictated largely by economy, however our final assembly fixtures have full provision for maintaining the requisite interchangeability points in their proper relative positions.

ENGINEERING INFORMATION SUPPLIED FOR THE TOOLING PROGRAM

Master Lines Glass Cloths:- As soon as the "Envelope" or shape of the aircraft is defined, full scale layouts of these "master lines" are drawn on glass cloth. These master lines glass cloths are reproduced onto glass cloth for the purpose of filling in the actual structural details in the area concerned. This is the Assembly Glass Cloth, and is merely the full scale master lines glass cloth repeated exactly, plus the inside envelope details. In addition, Basic Geometry Drawings are supplied by Engineering to define interchangeability locations.

Master Lines Glass Cloth reproductions on metal are used for the "Envelope" Control Tooling.

Assembly Glass Cloth is the basis for PART manufacture and associated tooling.

The Basic Geometry dimensions form the basis of the interchangeability tooling required.

MASTER MODEL PROGRAM FOR "ENVELOPE" CONTROL

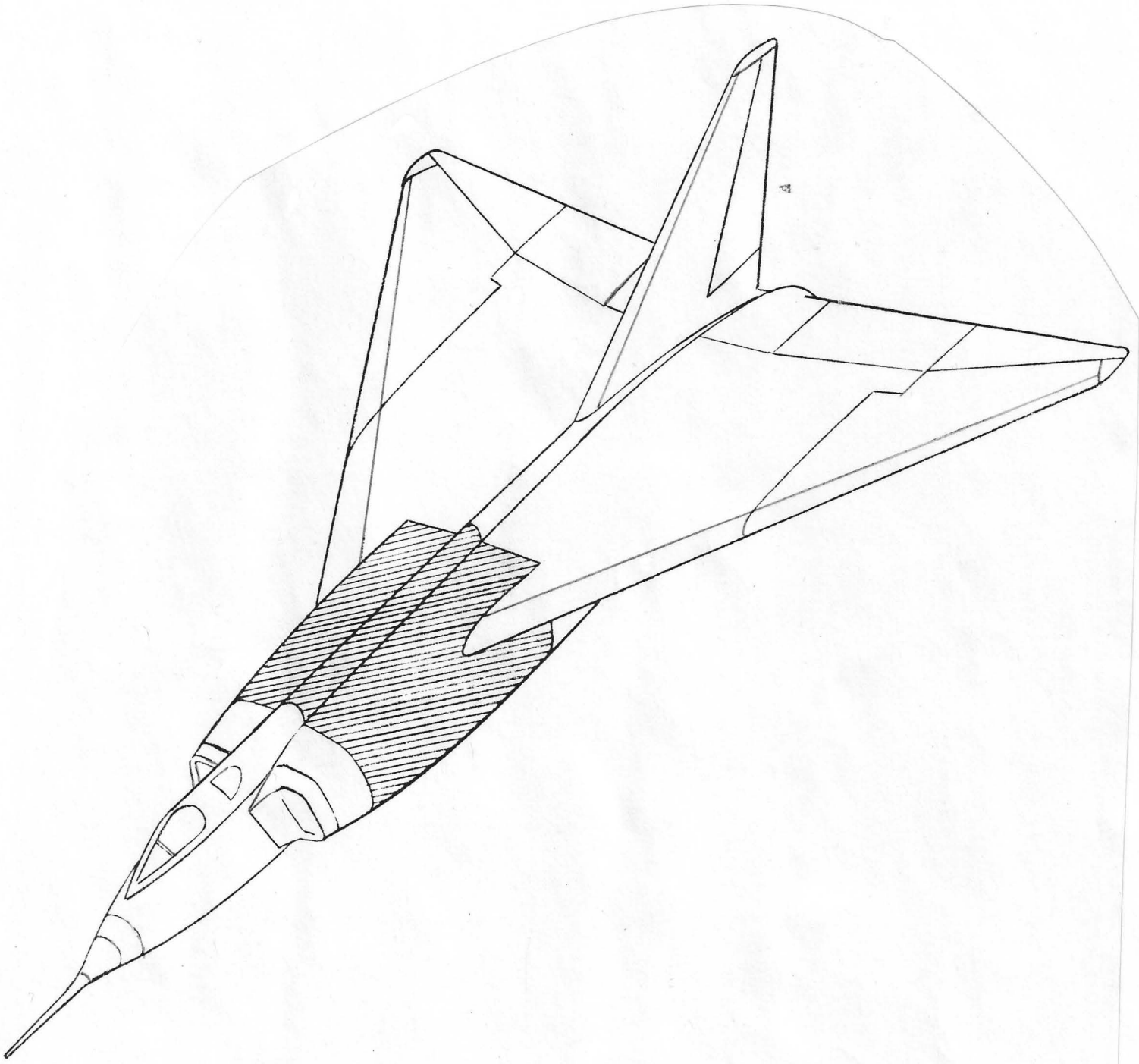
To construct the Master Model of a particular component, the Master Lines Glass Cloths are reproduced in light alloy template form, cut to profile and mounted on a suitable frame. After splining in to ensure accuracy of profile, the spaces between the templates are plastered in to present a finished model. Datum lines, Skin trim lines, cut-outs etc., are added as needed to obtain the fullest use of the Model. This Model is now the tooling MASTER. It establishes

the shape of the "Envelope" for that component, and the shape and size of the various skin panels.

All detail parts which are adjacent to the outside contour of the structure, and therefore control the aircraft's shape, must have their tooling related directly to this model.

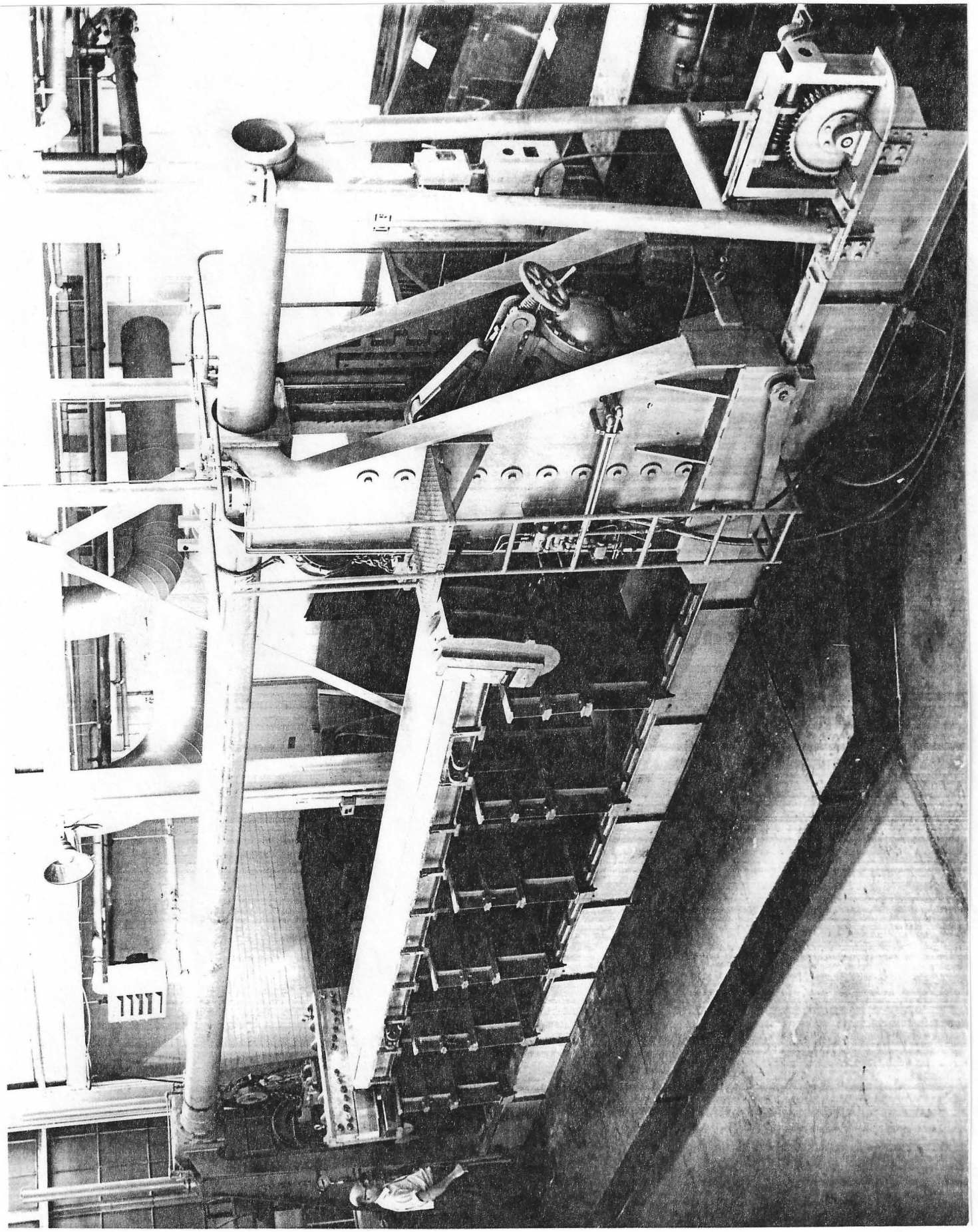
Sheet Metal parts having a double curvature require a model to define the exact shape of the finished part. From the model, splashes are taken to transfer the shape into the tools, such as stretch form blocks, drop hammer dies etc. Instead of having individual models for each part, it is more advantageous to have a Master Model for the entire component "envelope". Splashes can still be taken off the appropriate areas for tooling up the various sheet metal parts while the Master Model establishes the exact trim lines for each skin panel to ensure their proper fit. Another advantage of the master model is that it proves the master lines for the Assembly Glass Cloths from which the tooling for the detail parts and assemblies is made.

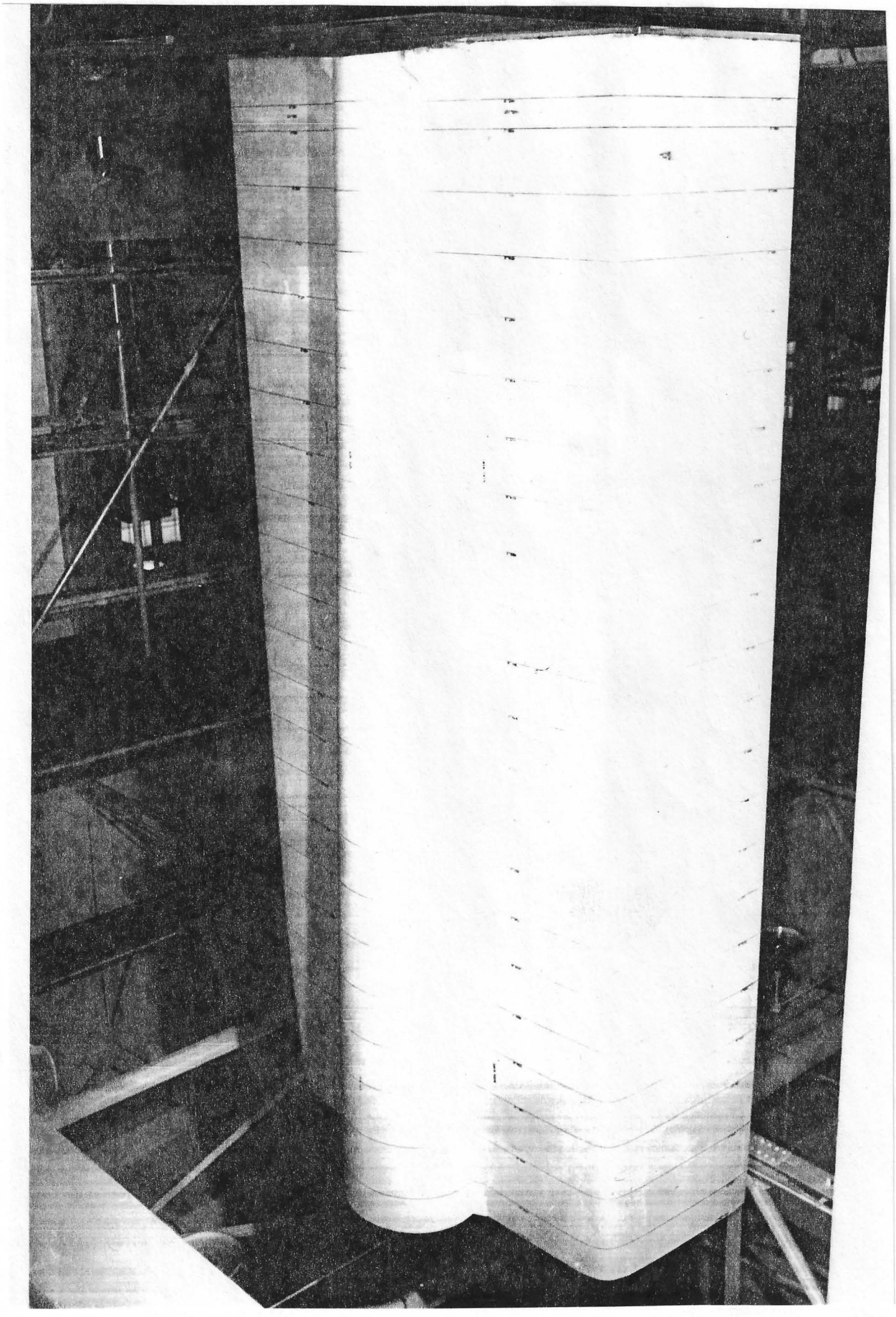
To illustrate how the "Control" is built into the master model, and how the master model is used, this brochure examines the Centre Fuselage Component of the CF-105.



C105 AIRCRAFT WITH CENTRE FUSELAGE OUTLINED

AVRO AIRCRAFT

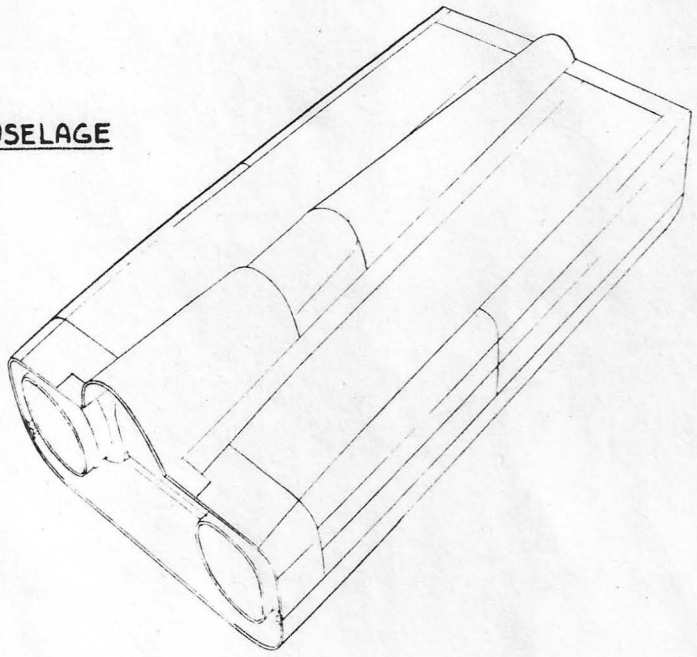




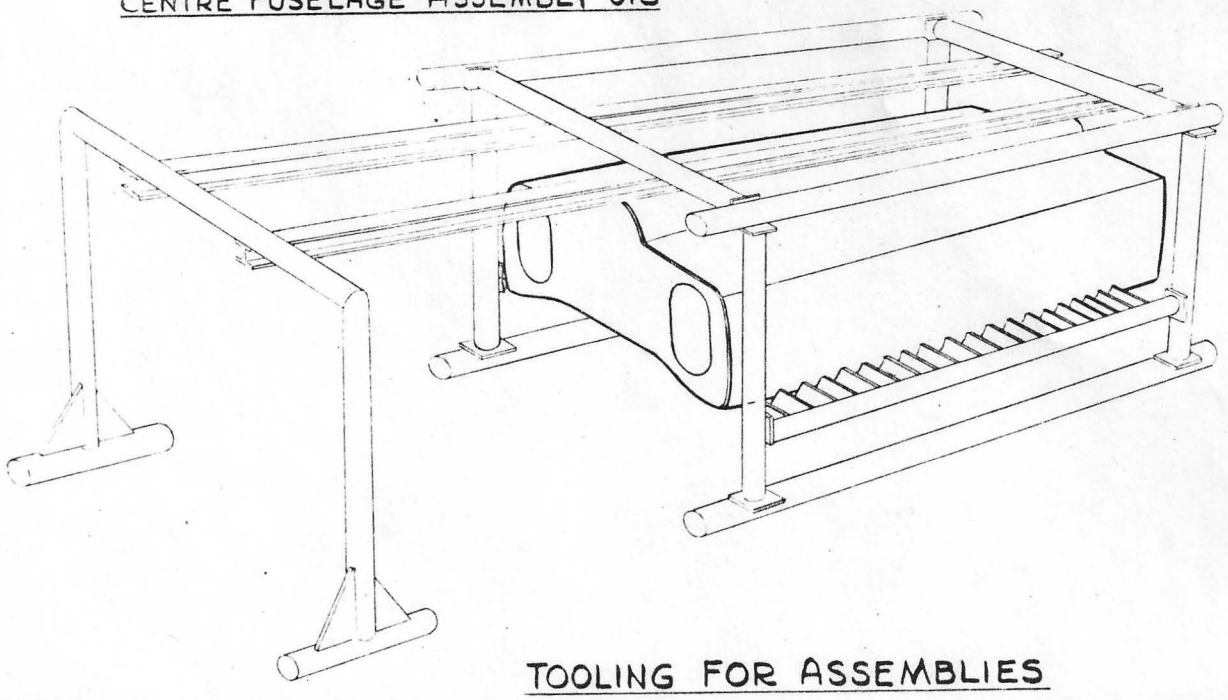
COMPONENT ASSEMBLY

A MAJOR ASSEMBLY JIG IS REQUIRED AT THIS STAGE TO CONTROL THE POSITION OF THE SUB/ASSYS AND THE REMAINING STRUCTURE ITEMS. THIS CONTROL IS NECESSARY TO INSURE THAT COMPONENT ENVELOPE IS IDENTICAL TO THE MASTER MODEL, AND THAT THE COMPONENT WILL MARRY-UP WITH ITS ADJACENT COMPONENT

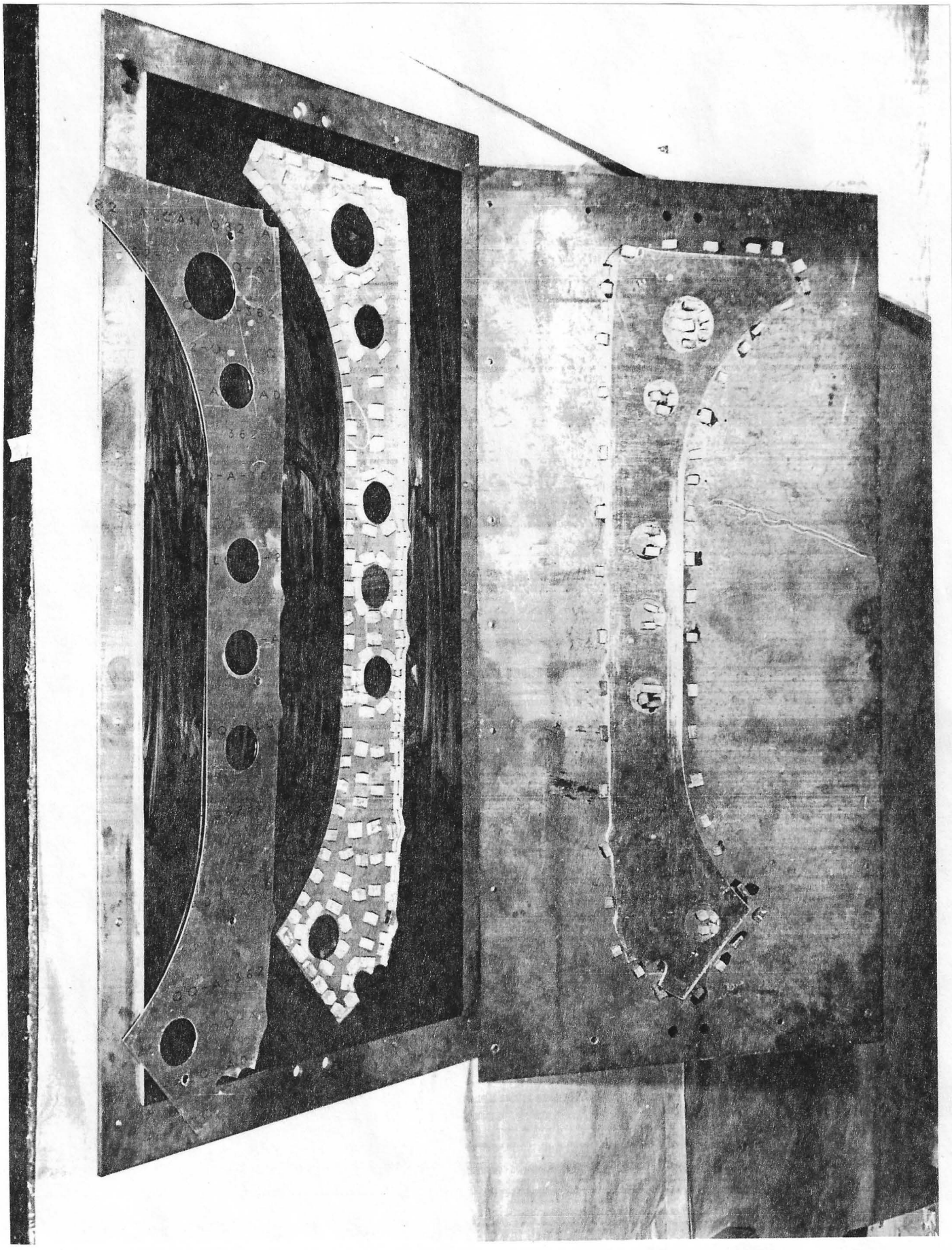
CENTRE FUSELAGE



CENTRE FUSELAGE ASSEMBLY JIG



TOOLING FOR ASSEMBLIES



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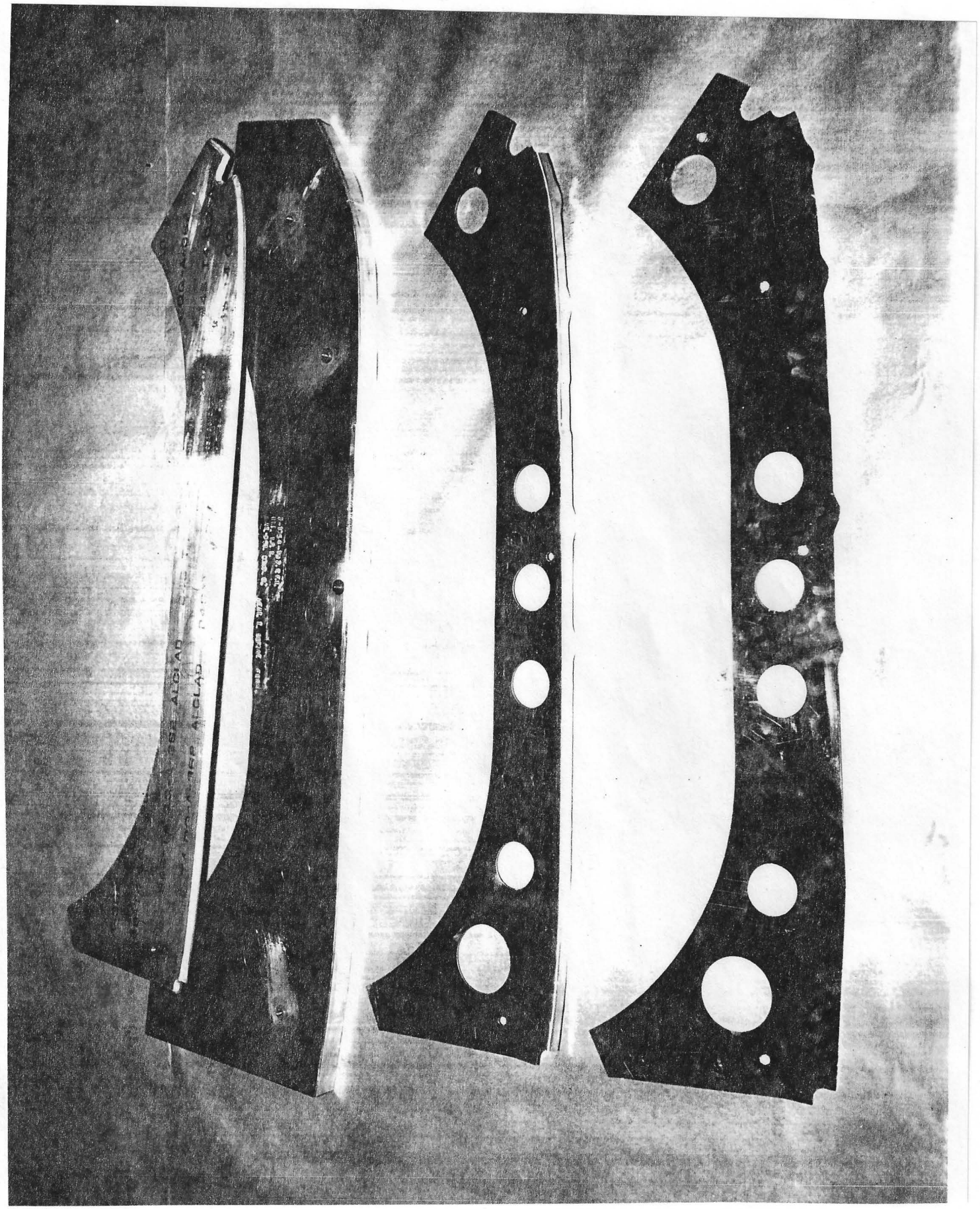
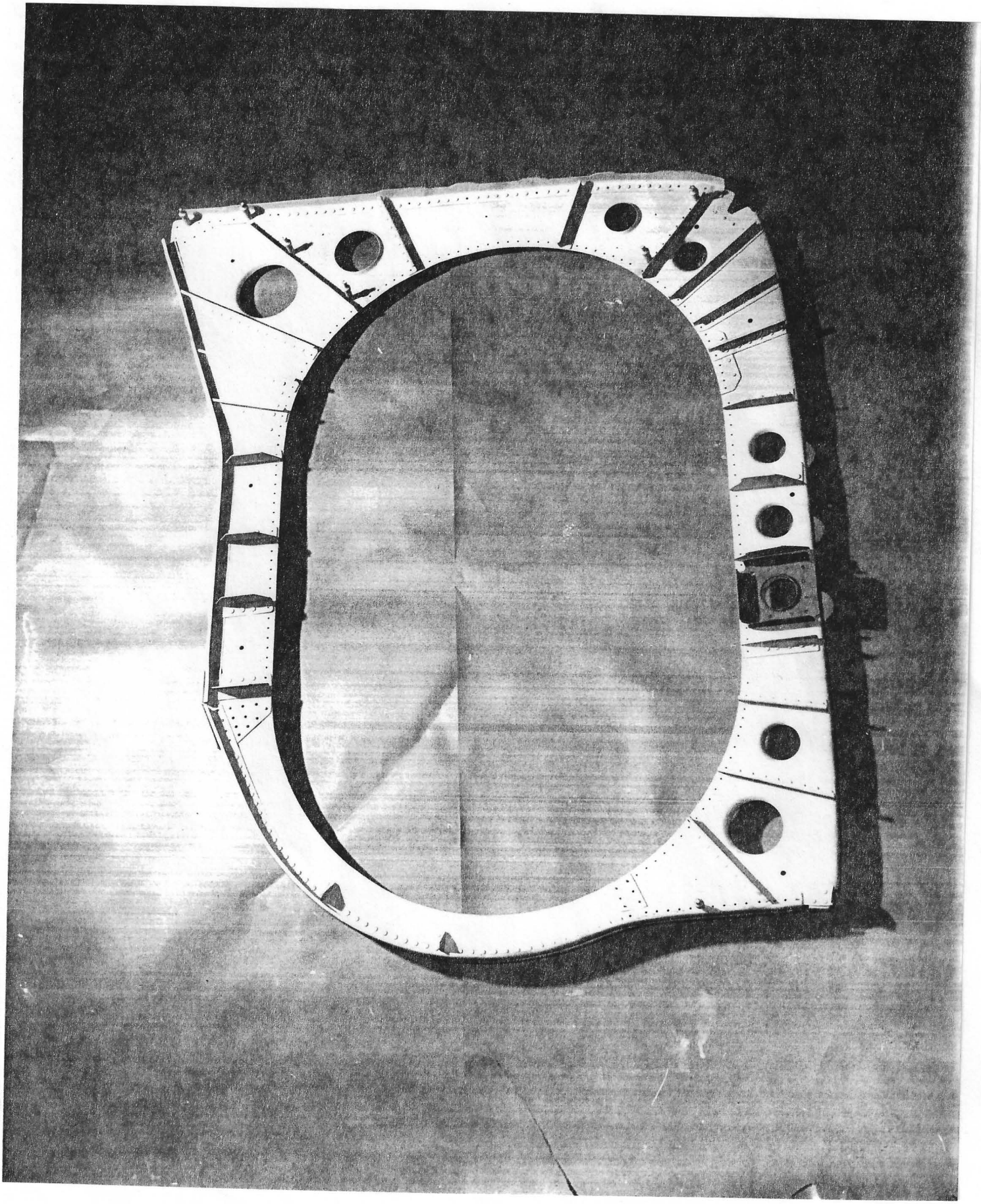
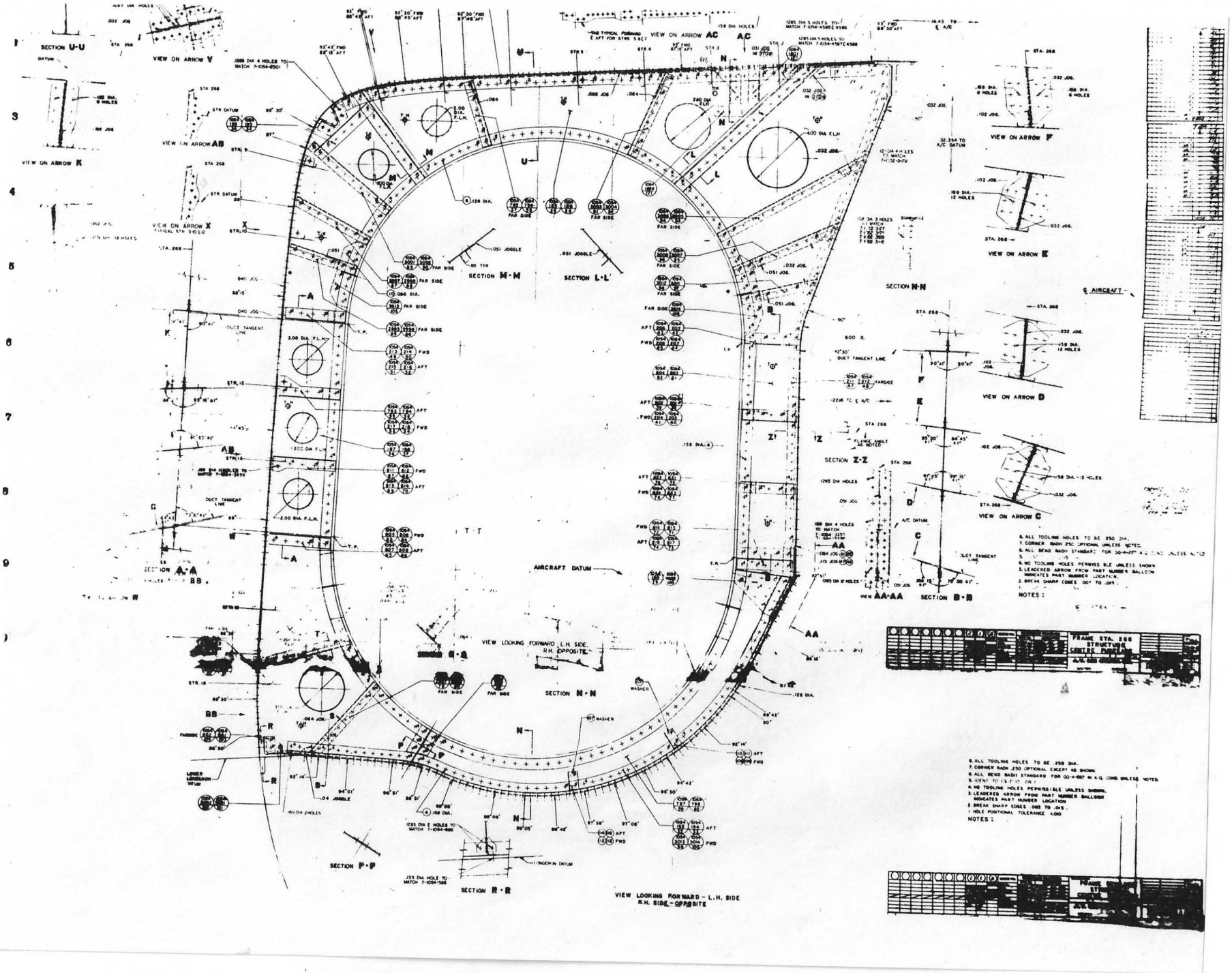
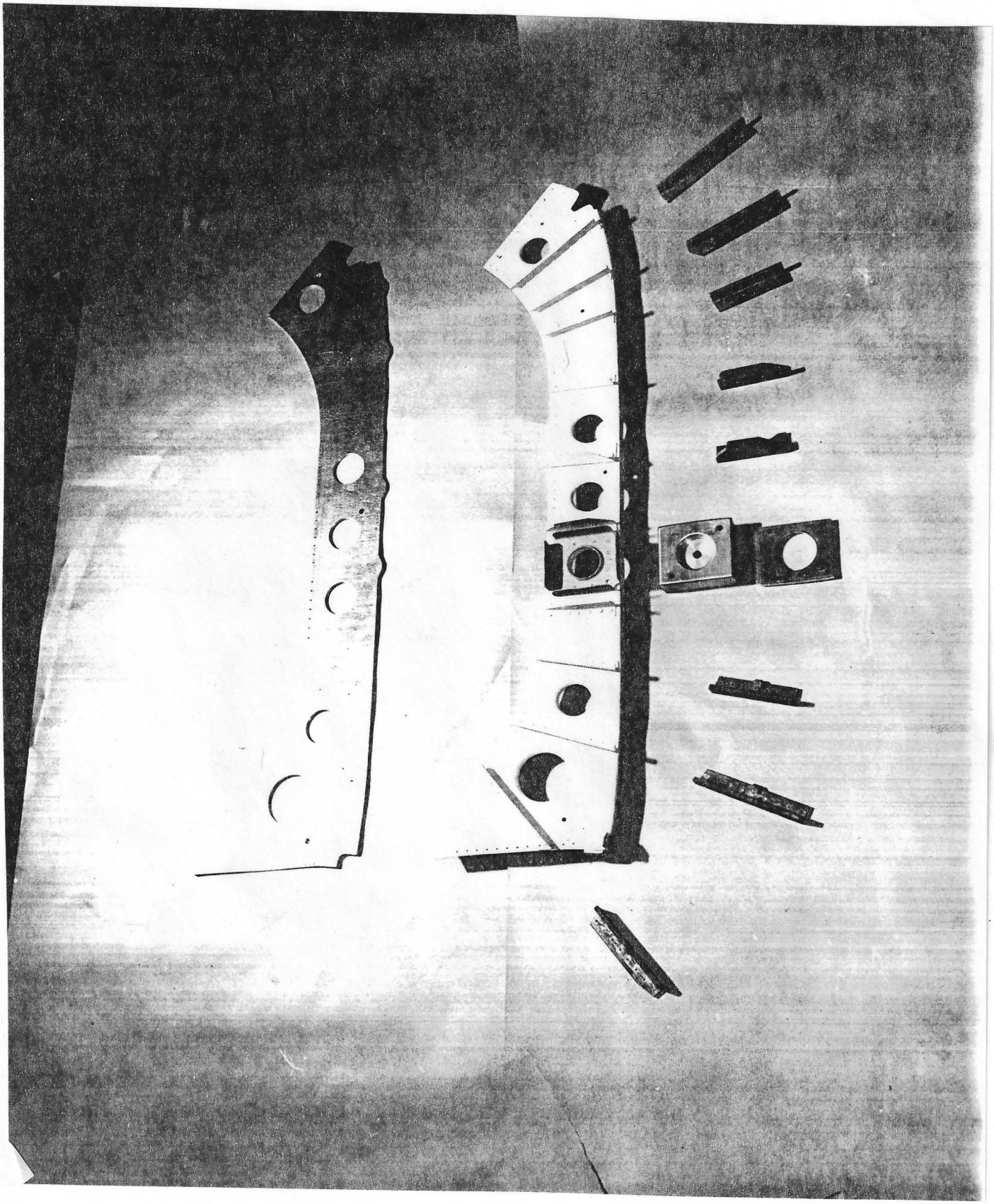
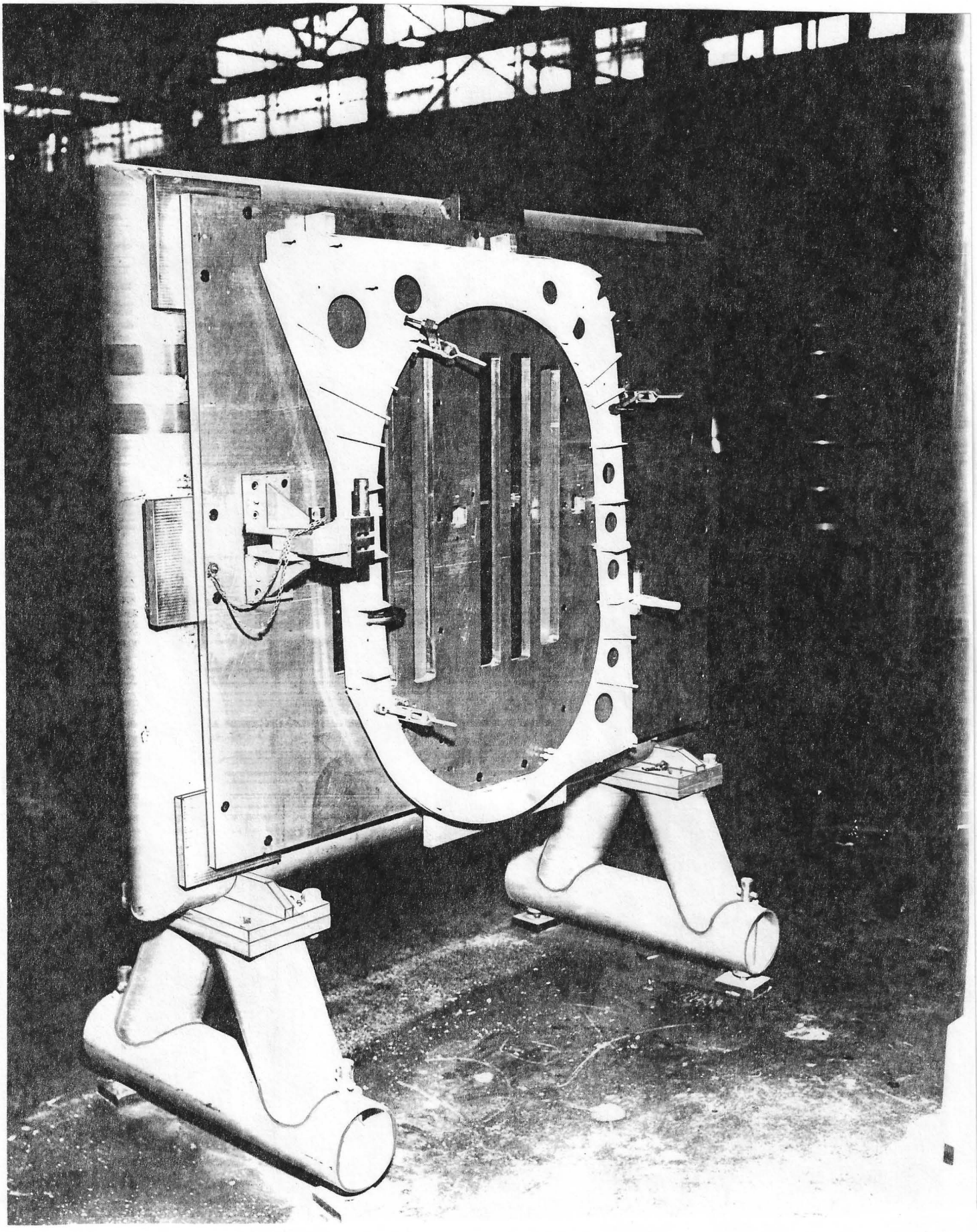


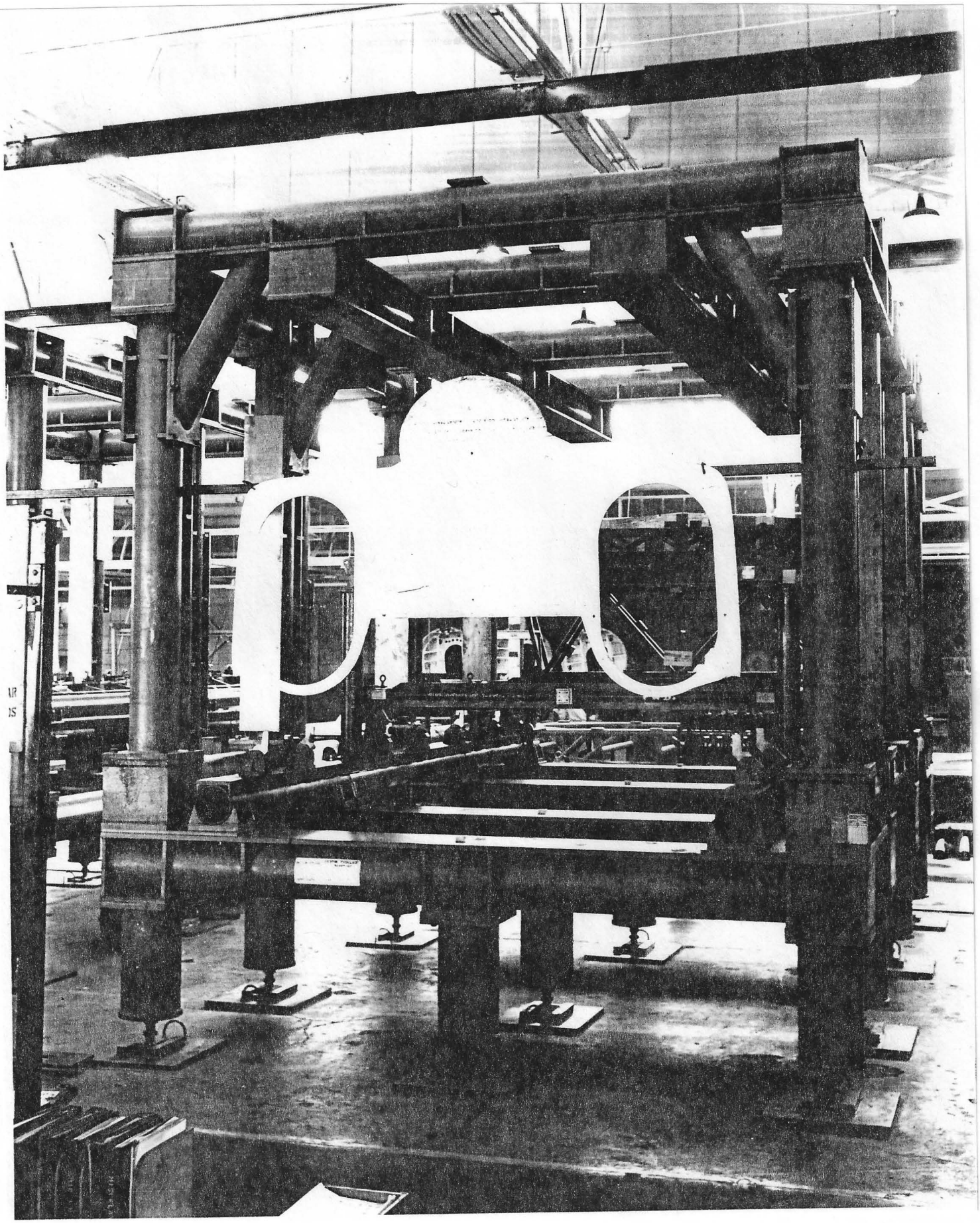


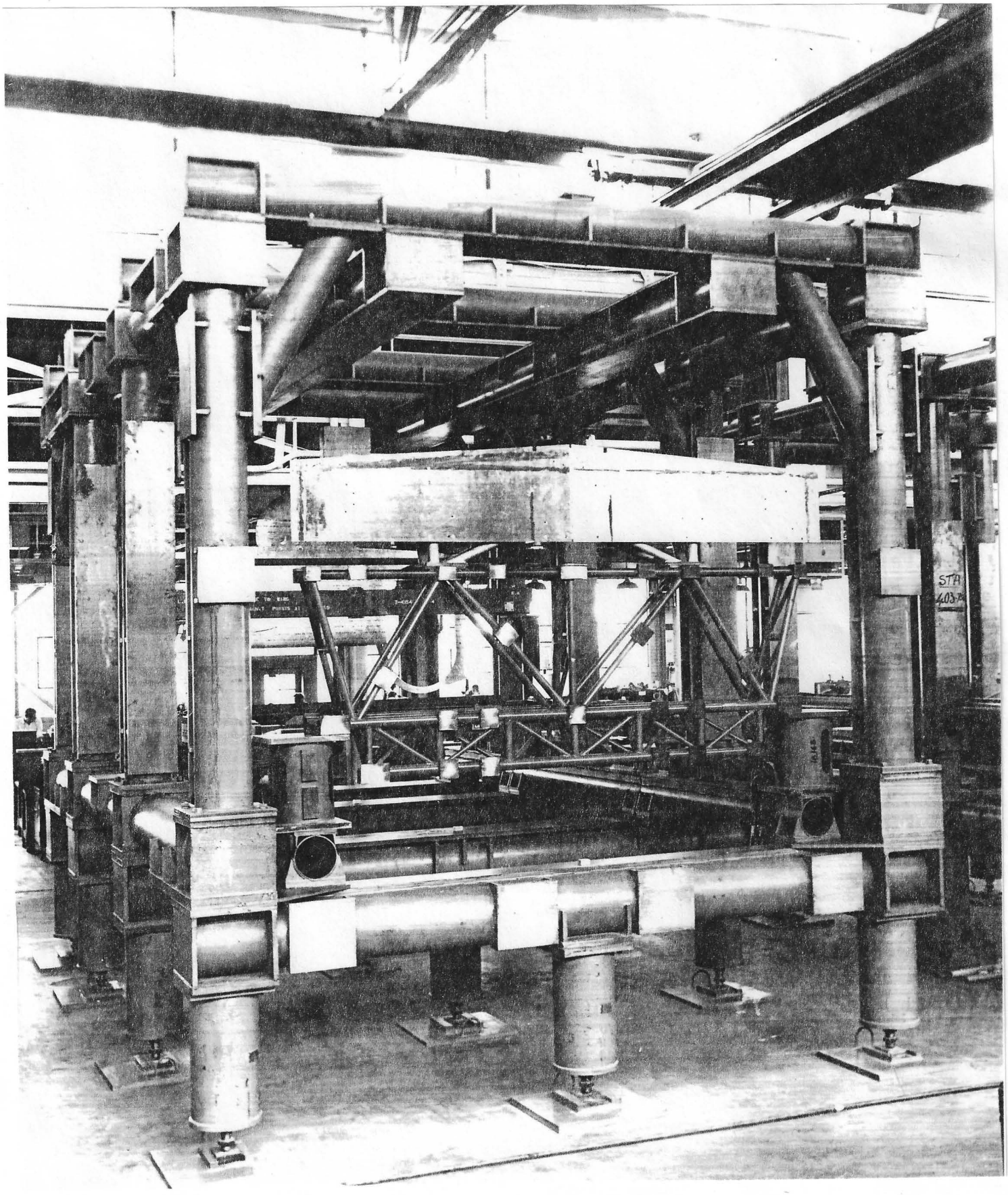

SECTION U-U
VIEW ON ARROW V
VIEW ON ARROW AC
VIEW ON ARROW K
VIEW ON ARROW AB
VIEW ON ARROW X
VIEW ON ARROW F
VIEW ON ARROW E
SECTION M-M
SECTION L-L
SECTION N-N
VIEW ON ARROW D
SECTION Z-Z
VIEW ON ARROW C
SECTION A-A
AIRCRAFT DATUM
SECTION B-B
SECTION N-N
VIEW LOOKING FORWARD L.H. SIDE R.H. OPPOSITE
SECTION P-P
SECTION R-R
VIEW LOOKING FORWARD - L.H. SIDE R.H. SIDE - OPPOSITE
NOTES :
FRAME STA. 268 STRUCTURE CENTER PANEL



AVRO AIRCRAFT







TOOLING FOR MACHINE PARTS

The following illustrations show three typical machine parts from the centre fuselage component, together with the required tooling.

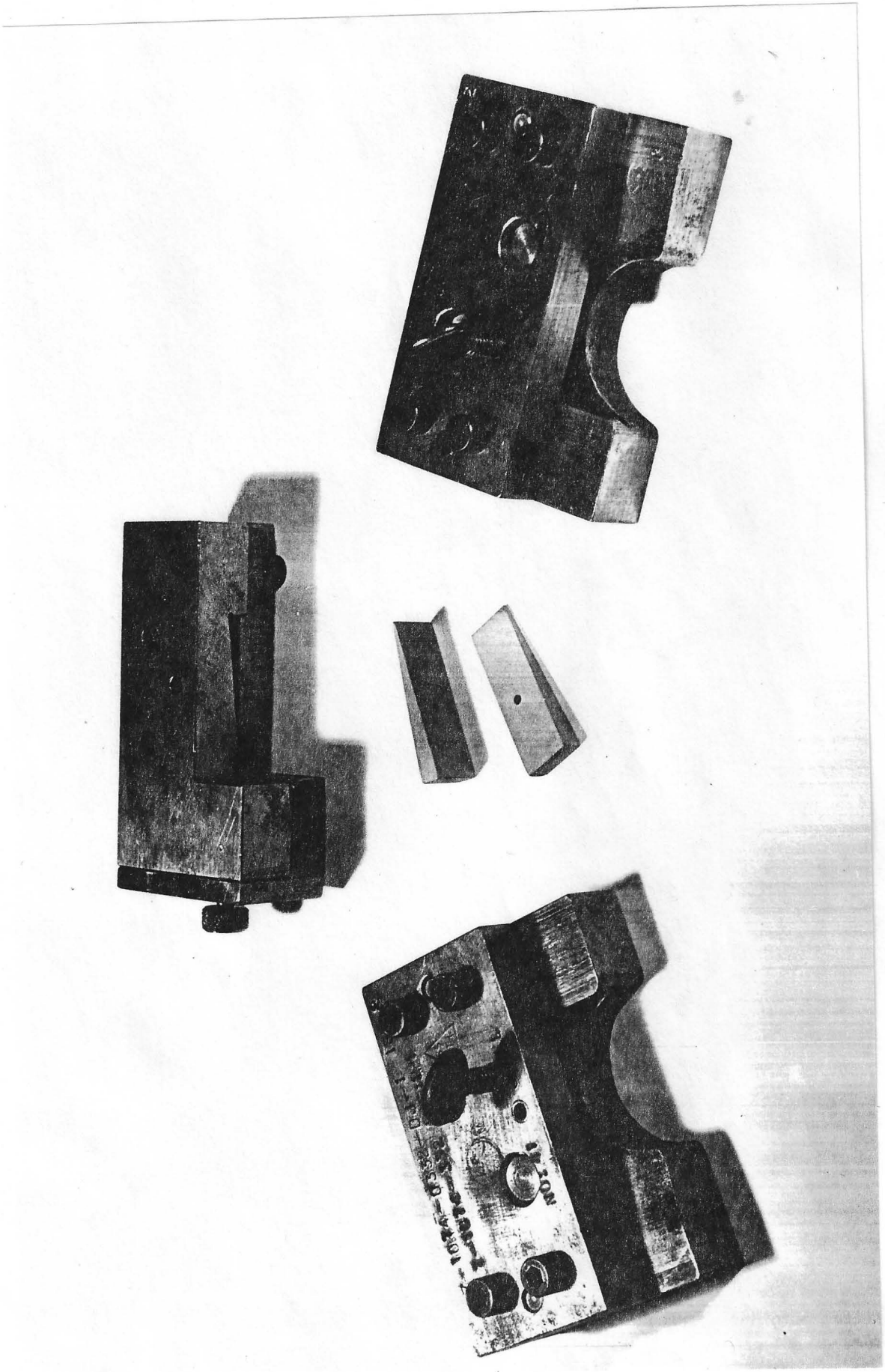
Our basic policy with regard to these and similar other parts is to provide the minimum number of tools, consistent with the quality required for the particular parts in question.

Example No.1 illustrates a part which is made without special tools using only the standard equipment presently available in the shops.

Example No.2 shows a more complex part and the simple type of fixtures provided to maintain the necessary dimensional control.

Example No.3 illustrates a part where interchangeability is involved. This requires 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.

To summarize, our approach is to provide only that necessary and simple tooling for difficult operations; where interchangeability control is required; or where the extensive set-up involved would jeopardize the required production rate.



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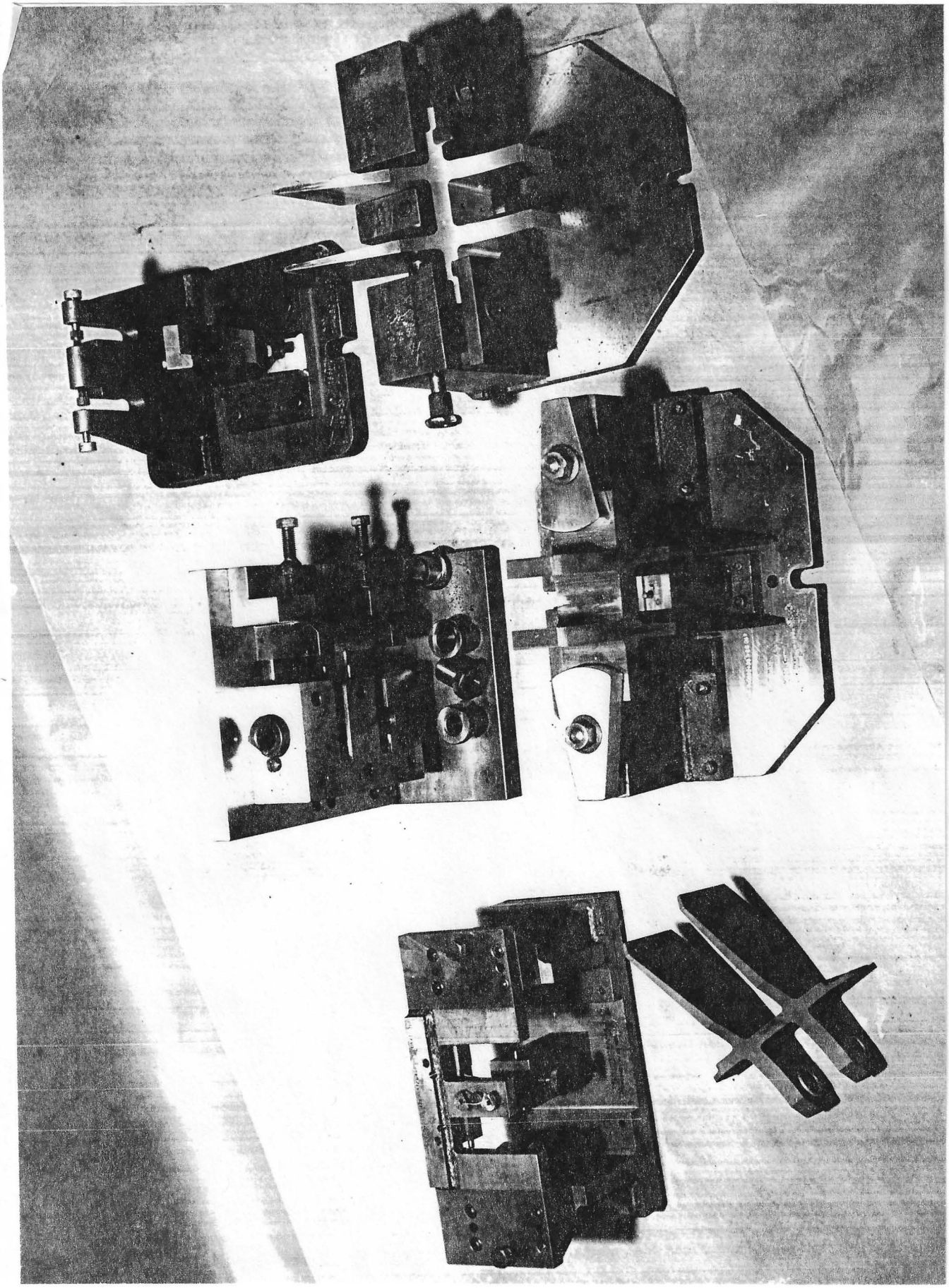


APPLICATION OF INTERCHANGEABILITY CONTROL

The following illustration shows how interchangeability control is provided by jig references and match plates.

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 required tolerance.

While this is of importance on 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 removed and the assembly jig is ready for use.

The Jig Reference is built to the master dimensions stated on the Basic Geometry drawing, and any profiles are obtained from the Master Lines Glass Cloth.

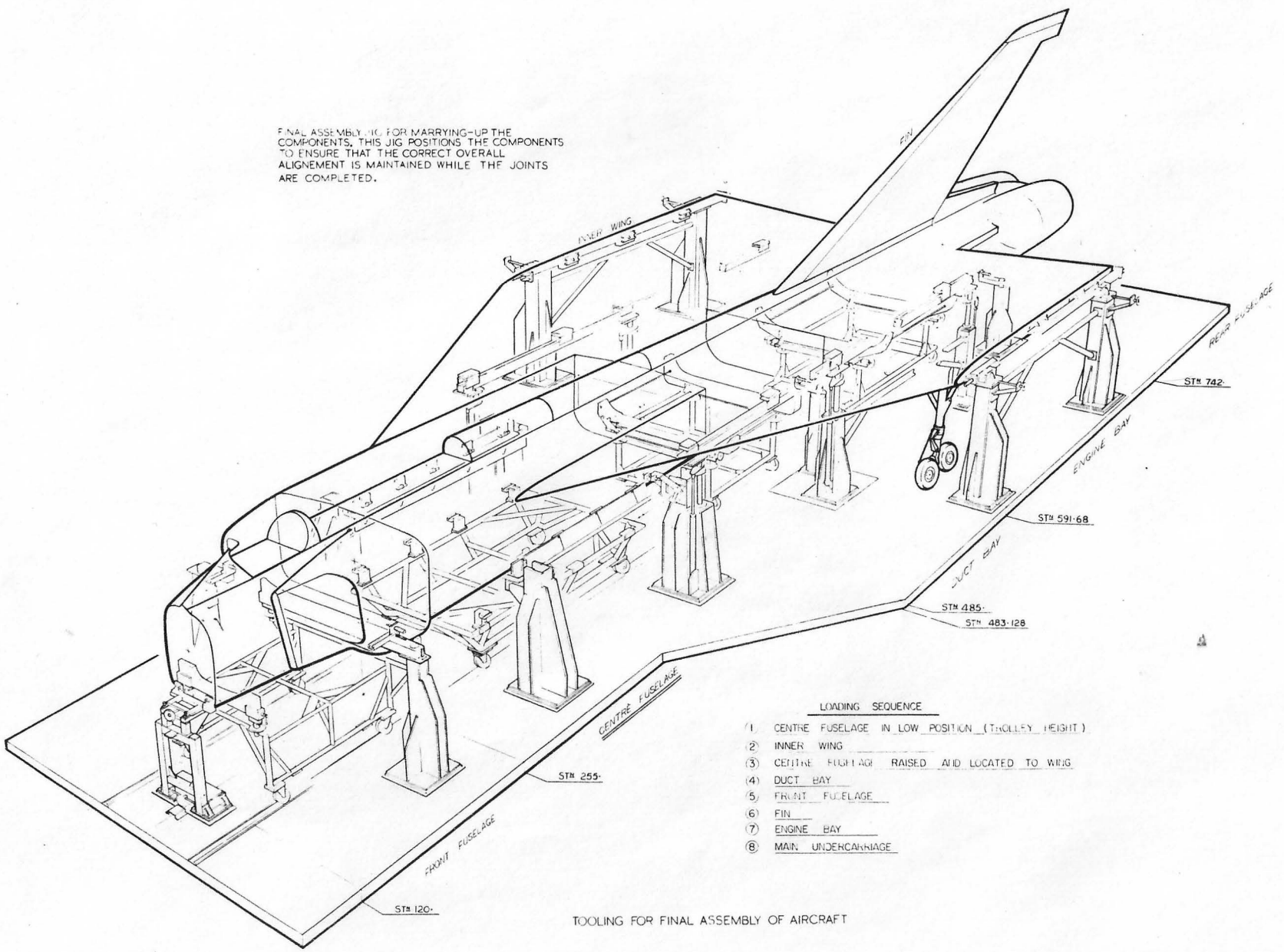
To control interchangeability at the joint between two components, two Jig References are built, one for each side of the joint. The two Jig References are first matched together to ensure that each is the counterpart of the other, then each is applied to its corresponding Component Assembly Jig. In a simple joint where the 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. (2) For periodic inspection of these jigs to see that the control is maintained. (3) To set up duplicate jigs at the plant or at a sub-contractor.

Jig References will be provided for setting up Component Assembly Jigs to pick up important items of equipment, for example under-carriage legs, mountings for various types of armament, radar chassis, supports for major flying control items, 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.

FINAL ASSEMBLY JIG FOR MARRYING-UP THE COMPONENTS. THIS JIG POSITIONS THE COMPONENTS TO ENSURE THAT THE CORRECT OVERALL ALIGNEMENT IS MAINTAINED WHILE THE JOINTS ARE COMPLETED.



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

TOOLING FOR FINAL ASSEMBLY OF AIRCRAFT

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