



C O N F I D E N T I A L

CF-105

POWER PLANT

GROUND SUPPORT EQUIPMENT

LOG/105/43

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1.

INTRODUCTION

1.1 Purpose of Report

The Company has, through the medium of the CF-105 Development Co-ordinating Committee, the Maintenance Sub-committee and the Ground Support Equipment Sub-committee, kept the Royal Canadian Air Force informed of the current design concept of ground equipment for engine handling, power plant build-up, transportation and installation in CF-105 aircraft.

At the CF-105 Mock-up Engineering Evaluation Conference held at Malton in February, 1956 the RCAF asked the Company that certain changes be investigated in respect of the mock-up ground equipment demonstrated for engine installation and removal. These change requests were:

- C-6 A positive mechanical lock be provided on the engine change stand to confirm elevation of forward rails - hydraulic achieved elevation may not be sufficiently reliable for transporting engines.
- C-7 The engine stand should be provided with steadying jack to raise it off wheels and fix its position during operation - a small movement of the stand can strain the stand to rail joints.
- C-8 That the engine stand shall be capable of being towed with the engine in place and positive braking be provided - this would allow the engine to be transported on the stand and to minimize loads on the airframe.
- C-12 Engine change trolley equipped with a cable and winch to effect the actual engagement of the trolley to the side rails - to ease and hasten the attachment.
- C-22 Engine change stand should be made to fold in order to reduce overall height after removal or before installation - to facilitate movement in hangar.

The Company has studied these change requests and deemed it necessary to present all the information which is currently available on this subject and its recommendations in one comprehensive report.

The purpose of this report is to establish an informed basis for discussion with the RCAF, with the object of arriving at a decision on what action is presently required to arrive at the best type of engine handling equipment to support CF-105 squadron operations.



1.2 Scope of Report

In order to fulfill its purpose, this report includes a description of the salient features of the power plant installation and explains how these have influenced the method which has presently been adopted for installing and removing the engine. It also discusses power plant maintenance with respect to engine handling and provides a detailed description of the proposed equipment for both Pratt and Whitney J75 and Orenda "Iroquois" power units.

The Company's recommendations on policy are to be found in the conclusion of this report.

1.3 Development Programme

CF-105 aircraft allotted to the aircraft development programme will be fitted with Pratt and Whitney J75 power plants with exception of aircraft No. 6 which has been reserved for flight development of the Orenda "Iroquois". A total of 31 J75 engines have currently been ordered for the development programme and it is planned that aircraft No. 11 and all subsequent aircraft will be fitted with "Iroquois" engines.

The design of handling equipment for the J75 engine and power plant is now complete and manufacture of the units will commence immediately DDP authorization is received. This equipment has to be made available to the Company's manufacturing division by 1st March, 1957.

The critical dimensions for the "Iroquois" engine differ considerably from those of the J75 engine with the result that the engine handling equipment for one installation is unsuitable for the other. Complete particulars of the "Iroquois" are not available yet and the design of the aircraft installation is therefore still at a preliminary stage; however, the features which influence the general design of the handling equipment for this engine have been established. It is essential that the detail design of the "Iroquois" ground equipment be completed by 1st February, 1957 in order that the hardware shall be available by 1st November, 1957.

The Company has recently sought the advice of the Air Logistics Corporation of Pasadena, California, who have specialized in the design and manufacture of prototype engine handling equipment for some of the latest USAF aircraft. AVRO Aircraft Ltd. has invited this Company to submit an engineering proposal for such equipment with respect to the "Iroquois" installation.



2.

AIRCRAFT DESIGN FEATURES

2.1 Aircraft Specification

The following paragraphs, extracted from AIR 7-4 issue 3 titled "Supersonic All-weather Interceptor Aircraft Type CF105", makes reference to engine removal and installation:-

- para. 6.1.3 The engine and afterburner installation shall be designed so that the complete unit in operating condition may be removed and another unit installed and ready for running in not more than thirty minutes. This shall be accomplished with no special tools other than an engine sling and an engine hoist or suitable trolley. The thirty minute period shall not include time required to set up or synchronize the engine controls.
- para. 6.1.4 Early aircraft built to this specification shall be equipped with two Pratt and Whitney J75 P3 or J75 P5 gas turbine jet propulsion engines with afterburners.
- para. 6.3.1 Within the limits imposed by the design of the engine and afterburner, the engine complete with afterburner and engine accessories, shall form a quickly detachable unit which will be readily removable from the aircraft, with a minimum disassembly of the aircraft.
- para. 6.3.3 All engine controls, fuel lines and electrical leads shall incorporate quickly detachable connectors to facilitate engine installation and removal.
- para. 6.3.4 Special attention shall be given to the engine and accessory installations so that maintenance and inspection will be facilitated to the utmost.

2.2 Power Plant Installation

A twin engine installation mounted within the rear fuselage has been adopted for this aircraft as this configuration, which keeps body drag to a minimum, was found to be the one best suited for high speed flight. This arrangement, however, presents a new problem with regard to engine installation, removal and servicing. Due attention has been given to this aspect when designing the rear fuselage; the high delta wing configuration and the air intake/fuselage design precludes installation or removal of the engine either from above or from the front; the only methods meriting serious consideration are indicated overleaf:-



- (a) The installation of large access hatches beneath the rear fuselage and in the engine shroud. This would provide access to the lower portion of the power unit and enable its removal and installation by means of a vertical hoist.
- (b) Installing the engine by passing it axially, from a position behind the aircraft, into the engine shroud and removing it by the same means. In this case, relatively small access hatches would be provided so that primary maintenance may be carried out on the power plants whilst in position in the engine shroud.

The first concept was thought to be the more convenient from the viewpoint of engine handling and ground servicing but the associated structural penalties, which are discussed below, were found to far outweigh its advantages.

Since the very thin wing of this aircraft will distort considerably in certain flight conditions, it was necessary to design the rear fuselage to accommodate both vertical and lateral deflections; this has been achieved by providing rigid support along the aircraft centre line and pin joint attachments at the outboard pick-up points of fuselage frames to the wing structure. A flexible fuselage of this type contributes to the primary aircraft structure but precludes the installation of large access hatches.

A further factor is that the engine shroud, which from a structural viewpoint is treated as a pressure vessel, has a differential pressure of 16 to 20 psi applied across it. Here again the provision of large access doors, which would be necessary for engine installation and removal, would inevitably result in a considerable increase in structural weight and thereby detract from the aircraft's performance.

In view of the foregoing, it was decided that power plants shall be moved within their shroud on rail(s) and that the handling equipment would be located at the rear of the aircraft. The design of both the power plant installation and its associated ground handling equipment had to provide for a power plant change, excluding synchronization of engine controls, in not more than thirty minutes. It is interesting to note that an approach similar to that outlined above has been taken by at least two other aircraft concerns producing a delta-wing fighter.

2.3 Pratt & Whitney J75 Installation

The engineering work on the J75 installation is now at an advanced stage. Figure 1 shows a side elevation of the power plant within the rear fuselage; the critical clearances between the power plant and the shroud are indicated in the accompanying cross sectional views. In order to effect installation and removal, it is essential that the engine change



facility shall have a traverse of at least 23 feet 6 inches. The estimated weight of the power plant is 6,443 pounds.

From perusal of Figure 2 which illustrates the engine mounting, it will be seen that the power plant is suspended from attachments to the wing; both static and flight loads are transmitted directly to the wing structure and the yellow arrows indicate the loads taken by each mount. The rear fuselage serves as a fairing for the power plants and accommodates the greater part of the aircraft services between the power plant shrouds.

The power unit is mounted from five points of which two are located on the compressor inlet casing at the front and in the plane of the turbine at the rear. These take the vertical and thrust loads whilst the rear mount linkage is designed to obviate torsional loads, due to wing distortion, being transmitted to the engine case. The rear centre fitting serves to centralize the engine and to restrain it from lateral motion.

Sufficient clearance exists between the J75 power plant and its shroud to permit two engine rails, which are items of handling equipment, to be slid into position on support brackets in the shroud. The power plant is moved in and out of the shroud on rollers fitted at its four lower mounting points; these rollers are raised clear of the rails when the power plant is mounted in position.

Particular attention has been paid to the design of the engine attachments to facilitate quick removal and installation. The only adjustments normally necessary are to the rear outboard strut, which raises the engine into position by means of a worm gear, and the eccentric in the rear central fitting.

2.4 Orenda "Iroquois" Installation

Although the design of the "Iroquois" installation is still at a preliminary stage, the main factors influencing its installation and removal have however been laid down in order that the design of the engine handling equipment may proceed. The cross-sectional views in Figure 3 indicate that the clearances between the "Iroquois" and its shroud are more critical, especially in the afterburner area, than those pertaining to the J75 engine; these dimensions precluded the adoption of the twin rail method described for the J75 power plant. It was found that the most satisfactory solution to this problem was to provide a single fixed rail on the outboard side of each engine shroud and the factors influencing this decision were:-

- (a) A single rail keeps aircraft structural weight down to a minimum.
- (b) The outboard location is the most suitable from the structural viewpoint.

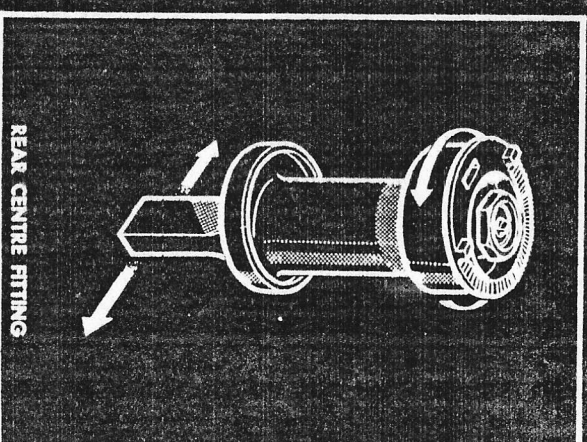
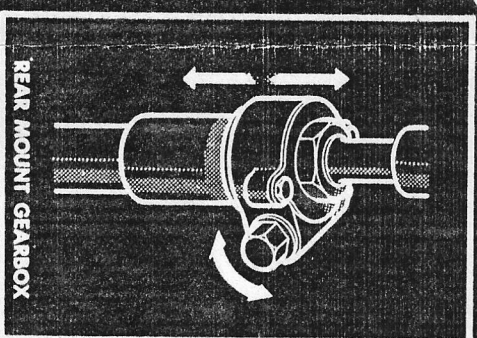
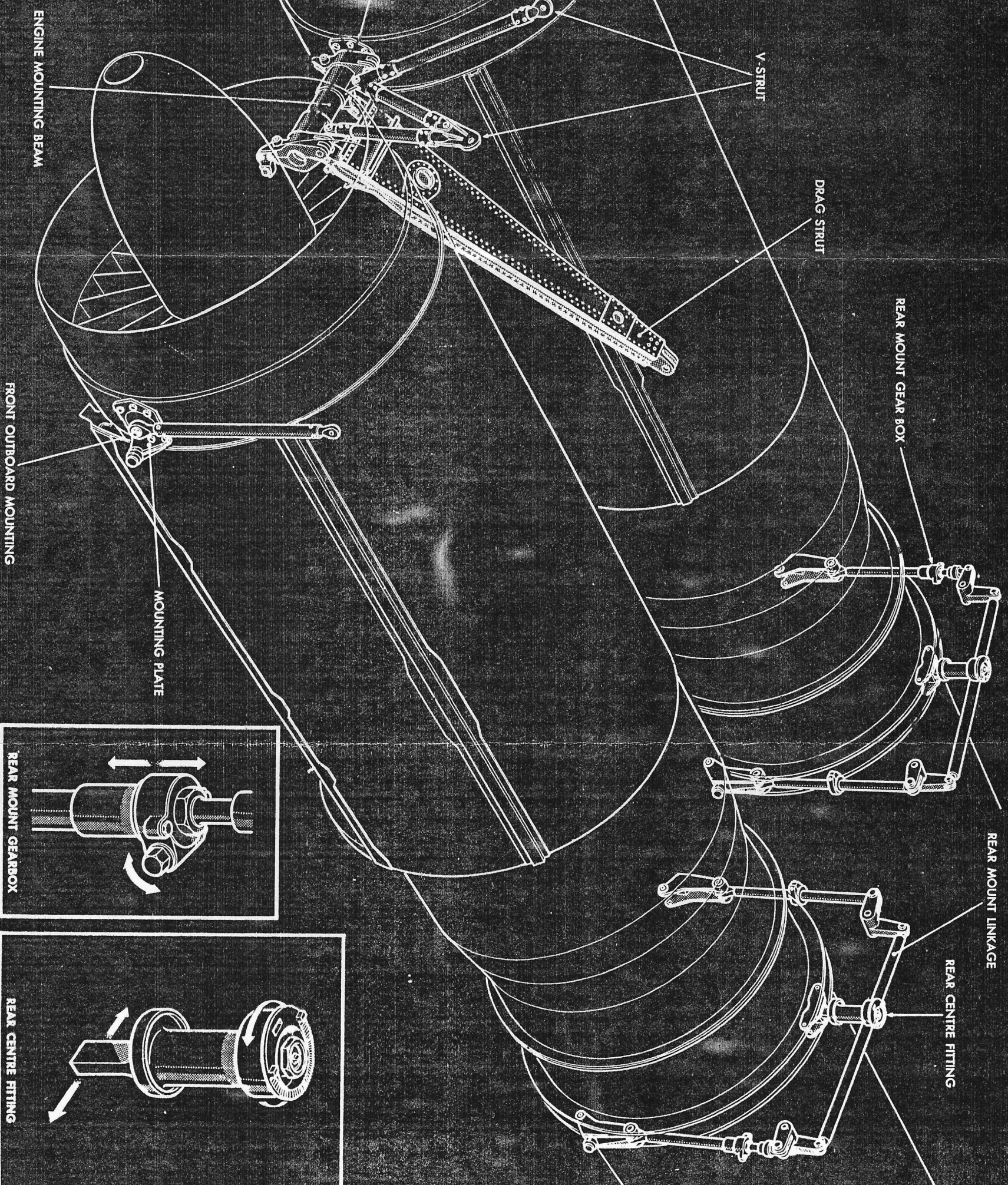
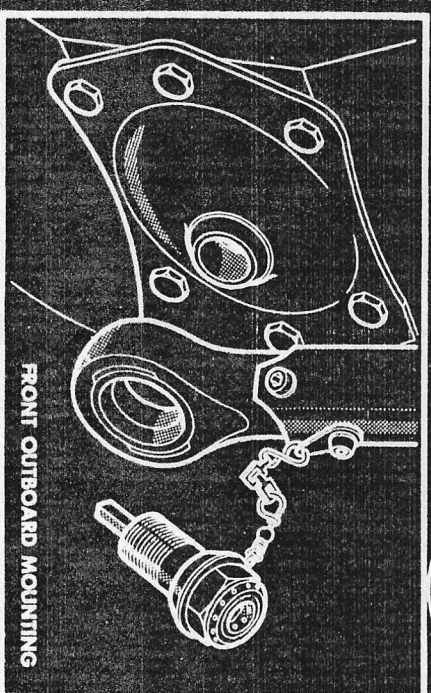
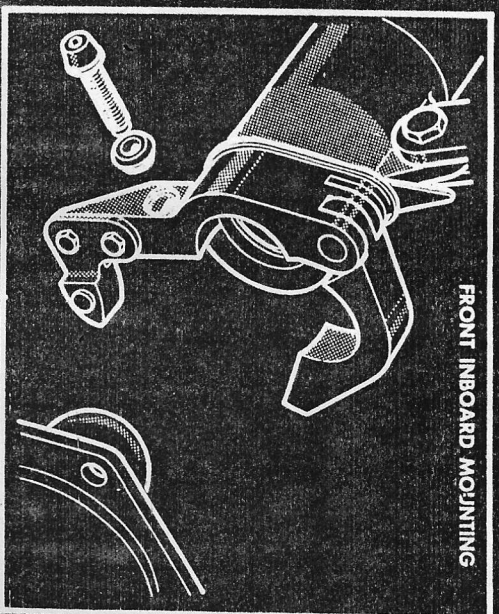
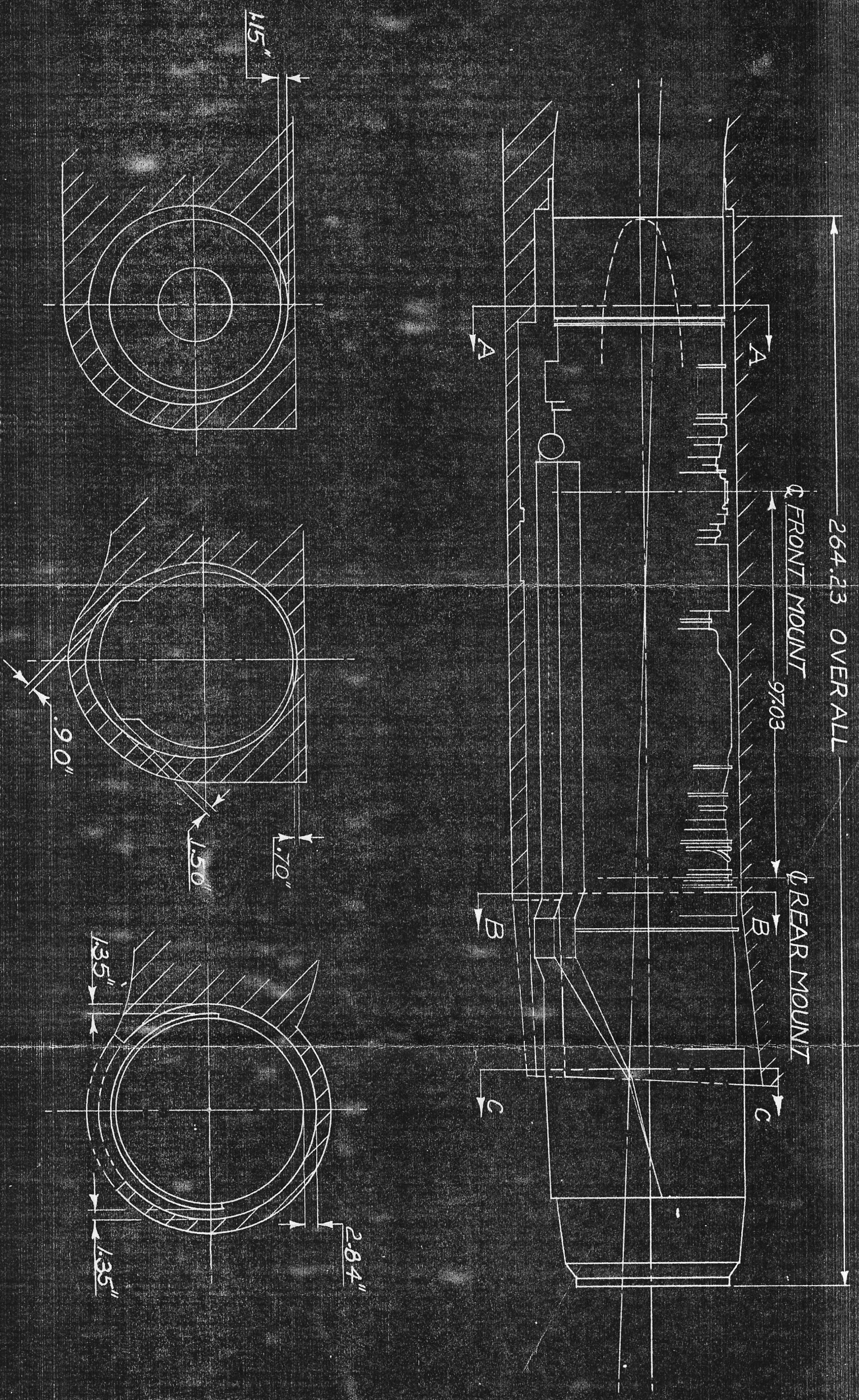


FIG. 2 J75 ENGINE MOUNTING



SECTION AA

SECTION BB

SECTION CC

FIG. 3 IROQUOIS INSTALLATION SCALE 1/30



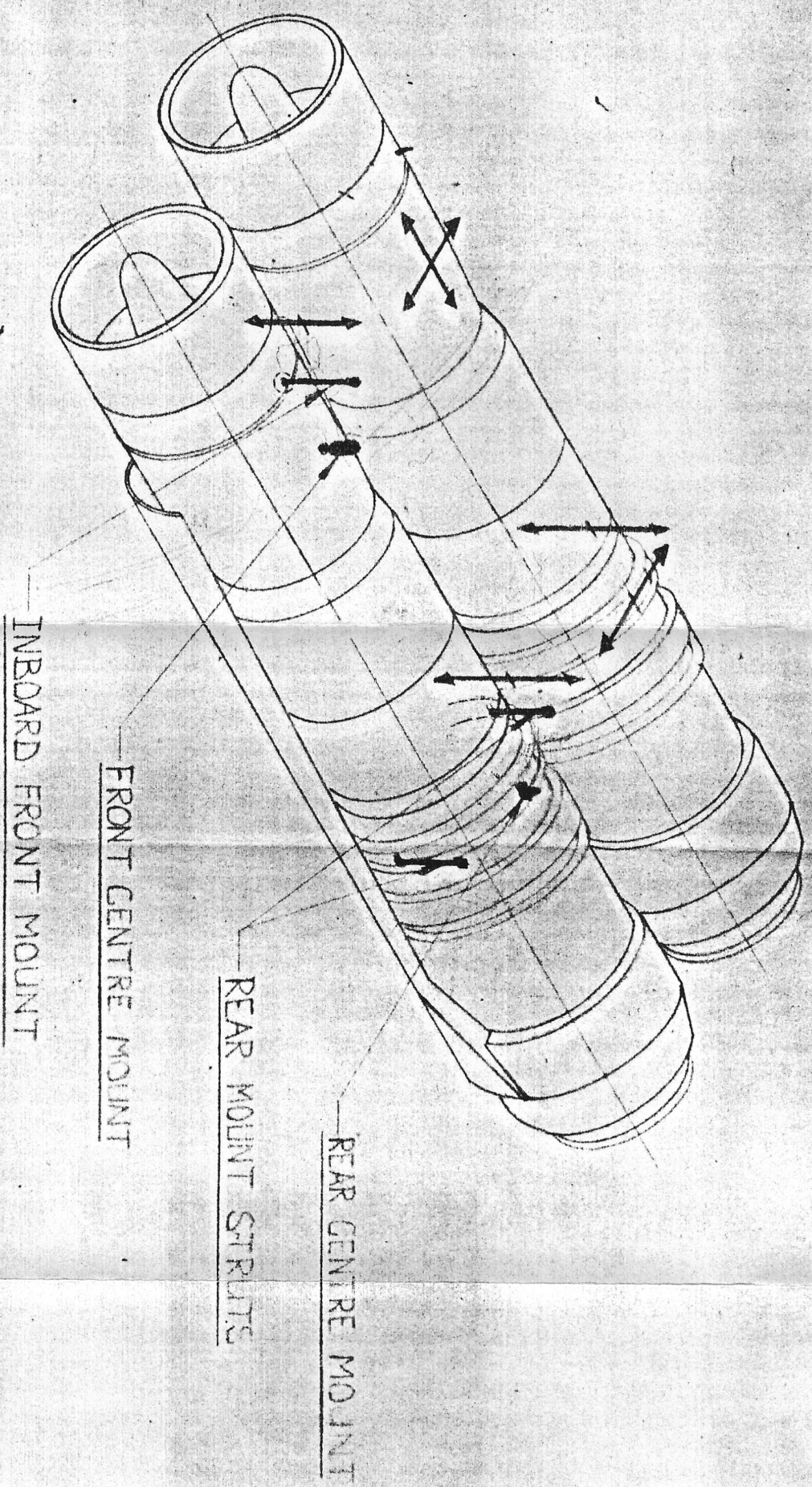
The function of this rail is merely to support and to guide the front of the power plant within the shroud; the rear of the engine would have to be supported and restrained from toppling by a carrier running in a track on the engine change stand.

It is estimated that the weight of this power plant will be slightly in excess of 4,900 pounds. A further factor to be taken into account when designing the handling equipment for the "Iroquois" power plant is that the loads applied to the rear aircraft structure during engine installation and removal must not exceed 750 pounds.

The engine installation in the aircraft, shown in Figure 4, is basically the same as that described for the J75 excepting that,

- 1) A front centre fitting is provided to take engine thrust and transverse loads.
- 2) The front inboard strut handles only vertical loads. There is no front outboard strut.
- 3) There is no necessity for the interconnecting linkage between the rear vertical struts.

The rear centre fitting serves the same purpose, namely to take side loads as it did on the J75 installation.



ARROWS INDICATE LOADS
 TAKEN BY MOUNTS

FIG 4

IROQUOIS ENGINE MOUNTING

SCALE 1/2



3. DESIGN CONSIDERATIONS FOR HANDLING EQUIPMENT

3.1 Factors Influencing Design

In designing the engine handling equipment for both Pratt and Whitney J75 and Orenda "Iroquois" power plants the following factors had to be taken into account:-

1. Power plant weights and dimensions as listed below:

<u>Estimated weight (lb)</u>	<u>J75</u>	<u>Iroquois</u>
Engine dry	5,900	4,500
Power Plant	6,443	4,916
<u>Dimensions (ins)</u>		
Overall length of power plant	301	264.23
Min. clearance between engine and shroud	0.98	0.90
To remove engine, it has to be withdrawn	282.80	234.20

2. Having regard to the length of the engines and the small clearances which exist between the power plants and the engine shroud, it is essential that they shall be kept aligned with and central to the shroud.

Since deflection of the aircraft's undercarriage struts will vary with load distribution within the aircraft, it will be necessary to jack the aircraft to a predetermined height and attitude whilst moving power plants in or out of the shroud.

3. The rear fuselage structure has not been designed to withstand abnormal vertical, fore or aft loads such as those which might be applied during engine installation or whilst aligning the engine change stand to the aircraft. It is therefore essential that the engine change stand shall be a very rigid structure and that due provision be made for positioning it rapidly so that it will align accurately with the engine shroud.
4. It is desirable that it be possible to change both aircraft power plants simultaneously.
5. The work involved in building up a power plant, see Chapters 5 and 6, is fairly considerable. The ground staff must have good access in order that they can accomplish this work efficiently.



Circumstances have compelled AVRO to make a conservative approach in the design of this equipment as it was imperative that it should be available in time for the manufacture and the support of the development aircraft; furthermore, an actual aircraft and engine will not be available for experimentation.

3.2 Alternative Configurations

During the preliminary design study, consideration has been given to the following alternative configurations:-

1. One all-purpose rigid dolly which would be employed for assembling the power plant, for its transportation and also for its installation into or removal from the airframe.
2. (a) Adopting the Air-Log system, described in Chapter 7, produced by the Air Logistics Corporation. The main element is the Model 4000-A heavy duty positioning trailer which is made fully adjustable by means of hydraulic and irreversible screw actuators.

(b) Some thought was also devoted to evolving a design whereby the "Iroquois" engine could be installed into the airframe direct from its storage can by incorporating integral rails in the can and a detachable end; provision being made for positioning the can behind the aircraft with either a self-contained lifting mechanism or by adapting the Air-Log System.
3. Two separate engine dollies. One being specifically designed for power plant build-up and transportation and the other specifically for the purpose of its installation and removal.

The first configuration was rejected at the outset as its high centre of gravity - some 5 or 6 feet above the ground - renders it unsuitable for transportation purposes, furthermore it would be difficult to manoeuvre on pneumatic tires and accessibility for power plant build-up would inevitably be restricted.

Although the Air Logistic concept has much to commend it, it was decided not to adopt it for the J75 powered prototype aircraft as (a) it is dubious whether the Model 4000-A trailer, with its knuckle joint linkage, has sufficient rigidity to obviate the possibility of excessive loads being transmitted to the rear fuselage structure, (b) the wheelbase and rail length of the existing unit would be too short, (c) the overall width of the unit is in excess of 6 ft.; this precludes the possibility of both aircraft power plants being changed simultaneously, (d) it would be more difficult to position accurately as compared to the last-mentioned concept and (e) the traverse of the engine advance mechanism was found to be too short.



The third configuration was the one finally chosen for the J75 installation as it provided the degree of rigidity which was necessary to obviate the possibility of structural damage to the aircraft, also the engine change stand could be readily manoeuvred into position. The cost of purchase should also weigh in its favour in that:-

- (a) It will be manufactured from commercial materials.
- (b) A considerable saving would be realized due to the fact that a maintenance establishment for 12 aircraft would only require two engine change stands together with six power plant dollies. These would be relatively cheap to manufacture as compared to an alternative establishment of six all purpose dollies.

The lead time available for the design of the engine handling equipment for the "Iroquois" power plant permits the Company to pursue the following policy:-

- (a) For its Engineering Department to proceed with its design of engine handling equipment. The current approach is similar to that for the J75 engine; it provides for engine servicing dollies and engine change stands.
- (b) Inviting the Air Logistic Corporation to submit their engineering proposal.

The Air Logistic Corporation has recently accepted our invitation and subject to obtaining the necessary security clearance, one of their engineers will shortly be visiting Malton to investigate the engine installation in the CF-105 aircraft. It is intended that these two proposals shall be evaluated, also that the findings and recommendations will be made available to the Royal Canadian Air Force in due course.

3.3 Design Objectives

Concurrent with the foregoing decision in respect of the configuration of the equipment, the following design objectives were established by the Engineering Department regarding this equipment:

1. The design of the engine change stand must be straightforward and shall feature only simple mechanical devices. Only commercial materials are to be employed.
2. The equipment shall be transportable in a Fairchild C-119F aircraft.
3. The resistance to rolling and castoring is known to be less when using cast steel wheels as compared with pneumatic tires of the same diameter on a smooth concrete surface. It was therefore decided that a) the engine change stand should be fitted with steel castors to facilitate manoeuvring, whilst b) the servicing dollies shall be equipped with pneumatic tires of not less than



16 inches diameter; these are better suited for rough surfaces and the tire serves as a shock absorber medium.

4. To further facilitate aligning the engine change stand to the aircraft, it was decided that the procedure for changing a power plant would be as outlined below:-
 - a) Jack aircraft to the predetermined height and attitude.
 - b) Align engine stand to the aircraft.
 - c) Withdraw the time expired or defective power plant on to the stand and then, by means of a crane or hoist, transfer it to a servicing dolly.

The replacement power plant would be installed by reversing the aforesaid procedure.

5. It is desirable that provision shall be made for changing port and starboard power plants simultaneously.
6. The engine servicing dolly shall provide optimum accessibility to the power plant and have a low centre of gravity when loaded; it shall be an air transportable unit.

Cranes or other lifting devices used for this purpose must in the case of the J75 be capable of raising a load of not less than 7,000 lb; it shall have a lift of at least 14 feet and a reach of 3 feet. The lifting device for the Iroquois engine shall be capable of raising 6,000 lb; it shall have a lift of $12\frac{1}{2}$ feet and a reach of 3 feet.

In addition to the foregoing, provision will also have to be made for lifting J75 engines and the Iroquois power plants in their shipping containers on and off transportation trucks, also for transferring the power units out to servicing dollies. It will be necessary to have a crane capable of raising 10,000 pounds to handle the J75 engine in its container; it shall, in addition, have a lift of not less than 8 feet and a reach of 3 feet 9 inches or more. The lifting device for the Iroquois power plant shall be similar excepting that it shall in this case be capable of raising 11,000 pounds.



4. POWER PLANT MAINTENANCE CONSIDERATIONS

4.1 Periodic and Unscheduled Maintenance

Both the power plants chosen for installation in the CF-105 are still at the development stage and it is premature to discuss in any detail the inspection and maintenance procedures pertaining to these engines and their associated equipment. It is inevitable that the engines will require frequent maintenance and that they will have a short overhaul life until such time as their reliability has been established.

From the information which is currently available it would seem, that preflight, daily and minor inspections will be carried out with the power plant in position. It will, however, probably be necessary to withdraw the power plant from its shroud in order to carry out major inspections and to change components not readily accessible whilst the engine is in position.

4.2 Air Base Facilities

The Logistic Office at AVRO is currently engaged on a study of the air base facilities which are necessary to support the CF-105 aircraft under service conditions. To date, only preliminary work has been done on the engine change facilities to be provided in second line maintenance hangars. The proposed scheme, which is described in this sub-chapter, may yet be subject to considerable change; the present concept of hangar lifting equipment has to a large measure been influenced by the following observations made by RCAF representatives:-

1. An appreciable amount of hangar floor space would be required to manoeuvre a crane whilst changing engines and also to drive it in and out of the hangar. For this reason, a crane is not favoured, more especially as we are already concerned about the effective hangar area which will be taken up by other items of ground support equipment for the aircraft.
2. The operation of a crane powered by an I.C. engine contravenes current Air Force safety regulations - it would seem likely, subject to certain precautionary measures being taken, that this regulation would be waived if no other suitable lifting device were provided in second line maintenance hangars.
3. If there was no alternative lifting device available in second line maintenance hangars, it would be necessary to have a crane - an expensive item of equipment - available at all times for changing power plants.
4. The RCAF does not intend to use manually operated cranes for this work as they are unwieldy and too slow.



Figure 5 illustrates a plan view of an RCAF second line maintenance hangar with six CF-105 aircraft in position; this arrangement allows liberal working space around the aircraft and an equipment area at the centre of the hangar. The diagram shows an engine change stand aligned with the bottom left hand aircraft and two servicing dollies - one with the power plant to be installed and the other for transporting the defective or time expired engine unit back to the workshop. The power units are handled by means of a monorail hoist in which the tracks are supported by frames which are either fixed to the floor of the hangar or alternatively mounted on flush fitting rails so that it may serve any of the three aircraft shown in the lower part of the illustration.

The possibility of supporting the monorail hoist from the hangar roof is currently being taken up by AVRO with those responsible for the design of second line maintenance hangars. The suitability of such a roof hoist for changing other airframe components is being investigated.

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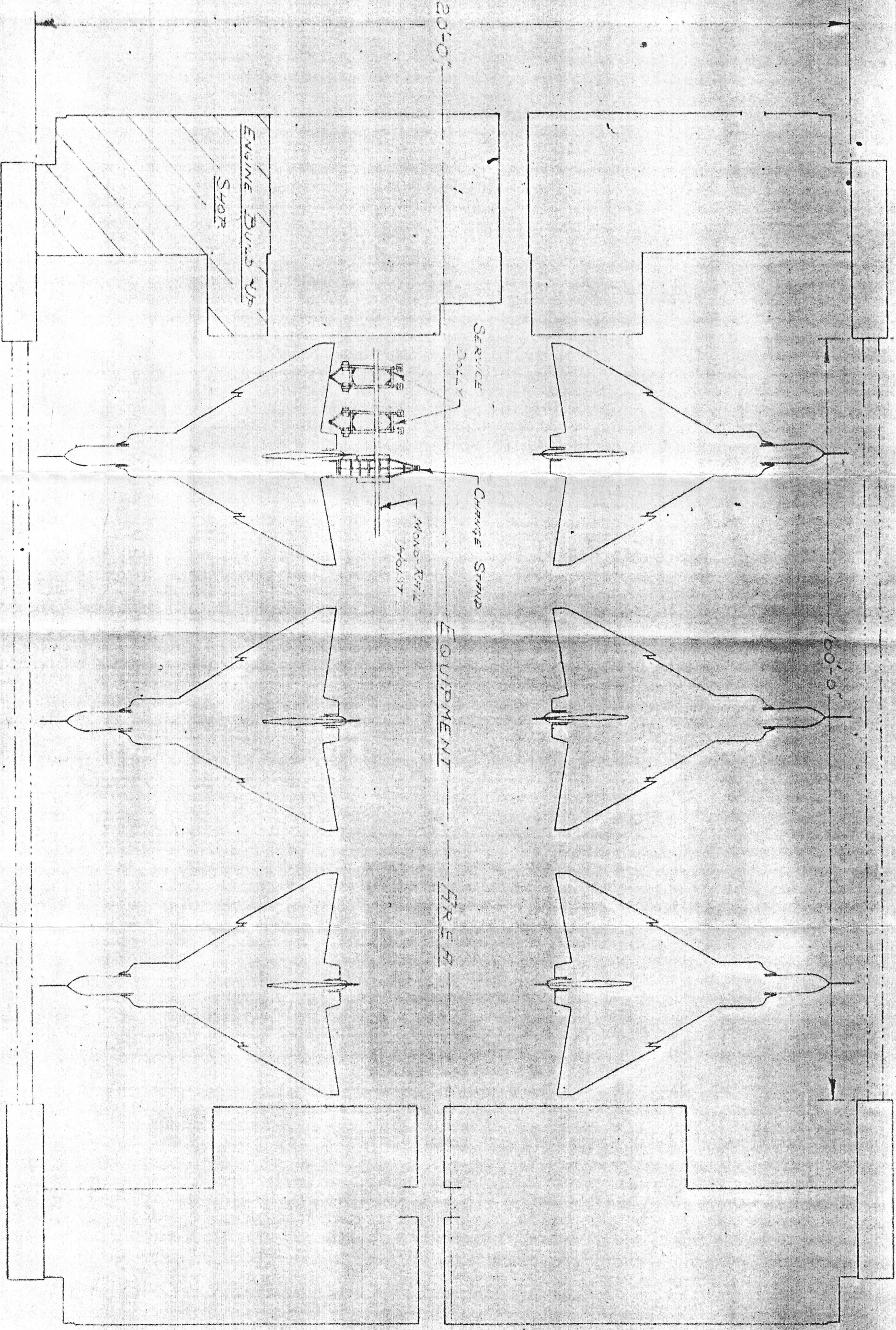


FIG. 5 SECOND LINE MAINTENANCE HANGAR

Scale-1:300



5.

J75 GROUND SUPPORT EQUIPMENT

The main engineering effort has to date been directed towards the J75 engine handling equipment. A prototype unit was displayed at the Mock-up Evaluation Conference and the improved design for development aircraft has been submitted to the RCAF for approval.

5.1 Power Plant Build-up Equipment

Figure 6 has been prepared to indicate the components to be installed when building up a J75 power plant for installation in the aircraft. The power unit is supplied by Pratt and Whitney in two cans, one containing the engine and the other the afterburner. It has been estimated that 48 manhours will be required to build up the power plant so that it is ready for installation; this work would in the normal course of events be carried out whilst the engine is in the servicing dolly, shown in Figure 7, and with the aid of the engine and afterburner slings shown. The servicing dolly consists of a simple tubular frame mounted on four twin pneumatic wheels, the front ones being mounted on shimmy dampers and the rear wheels are on spring swivel lock castors; the latter should be in the locked position whilst towing.

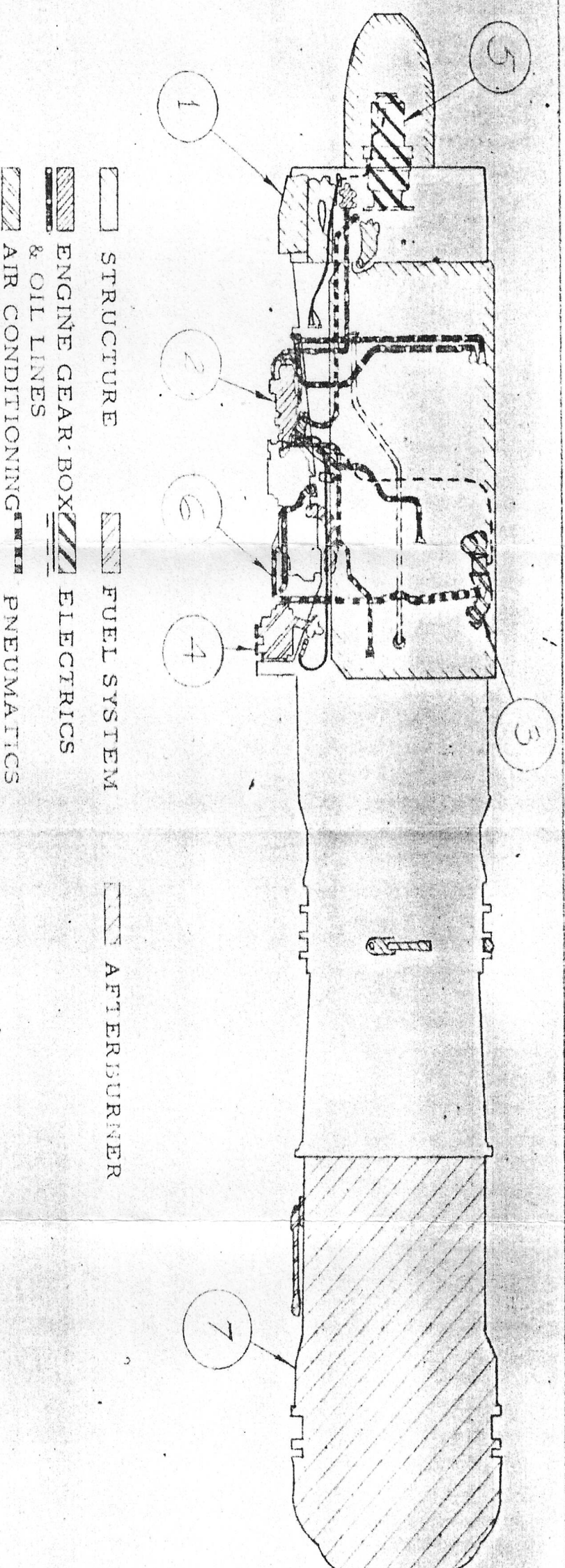
The power plant is supported by brackets which engage on the power plant handling rollers; incorporated in each of the rear brackets is a Lord shock mounting.

Temporary struts are also provided to support the rear of the engine during power plant build-up.

5.2 Aircraft Installation

Figure 7 also shows an engine change stand aligned with and connected to the detachable rails in the engine shroud. The stand, see also paragraphs 1 and 2, consists of a tubular frame structure mounted on four swivel lock steel castors; the front of the stand can be elevated to align with the shroud by means of manually operated hydraulic rams which are integral with the legs; when the stand is in position it is restrained from moving by two foot operated truck locks mounted at the rear of the unit. The engine is supported by means of four rollers which are integral with its mounting points; these run on angles fitted to the stand and on two extension rails which are readily installed on fixed attachments within the engine shroud. The rails are normally carried on support brackets on either side of the stand.

The engine is advanced into and withdrawn from the shroud by means of a double-crank spur gear mechanism, see photograph 2, this operates a closed chain circuit which runs in a track extending the entire length of the stand; there is provision for the installation of a strut from this chain to an attachment at the bottom of the engine. Automatic braking devices are incorporated in the engine advance/withdrawal mechanism. Folding



The following components are installed during power plant build up:

ITEM NO.	COMPONENT	ITEM NO.	COMPONENT	ITEM NO.	COMPONENT
1	Nose Fairing Engine Adaptor Ring Duct Heat Exchanger Strut - Nose Fairing R.H. Strut - Nose Fairing L.H. Instal. Mounting Plate Inbd. Instal. Mounting Plate Outbd. Fairing - Inboard Fairing - Outboard Packing Can - Engine P3 Lower Attachment - Eng. Can Ass'y Air Bleed Inbd. Ass'y Air Bleed Outbd. Locating Block Assembly Engine Bracket Assembly Strut - Rear Mount Inbd. Strut - Rear Mount Outbd. Bearing - Spherical Sleeve Bracket Pipe - Deicing Inst.	2	G.A. Engine Gear Box & Oil Lines Breather Oil Pipe Inst. Filler - Engine Oil Accessories Drive - Gear Boxes - Inst. Const. Spd. Unit - Oil Lines Inst. Oil Lines - Eng. Gear Boxes Inst. Oil Lines - Engine Oil Ass'y Elbow	5	Elbow Afterburner Fuel Drain Engine Wiring Ass'y Cable Arrangement Cable Arrangement Cable Arrangement Cable Arrangement Bracket Spacer Alternator Differential Pressure Switch - Oil Tube
		3	G.A. - Air Conditioning Air Shut Off Valve Manifold - Engine Manifold - Engine Ring - Spring Retainer Ring - Sealing Spring - Seal Retainer	6	G.A. Pneumatic System Instal. Pressure Ratio Transducer Nozzle Ass'y
		4	G.A. - Fuel System Drain - Waste Fuel Pipe Ass'y	7	Afterburner

FIGURE 6 - J75 POWER PLANT BUILD UP

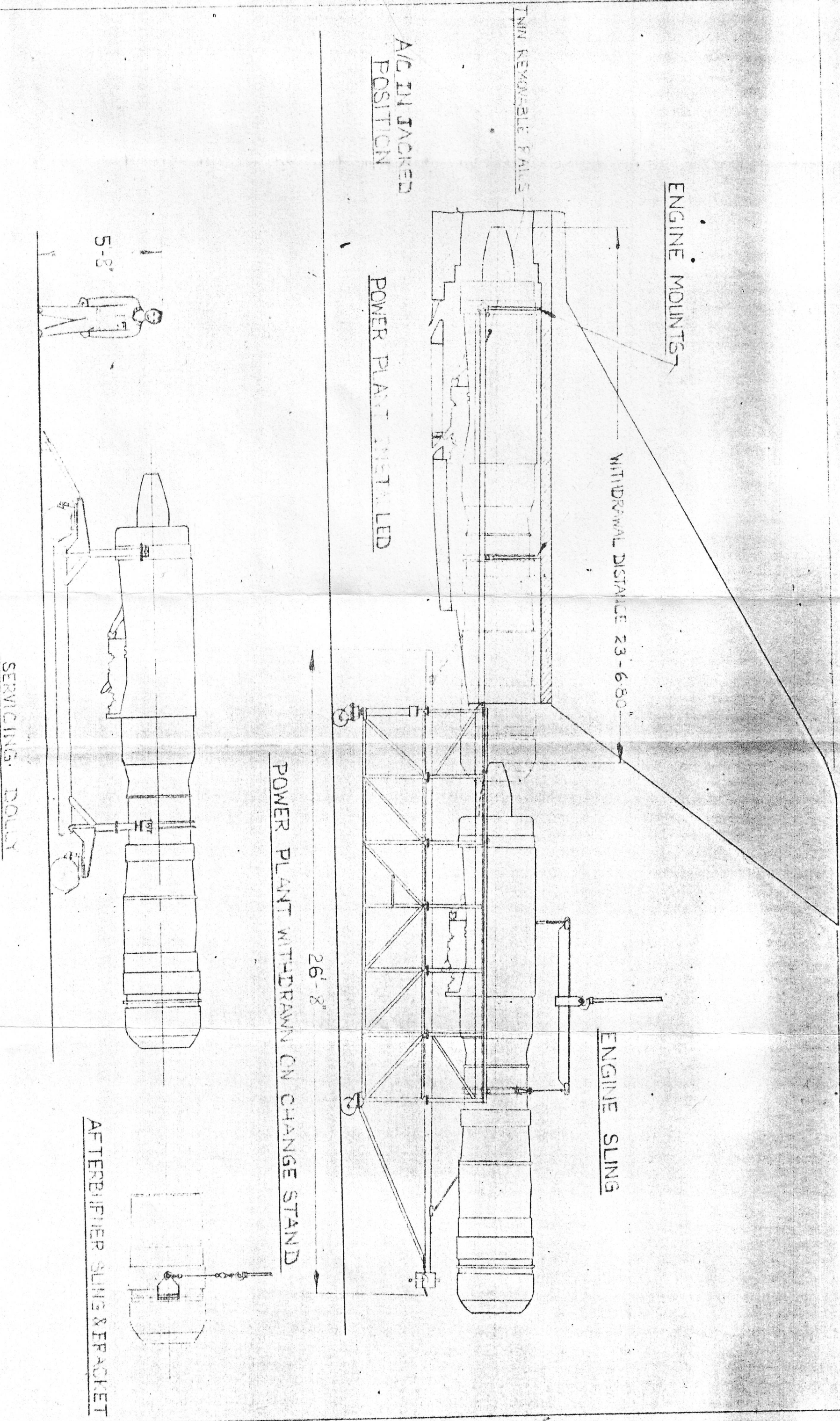


FIG. 7

J75 HANDLING EQUIPMENT

SCALE 1/50



service platforms are provided on either side of the stand to enable the ground staff to gain reasonable access to the power unit.

5.3 Handling Equipment

The other items of handling equipment are lifting slings, see Figure 7, for both the engine/power plant and afterburner. The engine sling consists of an "I" beam with chain and cable pick-up links to the engine; provision is made for moving the point of suspension to coincide with the centre of gravity of either the engine or the power plant.

5.4 Engine Change Procedure

Having jacked the aircraft, removed the stinger, tail cone and the appropriate engine access panels, the power plant change procedure will be as follows:-

1. Enter the change rails into the shroud and lock in position with pins at station 803 on the inboard rail and station 742 on the outboard rail.
2. Manoeuvre the change stand into position behind the aircraft and raise the front of the stand to align with the rails in the shroud and engage the pins through the attachments; apply the mechanical locks on the hydraulic rams. The rear of the stand is then restrained from moving by depressing the truck locks at the rear of the stand.
3. Advance the engine winching device until the connecting strut engages with the engine attachment point, then lock the winching mechanism in this position.
4. By this stage other members of the engine change team will have broken all the service connections and ascertained that they are clear of the power plant.
5. The engine is now lowered onto the rails in the following manner:-

Disconnect front outboard strut.
Disconnect front inboard mounting.
Extend the rear outboard strut until the rear rollers contact the rails then disconnect rear centre fitting, the rear outboard strut and finally the rear inboard strut.

6. The engine may now be withdrawn out of the shroud and transferred on to a servicing dolly by a crane or some other lifting device.

This replacement engine may be installed by reversing the above mentioned procedure; it is imperative that the rear inboard mount must be connected before the rear outboard mount.



6.

IROQUOIS GROUND SUPPORT EQUIPMENT

The lead time available for the design of the "Iroquois" ground support equipment, as explained in Chapter 3, has allowed the Engineering Department to proceed with an improved design and also to invite the Air Logistic Corporation to submit their engineering proposals. These concepts will be evaluated in due course.

The AVRO design for this equipment is as yet far from complete, nevertheless there is sufficient of the salient information now available to describe the features of some of the items. The basic engineering approach follows along much the same line as that for the J75 handling equipment; the general configuration of the equipment will be as illustrated in figure 8 and photograph 3.

6.1 Power Plant Build-up Equipment

Although no engineering work has been done on the design of this unit, its general configuration has been decided upon. From perusal of figure 7, it will be seen that the general arrangement of this item will be fundamentally much the same as that for the J75 power plant; it will consist of a low slung frame mounted on pneumatic wheels for transportability and will provide excellent accessibility for working on the power plant.

6.2 Aircraft Installation Equipment

The prototype unit of the engine change stand is now nearing completion, it will be used for the purpose of introducing and removing the "Iroquois" in the rear fuselage mock-up for this power unit. From figure 8 it will be seen that the unit is of much the same overall length as the change stand for the J75 engine. The frame is made in light alloy and is of beam construction; it is mounted on four swivel lock steel castors and the front end may be elevated when in position behind the aircraft by means of built-in hydraulic rams which are manually operated; a screw type levelling jack is fitted at the back of the stand to eliminate the tendency of lateral or longitudinal motion.

The power plant is supported on the change stand by means of two roller mounted carriers - see photograph 4 and accompanying notes - running in separate channel section tracks which are bolted to the frame. The engine is supported at its rear mountings by means of pins which engage on adjustable struts on the main carrier; this positive method of attachment is essential as it provides the only means of restraining the power plant from toppling whilst being moved in and out of its shroud. The other carrier supports the front of the engine by means of a centrally located hydraulic jack engaging with a support pad on the undersurface of the engine case.



The engine advancing mechanism and the braking device, shown in photograph 4, are also incorporated on the rear trolley. The former consists of a rack and pinion which is manually operated by means of a double crank; the brake mechanism consists of a screw jack expanding a linkage until the brake pads engage on the steel track.

6.3 Handling Equipment

The only other item of handling equipment for the Iroquois is an engine sling which is similar in configuration with that designed for the J75 power plant.

6.4 Engine Change Procedure

With the aircraft jacked, the stinger and tail cone and the appropriate engine panels removed the power plant change procedure will be as follows:-

1. Manoeuvre the engine change stand into position behind the aircraft. The front legs of the stand should at this stage be fully compressed so as to clear the engine afterburner; both carriers being in the fully forward position and the screw jacks on the rear carrier fully withdrawn.
2. When in position, the front of the stand is jacked until two registers engage with the airframe and align with the neutral position on the airframe pick up slots. Apply the mechanical locks at the front and rear of the stand to prevent further movement.
3. Move the main carrier until it aligns with the engine pick up flange, raise the screw jacks until they align with the engine support brackets and engage the pip pins. Now apply the brake on the main carrier to lock it in this position.
4. Lower the front of the engine until its single roller rides on the outboard monorail which is integral with the shroud and then retract the engine thrust pin.
5. Ensure that the engine mounts and all service connections are broken and clear of the engine.
6. Release the brake on the main carrier and withdraw the power unit until the main carrier engages the spring-loaded locks, shown in photograph 4, on either side of the frame of the stand.
7. Align the front carrier and raise the hydraulic jack to engage with the support pad at the front of the engine.

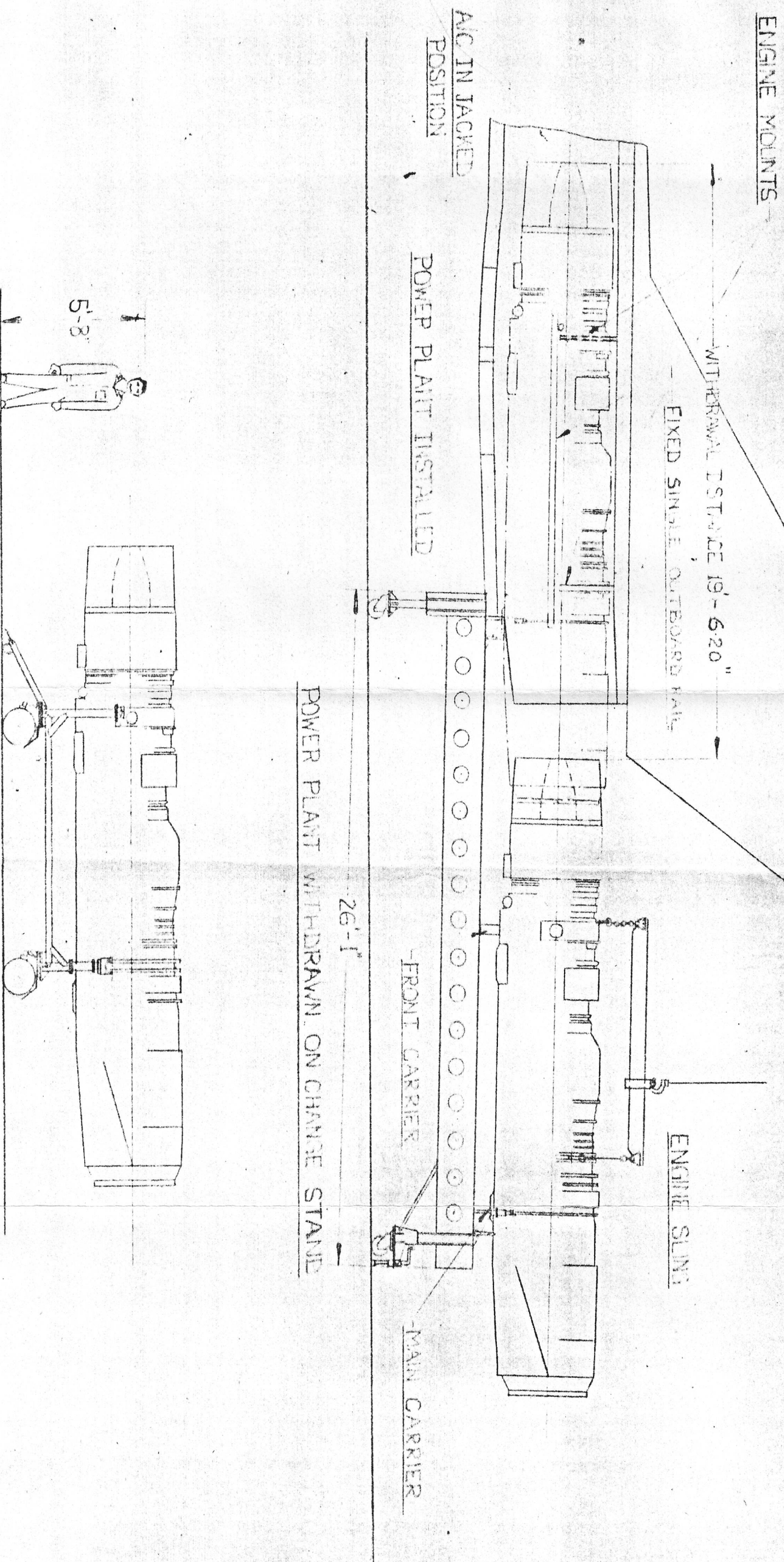


FIG. 8.

IROQUOIS HANDLING EQUIPMENT

SCALE $\frac{1}{4}$ " = 1'



LOG/105/43

8. Release the spring-loaded lock on the main carrier and crank the engine to the fully aft position.
9. Attach the engine sling, withdraw the pip pins attaching the engine to the main carrier and transfer the power plant on to an engine servicing dolly.

The replacement power unit is installed by reversing aforesaid procedure.



7. AIR LOGISTIC CORPORATION EQUIPMENT

7.1 Description of Existing Equipment

The Air Logistic Corporation have developed a range of ground support equipment known as the "Air-Log System" which is intended to serve a wide variety of aircraft. The equipment was primarily designed for engine/power plant handling but it also has other applications; information currently available indicates that their products are being purchased by the U.S. Air Force, Navy and Marine Corps to support a wide range of aircraft. The equipment consists of the basic elements illustrated in figure 9 and is briefly described below:-

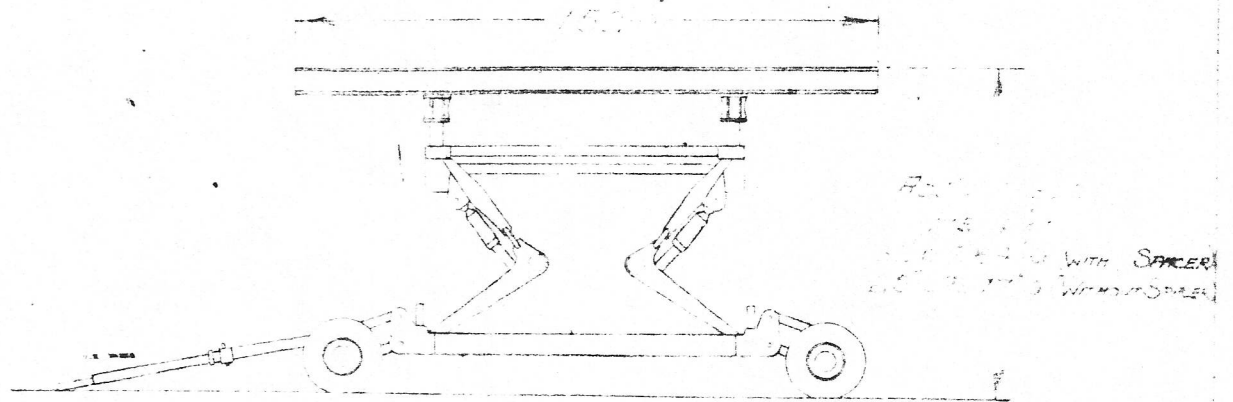
- | | |
|--------------|---|
| Model 2000 | Transportation trailer consisting of a simple frame mounted on pneumatic tires. It is similar in appearance to Model 3000 shown overleaf. |
| Model 3000 | Transportation and build-up trailer. |
| Model 3100 | Folding lightweight engine work stand. |
| Model 3400 | A yoke hoist which can be mounted on Model 2000, 3000 and 4000 trailers also to Model 3100 work stand. |
| Model 4000-A | Heavy duty positioning trailer. This is the key element in the Air-Log System. It is adjustable in height, tilt, roll and yaw, by means of a combination of hydraulic and irreversible screw actuators. |
| Model 5000 | A trailer with provision for rotating the engine through an angle of 210° about its own axis; it is suitable for power plant build-up and engine overhaul. |

All the above models incorporate a matched set of "I" section rails and their design has been directed so that engines (or other components) can be readily transferred from one model to another; this feature greatly reduces the problem of intermediate handling.

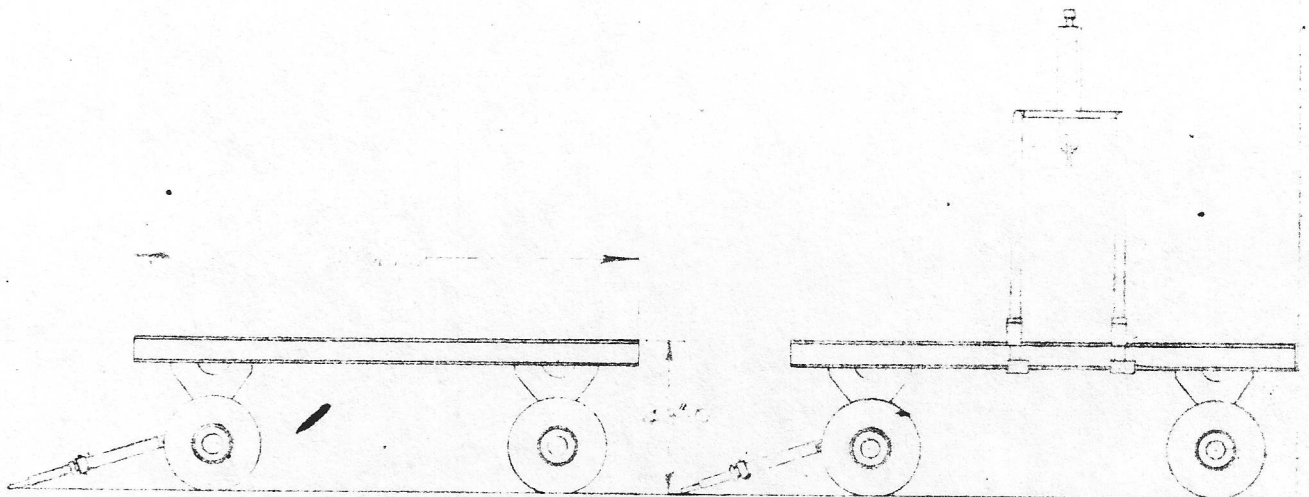
7.2 Discussion

The basic design objective of the Air-Log System has been to provide ground support equipment which may serve a variety of aircraft and may be used for a maximum number of functions on each type. The advantages claimed by the manufacturer for the system are:

1. If a service or an operating organization standardizes on their equipment for a wide range of aircraft they will be able to reduce procurement and supply cost.

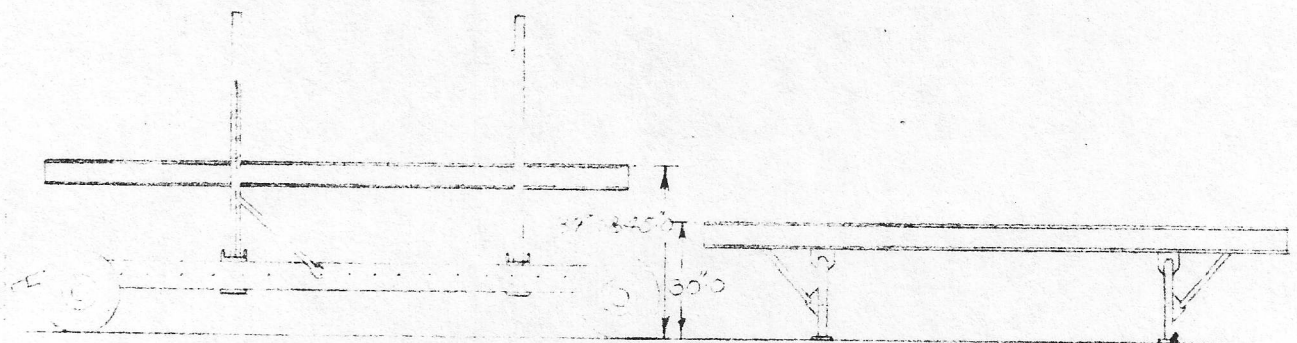


MODEL 4000-A FOOTDRIVING TRAILER



MODEL 3000 TRANSPORTATION AND BUILD B TRAILER

MODEL 3400 HYDRAULIC YOKE HOIST MOUNTED ON MODEL 3000



MODEL 5000 ENGINE ROLL-OVER TRAILER

MODEL 3100 FOLD-VIT WORK STAND

FIG. 9. ELEMENTS OF THE SYSTEM

SCALE-1:50



2. Elimination of conventional ground handling equipment.
3. It is suitable for air transportation.

The concept has much to commend it and their system has been given serious consideration by the design staff at Malton. There was insufficient time available to permit AVRO to invite Air Logistics to submit their proposals for J75 power plant handling equipment. In the case of the "Iroquois" engine, however, there still is sufficient lead time for AVRO to take this course; a representative of the firm will be visiting Malton to study its installation in the CF-105 for the week commencing October 1st, 1956. It is unlikely that the present installation of the "Iroquois" in the CF-105 lends itself to the use of their standard equipment, but it is expected that the Air Logistic Corporation will submit a design proposal.



8.

COMMENTS ON RCAF CHANGE REQUESTS

Representatives of the Royal Canadian Air Force attending the CF-105 Mock-up Engineering Evaluation Conference requested that certain changes should be made to the design of the equipment demonstrated. The change requests together with the Company's present comments are as follows:

- C-6 A positive mechanical lock be provided on the engine change stand to confirm elevation of forward rails - hydraulic achieved elevation may not be sufficiently reliable for transporting engines.

Comment: This has been incorporated.

- C-7 The engine stand should be provided with steadying jack to raise it off wheels and fix its position during operation - a small movement of the stand can strain the stand to rail joints.

Comment: This has been incorporated.

- C-8 That the engine stand shall be capable of being towed with the engine in place and positive braking be provided - this would allow the engine to be transported on the stand and to minimize loads on the airframe. ?

Comment: The AVRO design philosophy, see Chapter 3, makes no provision for towing the stand with the engine in place, consequently provision for positive braking would not seem necessary.

- C-12 Engine change trolley equipped with a cable and winch to effect the actual engagement of the trolley to the side rails - to ease and hasten the attachment.

Comment: The airframe structure has not been designed to withstand such loads. The main consideration which has influenced the Company's present design of engine handling equipment has been not to jeopardize the aircraft's performance by building in additional weight or drag.

- C-22 Engine change stand should be made to fold in order to reduce overall height after removal or before installation - to facilitate movement in hangar.



Comment: If it is intended that one dolly shall be employed for power plant removal, installation and transportation, it is essential that this should be a collapsible unit. This configuration was considered by AVRO in the preliminary design study and rejected for reasons given in this report. The proposal now sought by AVRO from the Air Logistics Corporation for the "Iroquois" power unit may be along the lines suggested by the RCAF.

It will be appreciated that the foregoing requests refer specifically to the mock-up units of J75 handling equipment which were demonstrated during the CF-105 Mock-up Conference.



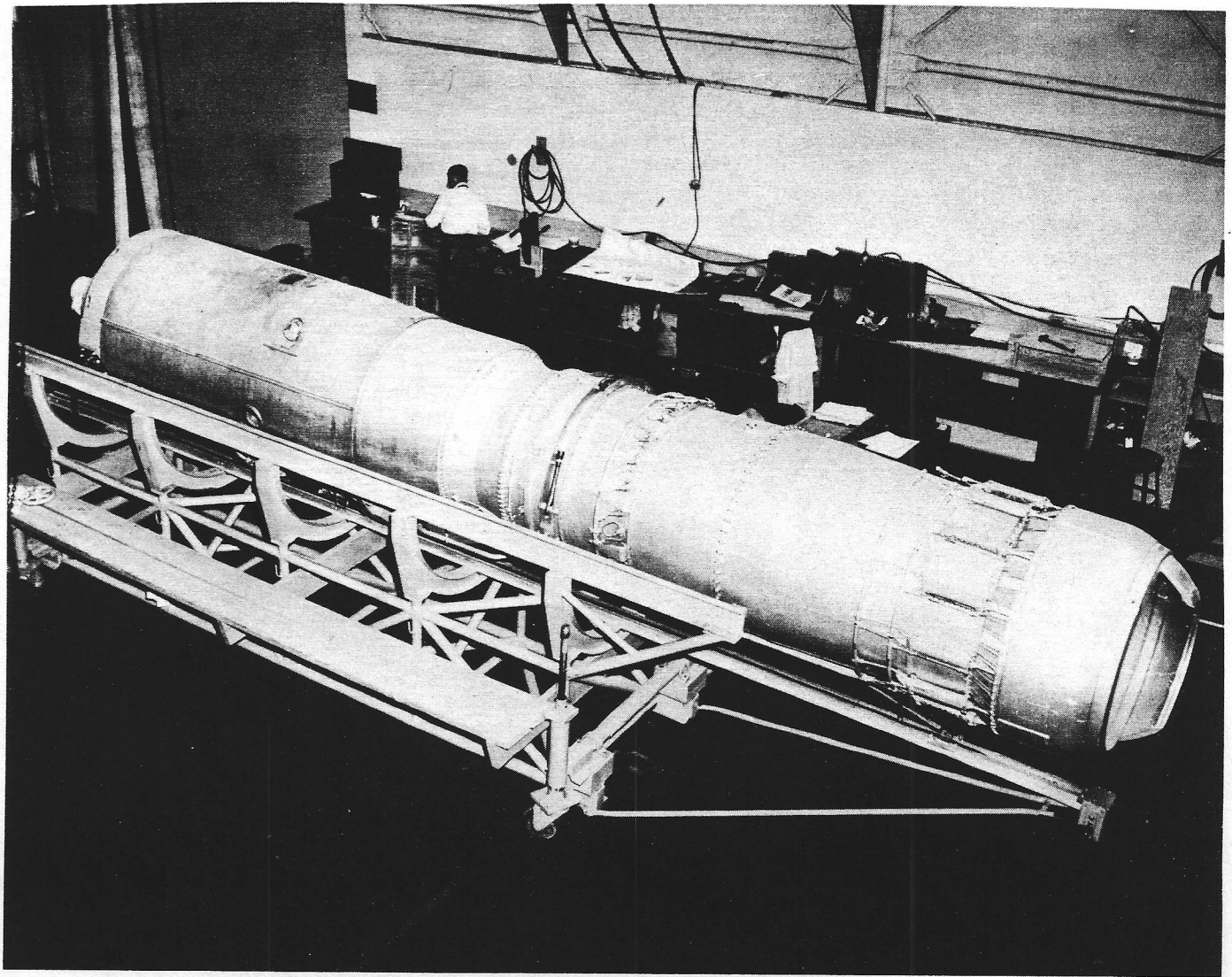
9.

CONCLUSION AND RECOMMENDATIONS

When emphasis is placed on combat performance in the design of an aircraft, increased complexity together with additional maintenance problems and the need for more ground handling equipment is in many cases inevitable. It became apparent, during preliminary studies, that a new engineering approach would be necessary when designing engine handling equipment to support CF-105 aircraft.

The observations which have been made by RCAF representatives, regarding the operational suitability of the existing design concept, have led to AVRO reviewing its engineering approach in the light of their comments and other information which is now available. The Engineering Department at AVRO is satisfied that its present policy, which is outlined below, does in the circumstances appear to be the logical course to follow at this stage.

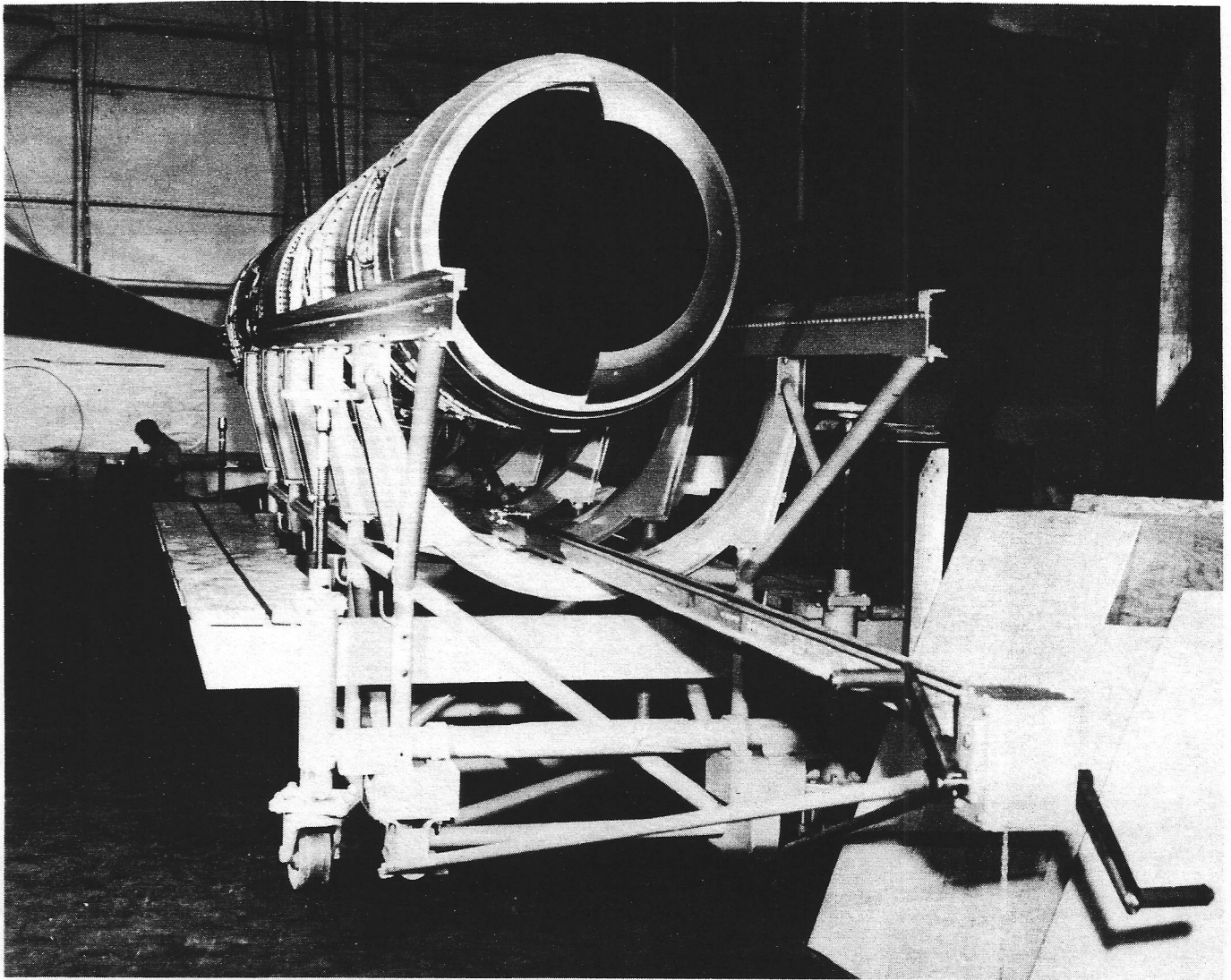
1. To proceed with the manufacture of the engine handling equipment, as presently designed, to support the J75 power plants installed in development aircraft.
2. (a) To evaluate its design concept for the "Iroquois" handling equipment in comparison with an engineering proposal now sought from the Air Logistics Corporation. It is intended that the findings shall be made available to and discussed with RCAF representatives.
(b) To manufacture at least one set of "Iroquois" handling equipment to present AVRO design to meet the immediate demands of our Experimental and Production Departments. It is recognized that another design concept for power plant handling equipment may provide the ultimate solution to the problem; it is felt, however, that this should be evolved during the course of the aircraft development programme so that full advantage can be taken of the experience gained with the existing equipment and so that a possible alternative design concept can be tried out on an actual aircraft.
3. Having established, in practice, the configuration of the power plant handling equipment which is best suited to support the CF-105 in service, the chosen design should then be modified in the light of experience gained on development aircraft.



PHOTOGRAPH 1

SIDE VIEW OF J-75 MOCK-UP ENGINE CHANGE STAND

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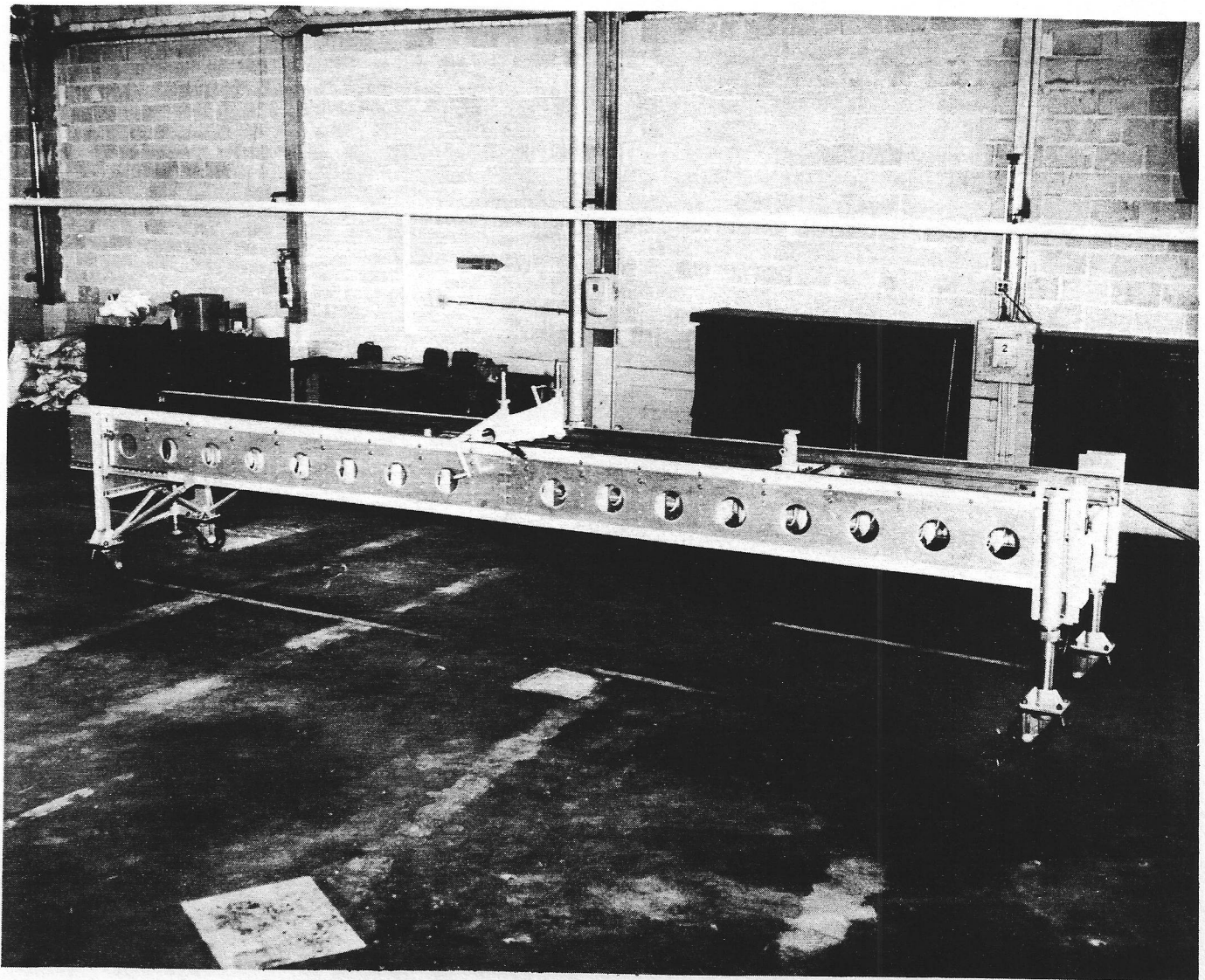


PHOTOGRAPH 2

END VIEW OF J-75 MOCK-UP ENGINE CHANGE STAND

Note the double crank mechanism for advancing and withdrawing the power plant.

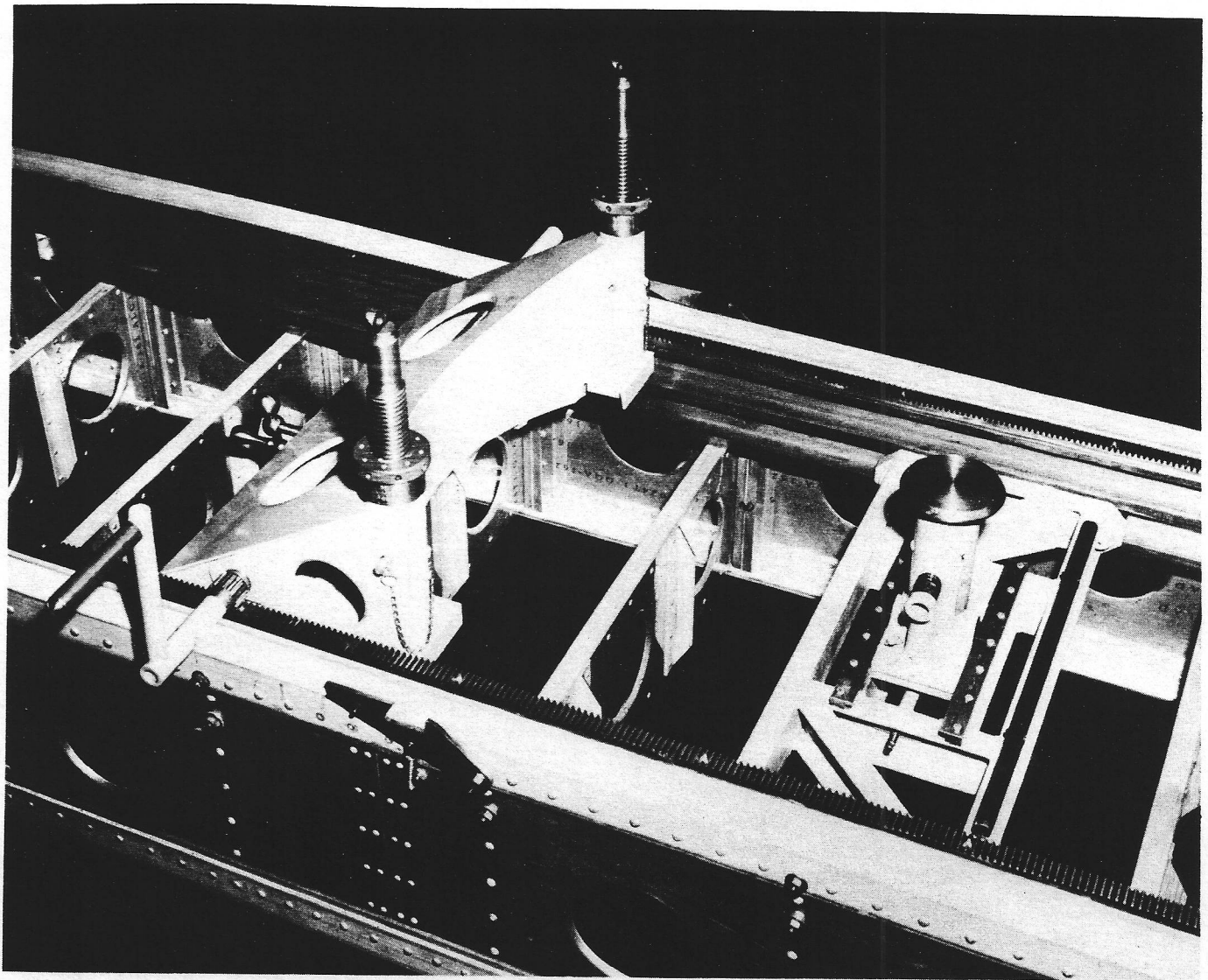
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PHOTOGRAPH 3

SIDE VIEW OF PROTOTYPE IROQUOIS ENGINE CHANGE STAND

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PHOTOGRAPH 4

CLOSE UP OF THE PROTOTYPE IROQUOIS ENGINE CHANGE STAND

NOTE:

1. Beam type frame construction.
2. Main carrier is on the left hand side; this runs in the upper track. The adjustable struts, the rack and pinion advancing mechanism, and the handle actuating the expanding brake are shown.
3. Spring-loaded locks on either side of the frame.
4. Front carrier is on the right hand side; this runs on the lower track. The hydraulic jack and its actuating handle are shown in position.

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