CONSOLIDATED

DIESEL ELECTRIC CORPORATION

Proposal
for
Ground Servicing Equipment
for
Avro Arrow II

CONSOLIDATED
DIESEL ELECTRIC CORPORATION
OF CANADA LTD.

CONSOLIDATED DIESEL ELECTRIC CORPORATION

OF CANADA LIMITED

REXDALE ONTARIO

Proposal
for
Ground Servicing Equipment
for
Avro Arrow II

Proposal No. 137 June, 1958.

SECTION 1

INTRODUCTION

SECTION 1

Introduction

The Arrow aircraft, being provided by Avro Aircraft Limited, has certain important requirements as far as ground handling equipment is concerned. The major items of equipment falling into this category include a starter unit and a servicing unit, which two articles form the basis of this proposal.

The starter unit, the requirement for which is set down in Avro report 72/GEQ/12 May 1958, consists of a low pressure air supply for ground starting and a small amount of 28 V D.C. electric power of which some is inverted to A.C. The whole of this equipment is to be mounted on a 4-wheeled trailer in such a way as to permit it being removed and mounted on the ground for a semi-permanent hangar installation.

The servicing unit is considerably more complex than the starter unit and really provides the design criterion for common equipment being specified for both the starter and servicing units. The requirements for this unit are set out in AVRO report 72/GEQ/10 May 1958. It consists of a source of compressed air together with an air cycle air-conditioning system, while in the same unit is an A.C. electrical supply source and a small amount of D.C. The A.C. source provides energy to test the electronics of the aircraft on the ground, while the air-conditioning system provides a means for keeping the electronic components at constant temperature during this test period. All this equipment is to be mounted on a self-propelled trailer.

The equipment for the prototype Arrow 1 aircraft was designed and manufactured by Consolidated Diesel Electric Corporation of Canada Ltd., and is now in operation at Malton in conjunction with the Arrow 1 development flight testing. The equipment specified for the Arrow 11 is basically very similar to that already in existence with the exception that the performance called for on the servicing vehicle is somewhat higher and more difficult to attain.

At the time of the requirement for the Arrow 1 ground support equipment, it was decided by Consolidated Diesel Electric Corporation to set up a Canadian subsidiary to cater for the needs of Canadian Industry without going South of the border and, consequently, the Canadian Subsidiary is now putting forward this proposal for ground equipment for the production Arrow 11 aircraft.

Throughtout all the work leading up to this proposal, and in all the following pages, the importance of supporting Canadian Industry and United Kingdom imports has been uppermost in our minds, and we believe that we are proposing equipment which has the following advantages over any competition from the U.S.A.

(i) Improved technical performance

(ii) Greater background of experience and testing on major components

(iii) Lower cost

(iv) More realistic and better delivery dates

(v) Greater systems experience to call on from our own prototype Arrow 1 equipment and from our parent company's experience in the U.S.A.

CONSOLIDATED

DIESEL ELECTRIC CORPORATION

OF CANADA LTD.

SECTION 2

Summary of Recommendations

CONSOLIDATED
DIESEL ELECTRIC CORPORATION
OF CANADA LTD.

SECTION 2

Summary of Recommendations

As implied in Section 1 of this proposal, the major problems arising in a search for the optimum configuration for these units were the choice of a suitable gas turbine compressor and allied cold air units. As stated already, the equipment for the servicing unit was the design criterion, the use of the same gas turbine compressor following for the non-critical starter unit.

A thorough investigation was undertaken in both the United Kingdom and the U.S.A. for all suitable gas turbine compressors, and it was found that the only two units which had any reasonable degree of background service experience and could be considered as developed units were the Turbomeca 'Artouste' built under licence in the U.K. by Blackburn & General Aircraft Limited and the AiResearch GTCP 85-20 Manufactured in the U.S.A. A full investigation of all the merits and demerits of these engines was carried out and it was decided that the Blackburn 'Artouste' appeared the more suitable for this project.

The reasons why the AiResearch unit appeared unsatisfactory were as follows:-

(i) The advertised performance was not as good as the 'Artouste'

(ii) The GTCP 85-20, i.e. the shaft power version of the GTC 85-20, appears to have no background although the straight bleed version is qualified and in service. Only a few of these shaft power versions have been manufactured and there appears to be no service programme in the U.S.A. calling for these units. Our parent company has had a development model of this version at Stamford recently and has had considerable difficulty with it, resulting in a failure after a short period of running.

(iii) Our own experience with AiResearch in developing the prototype equipment has been unsatisfactory. Initial delivery promises were long and even these were not met, resulting in late delivery of equipment to Avro Aircraft Limited. In addition to this, the service provided in Canada by the Garrett Corporation has not been satisfactory.

The points in favour of the Blackburn 'Artouste' are as follows:-

(i) This unit is in production in the U.K. for the Victor aircraft.

(ii) A considerable amount of development running and experience exists to back it up.

(iii) The performance is better than that of the AiResearch GTCP 85-20.

(iv) This unit has already been chosen by the R.C.A.F. and Canadair Limited for the CL 44 A.P.U.

(v) Qualified service exists in Canada for this engine and an overhaul facility has already been set up by the Department of Defence Production and, at the moment, technical liaison is proceeding in order to get this facility operating. A full stock of spares is already held in Canada.

(vi) General agreement exists that this unit is quieter in operation than the AiResearch GTCP 85-20.

(vii) So far on deliveries to Canada, Blackburn have been able to quote relatively short delivery dates and have in all cases kept them.

(viii) We understand that the experience at Orenda Engines Limited on the bleed air versions used for engine starting has shown a far greater reliability with the Blackburn engine than with the AiResearch GTC 85-20.

The next major item of equipment to be chosen was the refrigeration system to be used in conjunction with the Blackburn gas turbine compressor. It seemed obvious from the start that much could be gained by utilising cold air units developed and built in the United Kingdom, so that any qualification testing of the whole system could be carried out at the engine manufacturer's plant. In spite of this, however, we did not limit our investigations solely to the United Kingdom but investigated all the refrigeration systems available in the U.S.A. as well as the U.K. The result of this was that we came to the conclusion that the cold air unit at present in production by DeHavilland Propellers Limited, in the United Kingdom, for the Comet IV aeroplane was of the right size for our project; and that with a few minor modifications would produce the required performance. This unit was designed and built by DeHavilland Propellers under Licence from Hamilton Standard Propellers in the U.S.A. and, therefore, has as a type considerable background and experience quite apart from the fact that, as an individual unit, it is already in production in the United Kingdom.

From investigations carried out in parallel with ours, by Avro Aircraft Limited, the feeling seems to have arisen that there is some considerable virtue in utilising a system comprising a GTC and cold air unit manufactured by the same organisation, so as to ensure the matching of the two units. We investigated this quite thoroughly and came to the conclusion that there was no overwhelming advantage to be gained by such an arrangement since, in practically all cases of airborne cold air units, this arrangement is not possible and yet no problem has arisen regarding the matching of the cold air unit to the gas turbine engine, provided some test running is carried out by the engine and cold air unit manufacturers to establish and confirm performance.

Having arrived at the optimum configuration for the servicing unit, we examined the use of the chosen gas turbine compressor for the starting unit. Technical advantages were obvious here for the Blackburn 'Artouste' since its higher delivery and pressure of bleed air would result in a shorter engine starting time.

Summarising the foregoing, it is our intention to put forward servicing and starting units to the Avro requirement reports mentioned earlier, with the exception that we recommend, instead of the AiResearch GTC and cold air units, Blackburn 'Artouste' gas turbine compressors in conjunction with DeHavilland Propellers Limited cold air units.

As explained more fully later in this proposal, under Section 7, our choice of configuration and major components, although made strictly on a technical basis, has resulted in selection of units which would be entirely Canadian manufactured, utilising major components imported from the United Kingdom. This seems to us to present, in addition to the technical claims for this proposal, a desirable arrangement, bearing in mind the recently expressed Government intention to promote Canadian Industry coupled with British imports.

CONSOLIDATED

DIESEL ELECTRIC CORPORATION

OF CANADA LTD.

SECTION 3

DISCUSSION OF OUR PROPOSAL FOR SERVICING UNIT AND ITS COMPATIBILITY WITH REQUIREMENTS SET OUT IN AVRO REPORT 72/GEQ/10 MAY 1958.

CONSOLIDATED
DIESEL ELECTRIC CORPORATION
OF CANADA LTD.

SECTION 3

DISCUSSION OF OUR PROPOSAL FOR SERVICING UNIT AND ITS COMPATIBILITY WITH REQUIREMENTS SET OUT IN AVRO REPORT 72/GEQ/10 MAY 1958.

3.0 **Scope**

We propose in this section to describe the operation of the servicing unit and its performance. Having done this, we will then examine the Avro requirement paragraph by paragraph and discuss these to establish whether our proposal is in all cases in compliance with the requirement. In describing the system, we will refer to the following schematic diagrams which will be found together with any necessary keys at the back of this section:-

X 1036	Electrical Schematic, Air Conditioning System
X 1037	Schematic, Engine Electrical System
X 1038	System Diagram, Air Conditioning Pack
X 1039	General Arrangement of Servicing Unit

A further and more detailed description of the proposed unit will be found in Appendix 'A' in the accompanying volume.

3.1 **Description of System**

3.1.1 If X 1038, System Diagram, is referred to, it will be seen that the two prime movers employed are Artouste 510 shaft power gas turbine compressors. These engines are capable of delivering bleed air from the compressors at the same time as a certain amount of shaft power. The first of these engines is coupled to a 40 KVA 400 cycle alternator which supplies electrical power to the aircraft for the purpose of testing the electronic equipment on the ground. The second engine is coupled to a centrifugal fan which forces air through the primary heat exchanger in the air cycle system, thus affording additional cooling. This engine also drives a small D.C. generator.

3.1.2 The two bleed air outlets are coupled together through a series of valves which will be described later, and the common flow then passes through the primary and secondary heat exchangers. After this, the bleed air is once again split into two paths, each path passing through and driving the turbine of a simple cold air unit. The exhaust from these turbines is then once again combined into a single duct and after passing through a water extractor and several final sensing elements, the cool air is supplied to the aircraft through two 3-1/2' diameter hoses.

3.1.3 The cooling flow across the two heat exchangers is provided in the following manner. As described earlier, the engine driven fan forces air across the primary heat exchanger, taking ambient air into its inlet. Air is drawn through the secondary heat exchanger by the fans on the cold air units, thus absorbing power and providing a load for the cold air unit turbines.

3.1.4 Provision is also made for water injection into the secondary heat exchanger, and a water feed back from this heat exchanger and the water extractor in the cold air system is arranged to convey excess water to the tank, thus minimising the water consumption of the system as a whole.

3.1.5 It will be seen from this schematic, therefore, that cooling of the compressor bleed air is accomplished in three or all of the following four ways:-

(a) Primary Heat Exchanger

(b) Secondary Heat Exchanger

(c) Water Injection into the Secondary Heat Exchanger if required

(d) Expansion through the Turbines

Provision is made to control the water injection, described above, automatically, so that under extremes of ambient conditions, water is automatically injected into the heat exchanger when the normal system will no longer supply air at a low enough temperature.

3.2 Description of Components

We propose now to itemize the major components, i.e., those listed in the Key, and describe their functions.

3.2.1 A.D.V. - Air Delivery Valve

These valves, situated at each gas turbine compressor control the flow of bleed air out of the compressors.

3.2.2 P.R.V. - Pressure Regulating Valve

These valves provide pressure regulation in the bleed air between certain upper and lower limits and provide a safeguard for the equipment which follows in the system.

3.2.3 F.L.V. - Flow Limiting Venturis

These venturis provide similar limits on flow to those mentioned above for pressure and provide an upper limit, as called for in the requirement, to the air flow into the aircraft system.

3.2.4 P.H.E. - Primary Heat Exchanger

This provides an initial cooling for the high temperature air coming from the compressors.

3.2.5 S.H.E. - Secondary Heat Exchanger

This provides further cooling for the bleed air and has provision in it for water injection.

3.2.6 C.A.U. - Cold Air Units

These are simple type cold air units designed to cool the bleed air still further by expansion through the turbines which are loaded by their fans drawing air through the secondary heat exchanger.

3.2.7 W.E. - Water Extractor

This is a device introduced into the cold air system after final cooling has been effected, which provides a coalescer to coalesce free moisture present and a subsequent extractor to remove the water formed. This is necessitated by the requirement which specifies dry air entering the aircraft.

3.2.8 F.S. - Flow Sensor

This instrument measures flow at the output from the servicing vehicle and in addition to indicating flow on the instrument panel is coupled back to the electrical system so as to shut down the A.C. supply to the aircraft in the event of cooling air flows below a permissible minimum.

3.2.9 Delivery Ducts

These are two 3-1/2" silicon-dacron bleed air hoses to connect the cold air flow from the servicing vehicle to the cooling air inlets into the aircraft.

3.2.10 S.E. - Temperature Sensing Element in Aircraft

This is a sensing element in the cooling ducting in the aircraft after the cooling air has passed through the magnetron heat exchanger. This element calls for a consistent temperature of 70°F and passes back an error signal to the control equipment associated with the airconditioning package.

3.2.11 T.C.V. - Temperature Control Valve

A control valve is provided, as shown on the schematic, which is operated by a proportional solenoid from the control equipment. In order to maintain constant delivery temperature to the aircraft, the position of this valve is varied so as to mix more or less hot bleed air with the cold air to cope with varying ambient conditions.

3.2.12 Humidifier

This is the device used to inject water into the secondary heat exchanger.

3.2.13 W.F.C.V. - Water Flow Control Valve

A valve is provided, also operated by a proportional solenoid, which under extremely high ambient conditions allows water to flow through the humidifier and the secondary heat exchanger. Operation of this valve is automatic, the amount of water permitted to flow being controlled so as to give the required output temperature.

3.2.14 W.T. - Water Tank

This tank provides water for injection through the secondary heat exchanger and has its contents partly maintained by returning to it wasted water from the heat exchanger and water extracted from the cold air.

3.2.15 P.H.E. Fan - Primary Heat Exchanger Fan

As described earlier, this fan is driven off the shaft output of one of the Artouste engines and forces ambient air through the primary heat exchanger.

3.2.16 N.R.V. - Non Return Valve

Two non return valves are positioned as shown in the schematic in the bleed air ducting from the Artouste engine so as to prevent air flowing in the wrong direction while one engine is being started.

3.2.17 P.S. - Pressure Switch

A pressure switch is placed in the system just before the final delivery outlet for the purpose of shutting down the A.C. supply to the aircraft in the event that the pressure falls below a permissible minimum.

3.2.18 T.S. - Temperature Switch

In a similar manner to that indicated for the previous item, this provides temperature protection for the system.

3.2.19 P.S.E. - Pressure Sensing Element

This element senses the pressure in the Cold Air Unit fan suction system and, in the event of a blockage in the cooling air flow through the secondary heat exchanger, which would unload the C.A.U. turbines, this element causes the air delivery valves to be closed; thus shutting down the bleed air flow through the turbines.

3.2.20 A.I.C. - Anti Icing Control

Here, temperature is measured upstream of the water extractor and the signal is fed back into the control box.

The system is arranged so that the temperature here does not fall below 35°F, thus preventing ice formation.

3.2.21 R.V. - Relief Valve

This relief valve is provided in the output duct from the unit to limit the pressure delivered to the hoses to 10 p.s.i. as called for in the requirement.

3.3 PERFORMANCE SUMMARY

3.3.1 For the purposes of this proposal, the three worst cases out of the five conditions specified have been examined. These conditions are:-

(a) Sea Level 100°F Dry Bulb 80°F Wet Bulb
(b) 3,500 feet 100°F Dry Bulb 80°F Wet Bulb
(c) Sea Level -65°F Dry Bulb

3.3.2 The performance summary for these cases is set out below:

	(a)	(b)	(c)
Altitude	S.L.	3,500'	S.L.
Ambient D.B. Temp °F	100°F	100°F	-65°F
Ambient W.B. Temp °F	80°F	80°F	-
Air Flow LB/MIN	142	130	178
Pack Exit Temp °F	50	50	85
Aircraft Inlet Temp °F	55	55	70
Associated free moisture at Pack exit - grains/lb dry air	7.6	8.0	-
Free moisture left at 70°F grains/lb. dry air	0	0	-
Water consumption G.P.H.	14.0	13.2	-

3.3.3 For the tropical cases, the system is shown delivering air at the lower temperature limit and for the arctic at the upper limit, since these are the most severe cases. The alternative temperature limits can be readily obtained in each instance.

3.3.4 The water consumptions shown assume that all the moisture condensed in the secondary heat exchanger and the water extractor is fed back into the humidifier.

3.3.5 In order to give an overall picture of the functioning of the arrangement, conditions at various parts of the system have been calculated and they will be set out in tabular form on the next page. The various points chosen may be seen on reference to the schematic diagram and are described below for easier reference:

Point	Description
A	Intake to Primary H.E. Fan.
B	Output from each GTC at air delivery valve.
C	Outlet cooling air from Primary H.E.
D	Inlet cooling air to Primary H.E.
E	Bleed air after P.H.E.
F	Water Flow into humidifier. (by-pass extra)
G	Cooling air into S.H.E. Humidifier.
H	Cooling air between Humidifier and S.H.E.
J	Feedback water flow from S.H.E. to tank.
K	Bleed air after S.H.E.
L	S.H.E. cooling air flow into each C.A.U. Fan.
M	Cooling air exhaust from each C.A.U. Fan.
N	Bleed air after C.A.U. Turbines.
P	Bleed air as it enters delivery ducts.
R	Feedback water flow from W.E. to Tank.
W	Hot air Bypass.

CONSOLIDATED
DIESEL ELECTRIC CORPORATION
OF CANADA LTD.

AIR CONDITIONING PERFORMANCE

CASE (a) Sea Level 100°F Dry Bulb 80°F Wet Bulb

Point	Pressure P.S.I.A.	Temp °F.	Mass Flow LB./MIN	Water Vapour Gr/Lb Dry Air	Free Moisture Gr/Lb Dry Air	Water Flow G.P.M.
A	14.7	100	340			
B	52.6	455	71	123		
C	14.7	242	340			
D	15.5	130	340			
E		188				
F						14
G	14.7	100	290			
H		84				
J						6
K	41.5	92		74		
L	14.1	94				
M	14.7	124	145	218		
N	21.9	28.5 DAR 50.9 WET		36	38	
P	20.7	50.0	142	36	7.6	
R						3.7
W						

PRIMARY H.E.FAN: 12,000 R.P.M. 58 S.H.P.

C.A.U: SPEED 17,600 R.P.M.

H.E.EFFECTIVENESS: PRIMARY 0.82 SECONDARY 0.92

AIR CONDITIONING PERFORMANCE

CASE (b) 3,500' 100°F Dry Bulb 80°F Wet Bulb

Point	Pressure P.S.I.A.	Temp. °F	Mass Flow LB/MIN	Water Vapour Gr/Lb Dry Air	Free Moisture Gr/Lb Dry Air	Water Flow G.P.M.
A	12.96	100	320			
B	46.5	455	65	143		
C	12.96	238	320			
D	13.76	130	320			
E		185				
F						13.2
G	12.96	100	258			
H		84				
J						6.8
K	37.8	91		82		
L	12.29	94				
M	12.96	127	129	250		
N	19.96	26.5 DAR 50 WET		42	40	
P	18.96	50	130	42		8
R						3.6
W						

PRIMARY H.E.FAN: 12,000 R.P.M. 53 S.H.P.

C.A.U: SPEED: 18,500 R.P.M.

H.E.EFFECTIVENESS: PRIMARY .83 SECONDARY .93

CONSOLIDATED
DIESEL ELECTRIC CORPORATION
OF CANADA LTD.

AIR CONDITIONING PERFORMANCE

CASE (c) Sea Level -65°F Dry Bulb

Point	Pressure P.S.I.A.	Temp °F.	Mass Flow LB/MIN	Water Vapour Gr/Lb Dry Air	Free Moisture Gr./Lb Dry Air	Water Flow G.P.M
A						
B	66.5	286	89			
C						
D						
E		-47				
F						
G		-65				
H		-65				
J						
K	30.8	-61.5	98.9			
L						
M						
N	24.9	-75.5				
P	23	85	178			
R						
W		286	79.1			

PRIMARY H.E.FAN: 12,000 R.P.M. 59 S.H.P.

C.A.U: SPEED: 9,000 R.P.M.

H.E.EFFECTIVENESS: PRIMARY 0.95 SECONDARY 0.80

3.4 Engine Electrical System

3.4.1 In the following pages, the Engine Electrical System will be described, together with its protection devices and the procedure adopted for starting the pair of engines. Reference should be made to Schematic, Electrical System X 1037, which will be found together with its Key at the end of this section.

3.4.2 The Schematic on X 1037 shows the full system for one engine only, although the control panel end is shown in full. Provision is made to ensure that the engine carrying the D.C. generator is always started first, although the engines may be started separately or automatically in a dual sequenced arrangement.

3.4.3 Push buttons P.B.-3 and P,B.-5 are the individual starter buttons, while P.B.-1 is the dual starter button. Switch S.1 is a normally open over-ride switch provided so that engine number 2 can be started by itself for maintenance or checking purposes. It is protected by a suitable guard so that it will not be closed under normal operating conditions.

3.4.4 It will be seen that if start button P.B.5 is pushed first, there is no electrical supply to it and, consequently, the wrong engine cannot be started first.

3.4.5 Let us examine the sequence for starting the engines individually. Button P.B.-3 is closed, energising relay CR1 through the centrifugal switch for 36,000 and 16,000r.p.m. Contact CR1-2 closes, commencing the starting sequence, through the 6000 rpm switch. Contact CR1-1 closes, holding the relay. Contact CR1-3 opens but is not in circuit in this individual operation. When the engine reaches 6000 r.p.m., the starter components are de-energised and when 16,000 r.p.m. is reached, the circuit to CR1 is completed through the protective devices T.O. Sw. and O.P. Sw. At 32,000 r.p.m. the air delivery valve circuit is complete, permitting the air delivery valve to be opened when required. The 6000 r.p.m. switch has earlier energised the control circuit for engine number 2 which can now be started in a similar fashion by depressing P.B.-5.

3.4.6 Stopping either engine is accomplished by operating P.B.-2 or P.B.-4 which drops out the main relay CR1 or CR2, thus closing the fuel valve.

3.4.7 In the dual start case, start button P.B.-1 is closed energising D.S.R. Contact D.S.R.-1 now holds the relay in while D.S.R.-2 energises C.R.1 and commences the start cycle on engine number 1. At the same time, D.S.R.-3 changes over and prepares the second engine circuit to receive starting current.

3.4.8 At the completion of the starting cycle at 6000 r.p.m. on engine number 1, the centrifugal switch, while dropping out the starting components on engine number 1 energises the starting circuit on engine number 2 by by-passing the normal manual starter switch P.B.-5. The starting sequence on number 2 is now identical to the manual case.

3.4.9 Once C.R.2 has been energised, both contacts C.R.1-3 and C.R.2-3 are open and relay D.S.R. drops out under running conditions and prepares itself for the next dual starting cycle.

3.5 Air Conditioning Electrical System

3.5.1 Reference should be made to Electrical Schematic, Air Conditioning System, X 1036, which will be found at the end of this section.

3.5.2 It will be seen initially that, if the alternator power switch is closed before the air conditioning system is operating, no power will be fed to the output contactor since contacts K1-1 and K2-3 are normally open.

3.5.3 In order to commence the system operating, switch ACS is closed which energises the time delay relay 1T and K2. K2 would normally be energised through the duct temperature switch DTS but in the event that the ambient air temperature is higher than 85°F, K2 will be energised through the normally closed contact on the time delay relay. It is expected that the delay to be used on this relay before it operates will be of the order of 15 seconds. Energising K2 opens the circuit to the over-temperature warning light, closes one of the contacts in the alternator output circuit and opens the air delivery valves, thus starting the cooling system operating.

3.5.4 When the air conditioning system gets up to full speed and output, DPS and MFS close, and at the conclusion of the 15 seconds time delay 1T-0 closes, thus energising K1. At the same time, 1T-C opens leaving the energising of K2 dependent on the duct temperature switch DTS.

3.5.5 K1-1 now closes, enabling the switch APS to be closed to energise the output contactor for the alternator AOC and at the same time the hourmeter is started and the load light comes on. The whole system is now operating.

3.5.6 It will readily be seen that in the event of duct temperature rising, duct pressure falling, or mass flow falling, the alternator contactor is de-energised by either K1-1 or K2-3 opening, thus providing the necessary safeguard. If the duct temperature rises above the limit of 85°F, K2 dropping out will close contact K2-2, thus illuminating the over-temperature indicator light.

3.6 Air Conditioning Temperature Control Equipment

3.6.1 It is not proposed to describe this equipment in any detail in this proposal. This control box will take temperature error signals, evaluate them, amplify them, and provide power to the proportional solenoids operating the Temperature Control Valve and the Water Flow Control Valve.

3.6.2 We propose to use a magnetic amplifier circuit in this control so as to avoid the necessity for vacuum tubes. The circuits employed are well established and developed and the application here is perfectly straightforward.

3.7 Compatibility With Avro Requirement 72/GEQ/10 May 1958

3.7.0 Here it is proposed to examine the Avro requirement paragraph by paragraph and comment where necessary. Where complete compliance exists and no comment is necessary, this is indicated. The paragraph numbers refer to the AVRO document.

1. Introduction

This paragraph is complied with completely with the following obvious exceptions:-

(a) Instead of AiResearch GTCP 85 units we are proposing Blackburn ARTOUSTE 510 engines

(b) Instead of AiResearch "bootstrap" air conditioning package we are proposing de Havilland Propellers Ltd. "simple" air cycle system package

(c) Consolidated Diesel will be responsible for the system instead of Avro and will carry out overall design and manufacture.

2.1 to 2.4 Inclusive

Fully complied with.

3. Equipment Requirements

3.1 Air Compressor Pack Installation

Here 2 Artouste 510 units will be provided instead of AiResearch GTCP 85. The Artouste engines will more than meet the requirements laid down in this paragraph.

3.1.1 to 3.2.1 Inclusive

Fully complied with.

3.2.2 Refrigeration Equipment

Here we will be providing fully developed, production de Havilland Propellers Ltd. simple cold air units. All the rest of this paragraph is fully complied with, excepting that no electrically driven cooling fans will be used. The fans used will be mechanically driven either from the output shaft of one Artouste 510 or from the C. A. U. turbines.

3.3 Electrical System

We are proposing to provide here, as an alternative to the air cooled A. C. generator, an oil cooled Lucas Rotax generator identical to that used on the aircraft.

3.3.1 D. C. System

We understand from Avro Aircraft that the D. C. requirements are rather vague at the moment. We are proposing a 4 KW generator but this can be changed if the D. C. load decreases substantially.

3.3.1-1 and 3.3.1-2

Our proposed system complies fully with the quoted D. C. regulation and overload conditions.

3.3.1-3 Batteries

Although we are prepared to provide batteries of the type mentioned in the requirement, we would like to offer Nickel Cadmium batteries as an alternative. If one includes the cost of winterising a normal lead-acid battery the initial cost is almost equal and there is no doubt that the Nickel Cadmium variety will stand up to operation much better than the conventional type.

3.3.1-4 Components

All the components listed will be supplied.

3.3.2 A-C System

We comply fully with all the A. C. requirements including regulation and frequency variation. All the system components required will be supplied.

3.3.3 to 3.3.5 Inclusive

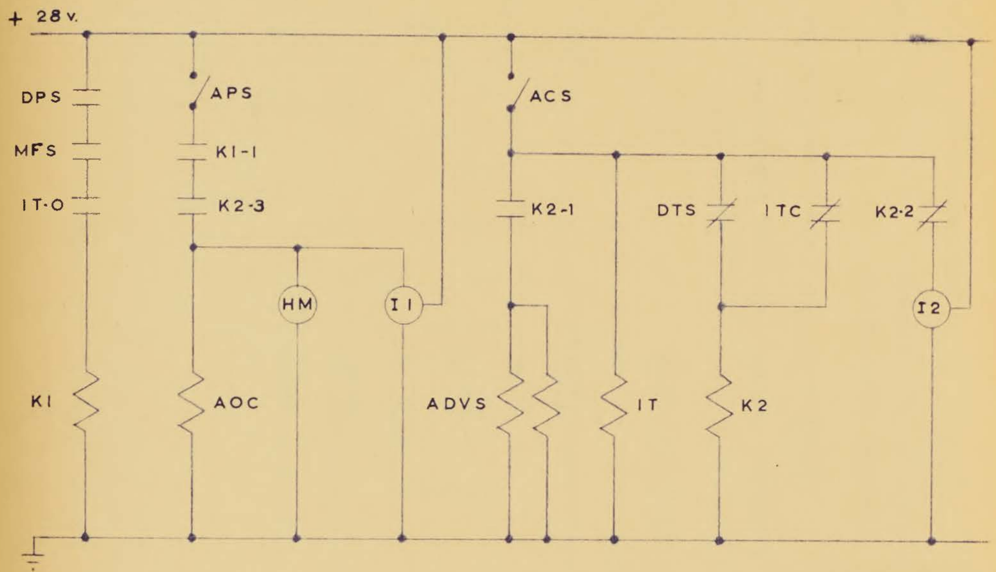
Full compliance.

3.4 Enclosure

All this section will be fully complied with excepting that we are not proposing to provide a dust filter at the gas turbine inlet. If excessive inlet pressure drops are to be avoided, an inlet dust filter would have to be of such an enormous area as to be impracticable. We feel that it would be extremely difficult to provide a worthwhile dust filter without increasing the total size of the equipment much beyond the desirable limits stated.

Regarding the self-mobility feature, we feel we should point out that we have had considerable experience in the design and production of this type of trailer. Photographs of several such units appear at the back of Section 8. Considerable design and development work is necessary in order to perfect the manual control for such a vehicle if starting from scratch and all this information is, of course, available to us.

CONSOLIDATED
DIESEL ELECTRIC CORPORATION
OF CANADA LTD.

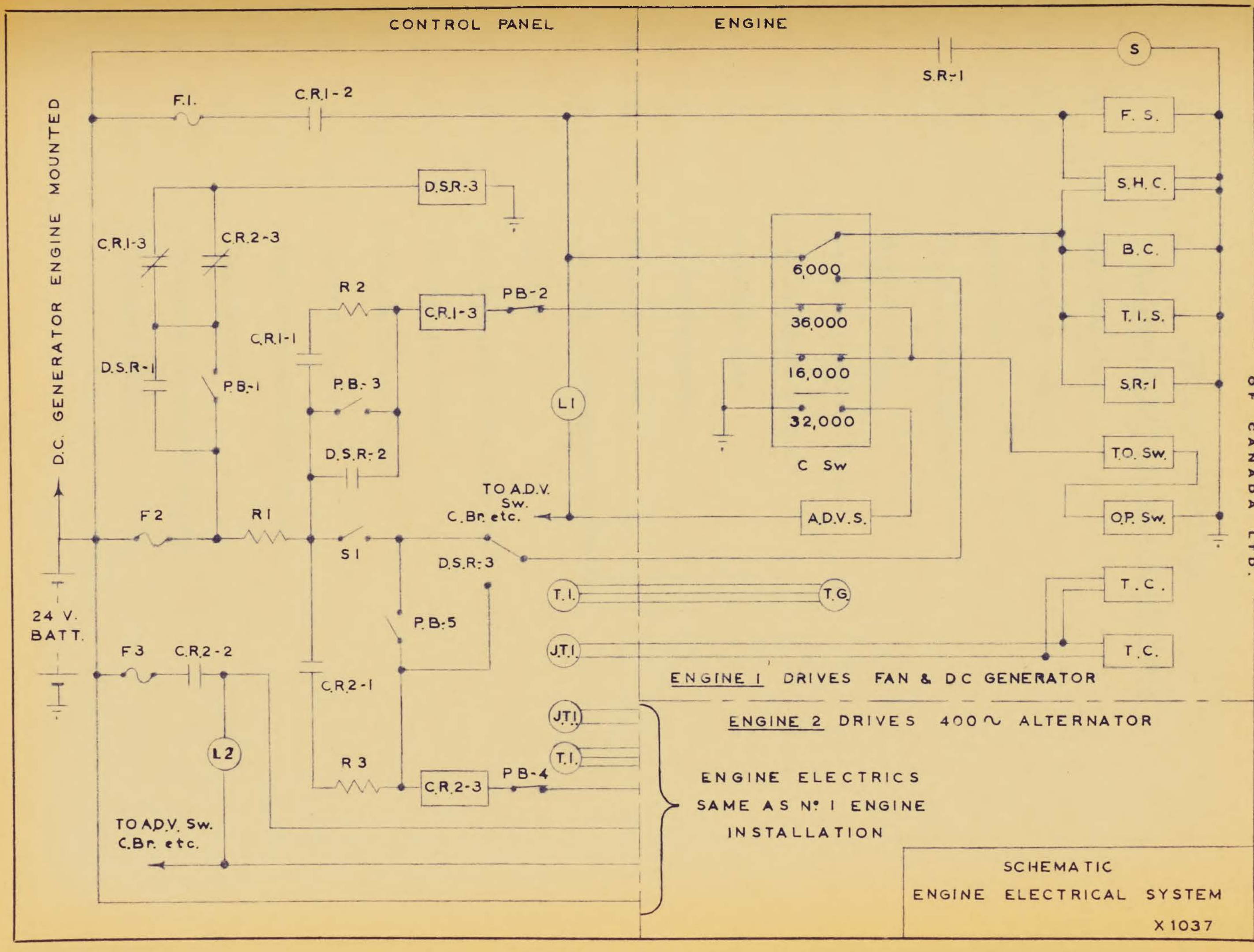


ACS	AIR CONDITIONING SWITCH
ADVS	AIR DELIVERY VALVE SOLENOID
AOC	ALTERNATOR OUTPUT CONTACTOR
APS	ALTERNATOR POWER SWITCH
DPS	DUCT PRESSURE SWITCH
DTS	DUCT TEMPERATURE SWITCH
HM	HOUR METER
I-1	INDICATOR LAMP, POWER ON
I-2	INDICATOR LAMP, OVER TEMPERATURE
IT	TIME DELAY RELAY (DELAY ON P.U.)
K1	CONTACTOR CONTROL RELAY
K2	AIR CONDITIONING CONTROL RELAY
MFS	MASS FLOW SWITCH

NOTE

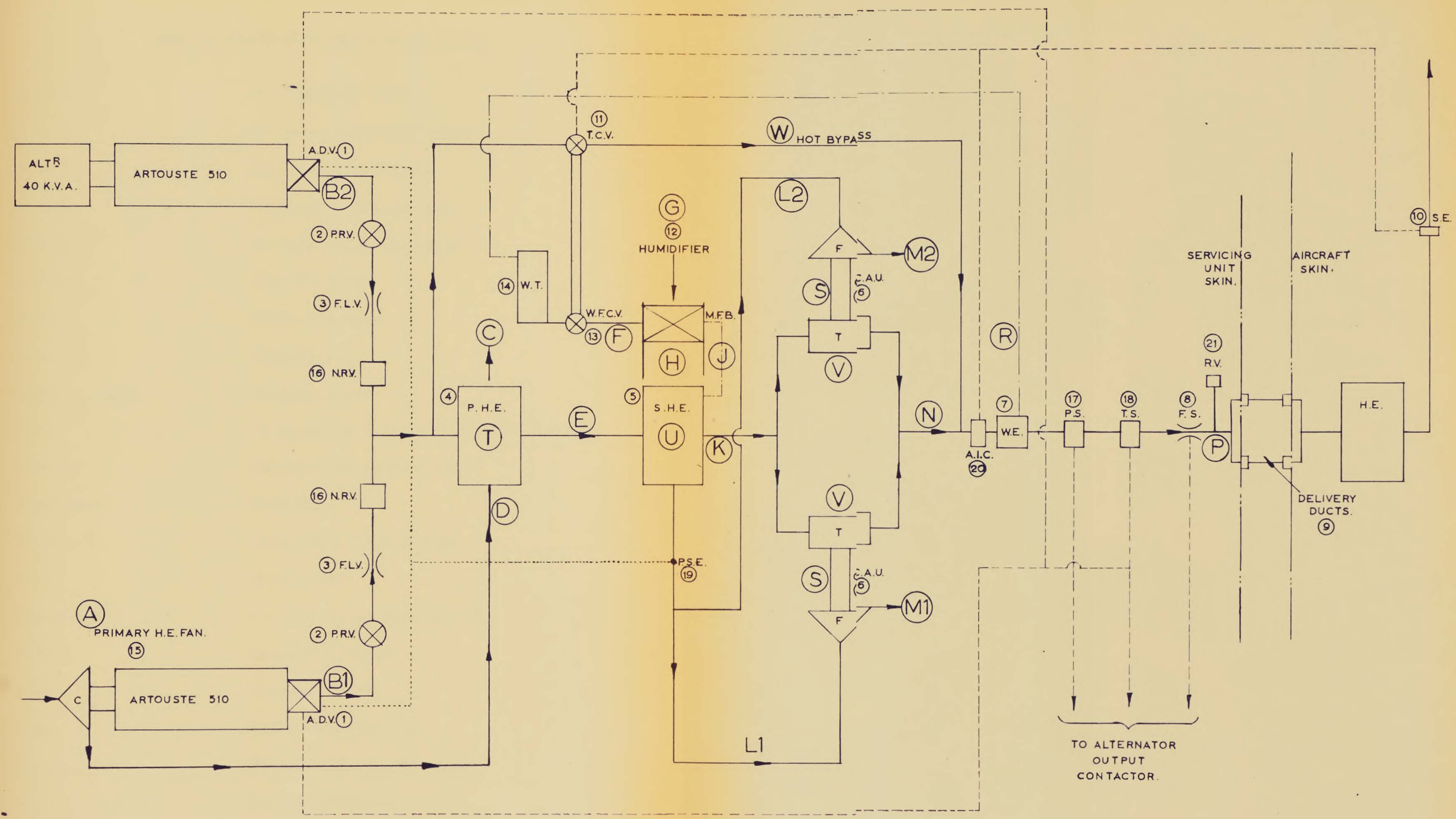
1. DTS OPEN WHEN DUCT TEMPERATURE IS ABOVE 85°F.
2. DPS OPEN WHEN DUCT PRESSURE IS BELOW 4 P.S.I.G.
3. MFS OPEN WHEN FLOW IS BELOW 130 lbs. per min.

ELECTRICAL SCHEMATIC
AIR CONDITIONING SYSTEM
X 1036



CONSOLIDATED
DIESEL ELECTRIC CORPORATION OF CANADA LTD.

CONSOLIDATED
DIESEL ELECTRIC CORPORATION
OF CANADA LTD.



SYSTEM DIAGRAM. AIR CONDITIONING PACK.

X-1038

KEY TO SYSTEM SCHEMATIC X 1038

1	A.D.V.	Air Delivery Valve
2	P.R.V.	Pressure Regulating Valve
3	F.L.V.	Flow Limiting Venturi
4	P.H.E.	Primary Heat Exchanger
5	S.H.E.	Secondary Heat Exchanger
6	C.A.U.	Cold Air Unit
7	W.E.	Water Extractor
8	F.S.	Flow Sensor
9	Delivery Ducts	Delivery Ducts
10	S.E.	Temperature Sensing Element in Aircraft
11	T.C.V.	Temperature Control Valve
12	Humidifier	Humidifier
13	W.F.C.V.	Water Flow Control Valve
14	W.T.	Water Tank
15	Primary H.E. Fan	Primary Heat Exchanger Fan
16	N.R.V.	Non Return Valve
17	P.S.	Pressure Switch
18	T.S.	Temperature Switch
19	P.S.E.	Pressure Sensing Element
20	A.I.C.	Anti-Icing Control
21	R.V.	Relief Valve

CONSOLIDATED

DIESEL ELECTRIC CORPORATION

OF CANADA LTD.

SECTION 4

DISCUSSION OF OUR PROPOSAL FOR STARTING UNIT AND ITS COMPATIBILITY WITH REQUIREMENTS SET OUT IN AVRO REPORT 72/GEQ/12

MAY 1958

SECTION 4

DISCUSSION OF OUR PROPOSAL FOR STARTING UNIT AND ITS COMPATIBILITY WITH REQUIREMENTS SET OUT IN AVRO REPORT 72/GEQ/12 MAY 1958

4.0 Scope

We propose in this section to describe the operation of the starting unit and its performance. Having done this we will then examine the Avro requirement and comment on the compatibility of our proposal with that requirement. In describing this unit, reference should be made to the General Arrangement drawing X 1040 to be found at the end of this section. A further and more detailed description of the proposed unit will be found in Appendix 'B' in the accompanying volume. As this system is so much simpler and to some extent based upon the design of the servicing unit described in Section 3, some reference will be made to this section.

4.1 Description of System

4.1.1 The system is an extremely simple one. It consists of a single Artouste 510 supplying compressor bleed air through two hoses to the engine in the aircraft. The Artouste also drives a D.C. generator of about 2-1/4 KW output, a small quantity of which is inverted to provide A.C.

4.1.2 The whole unit, in three sections, engine, fuel and electrics, is mounted on a common base carried on a non-self-propelled trailer. Provision is made for the whole assembly to be lifted off the trailer and operated as a stationary unit.

4.1.3 Protection devices for the gas turbine compressor unit are provided as discussed in Section 3.

4.2 Description of Components

The major components are as follows:

4.2.1 Artouste 510 Gas Turbine Compressor Unit

The intention is to keep this identical with that used in the servicing unit for logistic reasons.

4.2.2 D.C. Generator

This will be driven by a pad on the engine and will provide about 75 amperes. It will be an air cooled aircraft type.

4.2.3 Inverter

This will be an aircraft type and will have an output of 500 va .

4.2.4 Air Delivery Valve

This will be a similar valve to that used on the servicing vehicle, and will control the bleed air flow from the compressor.

4.3 Performance Summary

Although the requirement only calls for the performance claimed by AiResearch for their GTCP 85 series, the Artouste performance is in fact somewhat greater. The figures for the Artouste 510 are as follows:-

4.3.1 Sea Level

Ambient Temp.	Air Flow Lb./Min.	Air Pressure p.s.i.a.	Air Temp Degrees F.
-65°F	166	66.3	305
59°F	132	55.0	430
120°F	118	50.6	490

4.3.2 3500 Feet

Ambient Temp.	Air Flow Lb./Min.	Air Pressure p.s.i.a.	Air Temp. Degrees F.
100°F	107	45.7	470

SECTION 5

Description of Artouste 510/103

Manufactured by

The Engine Division
Blackburn & General Aircraft Ltd.
Brough, E.Yorks,
ENGLAND.

SECTION 5

Description of Blackburn Artouste 510/103

5.1 In Sections 3 and 4 the performance specification and method of operation of the Blackburn Artouste is discussed in some detail as part of the overall systems. In this section it is considered desirable to set out a description of the engine itself with whatever background information is relevant in the way of manufacturing specifications, inspection procedures etc.

5.1-1 This section is divided into the following Parts:-

Part 5.2	Description
Part 5.3	Applicable specifications, standards, drawings and publications.
Part 5.4	Inspection, test procedures and preparation for storage and transit.
Part 5.6	Engine performance curves.

Part 5.2 Description

5.2-1 LEADING PARTICULARS - ARTOUSTE 510/103

5.2.1-1 GENERAL

Engine type	Air bleed/shaft drive gas turbine.
Overall dimensions (engine only)	
Length	38.9 in.(excludes intake and exhaust ducts).
Max. dia.	19.1 in.
Weight ,..	230 lb. approx.N.D.W.(E.D.M.25)
Compressor	Single stage, single sided, centrifugal.
Turbine	Two stage, axial flow.
Combustion chamber	Annular, straight flow.
D. of R. (seen from intakes)	
Output shafts	Anti-clockwise - large face. Clockwise - small face.

5.2.1-2 PERFORMANCE

Max. continuous ... ... Either 2.4 lb.air/sec., at 3.57 press.ratio, plus O B.H.P.
Fuel consumption 320 lb./hr.
Or 1.93 lb. air/sec., at 3.75 press.ratio, plus 100 B.H.P.
Fuel consumption 338 lb./hr.

5.2.1-3 FUEL

	British Spec.	Canadian Spec.
Wide cut gasoline	D.Eng. R.D. 2486	3-GP-22b
Aviation turbine fuel	D.Eng. R.D. 2482	3-GP-23a
Aviation kerosine	D.Eng. R.D. 2488	3-GP-24
Aviation gasoline	D.Eng. R.D. 2485	3-GP-25c

5.2.1-4 OIL

Oil (synthetic)	D.Eng. R.D. 2487	-
Oil (mineral)	D.Eng. R.D. 2479/0	3-GP-54J
Oil tank capacity	Maximum 5 pints (oil)	
Oil consumption	0.25 pints/hr. maximum	

5.2.1-5 SERVICING

Routine maintenance	50 hr. inspection
Overhaul life	At the rating specified herein it is anticipated that the overhaul life will be 1,000 hours.

5.2.2 ENGINE

The structural description of the engine commences at the air intake casing and continues towards the rear terminating with a description of the gearbox. In this way the major part of the description can be applied to the Palouste as well as the Artouste.

5.2.2-2 The cast aluminum alloy air intake-compressor casing comprises the bifurcated air intake and two oil tanks. At the front two rectangular apertures provide entries to the twin intakes and between the convergent intake passages a cylindrical portion houses the front bearing flexible mounting. At the rear the casing bells out to form the compressor housing and a flange provides for attachment of the main casing. On the longitudinal centre line a machined face is provided at the top and bottom of the belled portion for the torch igniter. The alternate position to the one occupied by the torch igniter is used as a compressed air tapping point.

5.2.2-3 On the upper and lower surfaces of the front section several bosses are provided for breather pipes, vent pipes and the oil filler neck while at the extreme front machined faces and below the intake entries provide mountings for the accessories gearboxes. Between the intake entries another machined face provides the mounting for the fuel inlet housing, behind which a recess accommodates the drive pinion housing.

5.2.2-4 The diffuser assembly fits inside the air intake/compressor casing at the rear secured by four forward projecting flanged studs which are brazed to the front face of the radial diffusers. Four identical studs, but on a different diameter pitch circle to ensure correct assembly, are brazed to the rear face and provide for the attachment of the axial diffusers. The axial diffusers and the compressor backplate comprise a single aluminum alloy casting at the centre of which tapped holes are provided for attachment of the compressor labyrinth air seal and labyrinth lip. Between each hole radial grooves provide passages for pressurizing air which is circulated through the hollow rotor shaft.

5.2.2-5 The cylindrical main casing forms the engine backbone in that it interconnects the air intake/compressor casing and the turbine casings and an internal flange at the rear provides for the attachment of the combustion equipment. The casing is fabricated in stainless steel and is double skinned, the inner skin being perforated. Five tapped bosses are equally spaced about half of the outer casing periphery and the flange for the air bleed take-off is situated midway between the topmost bosses. The fuel drain dump valve is fitted in the bottom boss.

5.2.2-6 Drilled flanges at the front and rear of the casing provide for attachment to the air intake casing and second stage turbine casing respectively.

5.2.2-7 In addition to the combustion chamber the main casing houses the first stage nozzles which in turn form the first stage turbine shroud. The annular combustion chamber comprises two main components; an inner and an outer member, both of which are shaped, louvred and perforated to effect efficient combustion. A four piece strap also perforated, and dimpled to ensure correct location, is bolted around the outer member.

5.2.2-8 Five unequally spaced lugs welded to the outer member rear support ring correspond with five similar lugs on the front of the first stage nozzles. Set screws locked with tab washers secure the outer member to the nozzles. The inner member is secured with set screws to an internal flange on the nozzles and the inner member labyrinth is also secured to this flange with the same set screws.

5.2.2-9 The first stage nozzles are a welded fabrication comprising an inner and outer shroud with the hollow nozzle blades interposed. The outer shroud extends rearwards to form the first stage turbine shroud terminating in a drilled and tapped outward flange which provides for attachment to the main casing internal flange.

5.2.2-10 The second stage nozzles are of similar construction to the first stage but the outer shroud is flanged at the front for attachment to the main casing internal flange. The inner shroud is flanged internally for attachment of the interstage labyrinth seal.

5.2.2-11 The second stage turbine casing is interposed between the main casing and the rear bearing housing casing. It is simply a shallow cylindrical casing flanged at each end to provide attachment.

5.2.2-12 The rear bearing support casing is a welded fabrication comprising a cylindrical centre portion and three concentric annuli, the centre one is the exhaust gas passage and the other pair provide rear bearing cooling air passages.

5.2.2-13 Within the central cylinder the rear bearing is located within a light alloy housing which in turn is located by three hollow support arms which are utilized as oil passages. The bearing housing is grooved on its outer periphery for piston rings which seal the housing within the cylinder. At the rear end the cylinder is sealed by a blanking plate.

5.2.2-14 The rotating assembly, which runs in a ball thrust bearing at the front and a roller bearing at the rear, comprises steel rotating guide vanes, a light alloy impeller (to which the guide vanes are dowelled), a hollow main shaft, a two stage turbine unit, an interstage spacer and a stubshaft.

5.2.2-15 The rotor shaft is machined from a forging and throughout its length increases in bore and diameter from front to rear. The foremost portion of the shaft is threaded to receive the rotor nut and behind the threads the shaft is serrated for transmitting the drive, via a coupling, to the accessories. The shaft is utilized to circulate pressurizing air and fuel; they are prevented from mixing by retaining the fuel within a central tube which at the rear opens out into a small chamber which is sealed at the rear.

5.2.2-16 The rotating guide vanes, the impeller, and both turbines are machined from forgings. The blades on all items being integral. The stubshaft also is machined from a forging and has integral blades which induce and exhaust the rear bearing cooling air.

5.2.2-17 The drive for the accessories is taken from the serrations at the front of the rotor shaft via a hollow shaft which at the front is internally serrated to transmit the drive to the high speed pinion. This shaft is supported in a ball bearing which is located at the rear of the drive pinion housing. From the high speed pinion the drive is transmitted to the upper and lower accessories gearboxes through idler gears which are also supported by ball bearings located within the drive pinion housing. The drive to the output gearbox is transmitted from the high speed pinion directly to the gearbox pinion which also is located in a ball bearing.

5.2.2-18 Each accessory gearbox has three forward and three rearward mounting faces all of which are of the taper flange type. On the upper gearbox the fuel filter/pump/control unit is mounted centrally at the rear with its drive bearing housing opposite. Adjacent to the fuel unit on the right but not requiring a drive is the fuel pressure regulating valve and on the left is the overspeed switch with its bearing housing opposite. On the lower gearbox the oil pump/filter unit is mounted centrally at the rear with its drive bearing opposite. The electric starter is adjacent to the oil pump on the right with the roller clutch opposite and the tachometer generator is on the left with its bearing housing opposite attached to the rear of which is the ignition unit; also not requiring a drive.

5.2.2-19 Constant mesh spur gears are used throughout to drive the accessories, the fuel and oil pump units drive bearing housings each carry two gears, one of which is in mesh with an idler gear thereby transmitting the drive from the rotating assembly.

5.2.2-20 The lightweight tachometer generator is a two pole circular rotor magnet type. An adapter is interposed between the gearbox taper flange mounting and the bolted flange mounting of the tachometer generator.

5.2.2-21 The 24V electric starter motor is a relatively high speed, series wound type of commercial approved design. The starter is used in conjunction with a clutch mechanism of the cam and roller type and also incorporates a compound spur gear type reduction gear.

5.2.2-22 The air delivery valve body is a light alloy casting of circular shape but is formed with two tangential sections at right angles to one another. Two butterfly valves operate within the body and are interconnected by a control rod so that it is possible for only one valve to be open at any time. One valve controls the air delivery supply and the other the bleed air. The valves are actuated by twin opposed pistons interconnected by a rod which is formed with a rack which engages a pinion formed on the end of the delivery air butterfly. The operation of the valve relies on a selector mechanism permitting air to one side or the other of the pistons thereby causing them to shuttle which in turn opens or closes the delivery butterfly.

5.2.2-23 The single stage reduction gearbox is a light alloy casing and is attached to the front of the engine on two shallow angular extensions to the air intakes. Upper and lower taper flange mountings are formed on the front of the casing and all gears are constant mesh spur gears each supported in two bearings. On the engine which drives the alternator a further reduction stage is interposed between the main gearbox and the alternator. This gearbox is complete in itself and comprises a gear and pinion with an offset idler; all of which are supported by pairs of bearings. On the engine which drives the fan a supplementary gearbox is interposed which can be used as an accessory drive for a D.C. Generator if required.

5.2.3 FUEL SYSTEM

5.2.3-1 Since the engines are required to operate at a single rated speed the fuel system is extremely simple. It comprises a tank in which a fuel booster pump is fitted, a pressure regulating valve, a fuel unit made up of a filter, a pump, and a control unit from which fuel is supplied direct to the engine via a shut-off cock and to the Torch igniter via a second shut-off cock. Also included in the system is a pressurizing valve which is interposed between the fuel unit and the main shut-off cock.

5.2.3-2 The spring loaded diaphragm operated pressure regulating valve is of proprietary manufacture and is pre-set to regulate the fuel pressure at the entrance to the engine system at 2 lb. sq. in. The valve is adjustable but in the normal course of events adjustments are unnecessary.

5.2.3-3 The fuel unit comprises a gauze discs filter, a gear type pump and a control unit which embodies a centrifugal governor.

5.2.3-4 A waisted stud screwed into a boss on the fuel pump body provides the filter mounting and a perforated tube which fits around the stud carries the filter discs. The filter element stack is retained within the filter dome by a base plate secured by a circlip. The filter dome is sealed at each end by a rubber sealing ring and is secured on the stud by a plain nut locked with a tab washer.

5.2.3-5 The fuel pump body is an aluminum alloy casting, the rear face of which is machined to mate with the control unit and a tapped boss is provided for a fuel drain. The pump drive extends through the body to connect with the fuel control unit governor.

5.2.3-6 Fuel supplied to the pump inlet is carried round the pump chamber by the gears and delivered under pressure to the control unit through an internal passage; a rubber seal is recessed in the joint face between the pump and unit. The pump is self lubricating; a compound seal prevents fuel leaking into the accessories gearboxes and oil leaking into the pump. The space between the respective seals is vented to atmosphere.

5.2.3-7 The fuel control unit, through a system of variable orifices, controls the fuel flow to the engine under all conditions. A flyweight type governor linked to a piston valve controls and maintains engine maximum speed. Acceleration fuel bleed and governor by-pass adjusting screws are arranged to provide the basic adjustments controlling starting, acceleration and deceleration. In addition several valves are contained within the unit.

5.2.3-8 A pressurizing valve prevents fuel passing to the main burner until sufficient pressure is built up to ensure atomisation. This same valve whilst witholding the main delivery ensures that sufficient pressure is available at the torch igniter. A relief valve, for the safety of the pump, is adjusted to open a return line to the pump inlet in the event of an increase in pressure upstream of the governor piston valve. This line also incorporates a non-return valve to eliminate the possibility of over-fuelling by the booster pump during starting.

5.2.3-9 An acceleration pressurizing valve is fitted downstream of the control unit and is simply a spring loaded half ball valve incorporating a by-pass in addition to the main flow. During the early part of acceleration there is insufficient pressure to open the main flow, therefore, the fuel must reach the engine by the by-pass until such times as the fuel pressure overcomes the spring pressure thereby opening the main flow. This splitting of the acceleration flow and consequent slowing down of acceleration time is a desirable feature in that it ensures the exhaust temperature maintains within the specified limits during acceleration.

5.2.3-10 Between the pressurizing valve and the main burner the high pressure fuel shut-off solenoid operated cock is fitted. This cock is immediately upstream of the main burner and therefore is used to stop the engine.

5.2.3-11 The main fuel supply connects with the fuel inlet housing whence the fuel is transferred to the fuel tube which is housed and secured by a nut within the accessories drive shaft. A pressurized labyrinth seal prevents fuel leaking into the gearboxes. From the fuel tube the fuel passes to the hollow rotor shaft.

5.2.3-12 The rotary atomizer is a ring of small holes drilled radially in the rotor shaft. Fuel at pump pressure is boosted centrifugally and sprayed, finely atomized, into the combustion chamber and due to the radial distribution it mixes with the air from the compressor to form a homogeneous mixture giving even combustion.

5.2.3-13 For starting fuel is supplied, via a solenoid operated shut-off cock to a torch igniter which receives H.T. current from a booster coil type ignition unit supplied with L.T. current from batteries.

5.2.3-14 The torch igniter body is a mycalex moulding having three bores which receive the fuel and electrical connections and the hollow centre electrode. A passage from the fuel connection bore aligns with a hole in the electrode. A hole from the electrical connection bore accommodates a screw which secures the electrode within the torch body and also provides the electrical continuity between the H.T. connection and the electrode.

5.2.3-15 Fuel from the torch igniter shut-off cock is delivered to the igniter fuel connection where it must pass through a filter disc before entering the electrode. The fuel is sprayed from a fine hole at the end of the electrode against an anvil set in the base of the barrel and the spark across the gap between the electrode and the barrel ignites the fuel spray.

5.2.4 OIL SYSTEM

5.2.4-1 The oil system is completely self contained on the engine and is a closed circuit recirculatory system.

5.2.4-2 The twin oil tanks are interconnected by a large bore balance pipe from which a smaller diameter pipe delivers oil to the inlet side of the pressure pump. The tank vents are also interconnected and pressure balance pipes from each tank connect with the upper accessories gearbox. The pressure pump output is supplied direct to the oil filter through an internal passage and from the filter is fed to a six port junction block.. A pressure relief valve is fitted to the filter to open a return line to the inlet side of the pressure pump in the event of an excessive build up of pressure.

5.2.4-3 From the junction block six branches supply oil to the pressure switch, the pressure gauge, the rear main bearing, the front main bearing, the roller clutch and the sandwich gearbox. The branch pipe to the front main bearing is further divided to supply the high speed pinion and the reduction gearbox, oil from the rear main bearing is scavenged separately through two bearing housing hollow support arms and two pipes which unite before entering the pump. The remaining oil from the gearboxes at the front of the engine is collected in the lower gearbox from where it is all returned to the tanks via the scavenge pump.

5.2.4-4 The twin oil tanks are cast integral with the air intake casing. An oil filler incorporating a strainer in the extended filler neck is fitted to the left hand tank; the corresponding position on the right hand tank is fitted with a vent connection and a pipe interconnects this connection with the filler neck.

5.2.4-5 The pressure pump, the scavenge pump and the filter are incorporated in one unit. Each pump is of the spur gear type and due to the construction each is in effect a double pump; the central drive shaft carries a driving gear which is in engagement with a pair of diametrically opposed pinions.

5.2.4-6 The oil filter is of similar construction to the fuel filter in that the gauze disc element is housed in an alloy casing. The casing with the element secured in it is attached to the rear of the pump body by a clip and taper clamps. The gauze discs are mounted on a central perforated pillar which screws on a stud fitted in the base of the casing.

5.2.4-7 Restrictors and removable strainers are fitted throughout the system and the filler neck is fitted with a gauze through which the system must always be filled.

5.2.5 ELECTRICAL SYSTEM

5.2.5-1 The electrical system is designed to meet a definite operational sequence which entails an automatic starting cycle for each engine. Both engines are automatically protected against over-speeding, over-temperature, and low oil and fuel pressure and in the event of a close down the engine will shed its load automatically.

5.2.5-2 The wiring diagram is shown in sections 3 and 4 as combined with the remainder of the electrical system.

5.2.6 INSTALLATION

5.2.6-1 Each engine is mounted on a shallow cradle completely remote from the other with the exception that the air delivery trunking from each engine unites before entering the air conditioning unit. Taper flange mountings and connections are used exclusively on the ducting thereby affording easy removal.

5.2.6-2 The engine is mounted in the cradle on three rubber/metal bonded bushes which are bolted to fillet plates welded to the cradle. The forward mounting picks up on a bearer attached to the single stage reduction gearbox and the two equi-spaced rear mountings pick up on bearers attached to the air intake/main casing joint flange.

5.2.6-3 All electrical connections effected by unit removal and replacement will be fitted with multi-pin plugs and sockets.

Part 5.3 Applicable Specifications, Standards, Drawings and Publications.

5.3-1 Ministry of Supply Specifications and Publications.

D.T.D. 806	Aircraft material spec: graphited grease.
D.T.D. 904	Process spec: cadmium plating.
D.T.D. 910	Process spec: anodic oxidation of aluminium and aluminium alloys.
D.T.D. 923	Chromate passification of zinc surfaces.
Eng.R.D.4(b) 2017	Power plants airborne auxiliary.
Eng.R.D. 2024	Interchangeability requirements of engines (Pistons and Turbines) V.P. props: accessories necessary for the functioning of the engine and accessory gear boxes.
Eng.R.D. 2028	Protection of Gas Turbines during storage and transit.
Eng.R.D. 2100	Turbine engines, general type conditions and 150 hr. type test schedule.
Eng.R.D. 2300	General specification for Gas Turbine engines for aircraft.
Eng.R.D. 2479	Oil, turbine aviation 9 centistokes - viscosity.
Eng.R.D. 2482	Fuel turbine aviation.
Eng.R.D. 2485	Fuel aircraft reciprocating engines (covering fuels in the following grades: 73, 80, 91/96, 100/130, 115/145).
Eng.R.D. 2486	Fuel, military aircraft turbine engines. Wide cut gasoline type.
Eng.R.D. 2487	Oil turbine synthetic type.
Eng.R.D. 2488	Fuel military aircraft engines, high flash point.
B.S. 1580/1953	British standard unified screw threads (with metric equivalents).
B.S. 93	British Association (BA) screw threads.
E.L. 1692	Cable electric H.T. ignition, high temp. resistant for aircraft engines.
E.D.M. 25	Definition and measurement of weight and determination of centre of gravity of aircraft engines and engine change units.
E.D.M. 35	Fuel systems and fuel control systems for gas turbine engines.
A.P.4089/D 480	AID/AIS Inspection instruction radiological inspection of castings.

	A.P. 4089/D 481	AID/AIS Inspection instruction. Detection of flaws by electro magnetic methods.
5.3-2	Administrative Circulars	
	No. 71	Drawings procedure for Turbine Engines.
	No. 233	Drawing introduction sheet and modification procedure.
	No. 234	Modification classifications systems.
5.3-3	Blackburn & General Specifications and Instructions	
	E.D.O.1.	Painting processes for "Cirrus" engines.
	B.G.A. Specs.619	Instructions for the use of Ardrox.
	Appendix 1	No. 996 for the flaw detection of Nimonic 90 turbine wheels.
5.3-4	General Design Requirements for Aircraft Equipment	
	D.E.S. 1	Chaps: 201, 202

Part 5.4 Requirements

5.4-1 Materials used in the manufacture of the unit shall conform to Aircraft Material Specifications approved by the Ministry of Supply or to Aircraft Material Specifications approved by The British Standards Institution Requirements.

5.4.1-1 Metals used in the unit shall be of corrosion resistant type or shall be treated against corrosion. Where practicable the use of dissimilar metals with high electrolytic potential difference, in contact, shall be avoided.

5.4.1-2 Workmanship and Finish. The workmanship and finish on all parts shall be in accordance with the high grade aircraft manufacturing practice for equipment of this type.

5.4.1-3 Standard parts shall be used wherever they are suitable for the purpose.

5.4-2 Corrosion - Resisting Treatments, Coatings and Paint Finishes. Corrosion resisting treatments, coatings and paint finishes shall be selected from suitable D.T.D. Specifications where practicable.

5.4.2-1 Steel parts with the exception of the parts listed below, all exterior steel parts and other steel parts and other steel parts subject to corrosion, and not in contact with oil shall be treated by an applicable corrosion resisting process.

1. Corrosion resistant steel parts.
2. Members or portions of members that act as bearings or journals.

5.4.2-2 Aluminium parts with the exception of the parts listed below all exposed aluminium and aluminium alloy parts shall be anodised in accordance with D.T.D. 910C. Other parts may also be excepted, when application of a treatment is impracticable or considered unnecessary.

1. Surfaces which are in contact with oil.
2. Accessory pads and port covers.
3. Unalloyed aluminium and aluminium clad aluminium alloy.

5.4.2-3 Paint finishes with the exception of the parts listed below all exposed metal surfaces shall be painted in accordance with B. & G.A. Specification E.D.O.1. 130K. Additional parts may be excepted when application of paint finishes on any part thereof is impracticable or considered unnecessary.

1. Corrosion resistant steel.
2. Working surfaces.
3. Threads.
4. Oil holes.
5. Cadmium plated parts.
6. Unalloyed aluminium and aluminium clad aluminium alloy.

5.4-3 Threaded Parts.

5.4.3-1 All conventional straight screw threads shall conform to the requirements of B.S. 1580/1953 and B.S. 93.

5.4.3.1-1 Installation connections. The following internal screw threads shall be provided on the units to connect the following.

Fuel inlet pipe	M.S. 33656/6
Lub oil pressure	M.S. 33656/4
Drain block	M.S. 33656/4
Oil tank drain	M.S. 33656/6
Lower accessories gearbox drain	M.S. 33656/6
Combustion chamber drain	M.S. 33656/6
Oil system breather	M.S. 33656/16
Rear bearing cooling air outlet	Flange fitting 1.529" bore 4 tapped holes 1/4 x 28 U.N.F. on 2.25" P.C.D. in a 2.75" Dia. flange.

5.4.3-2 Special Screw Threads. Special screw thread forms for locking devices shall be acceptable where load requirements warrant their use.

5.4.3-3 Coating Threaded Parts. When aluminium alloy threaded parts are treated, at the time of assembly, with anti-seize compound, the compound shall conform to approved specifications.

5.4.3-4 Securing Threaded Parts. Threaded parts other than plumbing connections, shall be positively locked. Internal parts shall be locked by Nimonic 75 locking wire to Specification D.T.D. 703 or by locking tab washers. External parts may be locked by approved locking devices.

5.4.4-1 Drawings. Drawings shall be in accordance with the requirements of Administrative Circular No. 71.

5.4.4-2 Construction. The units shall be of compact design and of such construction as to withstand the shock vibration incident to normal shipment and normal use in service.

5.4.4.2-1 Interchangeability. In so far as practicable all B. and G.A. parts having the same part number shall be directly and completely interchangeable with each other with respect to installation and performance. Matched parts and selective fits will be permitted where required. Changes in B. & G.A. part numbers shall be governed by the drawing requirements of Administrative Circular No. 71.

5.4.5 Performance. Each Artouste 510 for use in the power plant will be fitted with a flow limiting venturi, the choking non-dimensional air mass flow for each venturi being equal to 0.7 (N.B. that is

$$\frac{M_B \sqrt{T_D}}{P_2} = 0.7$$

where M_B = Air delivery flow in lbs/sec.

T_D = Engine air delivery temp. in $^{\circ}$K.

P_2 = Total pressure at the venturi throat in p.s.i.a.

The above choking flow corresponds approximately to an air delivery flow of 1.6 lb/sec. at 34,200 R.P.M. and at an ambient temp. of 120°F.

5.4.5-1 Estimated Performance. The estimated performance of each engine for varying ambient conditions at 34,200 max. operating speed at 0, 50 and 100 (S.H.P. take-off) is shown on curves E.T.D. 577 - 579.

It should be noted that the delivery pressure ratio quoted in these curves refers to the delivery pressure at the common duct down stream of the flow limiting venturis and non return valves. These values are based on actual test measurements of the coupled bleed system.

5.4.5-2 In order that the performance may be estimated under any conditions of ambient temperature, a further set of curves is included (E.T.D. 567, 569, 571). These show the available shaft power/air bleed relationship.

Non-dimensional curves are included in order that the air bleed performance can be assessed under any ambient conditions. These curves (E.T.D. 556, 557 and 558) refer to the engine performance without shaft power and show the relationship of engine turbine inlet temperature, fuel flow and engine air delivery pressure for various values of air delivery flow (non-dimensional flow).

5.4.6 Bleed air quality. The bleed air shall be suitable for cabin air conditioning and shall be free from toxic gases as laid down in CAR.4B.

5.4.7 Polar moment of inertia. The polar moment of inertia of each compressor turbine system shall be no greater than 1.7533 lb. ft.^{2}.

5.4.8 Fuel system.

The performance characteristics of the unit shall be determined using fuel to D.Eng.R.D. 2482, Nato symbol F-30, Canadian symbol 3-GP-23A. The unit shall be capable of operating throughout its operating range with fuel to the following specifications.

Eng.R.D. Spec.	Nato Symbol		Canadian Symbol
2485	91/96 grade	F 15	3-GP-25C
	100/130 "	F 18	
	115/145 "	F 22	
2486		F-40	3-GP-22b
2488		F-42	3-GP-24

5.4.8-1 Fuel filter. A fuel filter shall be a component part of the unit and shall be of sufficient capacity to permit a minimum of 50 hrs. continuous operation at normal output without requiring cleaning. The unit shall be supplied with fuel as specified herein.

5.4.8-2 Fuel drains. A fuel drain shall be provided in the combustion chamber outer casing for draining any excess fuel from the chamber after a false start. The drain shall be pressure operated to remain open until the combustion chamber pressure has reached 5 to 10 p.s.i.g.

5.4.9 Lubricating system. The unit lubricating system shall form an integral part of the unit and shall be capable of lubricating all points in the unit requiring lubrication.

5.4.9-1 Lubricants. The engine shall be supplied with either of the following lubricating oils:-

Eng. R. D. Spec.	Nato Symbol.	Canadian Symbol
2479/0	0.138	3-GP-54J
2487	0.149	No equivalent

SECTION 7 SECTION 2 SECTION 9 SECTION 10 SECTION 6

Part 5.5 Inspection, test procedures and preparation for storage and transit.

5.5.1 General. Unit calibrations and tests specified herein shall be conducted at Blackburn and General Aircraft Limited and may be subject to witnessing by authorised representatives of the customer.

5.5.2 Test apparatus.

5.5.2-1 Accuracy of data. All instruments and equipment shall be inspected and calibrated once per calendar month, to ensure that the accuracy maintains within the tolerances stipulated by the manufacturer.

The accuracy of engine speed measurement shall be within .100%.

5.5.2-2 Unit Speed. The unit speed shall be measured by means of a positive counter indicating the time for 10,000 R.P.M.

5.5.2-3 Fuel flow. Fuel flow measurements shall be made by the volume method. The quantity selected for the volume method shall be such that each reading will cover an elapsed time of at lease one minute.

A direct reading flow meter shall also be employed for measurement of the fuel flow.

Fuel flow quantities shall be recorded on the weight basis.

5.5.2-4 Air flow. Air flow measurements shall be made by approved venturi type air meters.

5.5.2-5 Temperature. Gas temperature shall be measured with chromel-alumel thermocouples calibrated to chromel-alumel E.M.F. constants. Other temperatures shall be measured by calibrated mercury thermometers. All temperature measurements shall be recorded in °C.

5.5.2-6 Pressure. All oil and fuel pressures shall be recorded in pounds/sq.in. gauge. All air or gas pressures shall be recorded in inches of mercury absolute.

5.5.2-7 Fuel. Fuel conforming to D. Eng. R. D. 2482 shall be used for all testing.

5.5.2-8 Oil. The oil used for the preliminary runs and endurance testing shall conform to D. Eng. R. D. 2479 (a mineral base oil). The oil used for the final test run shall conform to D. Eng. R. D. 2487 (synthetic oil with inhibiting properties).

5.5.3 Test conditions. Unless otherwise specified herein all tests shall be conducted under prevailing atmospheric conditions.

5.5.3-1 Standard performance values. Performance values determined from testing the unit at ambient conditions shall be normalised to produce the equivalent values that would obtain if the tests had been carried out under I. C. A. N. standard sea level day conditions.

5.5.4 Type approval testing. Results obtained from the 150 hr. type approval test may be inspected by an authorised representative of the customer. Additional qualification testing may be carried out after mutual arrangements have been agreed between Blackburn & General Aircraft Limited and the customer.

5.5.5 Acceptance test. Units submitted for acceptance under contract shall be subjected to the following tests and shall demonstrate conformance to the test requirements herein.

5.5.5-1 Preliminary runs. The unit shall be run for a period necessary to determine the correct functioning of the control systems.

5.5.5-2 Performance acceptance test. On completion of a suitable run in period the units shall be subjected to a performance acceptance test as follows:

5.5.5.2-1 Endurance acceptance test.

1.	3 starts to synchronous speed on residual air load	O. S. H. P. Take off
2.	On completion of the 3rd. start: 1 hr. 50 mins. S. H. P. equivalent to the specified max. minimum continuous load	1.5 lb/sec. Bleed air delivery.

5 min. S.H.P. equivalent to the specified maximum load	1.5 lb/sec. Bleed air delivery
5 secs. S.H.P. equivalent to the specified overload conditions	1.5 lb/sec. Bleed air delivery.

5.5.5.2-2 Strip examination. The units shall be stripped examined and re-built in accordance with the procedure laid down in D.Eng. R.D. 2100.

5.5.5.2-3 Final acceptance test.

1.	2 starts to synchronous speed on residual air load	O S.H.P. Take off
2.	On completion of the 2nd. start 15 mins. S.H.P. equivalent to the specified maximum continuous load 5 mins. S.H.P. equivalent to the specified maximum load	1.5 lb./sec. Bleed air delivery 1.5 lb/sec. Bleed air delivery.
3.	Engine to be run at the ratings necessary to product the requisite performance curves	

5.5.5.2-4 Performance requirements. The units shall be considered to have passed the tests outlined under 3-5-2-1, 3-5-2-2 and 3-5-2-3, provided the performance does not fall below accepted minimum limits imposed by Blackburn & General Ai rcraft Ltd.

5.5.6 Preparation for storage. The units shall be prepared for storage and shipment in accordance with the normal procedure adopted by Blackburn & General Aircraft as follows:

1. After final test running the unit shall be internally and externally preserved against corrosion.

2. The oil system shall be drained and re-filled with the normal operating oil to D.Eng. R.D. 2487.

Part 5.6 Performance Curves

E.T.D. No.		Title
450		Non-dimensional air delivery temperature Vs engine speed.
577		Performance at 34,200 R.P.M. at sea level (static) and 120°F.
578		Performance at 34,200 R.P.M. at sea level (static) and 100°F.
579		Performance at 34,200 R.P.M. at 3,500 ft. altitude (static) and 100°F.
567	Estimated performance at sea level, static conditions.	Variation of fuel flow with turbine inlet temperature over a range of S.H.P. and ambient temperatures.
569		Variation of bleed flow with turbine inlet temperature over a range of S.H.P. and ambient temperatures.
571		Variation of bleed with pressure ratio over a range of S.H.P. and ambient temperatures.
556	Non dimensional bleed characteristics static conditions zero S.H.P.	Delivery pressure ratio Vs non dimensional bleed.
557		Non dimensional fuel flow Vs non dimensional bleed.
558		Cycle temperature ratio Vs non dimensional bleed.

These last three curves are plotted along lines of non dimensional engine speed.

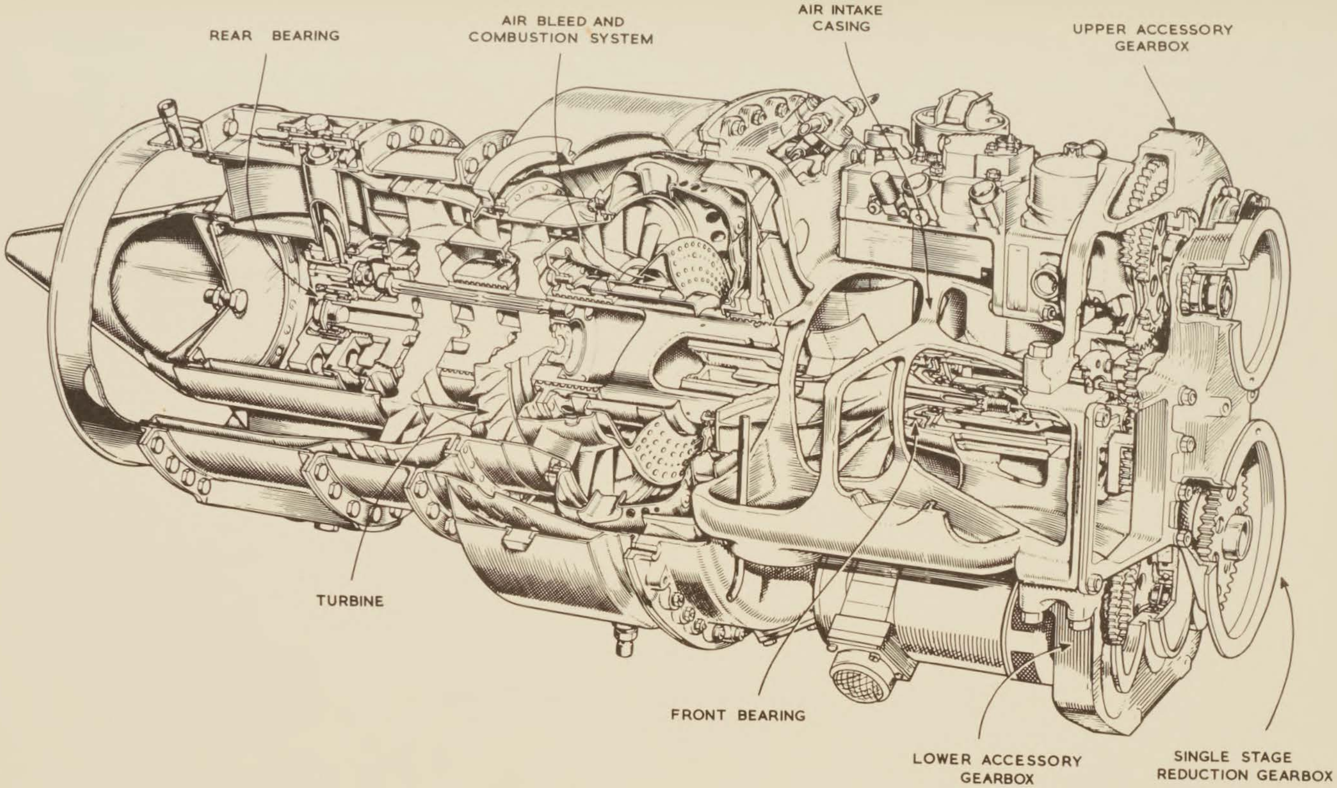


FIG. 1. ARTOUSTE 510

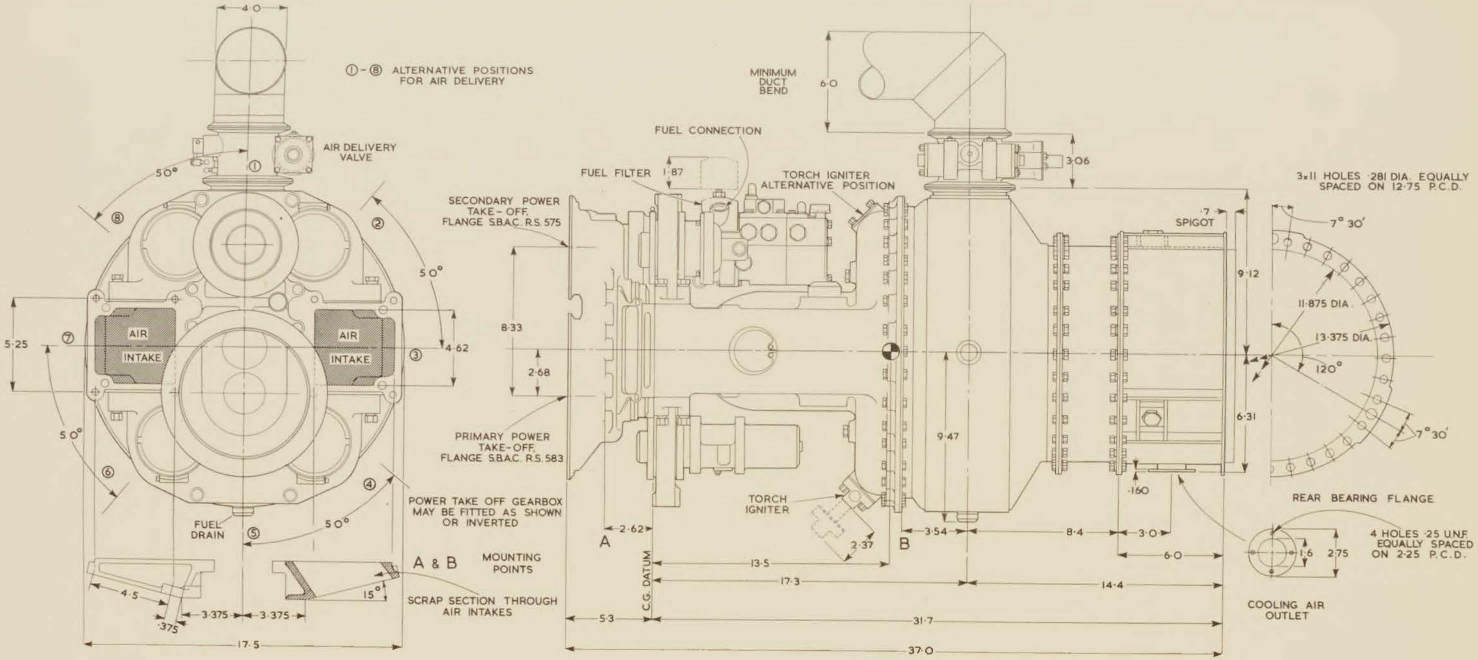
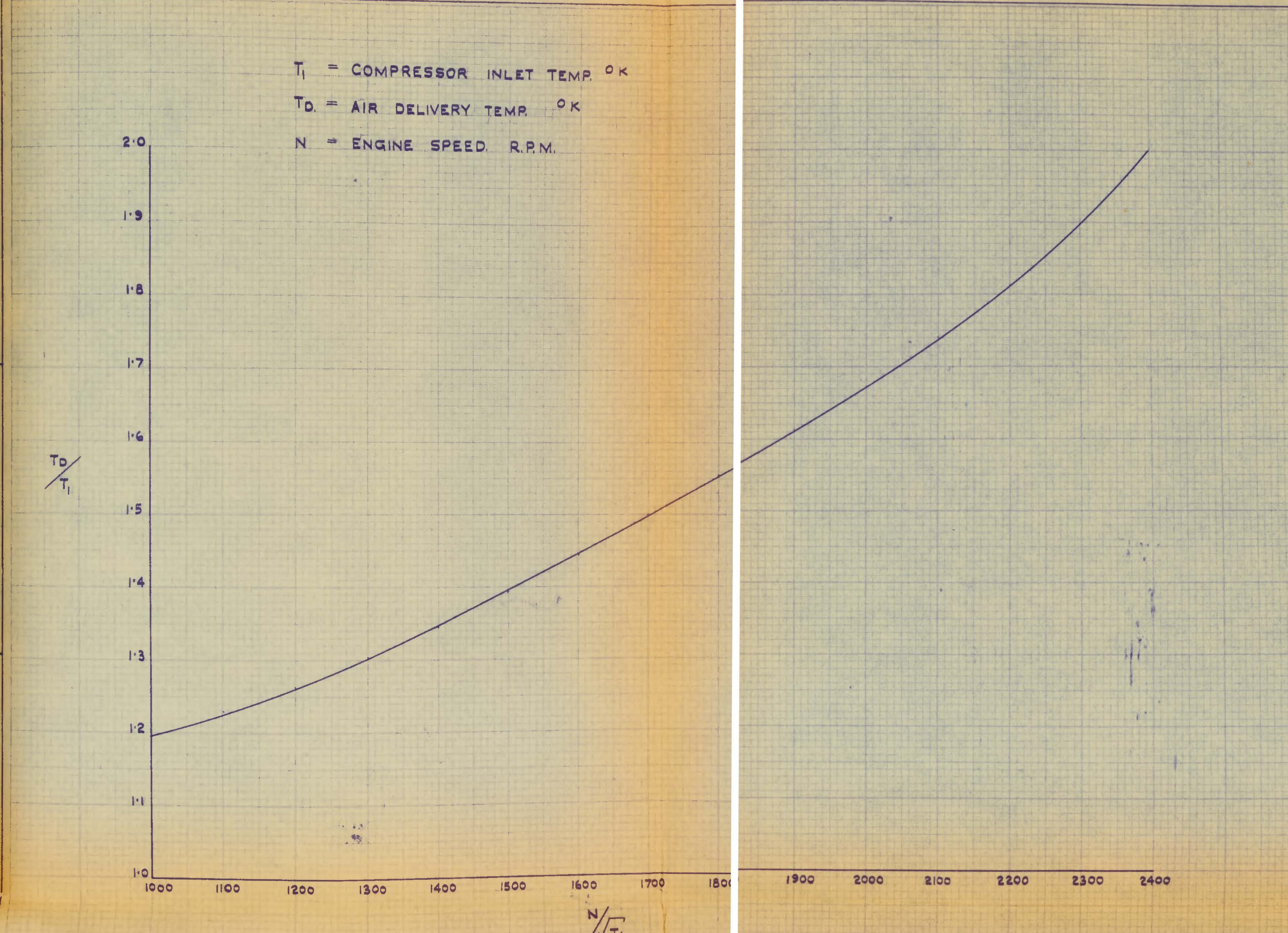


FIG.1. ARTOUSTE 510 INSTALLATION DIAGRAM

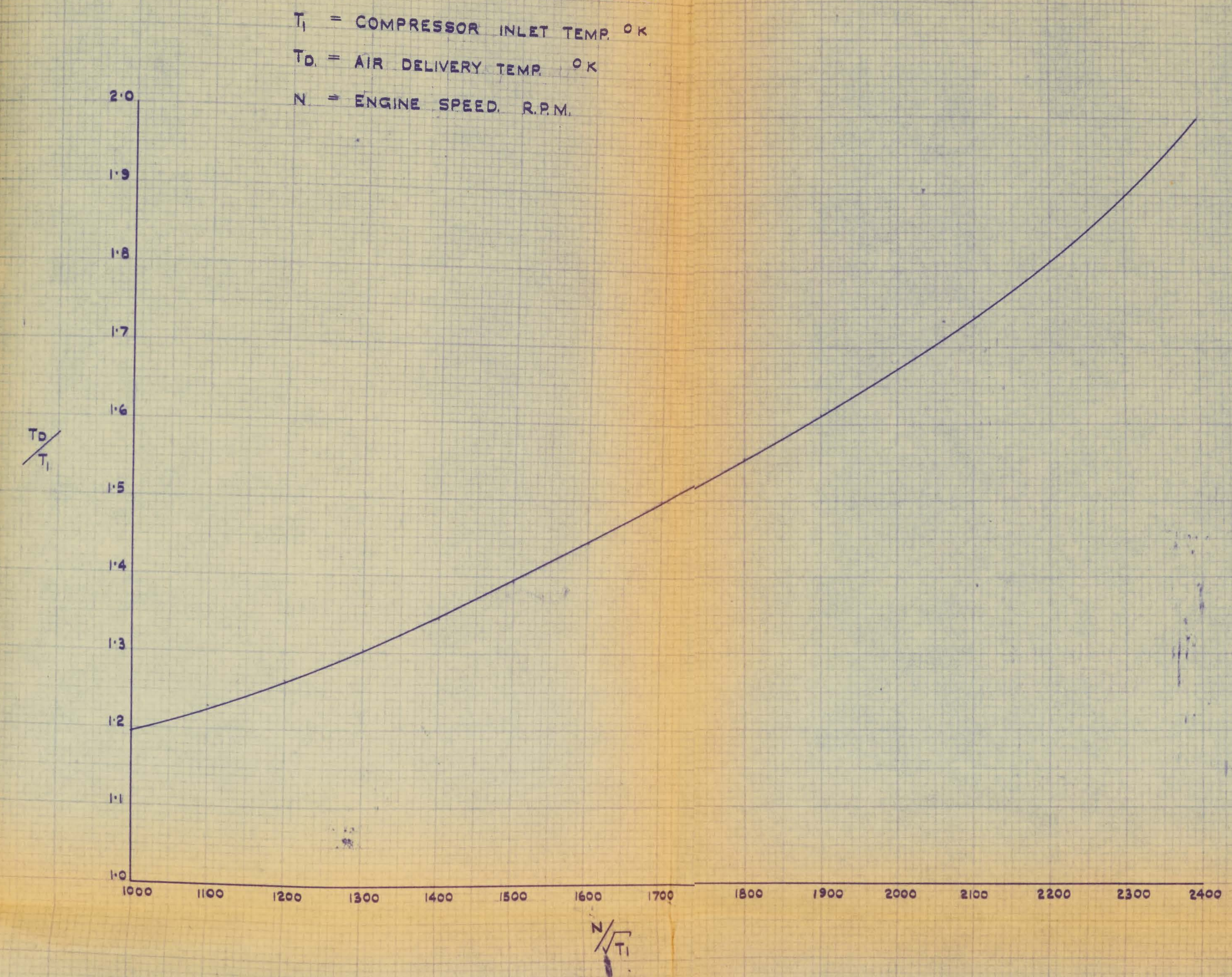
ARTOUSTE. 510.

NON DIMENSIONAL
AIR DELIVERY TEMPERATURE Vs ENGINE SPEED.



AIRCRAFT LIMITED,
BROUGH. E. YORKS.

... AIRCRAFT LIMITED,
BROUGH, E. YORKS.



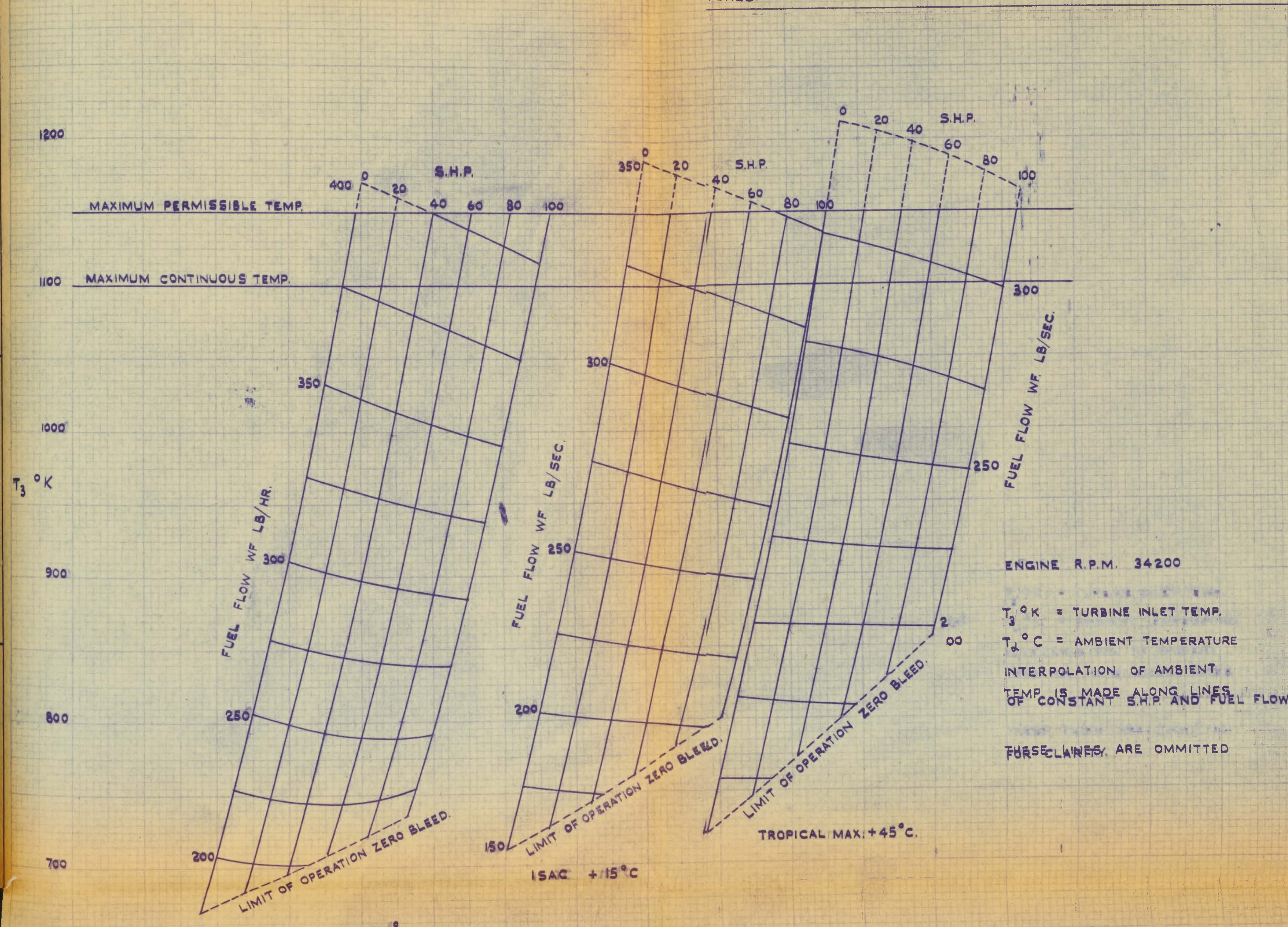
E.T.D. 450.

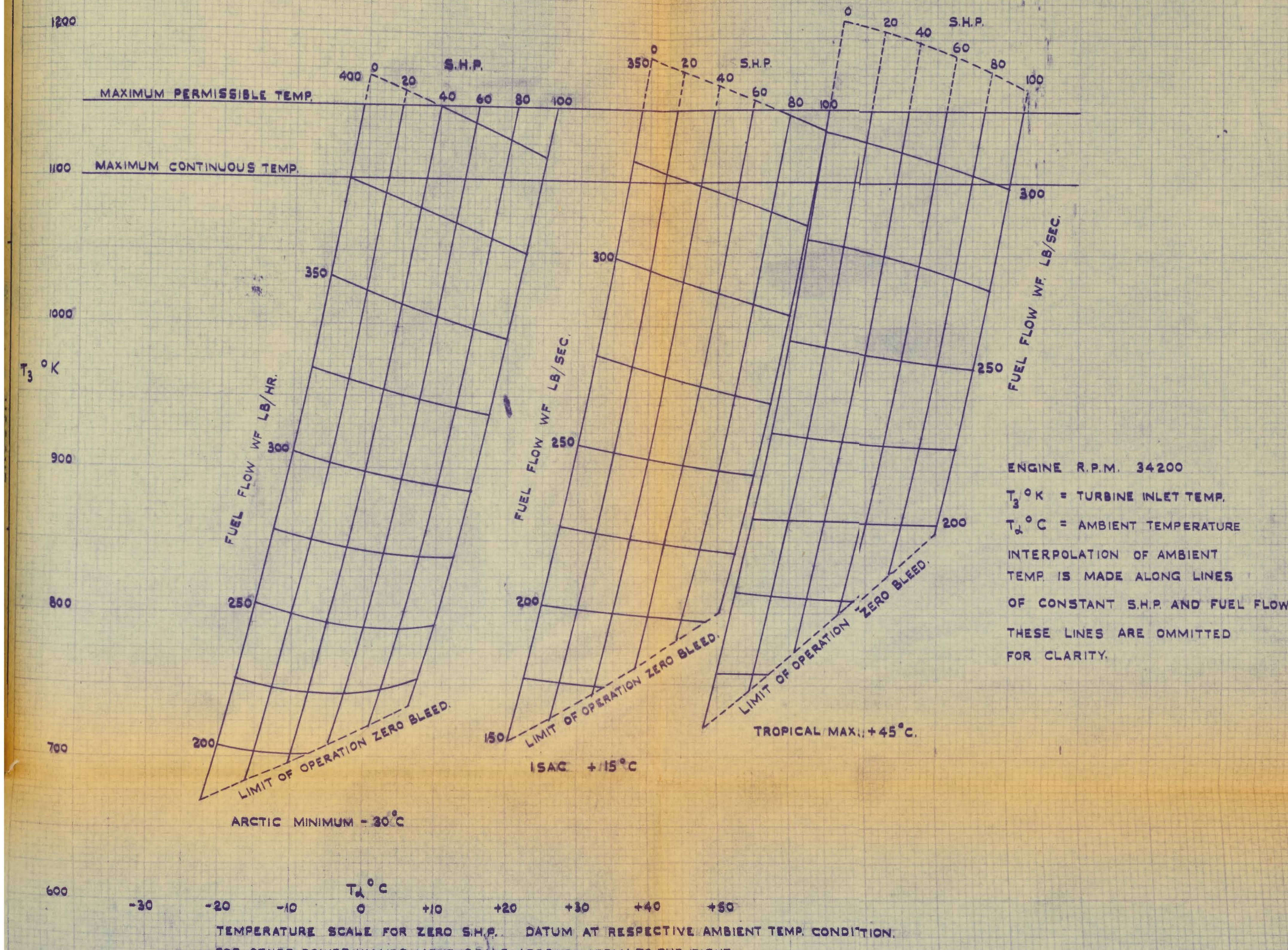
H.D.M. LTD., HULL

ARTOUSTE. 510.

ESTIMATED PERFORMANCE AT SEA LEVEL STATIC CONDITIONS
VARIATION OF FUEL FLOW WITH TURBINE INLET TEMPERATURE OVER
A RANGE OF S.H.P. AND AMBIENT TEMPERATURES.

BROUGH. E. YORKS.



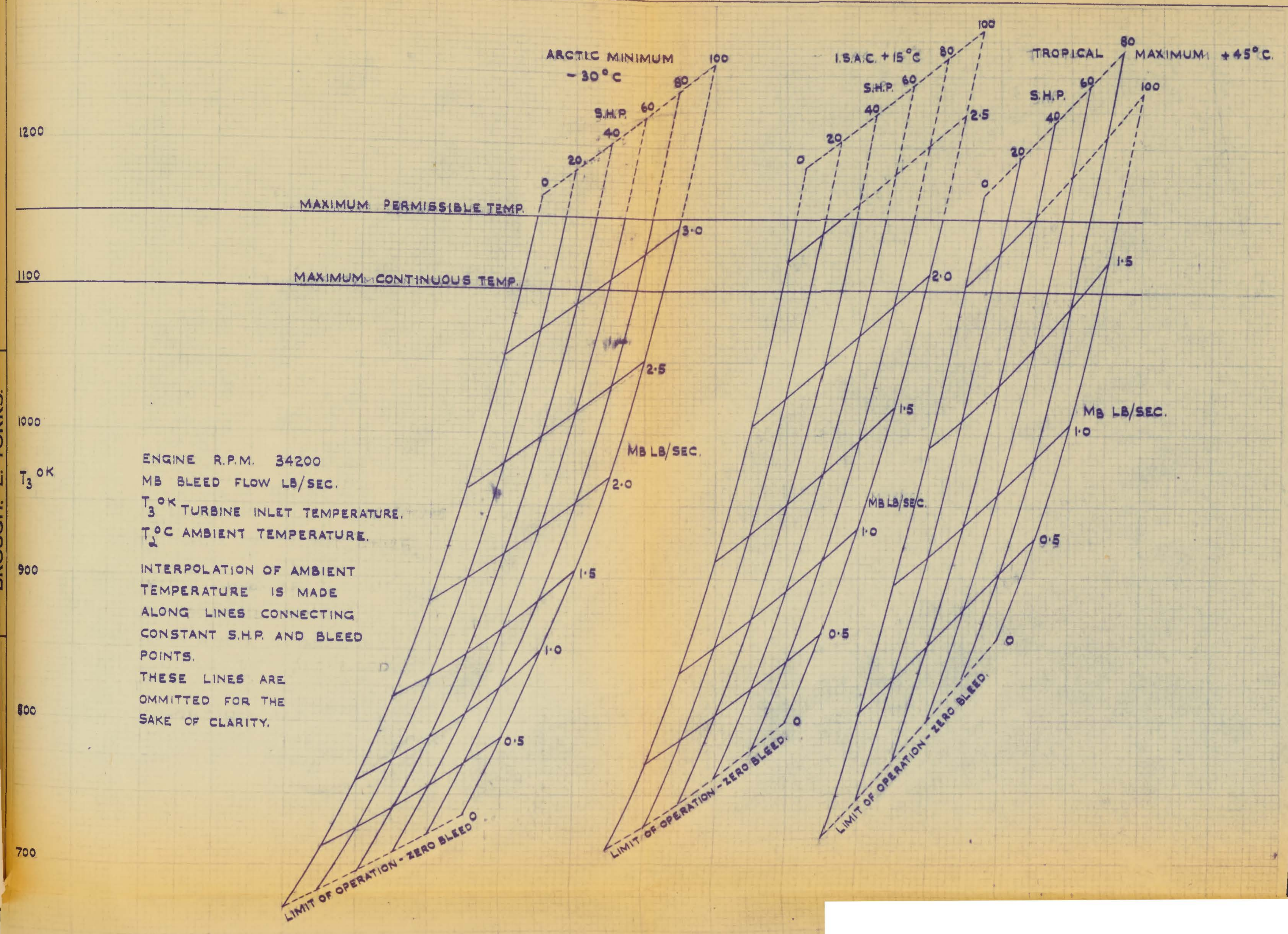


1200
1100
1000
900
800
700
600
T_3 °K
MAXIMUM PERMISSIBLE TEMP.
MAXIMUM CONTINUOUS TEMP.
S.H.P.
0 20 40 60 80 100
400
350
300
250
200
FUEL FLOW WF LB/HR.
LIMIT OF OPERATION ZERO BLEED.
ARCTIC MINIMUM - 30 °C
FUEL FLOW WF LB/SEC.
150
ISAC +15 °C
TROPICAL MAX. +45 °C.
ENGINE R.P.M. 34200
T_3 °K = TURBINE INLET TEMP.
T_α °C = AMBIENT TEMPERATURE
INTERPOLATION OF AMBIENT TEMP. IS MADE ALONG LINES OF CONSTANT S.H.P. AND FUEL FLOW.
THESE LINES ARE OMMITTED FOR CLARITY.
T_α °C
-30 -20 -10 0 +10 +20 +30 +40 +50
TEMPERATURE SCALE FOR ZERO S.H.P. DATUM AT RESPECTIVE AMBIENT TEMP. CONDITION.
FOR OTHER POWER VALUES MOVE SCALE APPROPRIATELY TO THE RIGHT.

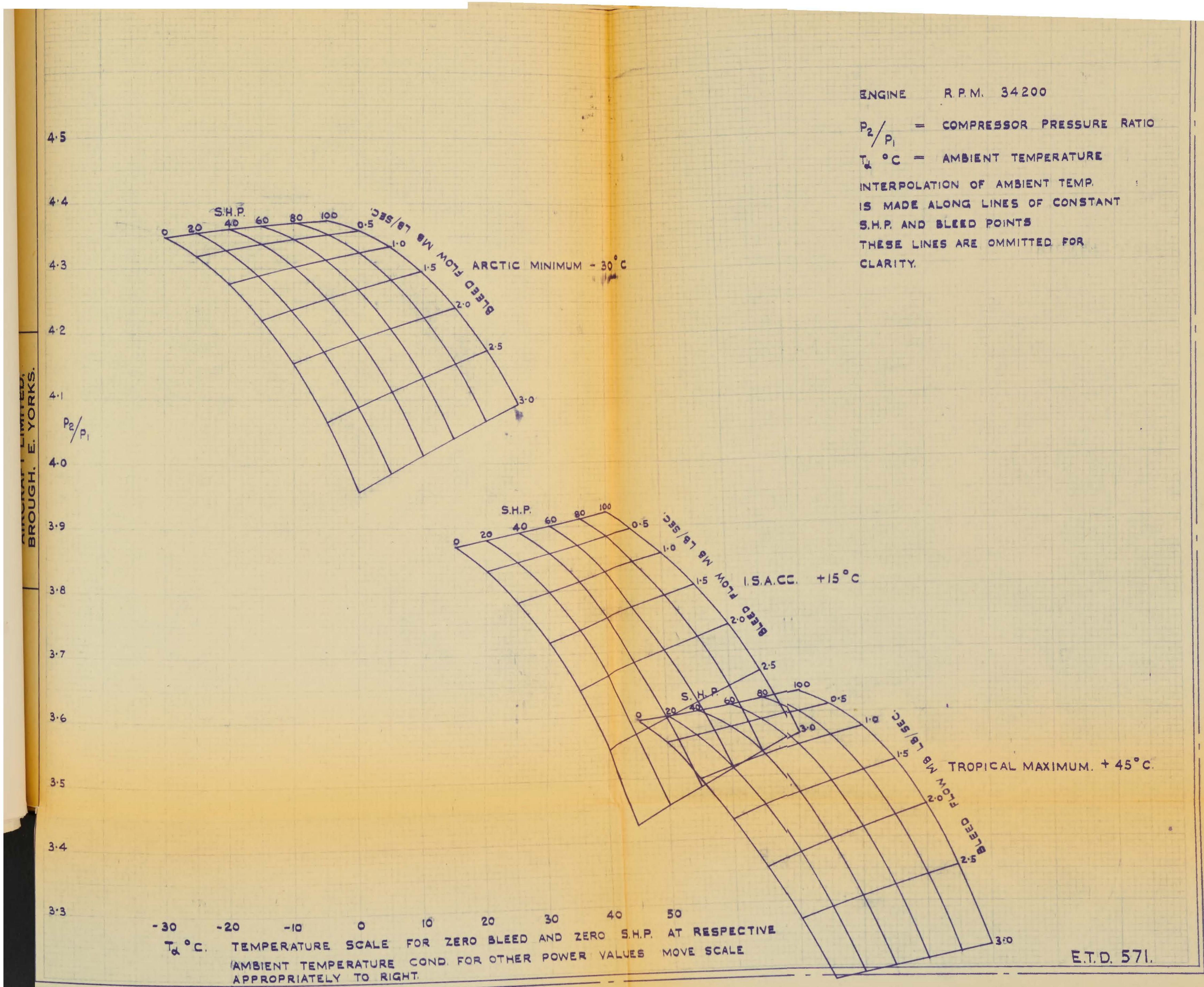
E.T.D. 567.

ARTOUSTE. 510.

ESTIMATED PERFORMANCE AT SEA LEVEL STATIC CONDITIONS
VARIATION OF BLEED FLOW WITH TURBINE INLET TEMPERATURE OVER A RANGE OF S.H.P. AND AMBIENT TEMPERATURES.



BROUGH. E. YORKS.

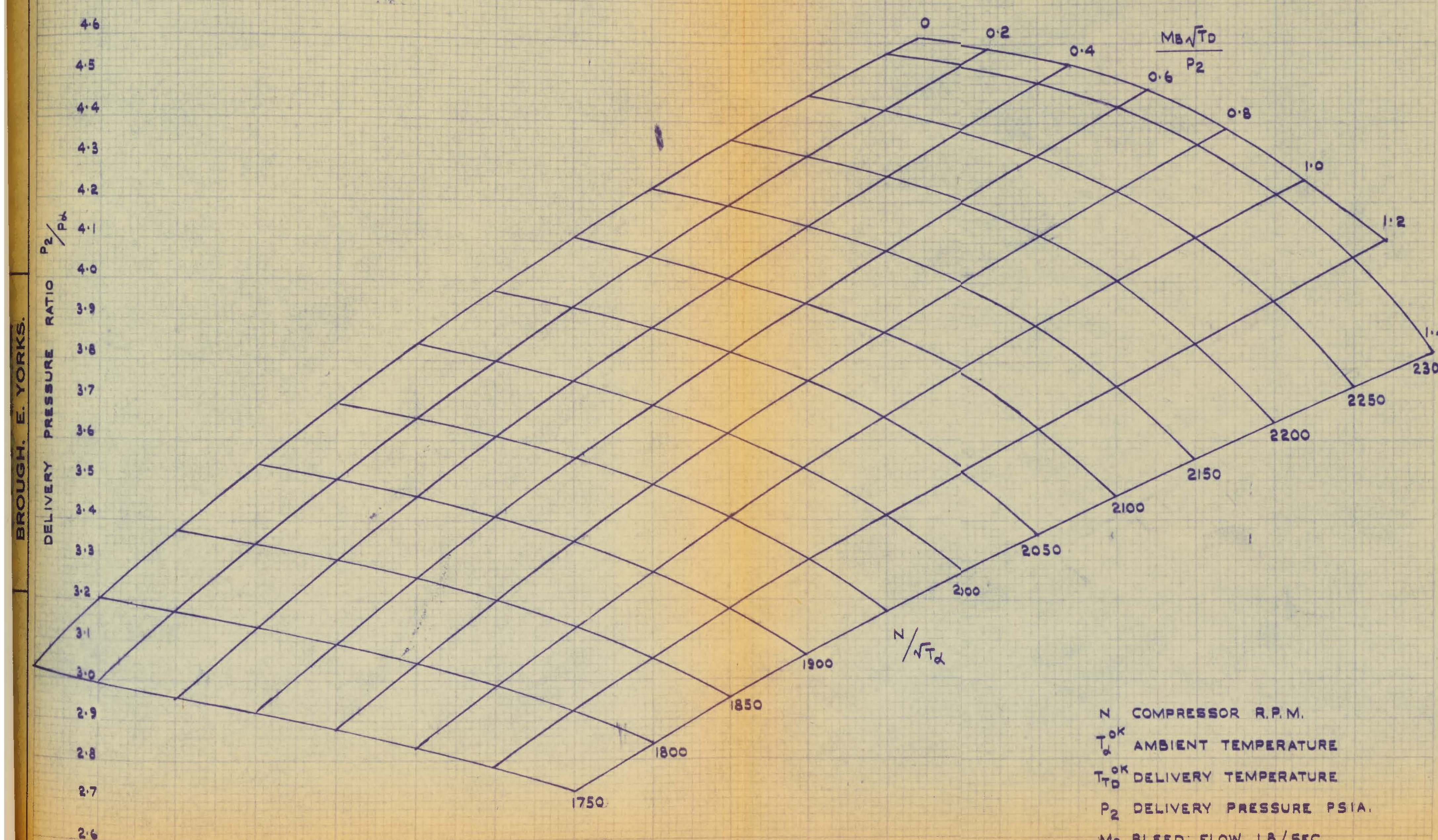


ENGINE R.P.M. 34200
P2/P1 = COMPRESSOR PRESSURE RATIO
Tα °C = AMBIENT TEMPERATURE
INTERPOLATION OF AMBIENT TEMP. IS MADE ALONG LINES OF CONSTANT S.H.P. AND BLEED POINTS
THESE LINES ARE OMMITTED FOR CLARITY.
P2/P1
4·5
4·4
4·3
4·2
4·1
4·0
3·9
3·8
3·7
3·6
3·5
3·4
3·3
S.H.P.
0
20
40
60
80
100
BLEED FLOW MB LB/SEC.
0·5
1·0
1·5
2·0
2·5
3·0
ARCTIC MINIMUM - 30°C
I.S.A.CC. +15°C
TROPICAL MAXIMUM. + 45°C.
-30
-20
-10
0
10
20
30
40
50
Tα °C. TEMPERATURE SCALE FOR ZERO BLEED AND ZERO S.H.P. AT RESPECTIVE AMBIENT TEMPERATURE COND. FOR OTHER POWER VALUES MOVE SCALE APPROPRIATELY TO RIGHT.
E.T.D. 571.
BROUGH, E. YORKS.
H.D.M. LTD. HULL

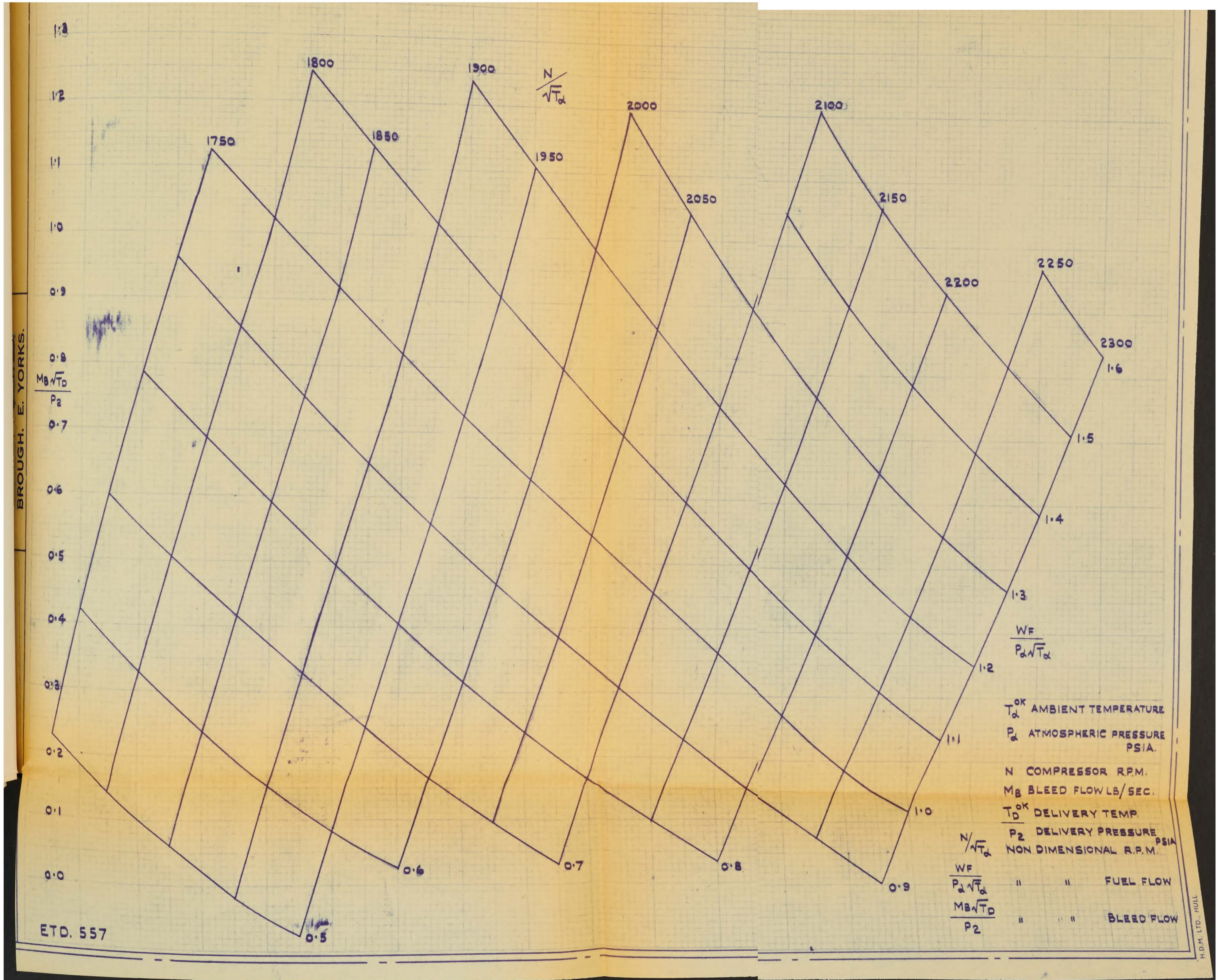
ARTOUSTE. 510.

NON DIMENSIONAL BLEED CHARACTERISTIC STATIC CONDITIONS.

ZERO SHAFT HORSE POWER. $\frac{M_B\sqrt{T_D}}{P_2}$, P_2/P_α, $N/\sqrt{T_\alpha}$ CARPET.



BROUGH. E. YORKS.

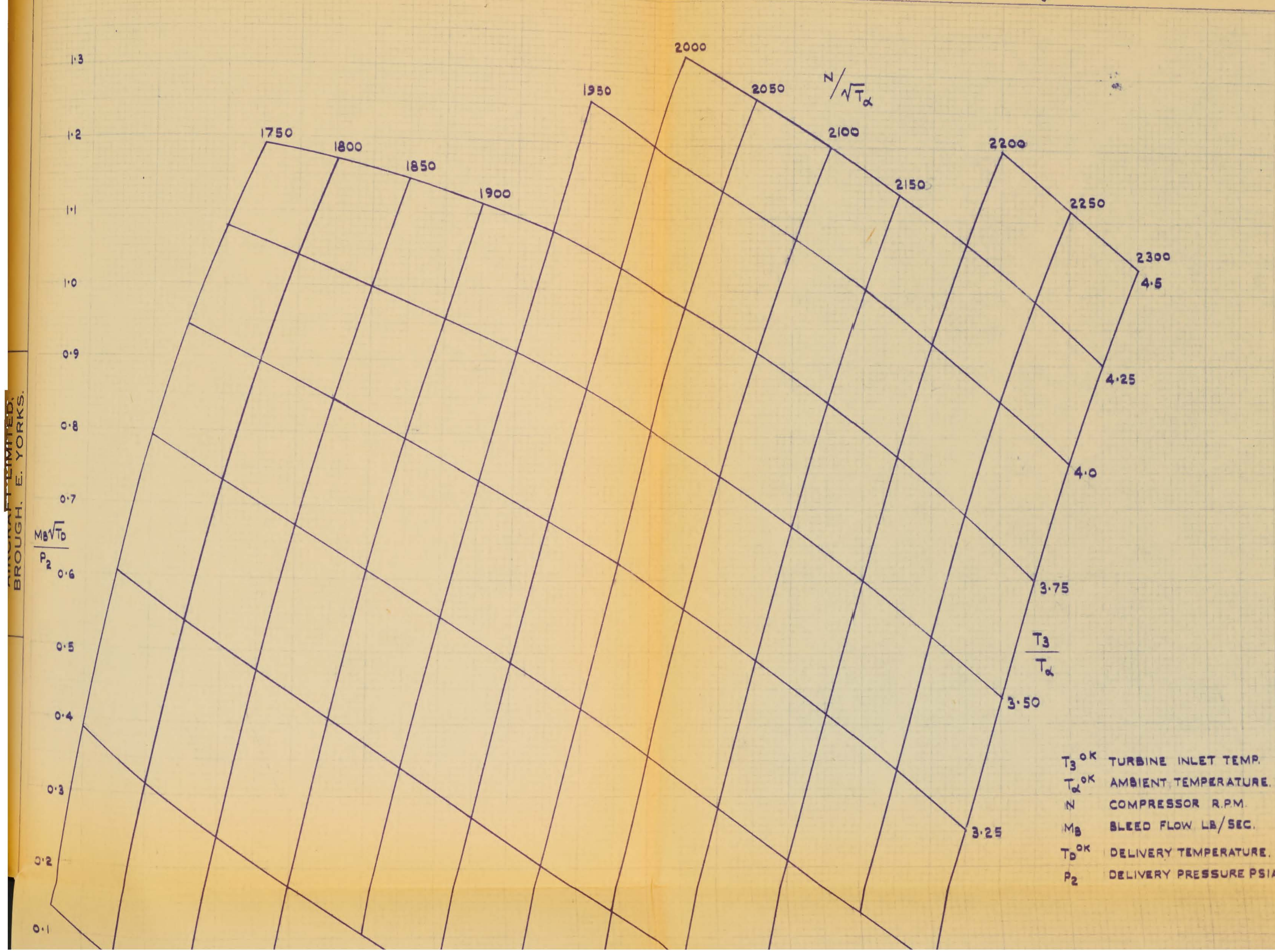


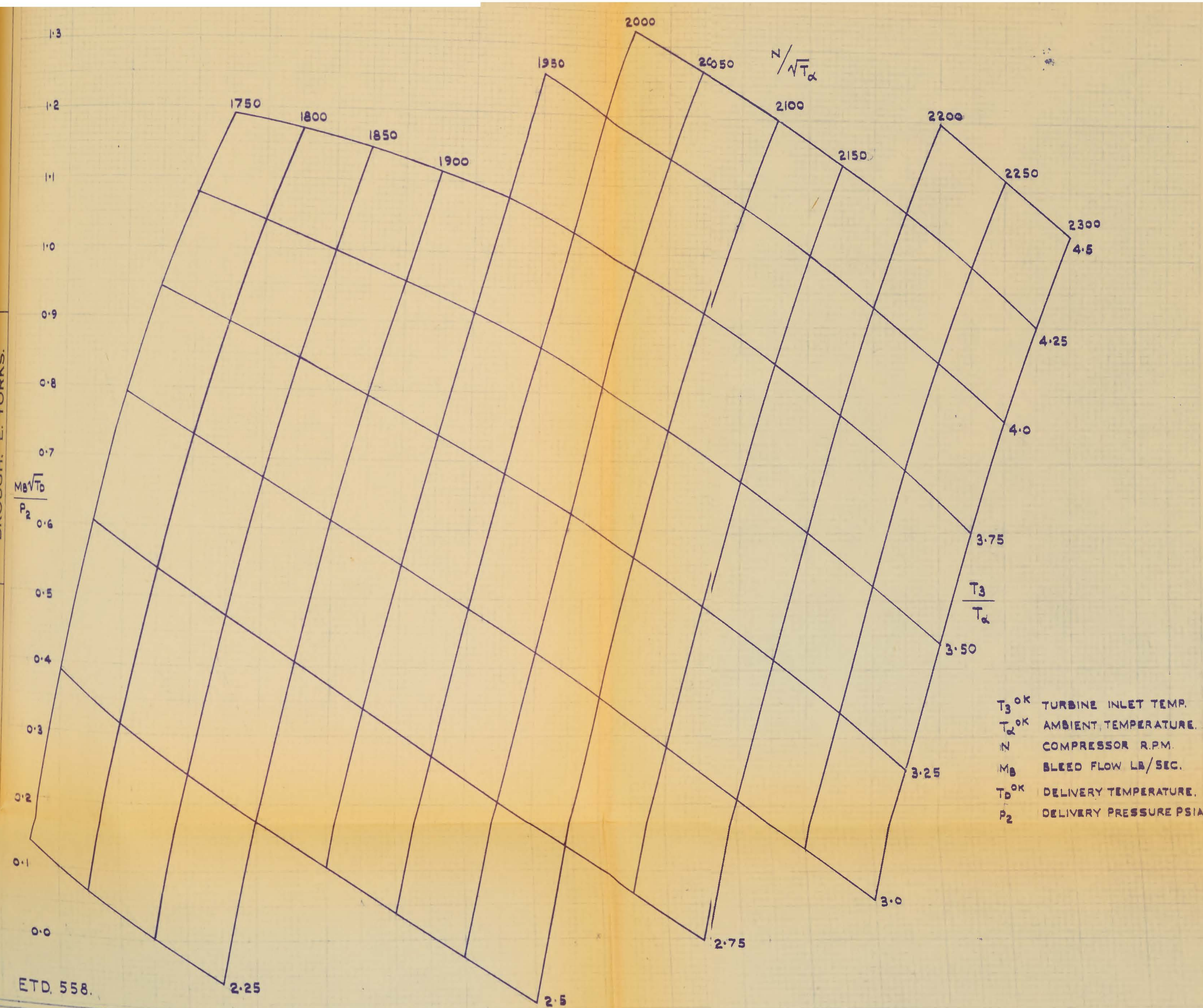
BROUGH. E. YORKS.
1·3
1·2
1·1
1·0
0·9
0·8
MB√TD / P2
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·0
1750
1800
1850
1900
1950
N / √Tα
2000
2050
2100
2150
2200
2250
2300
1·6
1·5
1·4
1·3
WF / Pα√Tα
1·2
1·1
1·0
0·5
0·6
0·7
0·8
0·9
Tα °K AMBIENT TEMPERATURE
Pα ATMOSPHERIC PRESSURE PSIA.
N COMPRESSOR R.P.M.
MB BLEED FLOW LB/SEC.
TD °K DELIVERY TEMP.
P2 DELIVERY PRESSURE PSIA
N/√Tα NON DIMENSIONAL R.P.M.
WF / Pα√Tα " " FUEL FLOW
MB√TD / P2 " " BLEED FLOW
ETD. 557
H.D.M. LTD. HULL

ARTOUSTE. 510.

NON DIMENSIONAL BLEED CHARACTERISTIC STATIC CONDITIONS.

ZERO SHAFT HORSE POWER. $\frac{M_B\sqrt{T_D}}{P_2}$, $\frac{T_3}{T_\alpha}$, $N/\sqrt{T_\alpha}$ CARPET.





ETD. 558.

AIRCRAFT LIMITED, BROUGH, E. YORKS.

DE HAVILLAND COLD-AIR UNITS

DESCRIPTION AND MAINTENANCE MANUAL
FOR
RU80 SERIES

Publication 5040

DE HAVILLAND PROPELLERS LIMITED
MANOR ROAD, HATFIELD, HERTFORDSHIRE

AMENDMENTS TO HANDBOOK

Registration and Change-of-Address cards are provided with this handbook. The recipient should complete and post the Registration card immediately upon receipt of this handbook if he wishes to be supplied with subsequent amendments, which cannot otherwise be forwarded. The Change-of-Address card should be retained for use when applicable or in the event of a transfer in the ownership of this handbook, in order that distribution records may be kept up to date.

First Published October 1957

AIR REGISTRATION BOARD APPROVAL

This manual is approved by the Air Registration Board

22.10.57

Amendments to this handbook invalidate the approval statement unless issued by the manufacturer with the concurrence of the Air Registration Board.

LIST OF CONTENTS

The detailed contents and the illustrations are listed at the commencement of each chapter.

LIST OF ASSOCIATED PUBLICATIONS
(intended for use in fully equipped repair organizations)

DHP 133	Electro-magnetic flaw detection - propeller overhaul version
DHP 566	Overhaul and repair of RU80 series cold-air units

LEADING PARTICULARS

RU80-01

GENERAL

Air flow (nominal):	80 lb. per minute
Direction of rotation (viewed from fan end):	Clockwise
Weight (with Durestos fan housing):	21 lb. (approx)
Dimensions:	
Length (overall):	14.38 in.
Diameter (maximum):	12 in.

INSTALLATION

Type of mounting:	Two mounting pads on centre casing each with spigot recess and four 1/4 in. BSF threaded holes.
Duct connections:	
Turbine inlet:	2.75 in. dia. SBAC plain pipe flange
Turbine outlet:	4.2 in. dia. SBAC plain pipe flange
Fan inlet:	8.4 in. o/d flange - outside SBAC range but of same profile
Fan outlet:	4.5 in. dia. SBAC plain pipe flange

LUBRICATION

Type:	Sump and scroll pumps
Oil specifications:	D. Eng. R.D. 2487 (OX-38) Esso Aviation Turbo Oil 35

CHAPTER 1

GENERAL DESCRIPTION AND PRINCIPLES OF OPERATION

List of Contents

List of Illustrations

A cold-air unit is installed in an aircraft pressurizing and air conditioning system to reduce the temperature of the air supplied to the cabin.

The cold-air units in the RU80 series are of the turbo-fan type and are used in turbine-engined aircraft where the air supply for pressurizing and air conditioning is bled from a late stage of the gas turbine compressors. The pressure of the charge air from this source is usually sufficient to meet all the requirements for pressurizing and cooling. The temperature, however, can be well in excess of 300°C and, therefore, a large temperature drop must be achieved before the charge air can be used for cooling the cabin.

Normally, the cold-air unit operates in conjunction with a cross-flow heat exchanger which enables the charge air to be pre-cooled before it enters the unit. A flow of cooling air is drawn across the heat exchanger by the cold-air unit and, therefore, the unit can operate effectively while the aircraft is on the ground with its engines running.

PRINCIPLES OF OPERATION

The cold-air unit consists basically of a rotating assembly, comprising a directly-coupled radial-flow fan and axial-flow turbine, which is enclosed within a body, comprising a fan housing, a centre casing, and a turbine exit duct.

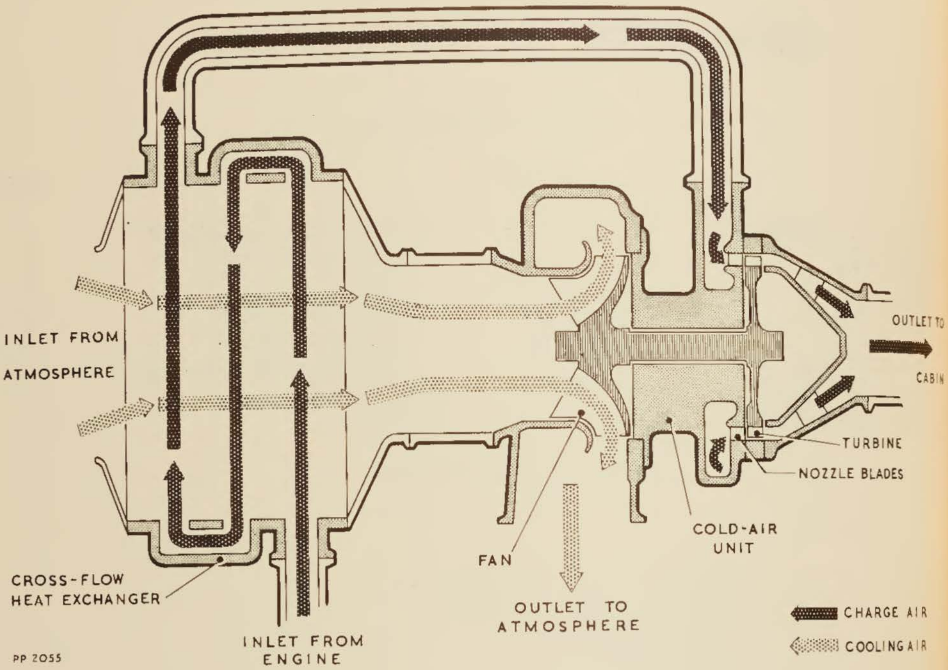


Fig. 1. PRINCIPLES OF OPERATION

When cold air is selected, the charge air from the engine compressor is directed through the heat exchanger (Fig. 1) where it passes around the matrix and becomes partially cooled. From the heat exchanger, the air enters the turbine inlet of the cold-air unit. In passing through the fixed nozzle blades and the moving turbine blades, the charge air expands and gives up a considerable amount of its remaining heat in the form of energy to drive the turbine.

The heat energy extracted from the charge air is converted into mechanical energy by the turbine, and in this form is transferred to the fan which is mounted on the opposite end of the common shaft. The fan transfers the energy mainly as heat to the cooling air which it draws in from atmosphere across the heat exchanger and then discharges back to atmosphere. In passing across the heat exchanger, the cooling air pre-cools the charge air. The amount of charge air pre-cooling achieved is dependent on the inlet temperature of the cooling air and the effectiveness of the heat exchanger.

The reduction in temperature of the charge air achieved by the turbine is such that the air normally leaves the cold-air unit at temperatures around freezing point, but often much lower temperatures can be obtained.

CONSTRUCTION

General

The cold-air unit consists of a turbine rotor and a fan mounted on a common shaft (Fig. 2). The rotor/fan shaft is supported by two ball bearings which are enclosed within a bearing assembly in the central bore of a centre casing. A fan housing is attached to the centre casing to enclose the fan and provide the inlet and outlet ports for the cooling air. The turbine rotor is enclosed by a turbine shroud and a turbine exit duct (forming the charge air outlet) which are attached to the opposite end of the centre casing. The charge air enters the unit through a turbine inlet volute which is formed at the turbine end of the centre casing and encloses a turbine nozzle ring.

Oil is supplied to the bearings from a self-contained lubrication system in the centre casing. Seals at each end of the bearing assembly prevent oil leaking from the assembly and contaminating the air flowing through the unit.

Centre casing

The centre casing is a light-alloy casting which forms the main body of the unit. A central bore accommodates the bearing assembly, and a mounting flange at each end of the casing provide the attachment points for the fan housing and the turbine shroud and turbine exit duct. A volute is cast integrally with the casing at the turbine end to form the turbine inlet. The volute terminates in a circular inlet port with a SBAC standard V-flange to which the aircraft duct is attached by a clamp. The turbine nozzle ring is fitted over the open turbine-end of the volute.

Two mounting pads, one on each side of the centre casing, provide for the installation of the cold-air unit in the aircraft. Each pad incorporates a central spigot-recess and four threaded holes for the attachment of brackets or similar aircraft components.

Oil for bearing lubrication is contained in a sump formed in the lower half of the centre casing. The components accommodated in the centre casing that form part of the bearing lubrication system and the bearing-assembly sealing are described under the headings "Lubrication" and "Sealing" respectively at the end of this chapter.

Fan housing

The fan housing is manufactured from laminated fibre (Durestos) - or light alloy on early units - and has a large single volute with one outlet port and one inlet port. The volute is of rectangular section and terminates in a circular outlet port with a SBAC standard V-flange for the attachment of the aircraft duct. The central inlet port terminates in a similar manner for the attachment of the aircraft inlet duct.

A light-alloy flange ring, which is secured to the inner face of the fan housing by countersunk screws, locates on a spigot formed on the mounting flange of the centre casing. The fan housing is secured to the centre casing by six bolts which pass through the mounting flange and screw into the flange ring on the fan housing.

Turbine shroud

The light-alloy turbine shroud is attached to the turbine end of the centre casing to form a close-fitting ring around the periphery of the turbine rotor. A spigot machined on the inner face of the shroud fits inside the mounting flange on the centre casing and locates on the periphery of the turbine nozzle ring. The shroud is secured to the mounting flange by two countersunk screws and then further secured by the eight turbine exit duct securing-bolts which pass through the shroud and screw into the centre casing. The weight of the shroud is reduced by eight milled recesses around the outside between the bolt holes.

Turbine exit duct

The turbine exit duct is a fabricated light-alloy assembly. In early versions of the units the assembly consists of an outer cone within which is an inner cone supported by four vanes, the components being secured by brazing. Later versions do not have the inner cone and vanes.

A mounting flange is brazed to the larger end of the outer cone for the attachment of the exit duct to the turbine shroud and centre casing. The exit duct locates on a spigot formed on the turbine shroud and is secured by eight bolts which pass through the shroud and screw into the mounting flange on the centre casing. Interposed between the exit duct and the turbine shroud is a Ferrobestos insulating disc which reduces the transfer of heat from the unit to the charge air leaving the exit duct. A sealing ring, let into the face of the turbine shroud, ensures an air-tight joint between the shroud and the exit duct.

A SBAC standard V-flange is brazed to the smaller end of the outer cone to form the turbine outlet port. The aircraft duct is attached to the flange by a clamp.

Turbine nozzle ring

The turbine nozzle ring is manufactured from light alloy and has seventeen blades machined on its periphery which are hard anodised for additional protection. The blades are arranged to form passages which direct the charge air on to the turbine blades to drive the turbine rotor. The nozzle ring is spigot-mounted on the centre casing and secured by six bolts which also secure the stationary part of the bearing-assembly seal at the turbine end. A sealing ring, located between the centre casing and the nozzle ring, ensures an air-tight joint.

The nozzle blades are stepped at their outer edge, the lower section of the step locating inside the mounting flange of the centre casing, and the higher section locating the turbine shroud.

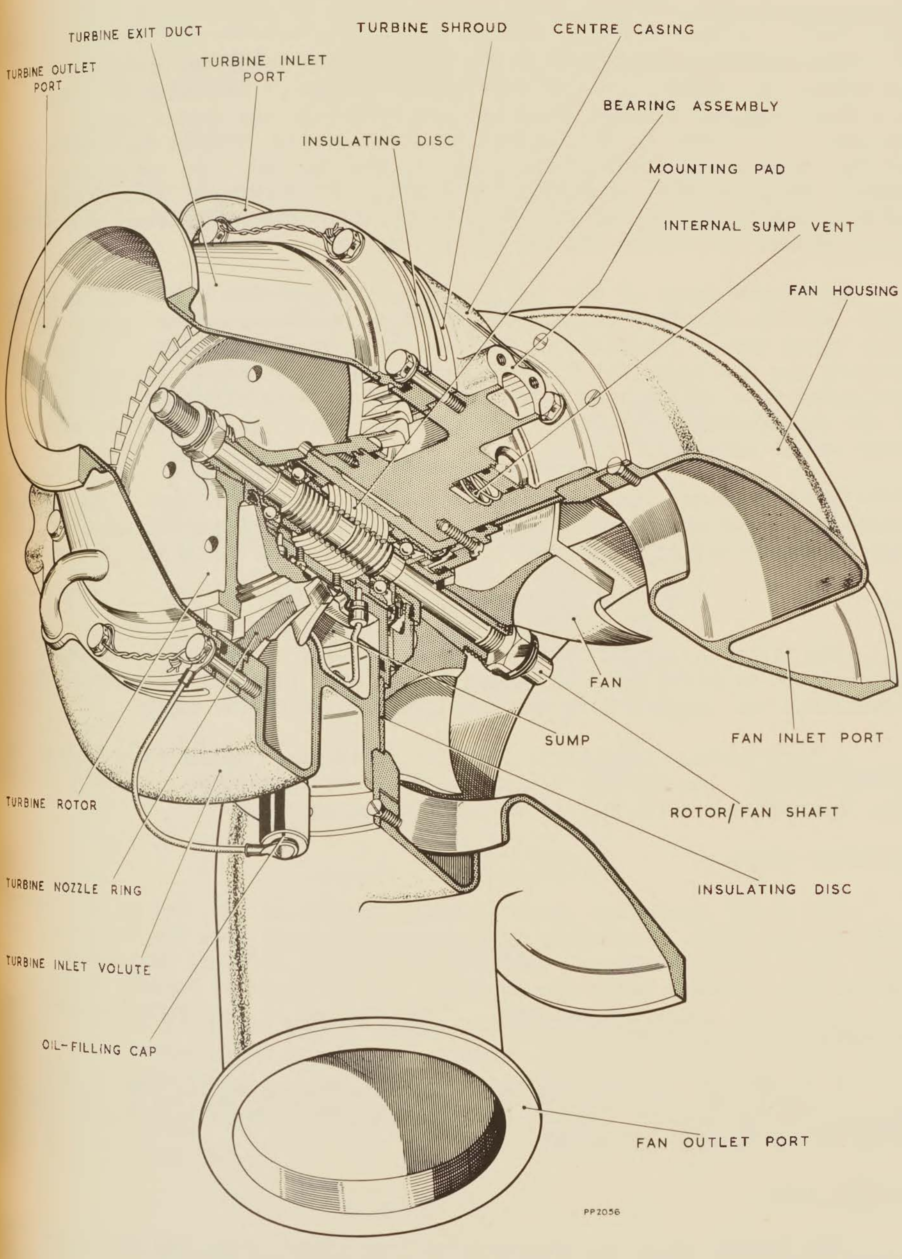


Fig. 2. COLD-AIR UNIT - RU80-01

Bearing assembly

The bearing assembly (Fig. 3) supports the rotor/fan shaft and is located within the central bore of the centre casing. The assembly is enclosed in a steel support bushing which is inserted into the centre casing from the fan end. A flange on the support bushing locates between the centre casing and the stationary part of the seal at the fan end, the components being secured to the centre casing by six countersunk screws. A sealing ring is let into the inner face of the support-bushing flange to ensure an air-tight joint between the flange and the centre casing.

The inner races of the ball bearings, which are of the angular-contact type, are an interference fit on journals on the rotor/fan shaft, and the outer races are an interference fit on steel bearing carriers. The bearing carriers are a sliding fit in the support bushing to enable the bearings to be pre-loaded by a coil spring which bears against both carriers. Axial movement of the shaft/carrier assembly is restricted by a circlip fitted around the outer end of each carrier.

The components in the bearing assembly that form part of the bearing lubrication system or bearing-assembly sealing are described under the headings "Lubrication" and "Sealing" respectively at the end of this chapter.

Fan

The light alloy fan has seven blades, the outer sections of which are bent to the required angle. The boss of the fan has a tapered bore to accommodate the tapered bush that retains the fan on the shaft.

A Ferrobestos insulating disc is positioned on the outer face of the centre casing, immediately behind the fan, to reduce the transfer of heat from the heated cooling-air to the centre casing.

Rotor/fan shaft.

The steel rotor/fan shaft carries the fan on one end and the turbine rotor on the other. Journals machined on the shaft form the location for the inner races of the bearings and also for the oil throwers and spacers. The fan and the turbine rotor are retained on the shaft by tapered bushes which are secured by self-locking nuts. The fan end of the shaft is rounded for identification purposes.

A right-hand scroll (fan end) and a left-hand scroll (turbine end) are machined on the centre section of the rotor/fan shaft to form the rotating parts of the scroll oil pumps.

Turbine rotor

The turbine rotor is manufactured from light alloy and has thirty-seven blades machined on its periphery which are hard anodised for additional protection. The boss of the turbine rotor has a tapered bore to accommodate protection. The boss of the turbine rotor has a tapered bore to accommodate the tapered bush that retains the rotor on the rotor/fan shaft. Four equi-spaced holes drilled through the rotor ensure a pressure balance across the rotor and prevent excessive bearing end loads.

Turbine labyrinth seal

A labyrinth seal is formed between the turbine rotor and the turbine nozzle ring to prevent leakage of charge air down the face of the turbine

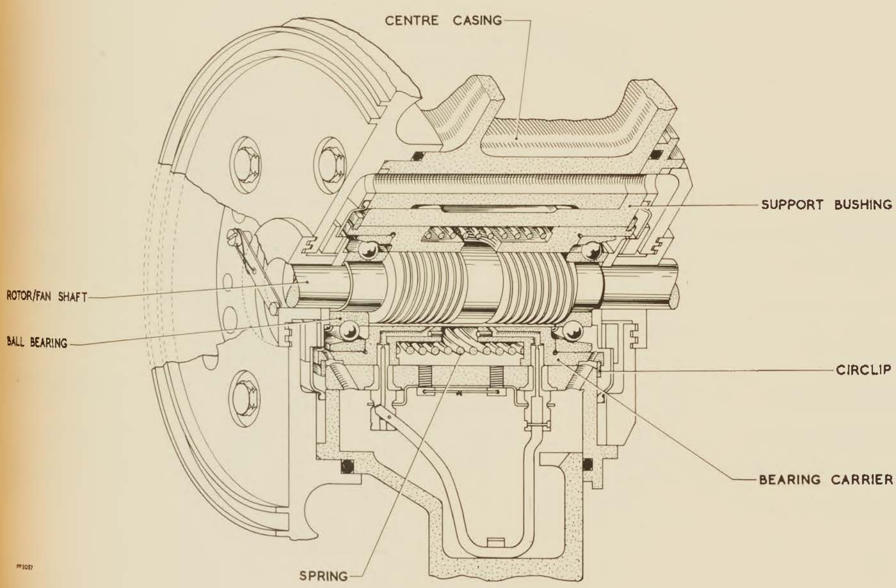


Fig. 3. BEARING ASSEMBLY

rotor. The seal is formed by two concentric lands machined on the outer face of the turbine nozzle ring and two concentric grooves machined in the inner face of the turbine rotor. Any leakage past this seal is vented to the fan housing, through drilled passages on each side of both the turbine nozzle ring and the centre casing, to prevent it from passing to the exit duct and mixing with the cold charge air.

LUBRICATION

The self-contained lubrication system (Fig. 4) is enclosed in the centre casing. The oil is contained in absorbent material, which fills a sump in the lower half of the centre casing, and is fed to the bearings by scroll pumps, machined on the rotor/fan shaft, which draw up the oil through a wick suspended in the sump.

The sump is filled through a stack pipe fitted in the underside of the centre casing. The lower end of the stack pipe is enclosed by a cap which has a spring-loaded bayonet fitting. The cap is attached by a cable to one of the turbine exit duct securing-bolts to avoid the loss of the cap when it is removed while topping-up the sump.

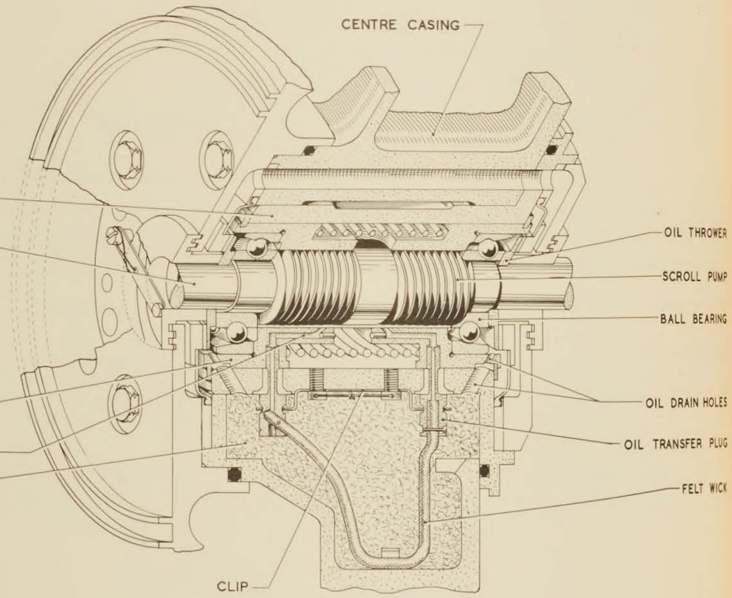


Fig. 4. LUBRICATION

Two oil transfer plugs are situated on the underside of the support bushing to carry the ends of the felt wick and provide for the transfer of the oil from the wick to the bearing carriers. The transfer plugs pass through holes in the support bushing to locate in holes in the bearing carriers, the larger holes in the support bushing and a waisted section on the plugs allowing for movement of the bearing carriers within the support bushing. The plugs are retained by the forked ends of a common clip which is secured to the support bushing by two screws. A metering hole is drilled in the top of each transfer plug to control the flow of oil from the wick. The oil passes from the plugs, through drilled passages in the bearing carriers, to the inner ends of the scrolls machined on the rotor/fan shaft. The scrolls, rotating within close-fitting sections of the bearing carriers, then take the oil to the bearings located at their outer ends. Surplus oil from the bearings passes to the outer ends of the bearing assembly where it is thrown outwards by the oil throwers. The oil then drains into the sump through holes drilled diagonally in the bearing carriers and the support bushing.

A sump vent, which consists of a spring-loaded felt pad in the side of the centre casing, connects the sump to one of the drilled passages which provide a pressure balance across the bearing-assembly face seals (described

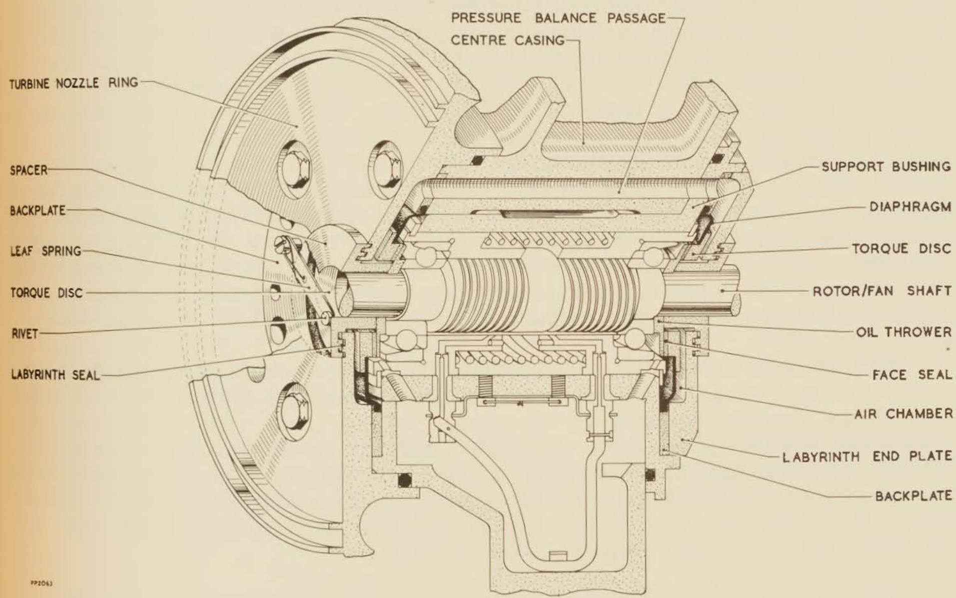


Fig. 5. SEALING

later), and the oil drains connect the sump to the bearing assembly, thereby creating an equal pressure throughout.

SEALING

A seal assembly encloses each end of the bearing assembly to prevent oil-contamination of the air passing through the unit. Each seal assembly (Fig. 5) comprises a diaphragm unit, incorporating a face seal, and a small labyrinth seal. The diaphragm unit consists of a circular synthetic-rubber diaphragm, to the centre of which is bonded a light-alloy torque disc. The outer edge of the diaphragm is beaded and locates in a groove machined around the inner edge of a light-alloy backplate; the edge of the diaphragm is pressed into the groove and retained when the diaphragm unit is in position.

A face seal is located on the inner face of the torque disc by the heads of three steel rivets and seats on the outer face of a steel oil-thrower (mounted on the rotor/fan shaft) to form the seal. The material used for the face seal has a very low coefficient of friction and is steel backed for rigidity. Three leaf springs provide the spring pressure behind the face seal; the outer ends of the springs are anchored by screws to the backplate and the inner ends are secured to the torque disc by the rivets used for locating the face seal. The springs are positioned to accord with the direction of rotation of the rotor/fan shaft thereby counteracting any tendency for the torque disc to rotate. Each diaphragm unit is secured by two countersunk screws and then further secured by the six common screws or bolts which secure the seal assemblies to the centre casing.

At the fan end, a light-alloy labyrinth end plate encloses the outside of the diaphragm unit, forming an air chamber between the two components. A small labyrinth seal, formed between the centre of the end plate and a steel spacer on the rotor/fan shaft, seals the air chamber from the air space behind the fan. A similar air chamber and seal is formed at the turbine end, the stationary component at that end being the turbine nozzle ring. The labyrinth seals at both ends consist of two concentric lands machined on the inner face of the rotating spacer and two concentric grooves machined in the outer face of the stationary component (labyrinth end plate or nozzle ring).

The two air chambers are connected by three drilled passages in the centre casing to enable a pressure balance to be achieved. The oil drains connect the bearing assembly to the sump, and the sump vent connects the sump to the air chambers, to ensure an equal pressure throughout the centre casing. This pressure balance is essential to avoid either a build-up of pressure on the outside of the diaphragms, which could cause excessive wear of the face seals, or a build-up of pressure inside the bearing assembly, which could lift the face seals off their seats.

CHAPTER 2

INSTALLATION AND REMOVAL

List of Contents

The cold-air unit is provided with two mounting pads, one on each side of the centre casing, which incorporate a central spigot-recess and four threaded holes for the attachment of brackets or similar aircraft components. The units must be mounted upright with the axis of the rotating assembly horizontal.

It is essential that the greatest care is taken at all times to prevent the entry of foreign matter into the unit. Whenever the unit is not fitted in an aircraft, or the ducts are disconnected, the ports should be blanked; if the appropriate blanking covers are not available, a suitable alternative is cardboard cut to shape and secured with adhesive tape.

Installation details will vary considerable and, therefore, the following installation and removal procedures are intended to serve only as a general guide. For details of a particular installation, reference should be made to the appropriate aircraft manufacturer's handbook.

The unit is normally stored standing upon its fan housing inlet flange. Before installation, stand the unit on its turbine exit flange for 30 minutes to enable oil in the lubrication system to penetrate into the bearings.

INSTALLATION

Before the initial installation of a cold-air unit in a new aircraft, or whenever work has been carried out, or a component failure has occurred, upstream of the cold-air unit which could have resulted in the contamination of the supply ducts, the ducts should be blown through thoroughly with engine air to remove any loose particles. Failure to observe this precaution can result in damage to the turbine blading, or pick-up between the turbine rotor and the stationary casings, thereby seriously impairing the efficiency of the cold-air unit.

The sump is filled with oil before despatch but should be topped-up after installation to compensate for any oil lost during transit or storage.

To install the cold-air unit, proceed as follows:-

(1) Remove the blanking covers from the aircraft ducts and ensure that the duct flanges are clean. Check the asbestos seals for serviceability.

(2) Remove the blanking covers from the inlet and outlet ports of the cold-air unit and ensure that the flanges are clean.

(3) Fit the aircraft components, where applicable, and mount the cold-air unit in the aircraft, as described in the aircraft manufacturer's handbook.

(4) Connect the ducts to the turbine and fan inlet and outlet ports, ensuring that the clamps are fitted correctly.

(5) Top-up the sump, as described in Chapter 3.

(6) If it is necessary to pressure test the system, reference should be made to the instructions given in the aircraft manufacturer's handbook.

REMOVAL

The procedure for removing the cold-air unit from an aircraft is essentially a reverse of that followed for installation.

(1) Disconnect the ducts from the turbine and fan inlet and outlet ports.

(2) Remove the cold-air unit from the aircraft, as described in the aircraft manufacturer's handbook.

(3) Fit blanking covers to all the ports and to the aircraft ducts.

CHAPTER 3

SERVICING

List of Contents

SUMMARY OF SERVICING

250 flying hours top-up the sump
2500 flying hours, or 3 years from the date of receipt, overhaul the unit.

PROCEDURE FOR SERVICING

Topping-up the sump

(1) Release the bayonet cap from the underside of the centre casing.

(2) Insert the spout of the polythene oil-charging bottle up the stack pipe until the cap on the bottle bears against the stack pipe flange. Inject oil into the sump in small squirts until an overflow occurs.

NOTE: It is essential that the oil-charging bottle is held fully home to ensure that the oil reaches the sump over the top of the stack pipe.

(3) Refit the bayonet cap securely.

Overhaul

Overhaul the unit in accordance with the instructions in repair publication DHP 566.

CONSOLIDATED

DIESEL ELECTRIC CORPORATION

OF CANADA LTD.

SECTION 7

Discussion of proposed working arrangements between C.D.E.C.Ltd., and their U.K.suppliers, together with programme for this project.

some points which we would like to emphasise, and some information which has become available since the relevant parts of the proposal were prepared, and we propose setting these out below.

In the proposal we indicate that the Artouste engine has been chosen for the Canadair CL 44. We have just learned that the same engine has now been specified for the CL 66. This obviously increases the logistic benefits accruing to the use of this same engine in the Arrow ground equipment.

We have recently, in the course of qualification testing of the prototype servicing unit for Arrow I, carried out flow tests on the AiResearch GTC85 units in both vehicles. In both cases the outlet pressure from the compressor bleed was approximately to specification but the flow was some 10-15% below that specified and guaranteed by AiResearch. Similar experience has been found by our parent organisation at Stamford in the past. We believe that in the case of both the proposed starting and servicing units for the Arrow II the AiResearch claims for the output of the GTC85 series are just marginal and, therefore, trouble might be experienced in producing units to specification using AiResearch equipment.

During recent discussions with de Havilland Propellers Limited, it appears that, instead of using the Comet RU 80 Cold Air Units as indicated in the Proposal, it might be advantageous from a time point of view to utilise the RU 75 Unit which is in production for the Victor. The units are nearly identical and the performance quoted will equally apply to the RU 75. However, it is easier to carry out the modifications required to the turbine and nozzles on this unit than it is on the RU 80, and it is also in greater quantity production. This change, however, has no effect on price and little on installation and can obviously be sorted out at a later date if necessary.

We would like to point out that in the price quotation accompanying this document we have not included the price of the air conditioning hose connectors to the aircraft, which we understand are already being provided by yourselves, or

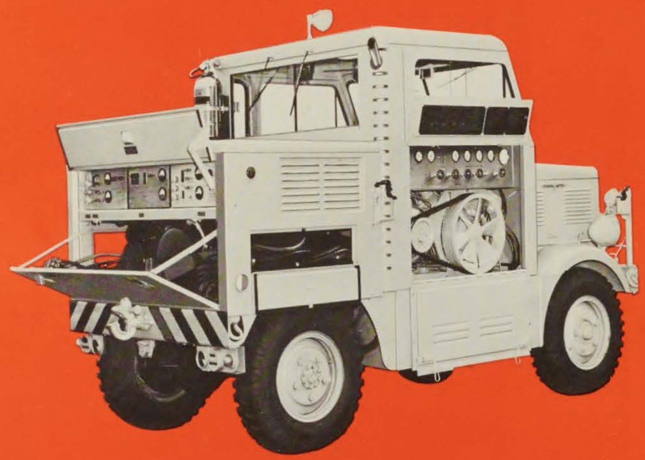
USAF MA-1

Self Propelled
Multi-Purpose
Ground Support Unit

MODELS: 2000 2001 2002

SPECIFICATION HIGHLIGHTS

1. *Mobile — self contained*
2. *V-8 gasoline engine prime mover*
3. *400 Cycle AC — 28-volt DC outputs*
4. *3500 psi pneumatic source (Models 2001 and 2002)*
5. *4500 pound drawbar pull*
6. *5 Speed transmission (Model 2000 or 2001) or torque converter (Model 2002)*
7. *All-weather operation*
8. *4 Wheel drive*



The Model 2000 series (USAF MA-1) self propelled ground support units were specifically developed for the multi-servicing requirements of today's aircraft and missiles. 2000's can service a craft's electrical and pneumatic requirements at one time, tow it into position, and then provide starting power prior to take off.

DETAILS

A. OUTPUTS

1. *Model 2000*
   a. *400 cycle AC, 3 phase — 30 kva continuous*
   b. *28 volt DC — 700 amperes continuous; 28 volt DC — 1500 amperes intermittent*
2. *Models 2001, 2002*
   a. *400 cycle AC, 3 phase — 30 kva continuous*
   b. *28 volt DC — 1500 amperes continuous; 28 volt DC — 2250 amperes intermittent*
   c. *Pneumatic — 13.5 cubic feet per minute at 3500 psi to a 1000 cubic inch receiver (pressure reducer included with unit)*
3. *Voltage Regulation (All Models) — The voltage variation due to load changes is kept within the following limits by the AC and DC voltage regulators.*

	LOW	HIGH
AC	112.5/195	117.5/203.5
DC	27.25	28.75

4. *Frequency Regulation (All Models) — The frequency regulation is maintained at ±5 per cent from no load to full load.*

CONSOLIDATED DIESEL ELECTRIC CORPORATION OF CANADA LTD.

66 RACINE ROAD, REXDALE • TORONTO, CANADA

SECTION 9

SECTION 10

USAF MA-2

Self Propelled
Multi-Purpose
Ground Support Unit

MODEL 2015

SPECIFICATION HIGHLIGHTS

1. *Mobile—self contained*
2. *AC—DC*
3. *3500 psi high pressure air*
4. *117 ppm 50 psia air*
5. *Over 4500 pound drawbar pull*
6. *5 Speed transmission or torque converter*
7. *All weather operation*
8. *Air hose, ducting and electrical cable supplied*
9. *4 Wheel drive*

The Model 2015 (USAF Model MA-2) self propelled ground support unit was specifically developed to meet the advanced multi-servicing requirements of today's aircraft and missiles. This unit is a mobile source of precisely controlled electric power and high pressure and high flow pneumatic power. The MA-2 is completely self-contained and can be driven off-the-road to reach isolated equipment.

DETAILS

A. OUTPUTS

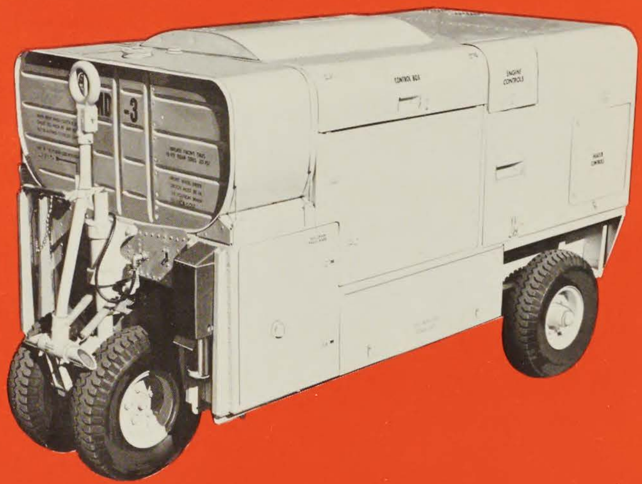
1. *400 cycle AC, 3 phase, 30kva continuous*
2. *28 volt DC—500 amperes continuous, 28 volt DC—1000 amperes intermittent*
3. *Pneumatic—13.5 cubic feet per minute at 3500 psi (pressure reducer included with unit).*
4. *Pneumatic—117 pounds per minute at 50 psia, 370 degrees F.*
5. *Regulation (no load to full load)*
   AC voltage
   Low 112.5/195.0 High 117.5/203.5
   AC frequency
   Low 380 High 420
   DC voltage (servicing)
   Low 27.25 High 28.75
6. *Recovery Times—The output voltage of the AC and DC generators and the frequency of AC generators during load changes between full and no-load recovers to and remains within 5% of steady state value within 0.2 seconds.*

CONSOLIDATED DIESEL ELECTRIC CORPORATION
OF CANADA LTD.
66 RACINE ROAD, REXDALE • TORONTO, CANADA

USAF MD-3

Self-Propelled
Aircraft Electrical
Ground Support Trailer

MODEL 2016



SPECIFICATION HIGHLIGHTS

1. *Self-propelled, lightweight*
2. *400 Cycle AC — 28 volt DC outputs*
3. *Aircooled gasoline engine driven*
4. *Fully instrumented*
5. *Pneumatic tired*
6. *Precise AC, voltage and frequency regulation*
7. *Low ripple, closely regulated DC*

The Model 2016 (USAF Model MD-3) self-propelled aircraft ground support trailer is a compact, lightweight source of AC and DC power for starting aircraft and missile propulsion systems, and servicing electric power and electronic systems. This unit can supply a total of 45 KW continuously of 28 volt DC and closely regulated 400 cycle, 3 phase AC. The unit may be used to service aircraft and missiles incorporating either single bus or split bus electrical DC systems and single and/or three phase AC systems.

Through the use of a steerable towbar and pneumatic tires a high degree of mobility and maneuverability are obtained. One man operating controls on the towbar can select three forward and one reverse speeds for self-propulsion, with a top speed of 5 MPH forward. For towing, the high speed DC drive motor can be disengaged by hand.

Prime power is supplied by an air cooled "Packette" 6 cylinder gasoline engine. For stable operation of AC equipment, and precise control of engine speed (and generator frequency), a hydraulic type, load sensing, isochronous governor is used, thus assuring excellent frequency regulation at all loads.

DETAILS

A. OUTPUTS

1. *The unit is rated for a combined AC and DC total load of 45 kw.*
2. *Five minute combined AC and DC overload rating is 50 kw.*
3. *The AC generator is rated 60 kva, .75 P.F., 120/208 volts, 3 phase 400 cps or 15 kw, single phase.*
4. *AC generator overload rating is 75 kva for 5 minutes.*
5. *Three DC generators are each rated at 500 amperes, 28 volts continuous. The generator is rated for a 5 minute overload of 700 amperes at 28 volts.*
7. *DC ripple is less than 1.5 volts.*
8. *AC frequency regulation is ±¼ of 1% at steady-state load conditions.*

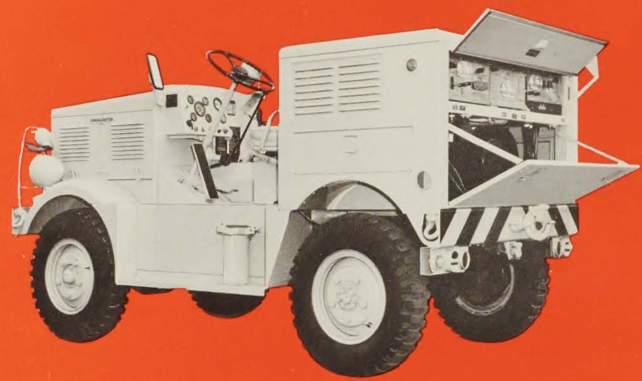
CONSOLIDATED DIESEL ELECTRIC CORPORATION OF CANADA LTD.

66 RACINE ROAD, REXDALE • TORONTO, CANADA

USN **NC-5B**

Self-Propelled Multi-Purpose Ground Support Unit

MODEL 2035



SPECIFICATION HIGHLIGHTS

1. *Mobile — self-contained*
2. *400 cycle AC — 28 volt DC outputs*
3. *4500 pound drawbar pull*
4. *5 speed transmission*
5. *4 wheel drive*

The Model 2035 (U.S. Navy Model NC-5B) self propelled support unit was specifically developed to meet the starting and multi-servicing requirements of today's aircraft and missiles. This unit is a mobile source of precisely controlled electric power. Model 2035 is completely self-contained for one-man operation and can be driven off-the-road to reach isolated equipment.

DETAILS

A. OUTPUTS

1. *400 cycle, 3 phase AC — 30 kva continuous*
2. *28 volt DC — 700 amperes continuous, 28 volt DC — 1500 amperes intermittent*
3. *Regulation (no load to full load)*

AC voltage	*Low 112.5/195.0*	*High 117.5/203.5*
AC frequency	*Low 380*	*High 420*
DC Voltage (Servicing)	*Low 27.25*	*High 28.75*

CONSOLIDATED DIESEL ELECTRIC CORPORATION
OF CANADA LTD.
66 RACINE ROAD, REXDALE • TORONTO, CANADA

SECTION 9

SECTION 10

Self Propelled
Aircraft Support
Generator Sets

"HP" SERIES

SPECIFICATION HIGHLIGHTS

1. *Ratings of 30 to 125 KVA*
2. *Lt. wt., moderate size*
3. *Self-propelled*
4. *With or without cab*
5. *Gasoline or Diesel Engine*
6. *AC or DC power or combination of both*
7. *Removable power pack*
8. *Many parts are interchangeable with other units in the CDEC system.*

For airline aircraft electrical systems ConDiesel has developed the "HP" series units with a variety of outputs. The units are flexible, mobile equipment of rugged design for long service life.

DETAILS

A. ENGINES

Each unit consists of a heavy duty (gasoline or diesel) engine driven alternator pack mounted on a self-propelled chassis. The engine and the alternator separately and collectively have adequate overload capabilities. The power pack is equipped with complete fuel and air induction systems, fuel tanks, engine cooling systems, and governors for speed regulation (standard 2%), and a heavy duty battery sized to meet engine start requirements under various environmental conditions.

Aircraft Equipment Division
CONSOLIDATED DIESEL ELECTRIC CORPORATION
STAMFORD, CONNECTICUT