ACT-2-1

Hang on to this.

Inglis

CANADA

CF 105-GROUND COOLING OF ELECTRONIC EQUIPMENT

SUBJECT

To establish the practicability of supplying conditioned air to electronic compartment and cockpit for stationary aircraft.

REQUESTED

Supply conditioned air at the rate of 150#/minute per aircraft at a pressure of $4\frac{1}{2}$ psig at the aircraft.

Air to be delivered at the aircraft within a temperature range of 55 to 80°F. when ambient air has a temperature of 0 to 95°F.

Equipment for supplying the air to be sized to deliver 150, 300 and 600# air/min. for 1, 2 and 4 aircraft respectively with the larger sizes of equipment capable of supplying air at the necessary rate from 150# to maximum capacity.

INITIAL SURVEY - The essential pieces of equipment were quickly established:-

1. Filters to remove foreign particles from the incoming air.
2. Air compressor to compress the air to 6 psig to allow for air duct and equipment losses due to friction and to give 4.5 psig at the aircraft.
3. Cooling equipment to maintain air temperature to the aircraft within the desired limits.
4. Air ducts to feed the conditioned air to the aircraft.

EQUIPMENT SELECTION

This selection is broken down into 4 main sections dealing with the equipment shown in the Initial Survey.

1. Filters

This requirement for filters poses literally no problem as there is a wide range of material and sizes available for all purposes. We have shown on the following pages sizes of filters which will do the necessary work. The main essential is that these filters should be readily cleanable and efficiently screen out unwanted foreign matter. Electrostatic filtering is not considered necessary.

2. Air Compressor

It was imperative that this machine be capable, under continuous operation, of maintaining maximum dependability. The machine also had to be capable

2. (cont'd.)
of delivering variations in volume whilst maintaining the air at a uniform pressure. A selection was, therefore, made of a multi-stage centrifugal blower directly connected to a 3600 R.P.M. motor.

Note:- It was found that a blower selected for 600# air/min. would surge when called upon to supply 150 or 300# air/min. Also, due to large load variation in the cooling cycle such a large variation in air delivery would tend to complicate the necessary cooling controls. It was therefore decided at this point only to select equipment suitable for supplying 150 and 300# air/min. It will be a simple matter to interconnect the ductwork so that 600# air/min. can be maintained for distribution purposes by using two sets of air conditioning equipment.

3. Cooling Equipment

Essentially, this equipment can be broken into four parts:-

(a) Cooling coil, containing liquid refrigerant, over which the air to be cooled is passed. Heat from the air will vaporize the liquid refrigerant with the vapor being returned to the compressor by the suction piping.

(b) Refrigerant compressor to maintain a pressure differential between the suction and discharge lines in order that refrigerant flow through the evaporator may be achieved.

(c) Condenser to provide a continuous supply of liquid refrigerant to the cooling coil by removing the heat of compression and latent heat of vaporization from the refrigerant gas delivered by the compressor discharge.

(d) Controls to adjust automatically the refrigeration system capacity to match the cooling load.

These four parts are further amplified thus:-

(a) The cooling coil should be finned to provide the necessary heat transfer resulting in a smaller size than for plain tube. The sizing of the coil has been shown on the following pages. The refrigerant inside the tubes should be maintained at a minimum temperature of 35°F to prevent the formation of ice on the finned tubes.

(b) The refrigerant compressor, V-belt driven by an electric motor, to be capable of adjusting its capacity automatically as the cooling load varies, and running without requiring any attention beyond normal maintenance.

(c) The condenser could be either -

(1) Water Cooled Condenser which, as its name implies, uses water passed through tubes to cool the refrigerant gas encased in the condenser shell.

3. (c) Cont'd.)

(ii) Evaporative Condenser which sprays water over coils containing the refrigerant whilst at the same time blowing air across the tubes. The prime consideration here is that less water is used than with the water cooled condenser. However, the evaporative condenser is larger than the water cooled condenser and precautions should be taken during the cold season due to the danger of the water freezing.

(iii) Air Cooled Condenser. This condenser is purely large areas of finned tube, containing the refrigerant over which air is blown. The disadvantage of price and large areas of finned tube is compensated by the fact that no water supply is required for this type of condenser. Multi-staging of the fans blowing the air will help to maintain constant head pressure at all ambients.

Dimensions of condensers with necessary water requirements are listed on the following pages.

(d) The main controls should consist of:

(i) Thermostat to ring alarm bell if air delivered to aircraft is above 80°F.

(ii) Suction Pressure Regulator to maintain a minimum refrigerant temperature in the cooling coil at 35°F.

(iii) Low Pressure Switches to reduce the capacity of the refrigerant compressor to coincide with the cooling coil load.

4. <u>Air Ducts</u>

The air after passing the filters will be fed via transition pieces to the blower, thence to the cooling coil. After the cooling coil a transition piece will feed the air into the main delivery ducts. The main delivery ducts of each set of equipment will be joined into a common distribution header system capable of handling a total of 600# air/min. From the header duct, branches will lead to the various aircraft stations. It is understood that the aircraft stations will be fixed as to position. It is therefore possible for the header and branch ducts to be led around the wall of the hangers or embedded in the floor. From the end of each air branch a flexible pipe will feed, via quick-release connection, to the 3" dia. opening in the plane. It is also understood that this 3" opening will be actually a streamlined orifice, otherwise a higher air pressure would be needed to supply this volume of air than the 6 psig allowed.

<u>OPERATION</u>

The air blower and refrigerant compressor would be started manually by means of electrical switches. Air would then be automatically conditioned and fed into the main delivery duct. No other action would be required to start or continue the delivery of conditioned air by the personnel. Connecting of the

OPERATION (cont'd.)

quick-release connection to the aircraft and manual operation of an air valve would allow the feeding of conditioned air to that aircraft. Regardless of the size of the equipment, if air is not required for a considerable time, say 12 hours or more, it would be necessary to shut down the equipment manually by means of the electrical switches. No harm will be done to the air blower or refrigerant compressor as air is not required for sometime. The air blower will continue to run but its performance characteristics are such that only a very slight increase in air pressure would result in the ducting system. The refrigerant compressor would automatically stop if there was no cooling load. If equipment were selected for delivery of 300# air/min. per set, then if only one aircraft required cooling the duct friction would be such that only slightly over half the requirement, that is, 150# air/min. would be fed to the one aircraft. No problem is envisaged if more than 150#/min. is fed to the one aircraft and, therefore, no special steps have been taken to control the delivery to a maximum of 150# air/min.

We believe that, as outlined above, equipment can be selected to give the necessary conditioned air in the quantities desired and maintain maximum dependability of operation.

It is felt that equipment as outlined above could be supplied f.o.b. Toronto, taxes extra, for the approximate sum of:-

For 150# air per minute, using	Water Cooled Condenser	$ 29,300.00
"	Evaporative Condenser	30,500.00
"	Air Cooled Condenser	31,000.00
For 300# air per minute, using	Water Cooled Condenser	$ 41,100.00
"	Evaporative Condenser	42,700.00
"	Air Cooled Condenser	44,600.00

Not included in the above costs are:

(a) Installation of equipment.

(b) Flexible duct and quick-release connection ti aircraft.

DIMENSIONS

Approximate dimensions of the major components are shown on Pages 5 and 6. A schematic layout of these components is shown on Page 7.

JOHN INGLIS CO. LIMITED

N. Risk,
Refrigeration and Air Conditioning Division.

The following data shows size and other pertinent detail for the major components on the system.

		For 150# Air/Min.	For 300# Air/Min.
1.	FILTERS		
	Overall size	32" x 20" x 2" th.	32" x 40" x 2" th.
2.	AIR BLOWER	L W H	L W H
	Overall size with motor	79" x 38" x 48"	110" x 41" x 54"
	Discharge Pressure psig.	6	6
	H.P. input	95	173
	Motor H.P. req'd.	100	200
	Discharge temp. at 0°F ambient	85	77
	" " " 95°F "	198	188
3(a)	COOLING COIL	H W D	H W D
	Overall size	27" x 33" x 15"	27" x 57" x 15"
(b)	REFRIGERANT COMPRESSOR	L W H	L W H
	Overall size with motor	70" x 36" x 36"	70" x 36" x 40"
	Cooling capacity at 35°F refrigerant temp.	27 tons	55 tons
	H.P. input	36.5	71 H.P.
	Motor req'd. H.P.	40	75
	Condensing Temp.	115°	115°
	Heat rejection BTU/hr.	410,000	830,000
(c)(i)	WATER COOLED CONDENSER (mounted over compr.)		
	Overall size	72" L x 12" dia.	18" dia. x 84" L
	Max. water req'd. U.S. g.p.m. @ 80° temp. eater on temp.	50	75
(ii)	EVAP. CONDENSER (stationed outside bldgs.)	H L W	H L W
	Overall size	84" x 54" x 62"	90" x 72" x 84"
	Fan H.P.	1-1/2	3

3(c)(ii) EVAP. CONDENSER (cont'd.)

	For 150# Air/Min.			For 300# air/Min.		
Approx. max. water req'd. U.S. g.p.m.	3			6		
Pump H.P.	1/3			1/2		
(iii) AIR COOLED CONDENSER (stationed outisde bldgs.)	H	W	D	H	W	D
Overall size	90" x 90" x 36"			2 x 90" x 90" x 36"		
Fan H.P.	4 - 1/2 H.P.			8 - 1/2 H.P.		
4. Main delivery duct size dia. - Max. length 100'	10"			12"		
Common header " " 600#/min., max. length 100'	14"			14"		
branch " " 300#/min., max. length 100'	10"			10"		
flexible " " 150#/min., Max. length 50'	6"			6"		

Note: - (a) Flexible duct to taper to 3" dia. for entry to aircraft.

(b) Duct lengths above are to show approximate allowance in cost figures and do not represent maximum lengths of ducts which could be used if so desired and any necessary increase in duct size allowed.

(c) Weight of equipment, less ductwork, for the supply of 150# air/min. is estimated to be in the region of 12,000#.

(d) Weight of equipment, less ductwork, for the supply of 300#/min. is estimated to be in the region of 18,000#.

(e) Above weights are based on air-cooled condensers will be reduced somewhat with water cooled condensers.