MEMO

SUBJECT : Measurements of Air flow & pressures in E80 System
TO : E80 File
FROM: [redacted] STATOTHR
DATE 9 September 1964

1. The following is a record of the calculations and measurements involved in evaluating the air coolant requirements for the E80 coordinatograph system.

2. Power requirements:
The most severe condition occurs when the coordinatograph positions points 5 times a second. This is every 200 milliseconds (.200 sec). The machine could be running at full speed forward for .060 sec and stopping for .060 sec. Maximum current forward as well as in reverse is about 50 amperes.

Each motor has an armature resistance of 0.5 ohms. Thus the energy requirement for one point and one motor is $(50 \text{ amps})^2 \times .5 \text{ ohms} \times .120 \text{ sec} = 150$ watt sec.
At the 5 point per second rate, the power is $150 \times 5 = 750$ watts.

3. Heat transfer to air:
The coefficient of specific heat for air is $.24 \frac{J}{\#/°F}$
[illegible] .03 [illegible].

Since 1 KW sec is approximately equal to 1 ⊕, the heat transfer equation is:

$$750 \text{ watts} = .75 \frac{⊕}{sec} = .24 \frac{⊕}{\#} \text{ per } {}^\circ F \times \frac{\#}{13 \text{ ft}^3}$$

$$\frac{.75 \frac{⊕}{sec}}{.24 \frac{⊕}{\#}} \cdot \frac{13 \text{ ft}^3}{\#} = 1^\circ F \text{ rise}$$

$40 \frac{ft^3}{sec}$ will cause air to rise 1° F

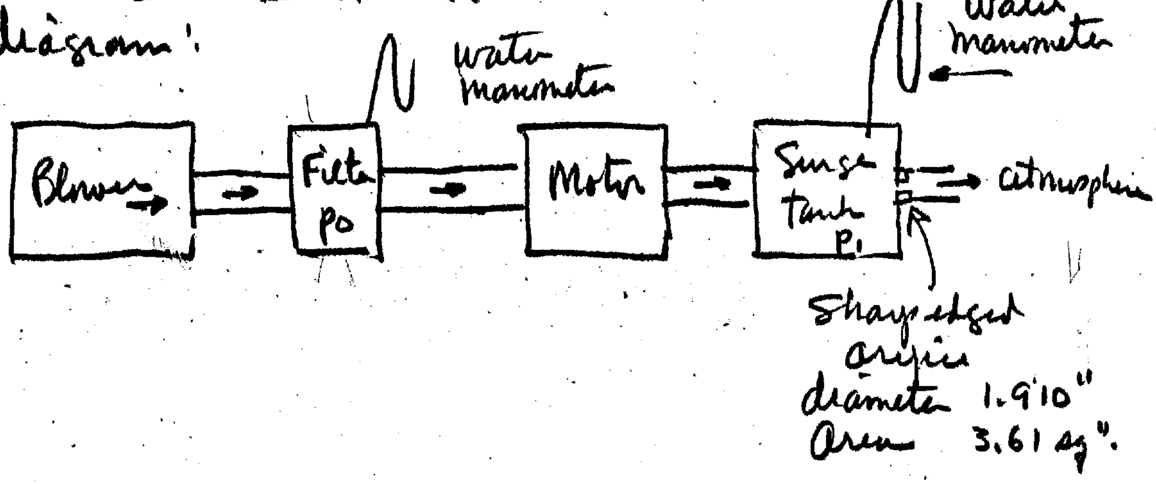
Greater air flow will cause less rise & vice versa.

4. Maximum Equipment temperatures:

It is very difficult to determine either the temperature of the motor brushes or the transistor junctions from exit air temperatures. However it seems reasonable to assume that motor exit air temperature ≦ 100°F, transistor tray temperature ≦ 120°F and power supply & electronic temperatures ≤ 100°F are applicable.

5. Air pressure & flow measurements:
The roots blower, hoses, filter box, surge tank, orifice and manometers were used to make the following tests:

Test I One motor (x axis)
diagram:



Test Data 70°F ambient

p_1 ("H_2O)	Cfm. *	p_0 ("H_2O)	$p_0 - p_1$ (across motor)
.25	14.9	.75	.50
.375	22.3	1.125	.75
.500	29.8	1.625	1.125
.75	44.6	3.56	2.81
1.00	59.5	4.00	3.00
2.12	126	9.69	7.57
3.75	223	17.75	14.00

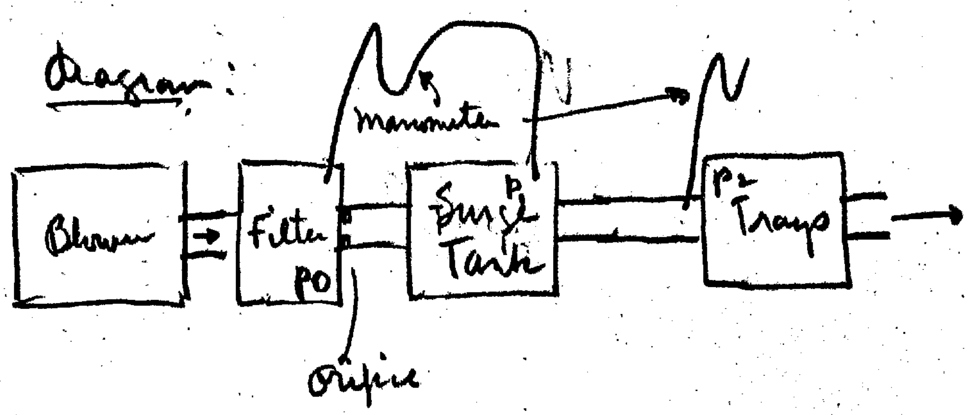
* Calculated [illegible] #/Sec [illegible] / $\sqrt{T}$ ([illegible] Handbook)

These results are also shown on plot NO. 1

Cfm reduces to 59.5 (??) for the orifice used.

Test II Power Transistor Trays.

Diagram:

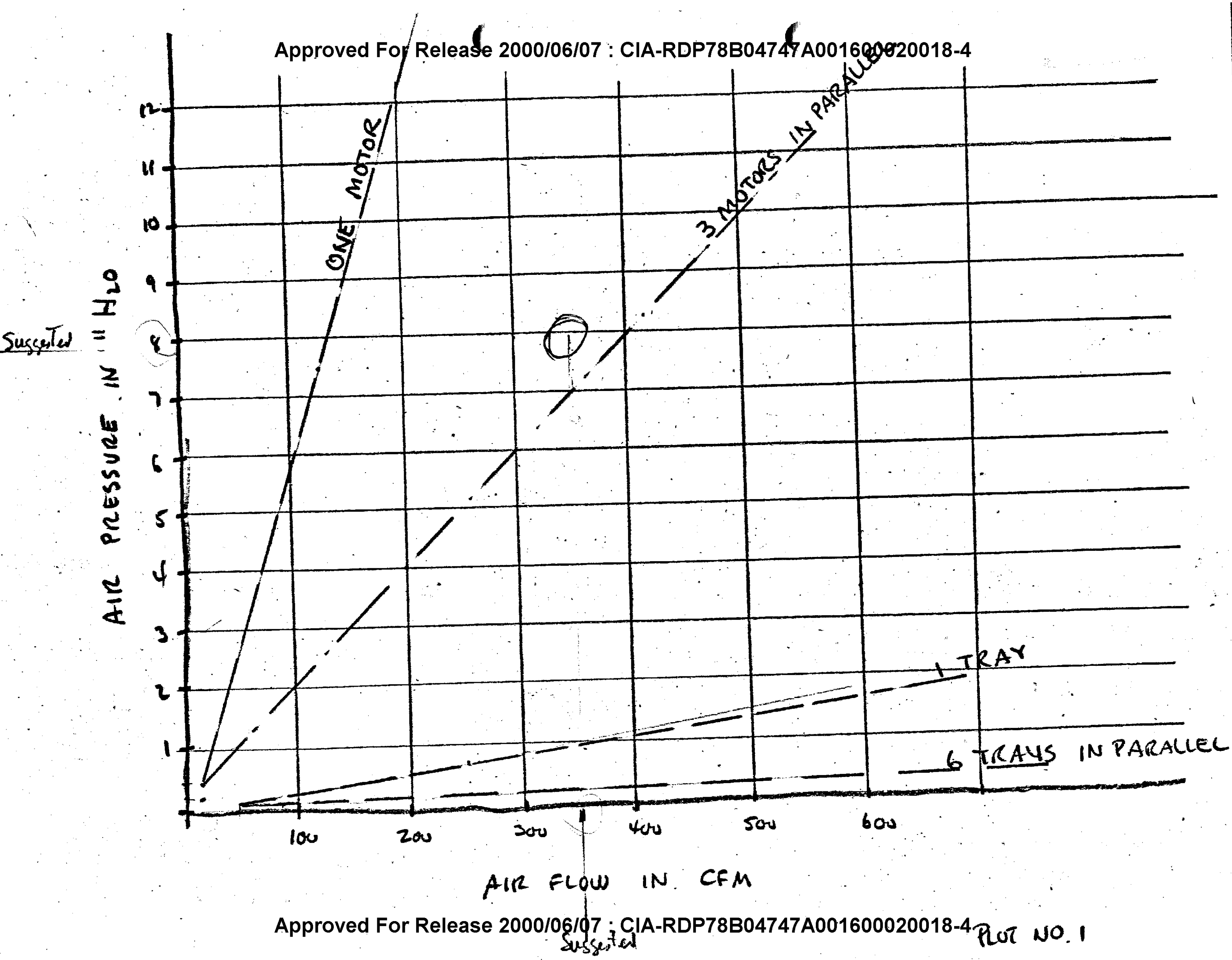


data:

For one tray

$p_0 - p_1$	Cfm	p_2
1 3/8"	81.5	1/8"
2"	119	3/16"
6"	358	1/4"

Results are also shown on plot NO. 1


ONE MOTOR
3 MOTORS IN PARALLEL
1 TRAY
6 TRAYS IN PARALLEL
Suggested
AIR PRESSURE IN " H_2O
1
2
3
4
5
6
7
8
9
10
11
12
100
200
300
400
500
600
AIR FLOW IN CFM
Suggested

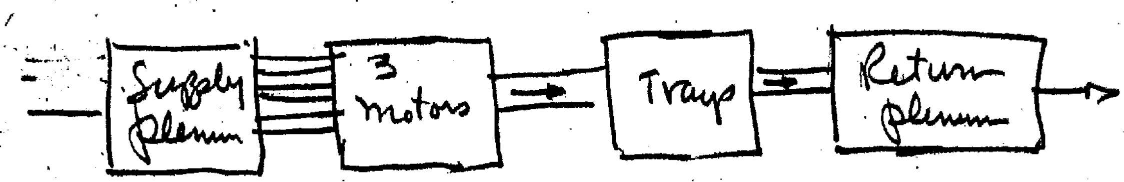
PLOT NO. 1

6. Coolant system requirements

From the motor test data it is evident that approximately 8" H2O is sufficient head to supply air for the three motors in parallel and is more than sufficient for the traps. In fact, the pressure drop across the traps is so small that some sort of throttling would be necessary.

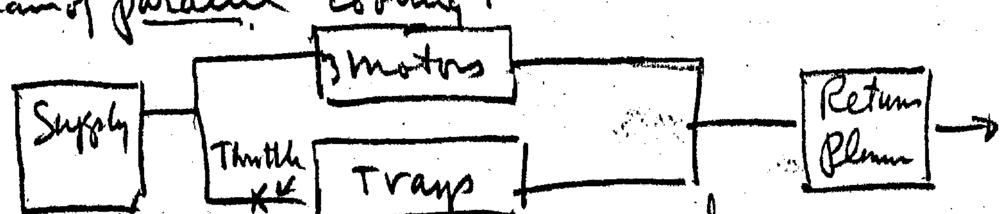
One suitable configuration might be to drop the majority of the pressure across the motors and feed that air in series to the traps. Fortunately the traps can stand the higher final exit air temperature.

diagram of series cooling.



a parallel configuration is also possible

diagram of parallel cooling:



[illegible]

7. Sample Calculation for Series.

Consider the miscellaneous heat requirement to be equivalent to one motor heat load. Therefore we have a total load of (for 1°F air rise)

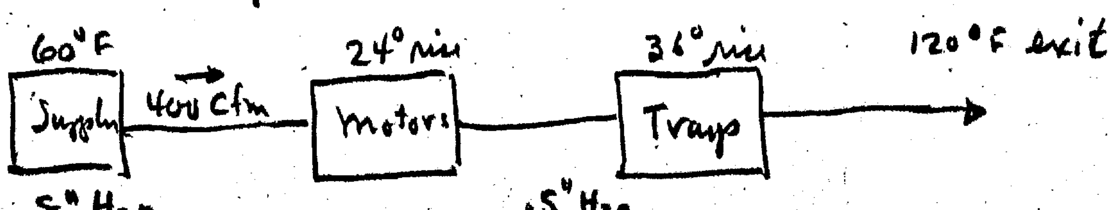
a. 4 "motors" at 40 $\frac{ft^3}{sec}$ = 160 $\frac{ft^3}{s}$ (with 100°F exit air)

b. 6 Traps at 40 $\frac{ft^3}{sec}$ = 240 $\frac{ft^3}{s}$ (with 120°F exit air)

Suppose 60°F air was available and 24°F rise was allowed in the motors, 36° rise in the traps making exit air 120°F. With a 24° rise in the motors only $\frac{1}{24}$ as much air flow is needed or $\frac{160}{24} = 6\frac{2}{3}\ \frac{ft^3}{sec}$ or

$6\frac{2}{3}\ \frac{ft^3}{sec} \times 60\ \frac{sec}{min} = 400$ cfm. In the traps, $\frac{1}{36}$ of 240 $\frac{ft^3}{sec}$ is needed. This is also 400 cfm and

so the two systems could be joined in series. Schematically:



8. Sample calculation for <u>parallel</u>.

Same heat loads; for 1° rise

4 "motors" = 160 $\frac{ft^3}{sec}$ (100°F exit)
6 trays = 240 $\frac{ft^3}{sec}$ (120°F exit)

With 60° supply air

motors rise 40° hence require 4 $\frac{ft^3}{sec}$ = 240 cfm
trays rise 60° hence require 4 $\frac{ft^3}{sec}$ = 240 cfm
480 cfm

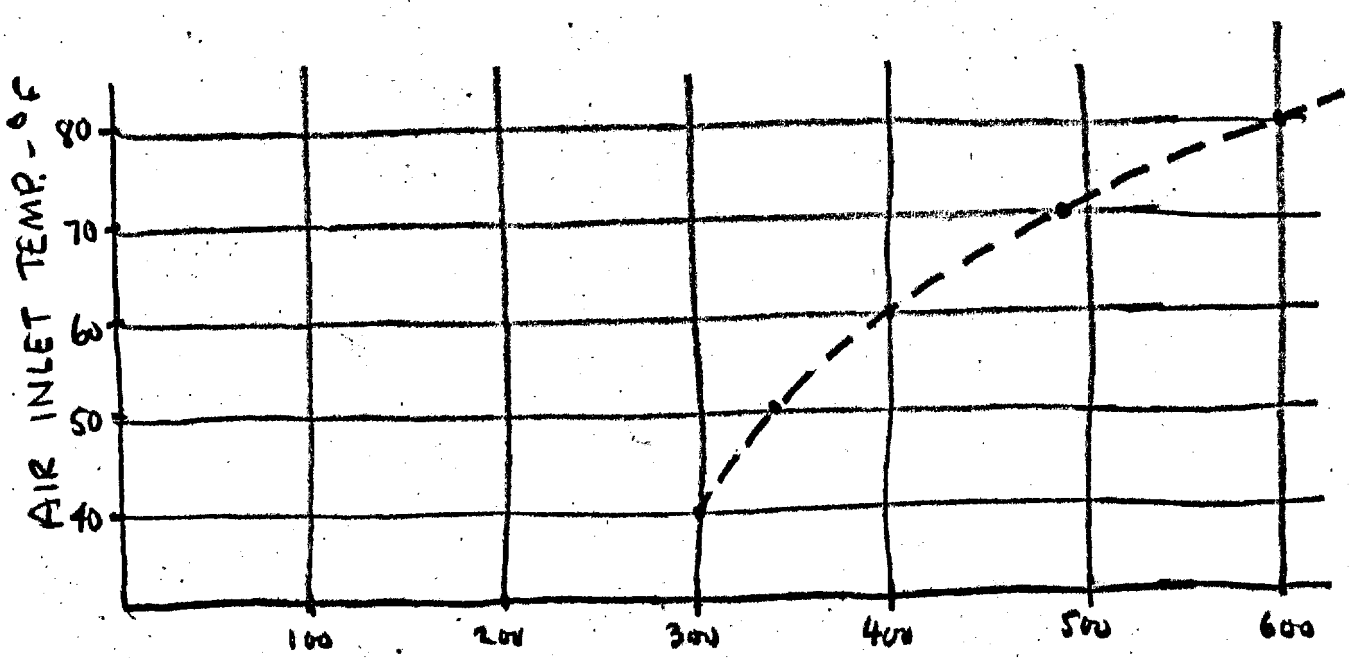
The flow is not greatly different but the pressure requirements at the motor or tray entrances are vastly different and some sort of throttle plate or valve would be required.

9. Other inlet air temperatures considered with the series configuration.

Inlet temp °F	① Motor rise	② tray rise	③ total exit °F	cfm 160 x60 / ①	
80 °F	16	24	120	600	
70	20	30	120	480	8"
60	24	36	120	400	
50	28	42	120	342	8" H2O
40	32	48	120	300	

Suggested

graphically as follows:



8" H2O

Centrufical Fan #
Drier –
Filter