AVROCAR CONTINUATION TEST PROGRAM

SPECIFICATION FOR PHASE 2 TESTS OF AN AVROCAR IN THE 40 X 80 FOOT WIND TUNNEL AT N.A.S.A., AMES RESEARCH CENTER

500/AERO TEST/405

AVRO AIRCRAFT LIMITED

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1.0 INTRODUCTION

The first series of wind tunnel tests on the first Avrocar were carried out in March and April 1960 at Ames Research Center, Moffett Field, California, and have been termed 'Phase 1 Tests'. These tests had as their objective, the determination of a transition trajectory for flight out of the ground cushion to free air. (Ref. 1). Although the deficiency in jet thrust on the Avrocar was well known, and although limitations due to the focussing ring control were expected, it was thought that flight in a restricted envelope would be possible.

Results of the Phase 1 Tests (Refs. 2, 3 and 4), show that apart from low speed flight (35/mph) at low heights above ground, no region for useful flight existed. The factors bearing on this state of affairs were as follows:

(i) The inability of the focussing ring control to divert the available jet thrust in an aft direction.

(ii) A generally large nose-up pitching moment at forward speeds.

(iii) A low value of lift curve slope, entailing large positive angles of attack to generate lift forces approaching the aircraft weight.

(iv) A rolling moment and side force of appreciable magnitude caused by intake flow entering the fan non-vertically at forward speeds.

Certain modifications have been proposed to overcome or alleviate these difficulties and these are listed in Section 3. The program schedule for the first Avrocar (Fig. 1) calls for Phase 2 wind tunnel tests commencing February 15th, 1961.

2.0 TEST OBJECTIVES

2.1 To define a forward flight performance envelope for the first Avrocar in its modified state, accepting the known thrust deficiency. To enable estimates of developed performance after thrust improvement to be made, and to assess the reasons for any deficiency between the latter and the performance originally specified (Ref. 5).

2.2 To establish the ability of the aircraft to accelerate in the ground cushion and, if possible, to find a maximum ground cushion speed.

2.3 To show that transition is feasible.

3.0 VEHICLE DESIGN CHANGES

The first and second Avrocar vehicles will be modified to incorporate the following changes in order to achieve the control and performance improvements required:

3.1 Wing Tip Structure and Cascades (see Fig. 2)

A large increase in forward thrust will be obtained by modifying the rear half (approximately) of the wing tip structure to incorporate a new radial duct and peripheral nozzle, extending from the existing radial ducts. This will provide an alternative flow path for the jet efflux. Fixed cascades will be situated at the radial extremities of the lateral quadrants of the new ducts to direct the jet flow in a rearwards and slightly outwards direction.

3.2 Transition Doors (see Fig. 3)

Flow splitters will be introduced to direct the jet flow through either the peripheral or the annular nozzle and will be operable in such a manner as to provide a gradual transition from hovering to forward flight. The splitters will take the form of twelve doors hinged at their lower outboard edge and controlled by three electric motors connected by flexible drives to the door jacks. The doors may be operated simultaneously or in three separate groups, i.e. two sets of lateral doors and the rear doors, the final mode of operation being determined by test.

3.3 Forward Flight Control Vanes (see Fig. 4)

In addition to the existing ring control, used in hovering and transition, it will be necessary to provide control in forward flight. This will be achieved by using the rear jet as a jet flap controlled by six vanes, occupying twenty degree segments at the rear one hundred and twenty degrees of the peripheral nozzle. These vanes will be hinged and coupled to the control system in such a manner as to operate in conjunction with the focussing ring control so that there will be no control hiatus during transition.

3.4 Yaw and Transition Vanes (see Fig. 5)

To achieve the required deflection of the forward lateral jet sectors, the existing yaw control vanes will be relocated forward of the lateral centerline of the vehicle (Fig. 6) and deflected rearwards collectively in forward flight.

3.5 Increased Travel of Focussing Ring Control

The simplest way of increasing the pitch and roll control in the hovering state is to increase the travel of the focussing ring control. The hanger rods, supporting the focussing ring, will be relocated outboard of the ring, and the ratio of cable movement to bellows jack movement will be increased at the phasing levers, (situated beneath the turborotor near the center of the vehicle) giving ± 3" travel of the focussing control ring.

3.6 Fin and Tailplane (see Fig. 7)

Supplementary trim control and increased longitudinal stability may be obtained by the addition of a tailplane, and a tailplane will be designed and made available for tests. It will have a ten foot span and a chord of three feet and will be mounted on a single fin guyed in place with suitable struts and wires. The tailplane will initially be set at twenty degrees to the wing chord but provision is made for changing the incidence through ± 12 degrees with removable blocks.

The fin is expected to provide sufficient directional stability and to overcome the small adverse effects of the canopies. The fin is mandatory for forward flight but the tailplane is an insurance feature.

3.7 Rotor Inlet Cascades (see Fig. 8)

It is intended to improve the flow distributions in forward flight by the addition of intake guide vanes, the design of which has been based on tests recently undertaken at NASA (Ames).

3.8 Instrumentation

There has been a complete re-appraisal of all pressure instrumentation on the first Avrocar vehicle to eliminate unnecessary piping and replace instrumentation damaged by the first series of wind tunnel tests at NASA. Furthermore, due to changes described in paras 3.1 to 3.7 inclusive, it has been necessary to re-evaluate the instrumentation requirements which are now detailed in Ref. 6.

3.9 First Avrocar Vehicle Repairs

Due to prolonged running at high engine rpm during the first series of wind tunnel tests at NASA, the first Avrocar vehicle rib structure has suffered from thermal and acoustic fatigue. Experience with the second Avrocar vehicle at the Avro Malton plant, has led to methods of repair to combat this deficiency, and these methods will be applied to the first Avrocar vehicle at NASA to establish a minimum life of thirty-five hours for further testing.

4.0 INSTRUMENTATION

Specifications of the Avrocar instrumentation and an outline of the proposed installation are given in Ref. 6. The following is a general description of the instrumentation proposed for the wind tunnel tests:

4.1 Tunnel Instrumentation

The aircraft support struts will be fitted with load cells at the junction with the three undercarriage legs, as for the previous tests.

This arrangement provides two distinct methods of obtaining force data:

(i) through the six-component balance

and (ii) through the load cells.

4.1.1 Six-Component Balance

The output of the balance is on printed tape from which IBM cards are punched manually for use with an IBM 704 program to calculate lift, drag, and side forces and pitching, rolling and yawing moments.

4.1.2 Load Cells

The load cells feed into a digitizer whose output is fed to a Flexo-writer. The data is available on punched tape for processing by the Datatron computer. The final output is given for three components, viz: corrected values of lift, drag and pitching moment and their coefficients. In addition, the Datatron program calculates the center of pressure location, the corrected angle of attack, and the corrected tunnel dynamic pressure.

In the first test series an analog computer, using the output from the load cells, provided values of lift, drag and pitching moments (in sequence, at each test point) which were manually recorded and plotted at the conclusion of a test run for a first look at the test results. This system is to be used again.

4.2 Angle of Attack

The maximum range of angle of attack required will be $\pm 24^\circ$ and will be recorded manually, using the standard tunnel gauge.

4.3 Air Speed Indicator

The pitot static boom on the aircraft will be removed.

4.4 Pressure Instrumentation

All pressures will be connected to manometer boards and photographed for each test point.

Static pressure taps buried in the skin of the upper surface along the centerline chord will be extended forward to points on the underside of the leading edge radius and aft to the trailing edge. A total of 36 taps is foreseen.

A total head rake above the fan will be installed to determine the intake pressure recovery in the region shown on Fig. 8.

For calculation of fan mass flow at q = 0,4 statics are provided around the intake lip. Pressure distributions beneath the fan will be measured by six rakes placed about 6" below the fan every 60° from the aircraft lateral axis. Each rake will have 5 total head and 5 static probes.

Six peripheral nozzle rakes (each having 6 total head and 5 static probes) will be installed. Individual readings of each of the 66 tubes will be made. Mass flow at all values of tunnel q will be calculated from fan outlet pressures and from the peripheral nozzle pressures. The total pressures measured at the peripheral nozzle will be used to calculate nozzle gross thrust.

In order to check the forces on the forward compartment door of the aircraft, differential pressure across it will be shown on the manometer board. A uniform differential pressure of 0.55 psi is allowed. If possible, this tube will be red-line in order to avoid exceeding this pressure.

4.5 Manometer Boards

The arrangement of tubes on the manometer boards will be as shown on the following tables.

Symbol	BOARD 1 ALKAZENE	Tube No.
PSI	Fan Inlet Static - 4 Tubes	1 TO 4
SO	Fan Outlet Static 30 Tubes	5 TO 34
TO	Fan Outlet Total 30 Tubes	35 TO 64

Symbol	BOARD 2 ALKAZENE	Tube No.
PJS	Nozzle Static 30 Tubes	1 TO 30
PJT	Nozzle Total 36 Tubes	31 TO 66

Symbol	BOARD 3 WATER	Tube No.
PU	Skin Pressure Static 36 Tubes	1 TO 36
PFT	Fan Inlet Total 10 Tubes	37 TO 46
PTS	Trunk Compt. Static 1 Tube	47

TOTAL:
64 + 66 + 47 = 177
Tubes

4.6 Aircraft Instrumentation

The engine remote control panel from the static rig will be mounted in the control room as previously for operation of the aircraft.

Data will be recorded by means of manometer boards, one standard photo-panel supplied by WADC, and two auxiliary control panels.

Parameters to be measured are listed below:

Photo Panel	4	fan inlet temperature
	3	intake temperature to J-69 engine (3 x 2 ganged)
	3	E.G.T. of J-69 engine (3 x 4 ganged)
	3	J-69 rpm
	1	rotor rpm
	1	clock
	1	digital counter
Manometer Boards	4	fan inlet static pressure
	60	fan outlet total and static pressure
	66	peripheral nozzle total and static pressure
	1	trunk compartment static pressure
	36	aircraft surface pressure
Auxiliary Control Panels	3	nozzle vane position
	4	focussing ring control position
	2	rudder angle
	3	transition door position

Rotor vibration will be monitored by a C.E.C. instrument as previously.

A strain gauge will be attached to the rod connecting the actuator lever to the forward control cable, the output being shown on a load indicator dial.

4.7 Flow Visualization

In view of the anticipated flow pattern changes with variation of forward speed and angle of attack in the ground cushion, some provisions for flow visualization should be made. It is recommended that a suitable number of cantilevered struts, carrying white or yellow ribbons, be attached to the lower surface of the aircraft and to the ground board under the aircraft. Supplementary lighting will be required in the tunnel to enable photographic records to be obtained.

4.8 Load Limitations

The maximum allowable load in the forward control cable is 1200 lb under any circumstance.

4.9 Hydraulic Jack Travel

Since travel of the focussing ring control and nozzle vanes is determined by potentiometers directly attached to them, mechanical stops are provided in the hydraulic jacks to prevent excessive travel and possible damage to the aircraft structure.

5.0 DATA REDUCTION

A first stage of data reduction is made via the Datatron, or the IBM 704, shortly after each test, providing corrected values of lift, drag, pitching moment, α , q and C. P.

Stage two of the data reduction calculates the mass flow and gross thrust using pressure data provided by the alkazene manometer boards. This data will be read from film using the Telereader coupled to an IBM 533 Summary Punch.

The IBM cards will be transcribed onto magnetic tape and processed by an IBM 704 program giving the mass flow m_j, the gross thrust X_g, and the two dimensionless coefficients C_{D_m} and C_j.

Stage three reduction requires the knowledge of the characteristics with power on and wind off (the 'static case'). Since various test points must be arranged in sets of two, i. e. one power-on, wind-on; and one static case; the sorting of the cases must be done manually. Processing on the IBM 704 produces induced aerodynamic coefficients.

The fourth stage of data reduction requires reading photographs of the water manometer board on the Telereader. The cards are taped, then processed on the IBM 704 with a program which calculates the pressure coefficient C_p and plots automatically on the printer.

6.0 TEST OUTLINE

Initial 'shake-down' tests will consist of static runs with varying engine rpm in the forward flight configuration, (i.e. transition doors fully open and yaw transition vanes in the collective aft position) to check the available propulsive thrust, lift and pitching moment at maximum height above ground. The results obtained from these tests will be used in the data reduction of the second group of runs, namely, forward flight tests at maximum h/D with the in-flight configuration at speeds up to about $q = 80\ lb/ft^2$ (i.e. $V \simeq 180$ mph). The pitch control vanes will be operated through their full range at each angle of attack (i.e. every 6°) in the forward flight tests. Data will be obtained at every 15° increment in vane angle.

The third and major group of tests is to establish the ability of the aircraft to accelerate in the ground cushion, to find a maximum ground cushion speed and to show that transition to the fully in-flight condition is possible. To achieve this, lift, drag and pitching moment will be measured statically at maximum h/D and wind-on at a selected height above ground (30" is suggested) for a range of angle of attack, control vane position, transition door setting, forward speed and engine rpm. To obtain a measure of stability in the ground cushion the central jet louvres will be opened for all tests at the 30" height.

As far as possible, all testing at a given angle of attack will be carried out consecutively and when a change in α is made the front struts will be raised or lowered to maintain a constant height above ground.

Further tests will determine: (a) the effect of the tailplane on trim and stability; (b) the effect of disconnecting the focussing control ring from the nozzle vanes and using only the latter to provide control power in pitch; and (c) the effect of the focussing control ring on aircraft drag.

7.0 REFERENCES

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8.0 TEST SCHEDULE

Notation

q	tunnel dynamic head	(lb/ft^2)
h/D	height parameter	
α	aircraft angle of attack	(degrees)
J_e	position of focussing control ring and nozzle pitch control vanes. ($J_e = \pm 1.0$ indicates control ring $\pm$ 3" from neutral position and pitch control vanes $\pm 30^\circ$ from neutral position, i.e. 60° and 0° with respect to aircraft datum. Positive J_e indicates ring aft and vanes down).	
N	percentage maximum engine rpm	
J_t'	position of rear transition doors ($J_t' = 1.0$ indicates doors down, i.e. forward flight position)	
J_t''	position of side transition doors ($J_t'' = 1.0$ indicates doors down, i.e. forward flight position).	
J_t'''	position of yaw-transition vanes ($J_t''' = 1.0$ indicates both port and starboard vanes turned fully aft).	

PARAMETER		q	h/D	$\alpha°$	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN Nº	RANGE OF VARIABLE									UNIT	TOTAL
1	0°, 15°, 30°, 45°, 60°	0	MAX	0	Vary	70	1.0	1.0	1.0	5	5
2						75					10
3						80					15
4						85					20
5						90					25
6						95					30
7		↓		↓		100					35
8		3		-24		90					40
9				-18							45
10				-12							50
11				-6							55
12				0							60
13				6							65
14				12							70
15				18							75
16		↓		24							80
17		10		-24							85
18				-18							90
19				-12							95
20				-6							100
21		↓	↓	0	↓	↓	↓	↓	↓	↓	105

PARAMETER		q	h/D	α°	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN Nº	RANGE OF VARIABLE									UNIT	TOTAL
22	0°, 15°, 30°, 45°, 60°	10	MAX	6	Vary	90	1.0	1.0	1.0	5	110
23				12							115
24				18							120
25		↓		24							125
26		35		-18							130
27				-12							135
28				-6							140
29				0							145
30				6							150
31				12							155
32		↓		18							160
33		MAX		-12							165
34				-6							170
35				0							175
36				6							180
37				12		↓					185
38				-12		85					190
39				-6							195
40				0							200
41				6							205
42	↓	↓	↓	12	↓	↓	↓	↓	↓	↓	210

PARAMETER		q	h/D	α°	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN Nº	RANGE OF VARIABLE									UNIT	TOTAL
43	0°, 15°, 30°, 45°, 60°	MAX	MAX	-12	Vary	95	1.0	1.0	1.0	5	215
44				-6							220
45				0							225
46				6							230
47				12							235
48				-12		100					240
49				-6							245
50				0							250
51				6							255
52				12							260
53		0		0		70	0	0	0		265
54						75					270
55						80					275
56						85					280
57						90					285
58						95					290
59						100					295
60						70			1.0		300
61						75					305
62						80					310
63						85					315

PARAMETER		q	h/D	α°	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN Nº	RANGE OF VARIABLE									UNIT	TOTAL
64	0°, 15°, 30° 45°, 60°	0	MAX	0	Vary	90	0	0	1.0	5	320
65						95					325
66						100	↓	↓			330
67						70	0.5	0			335
68						75					340
69						80					345
70						85					350
71						90					355
72						95					360
73						100		↓			365
74						70		0.5			370
75						75					375
76						80					380
77						85					385
78						90					390
79						95					395
80		↓	↓	↓		100	↓	↓	↓		400
81		2	.139 (30")	-12		90	0	0	0		405
82							↓		1.0		410
83							·5	↓			415
84	↓	↓	↓	↓	↓	↓	↓	·5	↓	↓	420

PARAMETER		q	h/D	α°	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN Nº	RANGE OF VARIABLE									UNIT	TOTAL
85	0°, 15°, 30°, 45°, 60°	2	.139 (30")	-12	Vary	90	1.0	1.0	1.0	5	425
86		4					0	0	0		430
87							↓		1.0		435
88							·5	↓			440
89							↓	·5			445
90		↓					1.0	1.0			450
91		7					0	0			455
92							·5	↓			460
93							↓	·5			465
94		↓					1.0	1.0			470
95		10					·5	0			475
96							↓	·5			480
97		↓					1.0	1.0			485
98		15									490
99		20		↓			↓	↓	↓		495
100		2		-6			0	0	0		500
101							↓		1.0		505
102							·5	↓			510
103							↓	·5			515
104		↓					1.0	1.0	↓		520
105	↓	4	↓	↓	↓	↓	0	0	0	↓	525

PARAMETER		q	h/D	α°	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN Nº	RANGE OF VARIABLE									UNIT	TOTAL
106	0°, 15°, 30°, 45°, 60°	4	.139 (30")	-6	Vary	90	0	0	1.0	5	530
107							·5	↓			535
108							↓	·5			540
109		↓					1.0	1.0			545
110		7					0	0			550
111							·5	↓			555
112							↓	·5			560
113		↓					1.0	1.0			565
114		10					·5	0			570
115							↓	·5			575
116		↓					1.0	1.0			580
117		15									585
118		20		↓			↓	↓	↓		590
119		2		0			0	0	0		595
120							↓		1.0		600
121							·5	↓			605
122							↓	·5			610
123		↓					1.0	1.0	↓		615
124		4					0	0	0		620
125							↓		1.0		625
126	↓	↓	↓	↓	↓	↓	·5	↓	↓	↓	630

PARAMETER		q	h/D	α°	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN No	RANGE OF VARIABLE									UNIT	TOTAL
127	0°, 15°, 30°, 45°, 60°	4	.139	0	Vary	90	·5	·5	1.0	5	635
128		↓					1.0	1.0			640
129		7					0	0			645
130							·5	↓			650
131							↓	·5			655
132		↓					1.0	1.0			660
133		10					·5	0			665
134							↓	·5			670
135		↓					1.0	1.0			675
136		15									680
137		20		↓			↓	↓			685
138		2		+6			0	0	0		690
139							↓		1.0		695
140							·5	↓			700
141							↓	·5			705
142		↓					1.0	1.0	↓		710
143		4					0	0	0		715
144							↓		1.0		720
145							·5	↓			725
146							↓	·5			730
147	↓	↓	↓	↓	↓	↓	1.0	1.0	↓	↓	735

PARAMETER		q	h/D	$\alpha°$	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN Nº	RANGE OF VARIABLE									UNIT	TOTAL
148	0°,30°,60°	7	.139	+6	Vary	90	0	0	1.0	5	740
149	↓	↓	↓	↓	↓	↓	5	↓	↓	↓	745
150	↓	↓	↓	↓	↓	↓	↓	5	↓	↓	750
151	↓	↓	↓	↓	↓	↓	1.0	1.0	↓	↓	755
152	↓	10	↓	↓	↓	↓	5	0	↓	↓	760
153	↓	↓	↓	↓	↓	↓	↓	5	↓	↓	765
154	↓	↓	↓	↓	↓	↓	1.0	1.0	↓	↓	770
155	↓	15	↓	↓	↓	↓	↓	↓	↓	↓	775
156	↓	20	↓	↓	↓	↓	↓	↓	↓	↓	780
			TAILPLANE	ON		α_T	= 8°	to A/C DATUM			
157	0°,30°,60°	35	MAX	-18	Vary	90	1.0	1.0	1.0	3	783
158	↓	↓	↓	-12	↓	↓	↓	↓	↓	↓	786
159	↓	↓	↓	-6	↓	↓	↓	↓	↓	↓	789
160	↓	↓	↓	0	↓	↓	↓	↓	↓	↓	792
161	↓	↓	↓	6	↓	↓	↓	↓	↓	↓	795
162	↓	↓	↓	12	↓	↓	↓	↓	↓	↓	798
163	↓	↓	↓	18	↓	↓	↓	↓	↓	↓	801
					α_T	=	14°				
164	0°,30°,60°	35	MAX	-18	Vary	90	1.0	1.0	1.0	3	804
165	↓	↓	↓	-12	↓	↓	↓	↓	↓	↓	807
166	↓	↓	↓	-6	↓	↓	↓	↓	↓	↓	810

PARAMETER		q	h/D	α°	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN Nº	RANGE OF VARIABLE			α_T = 14° (cont'd)						UNIT	TOTAL
167	0°,30°,60°	35	MAX	0	Vary	90	1.0	1.0	1.0	3	813
168	↓	↓	↓	6	↓	↓	↓	↓	↓	↓	816
169	↓	↓	↓	12	↓	↓	↓	↓	↓	↓	819
170	↓	↓	↓	18	↓	↓	↓	↓	↓	↓	822
				α_T = 20°							
171	0°,30°,60°	35	MAX	-18	Vary	90	1.0	1.0	1.0	3	825
172	↓	↓	↓	-12	↓	↓	↓	↓	↓	↓	828
173	↓	↓	↓	-6	↓	↓	↓	↓	↓	↓	831
174	↓	↓	↓	0	↓	↓	↓	↓	↓	↓	834
175	↓	↓	↓	6	↓	↓	↓	↓	↓	↓	837
176	↓	↓	↓	12	↓	↓	↓	↓	↓	↓	840
177	↓	↓	↓	18	↓	↓	↓	↓	↓	↓	843
				α_T = 26°							
178	0°,30°,60°	35	MAX	-18	Vary	90	1.0	1.0	1.0	3	846
179	↓	↓	↓	-12	↓	↓	↓	↓	↓	↓	849
180	↓	↓	↓	-6	↓	↓	↓	↓	↓	↓	852
181	↓	↓	↓	0	↓	↓	↓	↓	↓	↓	855
182	↓	↓	↓	6	↓	↓	↓	↓	↓	↓	858
183	↓	↓	↓	12	↓	↓	↓	↓	↓	↓	861
184	↓	↓	↓	18	↓	↓	↓	↓	↓	↓	864

PARAMETER		q	h/D	α°	J_e	N	J_t'	J_t''	J_t'''	NUMBER OF TEST POINTS	
RUN Nº	RANGE OF VARIABLE				= 32°					UNIT	TOTAL
185	0°, 30°, 60°	35	MAX	-18	Vary	90	1.0	1.0	1.0	3	867
186	↓		↓	-12	↓	↓	↓	↓	↓	↓	870
187	↓		↓	-6	↓	↓	↓	↓	↓	↓	873
188	↓		↓	0	↓	↓	↓	↓	↓	↓	876
189	↓		↓	6	↓	↓	↓	↓	↓	↓	879
190	↓		↓	12	↓	↓	↓	↓	↓	↓	882
191	↓		↓	18	↓	↓	↓	↓	↓	↓	885
			FOCUSSING RING CONTROL DISCONNECTED AND SET TO NEUTRAL								
192	2, 4, 6, 8, 10	Vary	.139	0	60°	90	5	5	1.0	5	890
193	↓		↓	↓	45°	↓	↓	↓	↓	↓	895
194	↓		↓	↓	30°	↓	↓	↓	↓	↓	900
195	↓		↓	↓	15°	↓	↓	↓	↓	↓	905
196	↓		↓	↓	0°	↓	↓	↓	↓	↓	910
		POWER-OFF TESTS, INTAKE SEALED									
197	-24°, -12°, 0°, 12°, 24°	3	MAX	Vary	0	0	1.0	1.0	1.0	5	915
198	↓	10	↓	↓	↓	↓	↓	↓	↓	↓	920
199	-12°, 0°, 12°	35	↓	↓	↓	↓	↓	↓	↓	3	923
		REAR 120° REMOVED FROM FOCUSSING RING CONTROL									
200	-24°, -12°, 0°, 12°, 24°	3	MAX	Vary	0	0	1.0	1.0	1.0	5	928
201	↓	10	↓	↓	↓	↓	↓	↓	↓	↓	933
202	-12°, 0°, 12°	35	↓	↓	↓	↓	↓	↓	↓	3	936

PROGRAM SCHEDULE 1st AVROCAR VEHICLE

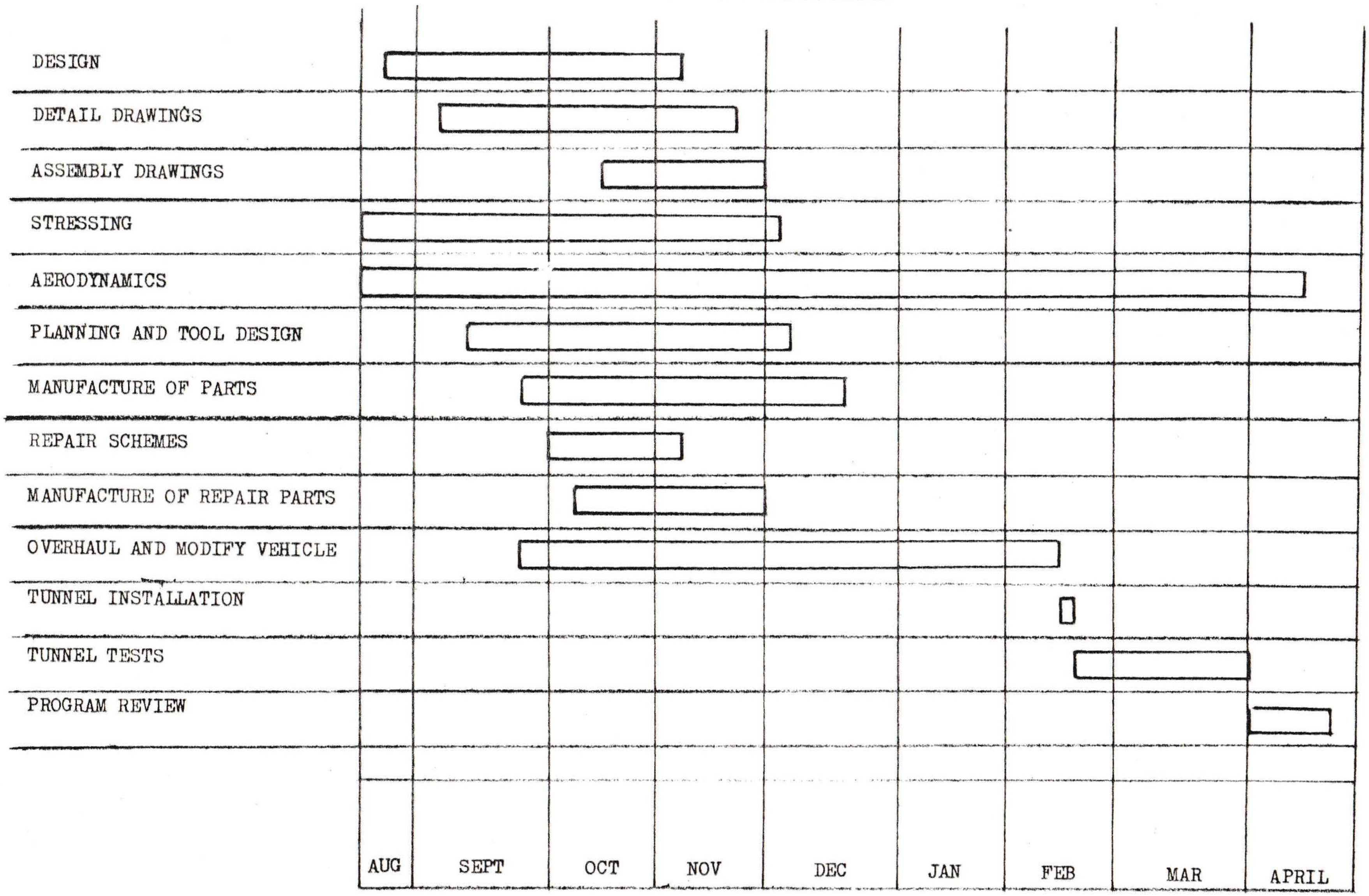

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FIG. 1 PROGRAM SCHEDULE FOR THE FIRST AVROCAR

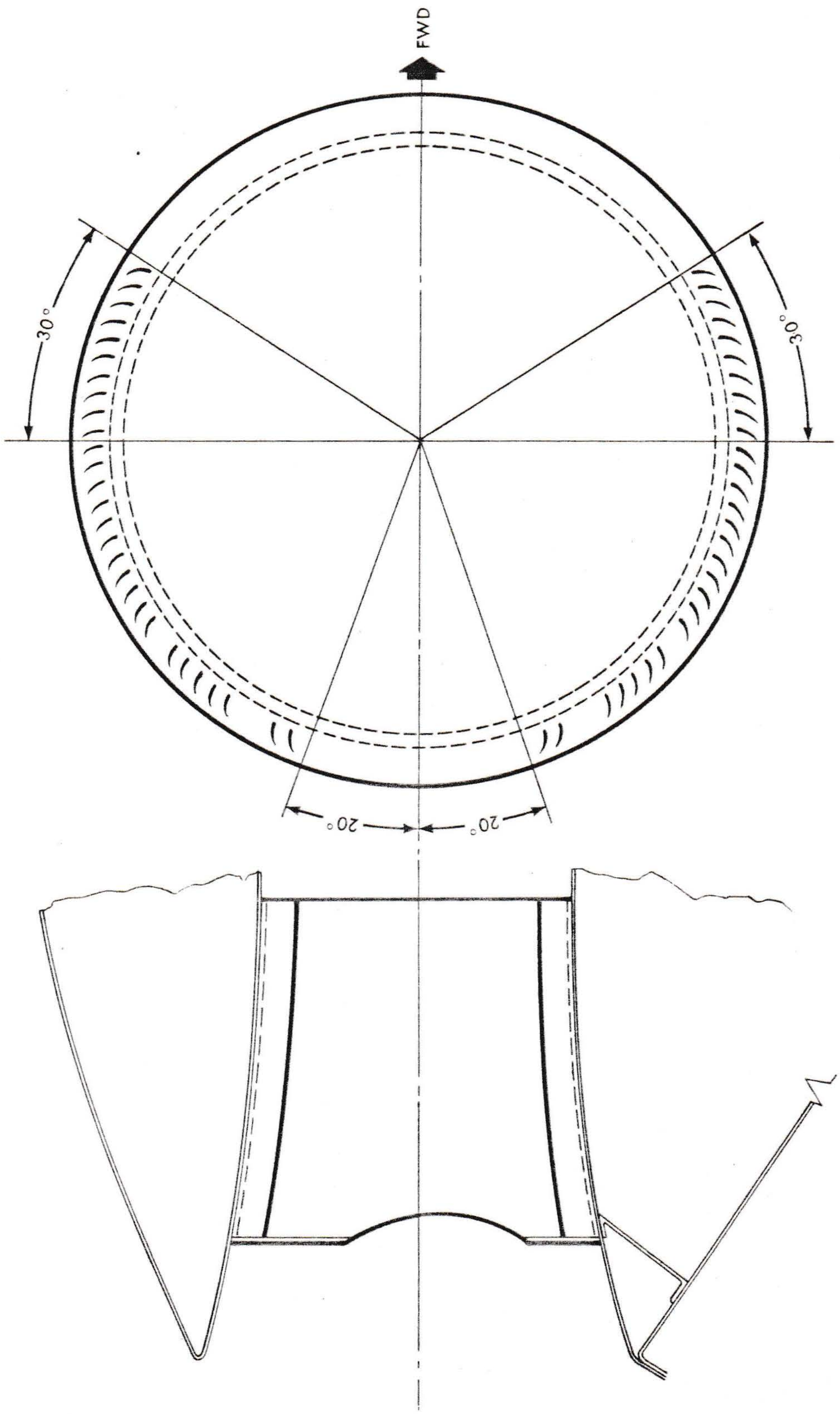


FIG. 2 WING TIP STRUCTURE AND CASCADES

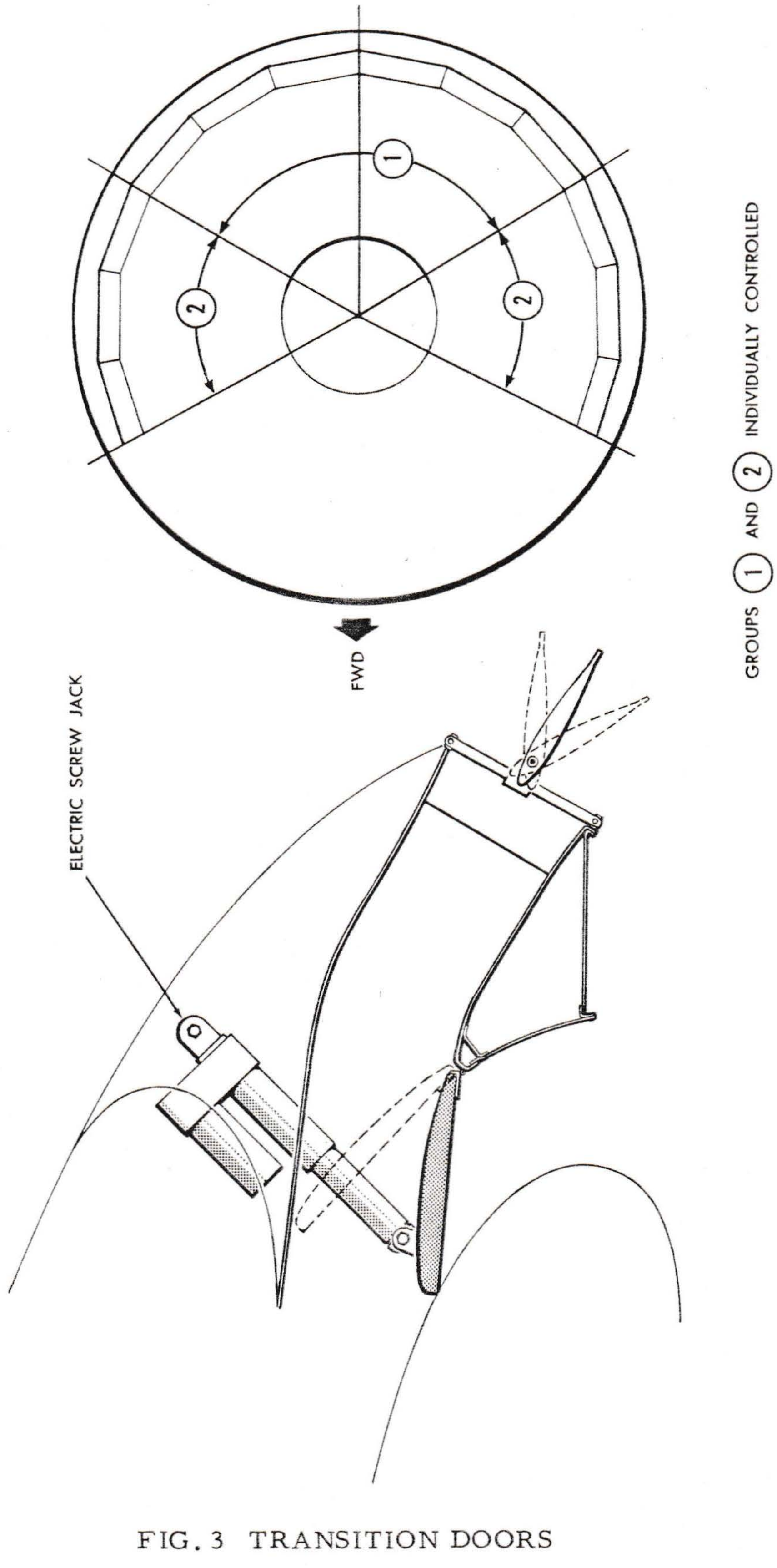


FIG. 3 TRANSITION DOORS

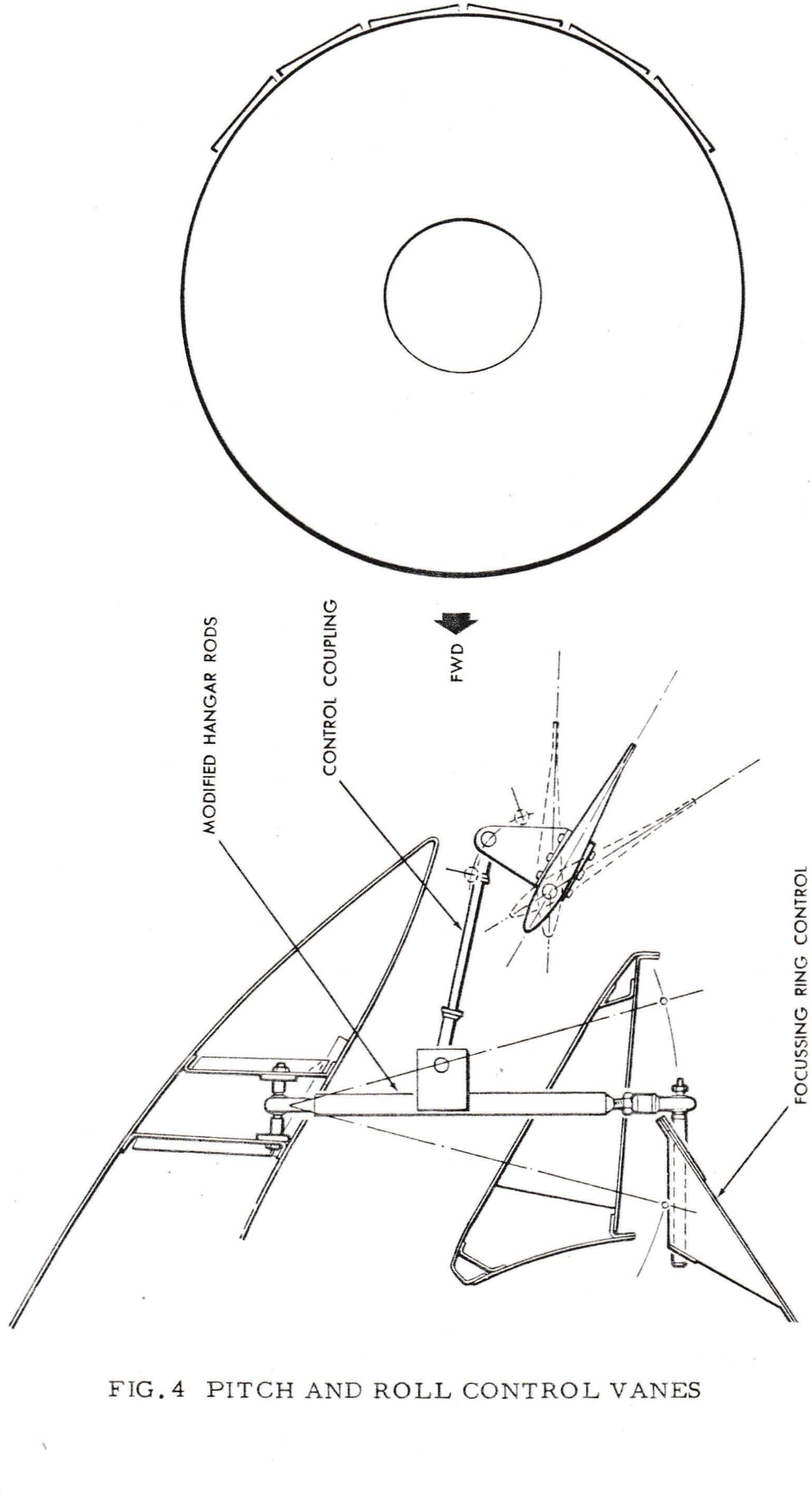


FIG. 4 PITCH AND ROLL CONTROL VANES

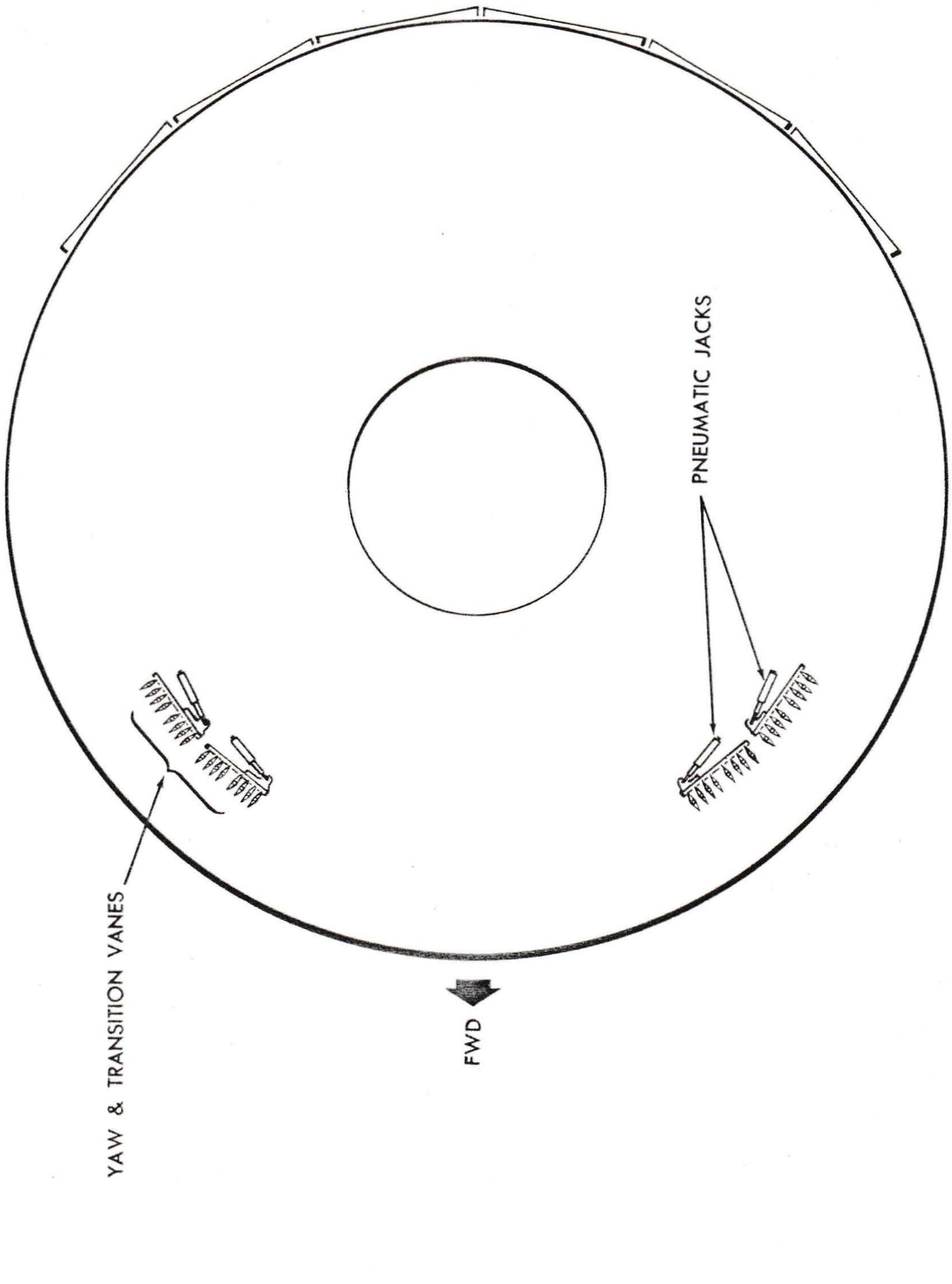


FIG. 5 YAW AND TRANSITION VANES

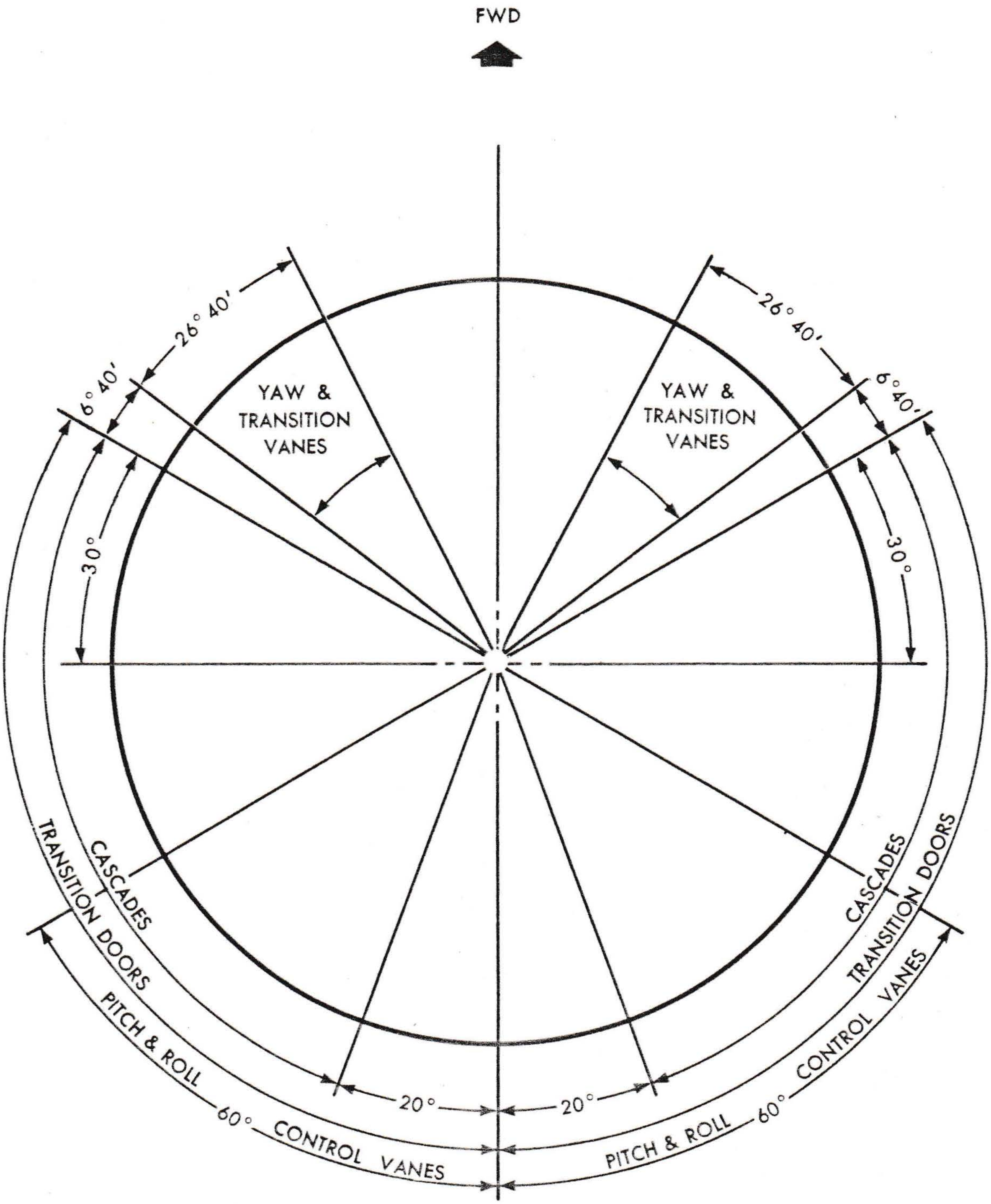


FIG. 6 ARRANGEMENT OF CONTROLS

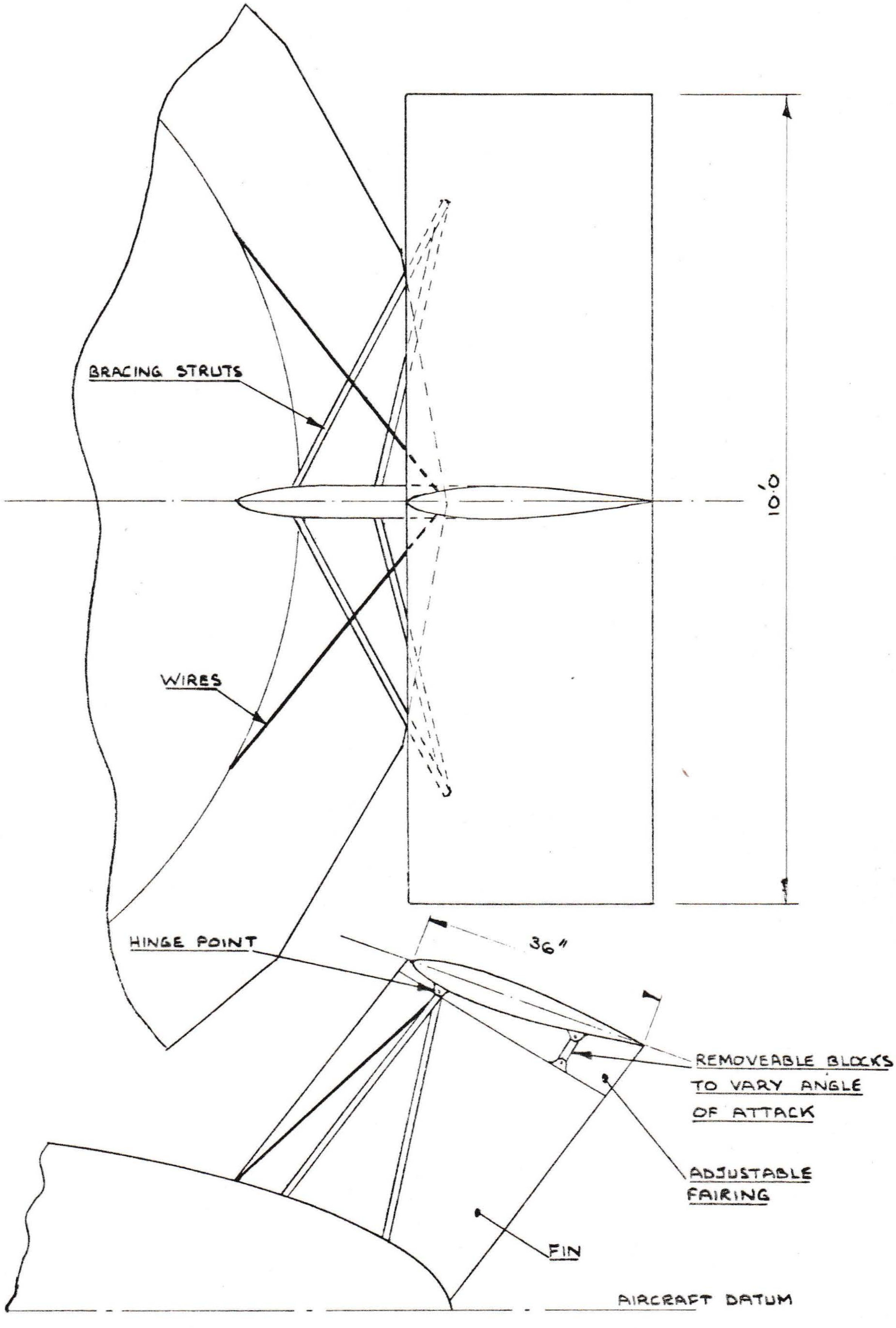
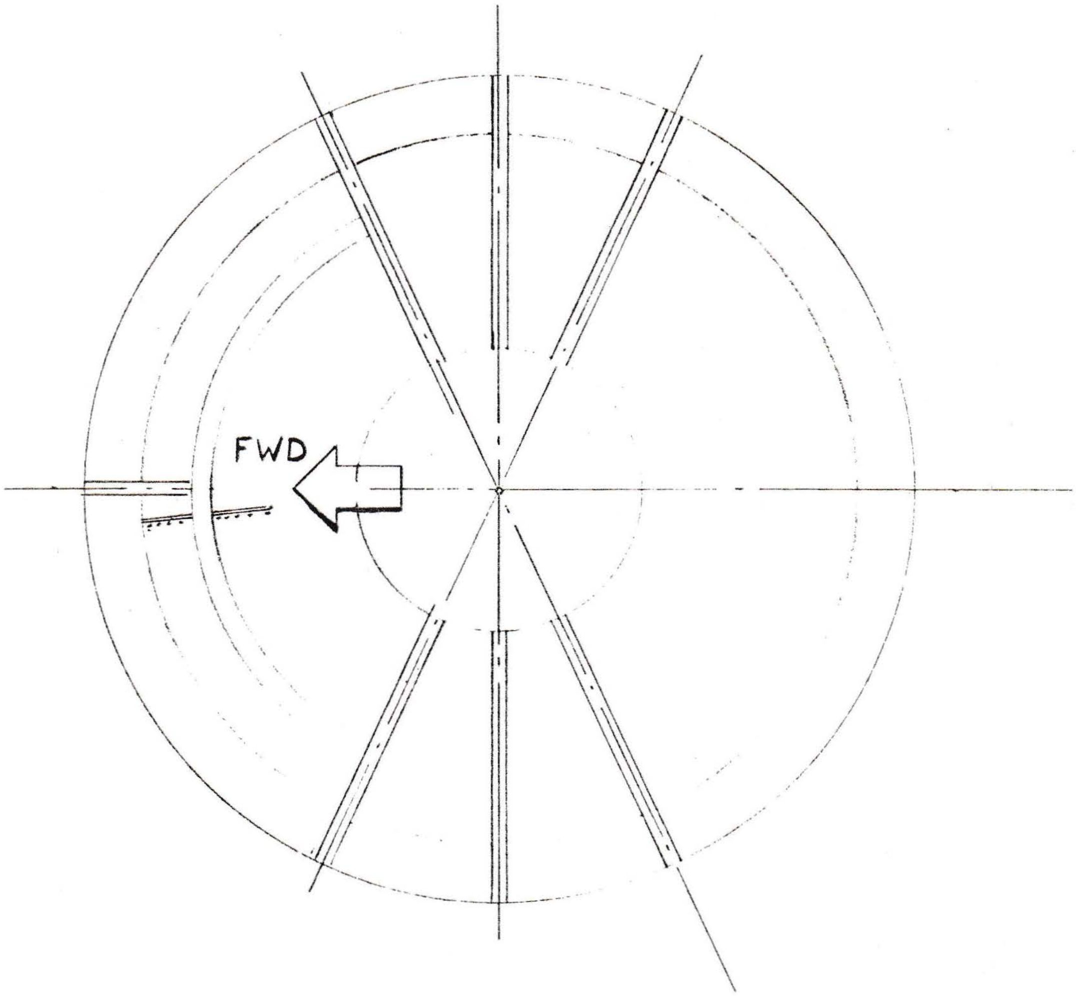


FIG. 7 FIN AND TAILPLANE



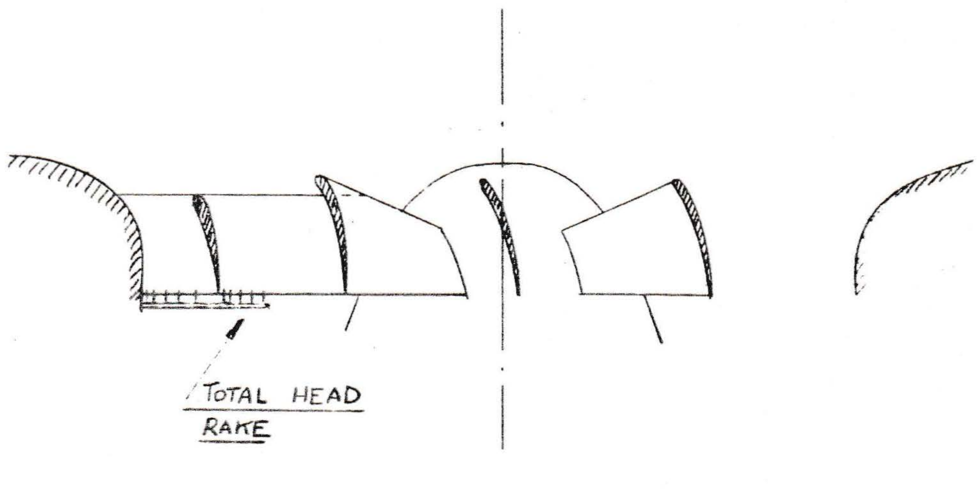


FIG. 8 FAN INTAKE GUIDE VANES