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HEADQUARTERS
AIR MATERIEL COMMAND

MCIA/JCB/amb
Wright-Patterson Air Force Base
Dayton, Ohio
23 APR 1948

MCIA

SUBJECT: Project "SIGN"

TO: Chief of Staff
United States Air Force
Washington 25, D. C.
ATTN: Director of Intelligence

1. This is an initial report on unidentified flying objects as directed by Hq, USAF letter dated 30 December 1947, signed by General L. C. Craigie, subject: "Flying Discs". Quarterly reports will be submitted beginning 1 July 1948.

2. As a result of this letter, Project HT-304 was activated on 26 January 1948 and Technical Instruction 2185, dated 11 February 1948, was published. Present files on Project "SIGN" represent a consolidation of reports received directly by Hq, AMC and those forwarded by the Director of Intelligence, USAF.

3. Schedules of activities of lighted night-flying advertising blimps have been secured and cross-checked at this Headquarters to consider them as a possible source of incident reports.

4. Inclosure 1 represents a tabulation and breakdown of all available reports through 1 February 1948.

5. The following is a series of interesting observations that were noted when reviewing the many incident cases:

a. High rate of climb, as well as the apparent ability to remain motionless or hover for a considerable length of time.

b. The object was described as being oval, disc or saucer-shaped 31 times.

c. Associated sound was present 11 times.

d. Reported sizes have varied from that of a 25-cent piece to 250 feet in diameter, and from the size of a pursuit plane to the bulk of six B-29 airplanes.

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AMC
Subject: Project "SIGN"

23 APR 1948

e. Number of objects per sighting:

Objects per sighting	1	2-5	5-10	over 10
Number of sightings	77	21	8	9

f. Exhaust trails were reported 23 times.

g. Speed has been estimated throughout the entire range from very slow or hovering to supersonic.

6. Inclosures 2 and 3 are enlargements of photographs taken of Incident #40. Inclosure 4 is an evaluation of inclosure 2 by this Headquarters. Attention is invited to the marked similarity between inclosures 2 and 3, and inclosure 5. Similarity also exists between inclosures 2 and 3 and configurations illustrated in inclosure 6.

7. Representatives from this Headquarters visited Dr. Irving Langmuir of the Research Laboratories, General Electric Company, Schenectady, N. Y. to discuss Project "SIGN". It was the opinion of this scientist that present available data does not encompass sufficient information to enable a positive identification to be made. Dr. Langmuir was reluctant to consider the so-called "flying discs" as a reality. However, it is believed at this Headquarters that it is possible to construct a low aspect ratio aircraft that would duplicate many of the appearance and performance characteristics of reported "flying discs". Experts have agreed that this would be possible through the intelligent application of boundary layer control.

FOR THE COMMANDING GENERAL:

H M McCoy
H. M. McCOY
Colonel, USAF
Chief of Intelligence

6 Incls
1. Tabulation
2. Photo
3. Photo
4. Eval of Incl 2
5. Horten Parabola
6. Biology of Flying Saucer

Incident No.	Date	Hour	Location	No. Sighted	Observed From
1	8 Jul 47	0930	Muroc Air Field, Muroc, Calif.	2	Ground
1a	8 Jul 47	0930	Muroc,Air Field, Muroc, Calif.	2	Ground
1b	8 Jul 47	0930	Muroc Air Field, Muroc, Calif.	2	Ground
1c	8 Jul 47	0945	Muroc Air Field, Muroc, Calif.	2	Ground
1d	8 Jul 47	1000	Muroc Air Field, Muroc, Calif.	3	Ground
1e	8 Jul 47	1000	Muroc Air Field, Muroc, Calif.	3	Ground
2	8 Jul 47	1200	Muroc Air Field, Muroc, Calif.	1	Ground
3	7 Jul 47	1010	Muroc Air Field, Muroc, Calif.	1	Ground
4	8 Jul 47	1150	Area #3, Rogers Dry Lake, Muroc Air Field, Muroc, Calif.	1	Ground
5	4 Jul 47	1305	Portland, Oregon	5	Ground
6	4 Jul 47	1305	Milwaukee, Oregon	3	Ground
7	4 Jul 47	1305	Portland, Oregon	1	Ground
8	4 Jul 47	1305	Portland, Oregon	3	Ground
9	4 Jul 47	1305	Portland, Oregon	undetermined	not stated
10	4 Jul 47	2004	Boise, Idaho	5	Air
11	4 Jul 47	not stated	Seattle, Washington	1	Ground
12	4 Jul 47	1305	Vancouver, Washington	20-30	Ground
13	4 Jul 47	1400	Portland, Oregon	4	Ground
14	4 Jul 47	1630	Portland, Oregon	1	Ground
15	4 Jul 47	1700	Portland, Oregon	3	Ground
16	4 Jul 47	1100	Mount Jefferson near Redmon, Oregon	4	Ground
17	24 Jun 47	1500	Mt. Rainier, Washington	9	Air
18	not stated	not stated	Toronto, Canada	1	Ground
19	20 Oct 47	1320	Dayton, Ohio	2	Ground
20	20 Oct 47	1100	Xenia, Ohio	1	Ground

Inc 1

Incident No.	Date	Hour	Location	No. Sighted	Observed From
21	29 Jun 47	1645	Des Moines, Iowa	18	not stated
22	21 Jun 47	about noon	Spokane, Washington	several	Ground
23	30 Jun 47	1745	Boise, Idaho	1	Ground
24	12 Jun 47	1815	Weiser, Idaho	2	Ground
25	4 Jul 47	2345	West Trenton, N. J.	1	Ground
26	10 Jul 47	not stated	Harmon Field, Newfoundland	1	Ground
27	10 Jul 47	2000Z	Harmon Field, Newfoundland	1	Ground
28	24 Jun 47	not stated	Idaho	1	Ground
29	23 Jun 47	not stated	Bakersfield, Calif.	10	Ground
30	7 Jan 48	1925EST	Lockbourne AB, Columbus, Ohio	1	Ground
30a	7 Jan 48	1925EST	Lockbourne,AB, Columbus, Ohio	1	Ground
30b	7 Jan 48	1915EST	Lockbourne AB, Columbus, Ohio	1	Ground
30c	7 Jan 48	1940	Lockbourne AB, Columbus, Ohio	1	Ground
31	mid-December 1946	early a.m.	Northern Arizona	1	Ground
32 32	not stated	after dark	Columbus, Ohio	1	Air
33	7 Jan 48	1330-1700	Godman Field, Ky. (south of)	1	Ground
33a	7 Jan 48	1400CST	Godman Field, Ky.	1	Ground
33b	7 Jan 48	1320CST	Godman Field, Ky.	1	Ground
33c	7 Jan 48	1420 CST	210° from Godman Field, Ky.	1	Ground
33d	7 Jan 48	1400	Godman Field, Ky.	1	Ground
33e	7 Jan 48	1430-1600	Godman Field, Ky.	1	Ground
33f	7 Jan 48	1445	Godman Field, Ky.	1	Air
33g	7 Jan 48	1854-1906	Madisonville, Ky.	1	Ground
34	13 Oct 47	0530	14 miles north of Dauphin, Manitoba, Canada	1	Ground
35	12 Nov 47	early a.m.	Ticonderoga at sea (40 miles south of Cape Blanco, 20 miles off shore)	2	Boat

INCIDENT No.	Date	Hour	Location	No. Sighted	Observed From
36	Not Stated	Not Stated	Boise, Idaho	1	Ground
37	12 Oct 47	1200	Cave Creek, Arizona	1	Ground
38	10 Jun 47	Not Stated	Budapest, Hungary	1	Ground
39	9 Jul 47	2330	Grand Falls, Newfoundland	5	Ground
40	7 Jul 47	1600	Phoenix, Arizona	1	Ground
41	11 Jul 47	Not Stated	Elendorf Field, Alaska	1	Ground
42	12 Jul 47	0430Z	Elendorf Field, Alaska	1	Ground
43	29 Jun 47	1645	Clarion, Iowa	18	Ground
44	28 Jun 47	1543	Rockfield, Wisconsin	7-10	Ground
45	28 Jun 47	Afternoon	Illinois	7-10	Ground
46	22 Jun 47	1130	Greenfield, Mass.	1	Ground
47	6 Jul 47	Not Stated	Fairfield-Suisun Air Base, Calif.	1	Ground
48	7 Jan 48	1920-1955	Wilmington, Ohio	1	Ground
48a	7 Jan 48	1925	Wilmington, Ohio	1	Ground
48b	7 Jan 48	1910EST	Wilmington, Ohio	1	Ground
48c	7 Jan 48	1930	Wilmington, Ohio	1	Ground
48d	7 Jan 48	1920-1950	Wilmington, Ohio	1	Ground
49	9 Jan 48	2300-2315	Danville, Kentucky	1	Ground
50	10 Jan 48	2200	Wildwood, New Jersey	One at this date, previously 1 each 27 Dec, 3 Jan all at 2000 o'clock.	Ground
51	3 Sept 47	1215	Oswego, Oregon	12-15	Ground
52	29 Jul 47	1450	Hamilton Field, California	2	Ground
52a	29 Jul 47	After 1200	Hamilton Field, California	2	Ground
53	28 Jun 47	1515	Lake Mead, Oregon	5-6	Air
54	16 Jan 47	2230	North Sea (50 miles from the Dutch Coast)	1	Air
55	23 Jul 47	0345Z	Harmon Field, Newfoundland	1	Ground

Incident No.	Date	Hour	Location	No. Sighted	Observed From
56	6 Jul 47	2045	Birmingham, Alabama	7-10	Ground
57	20 Jul 47	0015Z	Aboard the Burgeo (at Sea one hr. from Sydney, Australia)	1	Boat
58	4 Aug 47	Evening	Bethel, Alaska	1	Air
59	14 Sept 47	0558GCT	Necker Island	1	Air
60	10 Jul 47	1000	Cordroy, Canada	1	Ground
61	8 Sept 47	2230	Salt Lake City, Utah	12	Ground
62	8 Sept 47	2230-2300	Salt Lake City, Utah	5 groups each containing 35-60 objects.	Ground
63	29 Jul 47	1205	Canyon Ferry, Montana	1	Ground
64	19 Aug 47	2130	Twin Falls, Idaho	Approx. 55.	Ground
65	2 Jun 47	Not stated	Rehoboth Beach, Deleware	1	Ground
66	10 Aug 47	2100	Silver Springs, Ohio	1	Ground
67	14 Aug 47	1600	Placerville, California	1	Ground
68	24 Jun 47	Not stated	Cascade Mountains, Portland, Oregon	6	Ground
69	6 Aug 47	2230-2245	Philadelphia, Pa.	1	Ground
70	6 Aug 47	1045	Philadelphia, Pa.	1	Ground
71	8 Oct 47	Not stated	Las Vegas, Nevada	1	Ground
72	Not stated	Not stated	Fort Richardson, Alaska	1	Ground
73	4 Aug 47	1600	Boston (10 miles NW) Mass.	2	Air
74	24 Jun 47	App. 1500	Mt. Adams, Washington	Not Stated	Ground
75	13 Aug 47	1300	Smoke River Canyon, Idaho	1	Ground
76	13 Aug 47	Morning	Salmon Dam, Idaho	2	Ground
77	3 July 47	1830Z	South Brookville, Maine	10	Ground
78	30 Jun 47	0910 MST	Grand Canyon, Arizona	2	Air
79	Apr 47	1100 EST	Richmond, Virginia	1, others on other occasions	Ground

Incident No.	Date	Hour	Location	No. Sighted	Observed From
80	7 Jul 47	2230-2300EDT	Arlington, Virginia	1	Ground
81	7 Jul 47	0900	Hickam Field, Hawaii	1	Ground
82	17 May 47	2030-2100	Oklahoma City, Oklahoma	1	Ground
83	9 Jul 47	1217	Boise (Between Boise and Meridian) Idaho	1	Air
84	7 Jul 47	1300-1400EST	Lakeland, Florida	5	Ground
85	14 Jun 47	1200	Portland, Oregon	10	Ground
86	6 July 47	Not stated	Hollywood, California	1	Ground
87	Not stated	Not stated	Habberbishopshiem (20 miles north) Germany	1	Ground
88	3 Aug 47	Afternoon	Hackensack, N. J.	1	Ground
89	6 Jul 47	1345	Kansas City (100 miles west), Kansas	1	Air
90	29 Jun 47	1300-1330	Las Cruces, New Mexico	1	Ground
91	28 Jun 47	2120-2145	Maxwell Field, Alabama	1	Ground
92	19 Jun 47	1215-1315	Colorado Springs, Colorado	1	Ground
93	11 Jan 48	1 1630	Hartford, Connecticut	1	Air
94	30 Dec 47	1926PST	Between Great Falls, Montana and Fairfield, California	1	Air
95	30 Dec 47	1925PST	Rosedale, California	1	Air
96	30 Dec 47	1926	Lovelock (30 miles west), Nevada	1	Ground
97	30 Dec 47	1925PST	Between Medford and Mt. Chasta, Oregon	1	Air
98	2 Nov 47	Daybreak	Houston, Texas	1	Ground
99	3 Jan 48	Not stated	Vassa, Finland	1	Ground
100	5 Jan 48	Not stated	Pretarsaari, Finland	1	Ground

Incident No.	Observer's Occupation	Maneuvers	Weather
1	1st Lt, USAF	None - horizontal flight	Not stated
1a	S/Sgt, USAF	Not stated	Not stated
1b	Unknown	Not stated	Not stated
1c	S/Sgt, USAF	Not stated	Not stated
1d	Pfc, USAF	Flying in tight circle	Not stated
1e	Not stated	Horizontal and tight circles	Not stated
2	Maj, USAF	Descended from an intermediate altitude in an oscillating fashion almost to the ground, then started climbing again to a very high altitude and moved off slowly in the distance.	Not stated
3	Major, USAF	Oscillating in a downward twirling movement	Not stated
4	Capt, USAF	Falling at three times the rate of a parachute	Not stated
5	Patrolman, Portland Police Dept.	Dipping up and down in oscillating motion	Not stated
6	Sgt, Oregon Police	Following each other	Clear with little or no cloud formation
7	Patrolman, Portland Police Dept., former Air Force pilot	Not stated	Clear with little or no cloud formation
8	Patrolman, Portland Police Dept. Private pilot	Straight line formation; last disc fluttered very rapidly in side-way arc	Clear with little or no cloud formation
8a	Patrolman, Portland Police Dept. Private pilot	Straight line formation; last disc fluttered very rapidly in side-way arc	Clear with little or no cloud formation
9	Capt., Harbor pilot	Discs would oscillate and sometimes a full disc would be visible, then a half-moon shape, then nothing at all	Not stated

Incident No.	Observer's Occupation	Maneuvers	Weather
10	Capt, United Airlines	Straight-away horizontal flight	Not stated
11	Coast Guard	Horizontal flight	Not stated
12	Deputy Sheriff	Not stated	Not stated
13	Not stated	Not stated	Not stated
14	Not stated	Flipping around	Not stated
15	Not stated	Not stated	Not stated
16	Not stated	Not stated	Not stated
17	Private pilot	Straight horizontal flight	Clear as crystal
18	Not stated	Horizontal flight	Clear
19	Farmer	Straight course - were flying about a city block apart, one behind the other	Cloudless and sunny
20	Not stated	Straight course	Not stated
21	Not stated	Single file	Not stated
22	Not stated	Flashing	Not stated
23	Not stated	Horizontal flight	Not stated
24	Not stated	Shooting up and down	Clear
25	Not stated	Horizontal flight	Bright moonlight
26	Mechanic	Not stated	Not stated
27	TWA Representative	Not stated	Clear
28	Lt Governor	Not stated	Not stated
29	West Coast Pilot, 7000 hrs.	Not stated	Not stated
30	Capt, USAF, Asst Operations Officer	Climbing and descending vertically	Solid overcast
30a	VHF/DF Operator	Hovering, made three 360° turns around one place. Moved to another position and circled more. Turns required 30-40 sec. Diameter estimated at 2 miles.	Overcast, 1000 ft.

Incident No.	Observer's Occupation	Maneuvers	Weather
30b	Traffic Air Controller	Bobbing up and down	Overcast
30c	Not stated	Climbing and descending	High overcast
31	Professor and Head of Aero Engineering	None	Clear
32	Lt, USAF	None	Overcast
33	T/Sgt, USAF	None	High scattered clouds Visibility unlimited.
33a	1st Lt, USAF	None	High scattered
33b	PFC	None	Not stated
33c	Capt, USAF	May have been turning	High overcast with BKS
33d	Capt, USAF	None	High scattered, visibility unlimited
33e	Col, Ky. State Police	None	Clear
33f	Capt, USAF (Flight Leader NG 869)	Not stated	Not stated
33g	Unknown	Not stated	Not stated
34	Judge	None	Clear
35	Second Officer, Navy	None	Not stated
36	CAA Official	Not stated	Not stated
37	Pilot	None	Clear
38	Hungarian Peasants	Not stated	Not stated
39	Constable	None	CAVU
40	Not stated	Spiraled downward from 5,000 to 2,000 ft and then went upward at a 45° angle	Cumulus clouds

Incident No.	Observer's Occupation	Maneuvers	Weather
41	Colonel, USAF	Not stated	Not stated
42	Major, USAF	Not stated	Not stated
43	Bus Driver	None	Not stated
44	Not stated	None	Not stated
45	Not stated	Not stated	Not stated
46	Not stated	None	Cloud banks.
47	Captain, USAF	Rolled from side to side	Not stated
48	Major, USAF	Ascending and descending	Not stated
48a	T/Sgt	Up and down and side to side	Cold and clear with few scattered clouds.
48b	Cpl.	Ascending and descending	Light scattered clouds with haze towards S/W.
48c	S/Sgt	Ascending and descending very rapidly	Clear with over-cast in S/W.
48d	Not stated	Ascending and descending	Clear to scattered.
49	Not stated	None	Not stated
50	Knitting designer	Approaching shore from Ocean then rise and fall slowly.	Not stated
51	Not stated	Not stated	Not stated
52	Capt, USAF, ASST. Operations Officer and instructor Pilot	Horizonal left to right, right to left like a guard in an airplane formation.	Clear
52a	1st Lt. in Air Reserves former B-29 Pilot	Similar to a fighter aircrafts maneuvers when accompanying heavier ships.	Not stated
53.	1st Lt, USAF, Pilot	Horizonal very close formation	Not stated
54	Mosquito Pilot	Efficient controlled evasive action	Not stated
55	Government Employee	Abrupt darts	High scattered condition visibility 15 miles.
56	S/Sgt, USAF	Traveling in a defimite arc.	Not stated

Incident No.	Observer's Occupation	Maneuvers	Weather
57	Bridge Construction	Not stated	Clear and dark.
58	Chief Pilot-Flying service	Not stated	Not stated
59	Pilot	None	Not stated
60	Storekeeper	Not Stated	Clear at dusk
61	Not stated	None	Not stated
62	Not stated	Not stated	Cloudy
63	Not stated	Hovering and fluttering, rising and descending.	Scattered small clouds.
64	Executive Direct-or of Housing Authority.	Horizonal	Overcast
65	Pilot	Not stated	Not stated
66	Lt. Col, GSC Scientific Branch Research Group.	Horizonal Flight	Not stated
67	Insurance Adjuster	None	Clear
68	Prospector	Banking	Clear
69	Not stated	Not stated	Not stated
70	Insurance Agent	Not stated	Clear
71	Capt. AC Reserves	Not stated	Clear
72	Army Officer	Not stated	Cloud formation scattered above 10000 ft.
73	Navigator (Constellation type aircraft)	Not stated	5/10 scattered cumulus with tops at 10000, visibility 10 miles.
74	Prospector	Standing on edge and banking in the clouds.	Not stated
75	Trout Farm Oper.	Rode up and down over the hills and hollows of the canyon floor.	Not stated
76	County Commissioner	Not stated	Not stated

Incident No.	Observer's Occupation	Maneuvers	Weather
77	Astronomer	Not stated	Not stated
78	Lt, USN (P80 Pilot	Not stated	Not stated
79	Weather reporter	Not stated	Clear
80	Lt. Col, USAF	Not stated	Scattered clouds visibility 10-12 miles.
81	Civil Service Employee	Ascending slowly	Cloudy
82	Field Engineer	Not stated	Not stated
83	Pilot	Slow roll or barrel	Some clouds
84	Sign Painter	Climbing	Clear-scattered clouds
85	Private Pilot	Not stated	Not stated
86	Not stated	Turned a corner and seemed to roll.	Clear
87	U. S. Army	Descended slowly and then dropped in a spiral motion.	Not stated
88	Not stated	Not stated	Not stated
89	Major, USAF	Not stated	CAVU
90	Administrative Asst, Rocket Sonde Section	Not stated	Clear
91	Captain	Traveling in zig-zag course	Clear
92	Railroad Employees	Climbing, diving and reversal of direction which happened every few seconds.	Clear and sunny
93	Capt, USAF	Shooting towards the east at 45° angle	Not stated
94	Lt Col, Hq, EPW	Descending vertically - seemed to slow down on nearing the earth	Not stated
95	C-47 crew	Not stated	Not stated
96	Not stated	Not stated	Not stated
97	Airplane crew	Not stated	Not stated
98	Immigration Service	Appeared to be spinning in its descent	Not stated
99	Not stated	Not stated	Not stated
100	Not stated	Not stated	Not stated

Incident No.	Color	Shape	Size	Sound
1	Silvery	Not stated	Not stated	Not stated
1a				
1b				
1c	Silvery	Saucer shaped	Not stated	None
1d	Reflected the sun's rays	Disc	Not stated	Not stated
1e	Silvery	Disc	Not stated	None
2	Aluminum colored surface	Thin metallic object, unconventional shape	Pursuit ship	Not stated
3	Yellowish-white	Spherical	5 - 10 ft, diameter	Not stated
4	White aluminum	Distinct oval outline; two projections on upper surface which might have been thick fins or nobs. These crossed each other at intervals, suggesting either rotation or oscillation of slow type	50 ft.	None
5	Not stated	Round	Not stated	None
6	Whitish-brown	Disc	Not stated	None
7	Aluminum	Disc	Not determined	None
8	White	Disc	Out of sight before detailed observation made	None
8a	White	Disc	Out of sight before detailed observation made	None
9	Like shiny chromium hub cap	Disc	Not stated	Not stated
10	Not stated	Thin and smooth on bottom; rough appearing on top	Not stated	Not stated

Incident No.	Color	Shape	Size	Sound
11	White	Saucer	Not stated	Not stated
12	Not stated	Like flock of geese	Not stated	Low humming sound
13	Resembled metallic	Not stated	Not stated	Not stated
14	Like a new dime	Like a new dime	Like a new dime	Not stated
15	Silver	Not stated	Not stated	Not stated
16	Not stated	Disc	Not stated	Not stated
17	Mirror bright	Approximately circular, no tail	Diameter equal to distance between outboard engines of DC 4	Not stated
18	Yellow	Ball	Not stated	Not stated
19	Reflected the sun brilliantly	Like cigars - much longer than wide	Not stated	None
20	Silver	Round	About 12 inches in diameter	None
21	Dirty white	Between circle and oval - inverted saucer	175-250 ft. diameter 12 ft. thick	Like electric motor or dynamo
22	Shiny silvery	Slim body	Quite large	Not stated
23	Bright and silvery	Half-circle	Not stated	Not stated
24	Glistened in sun	Too far away to determine shape	Too far away to determine shape	None
25 25	Luminous	Flying saucer - no tail	Not stated	Not stated
26	Not stated	Not stated	Not stated	Not stated
27	Silvery	Circular in shape like a wagon wheel	Same span as C-54 at 10,000 ft.	Not stated
28	Not stated	Comet-like	Not stated	Not stated
29	Not stated	Almost round	Not stated	Not stated
30	White (light)	Not stated	Not stated	None

Incident No.	Color	Shape	Size	Sound
30a	Amber	Round or oval	C-47 airplane	None
30b	Bright white to amber	Cone-shaped, blunt on top and tapering off toward bottom	Enormous	None
30c	White (light)	Round	Comparable to runway light	None
31	White	Not stated	Not stated	None
32	Amber	Not stated	Not stated	None
33	Sun flashes on metal or metallic	Roughly circular	At the distance and altitude the object appeared to be the size of silver dollar	None
33a	White or luminous. Turned to be more red as the sun set	Round tending to be conical	Unknown - altitude and distance too great	None
33b	Not stated	Cone, topped with red	Not stated	None
33c	Silver with shadow	Raindrop	Unknown - believed to be large	Unknown
33d	White	Round at times - cone shaped	Uncertain because of distance	None
33e	White	Round	1/4 size full moon	None
33f	Metallic	Not stated	Tremendous	Not stated
33g	Not stated	Cone	100 ft. high, 43 ft. across	None
34	Redish tinge	Round	Large grapefruit	None
35	Fire color	Ball	Not stated	Not stated
36	Not stated	Not stated	Not stated	Not stated
37	Reddish with blue background. Black with white background	Not stated	3 ft. from point of view	None
38	Silver	Ball	Not stated	Not stated

Incident No.	Color	Shape	Size	Sound
39	Phosphorus	Egg-shaped discs	Not stated	Not stated
40	Gray	Elliptical	20-30 ft.	Noise like jet aircraft prior to its appearance. No audible sound heard while object was in view.
41	Aluminum	Round	3 ft. diameter	Not stated
42	Grayish	Balloon	10 ft diameter	Not stated
43	Dirty white	Between a circle and an oval (Inverted saucer)	12 ft thick and 175-250 ft diameter	Electric Motor or dynamo
44	Not stated	Flying Saucers (not actually described as being this shape)	Not stated	None
45	Not stated	Not stated	Not stated	Not stated
46	Silvery white	Round	Small	Not stated
47	No definite color top side reflected light.	No definite shape	C-54 airplane	Not determined due to the noise of airplane.
48	Red	Flaming Red cone	Not stated	Not stated
48a	Bright light changing to red then to white or yellow	Circular-like a star in the sky only larger.	Very large compared to an aeroplane light.	None
48b	Red - when descending	Cone	Not determined	Not stated
48c	Red when moving then grean and black to red.	Not stated	Not stated	Not stated
48d	Yellow or flame colored.	Not stated	Not stated	Not stated
49	Not stated	Pencil shaped object	Not stated	Not stated

Incident No.	Color	Shape	Size	Sound
50	Stated as queer light.	Referred to as saucer but not stated as being of this definite shape.	Not stated	Not stated
51	Silver	Round	Not stated	Not stated
52	White, shiny	Circular like a ball on the bottom but not completely round.	15-25 ft Diameter	Not stated
52a	Milk white	Not stated	Not stated	None
53	White	Circular	36 inches diameter	Not stated
54	Not stated	Not stated	Not stated	Not stated
55	Redish	Not stated	Not stated	None
56	Dim glow of light	Round	2 ft. diameter	None
57	Silver to Red	Not stated	Not stated	Not stated
58	Black	Saucer (not definitely stated as being this shape)	Larger than C-54 airplane	Not stated
59	Incandescent light without appreciable blue and no reddish tinge.	Not stated	Not stated	Not stated
60	Flame color	Disc shaped (the after glow made it look like a cone)	Barrel Head, dinner plate and the size of a plane flying high.	Not stated
61	White and illuminated	Not stated	Size of Pigeons	Not stated
62	Yellowish white	Not stated	Small	Not stated
63	Gleamed and Shimmered	Disc (not actually stated as being of this shape)	3 ft. diameter and of no great thickness.	Not stated
64	Color similar to electric light.	Not stated	Not stated	Not stated
65	Not stated	Not stated	15 inches diameter	Not stated
66	Bright Orange	Not stated	Not stated	Not stated
67	Mutal color highly polished chromium.	top surface slightly curved-larger in front than in the rear.	4-6 ft in length and 10-14 inches wide.	Not stated

Incident No.	Color	Shape	Size	Sound
68	Not stated	Disc - appeared to have a tail.	30 ft diameter	None
69	White	Not stated	Not stated	Buzzing sound.
70	Not stated	Giant fire cracker	Not stated	Buzzing sound not as loud as a rocket ship.
71	Not stated	Not stated	Not stated	Not stated
72	Silver	Sphere(was not like saucer or disc.	2-3 ft diameter	Not stated
73	Deep Gold	Elliptical	15 ft long 2-3 ft in length.	Not stated
74	Not stated	Tapered sharpely to a point in the front end.	30 ft. diameter	None
75	Sky blue	Oblong like a broad rim hat with a low crown.	20 ft. long and 10 ft. thick.	Made a swishing sound.
76	Not stated	Not stated	Not stated	Like the echo of a motor.
77	Light colored	Only concrete evidence of form appeared on the left tangent of the group.	50-100 ft wide.	Loud roar
78	Light gray	Circular	8 ft. diameter	Not stated
79	Silver	Not stated	Larger than a Pibal balloon when observed through a theodolite.	Not stated
80	Reflected white light.	"Blob"	Small airplane	None
81	Silver	Large Balloon with silver disc below it, no attaching cables were noticed.	Large	Not stated
82	Frosty white	Round and flat	Equal to bulk of 6 each, B-29 airplanes with diameter to thickness ratio of 10-1.	A slight swishing.
83	Black	Round	Twenty-five cent piece.	Not stated

Incident No.	Color	Shape	Size	Sound
84	Shinny	Round	Not stated	More or less Shrill.
85	Not stated	Resembled the XF5U-1.	Not stated	Not stated
86	Not stated	Not stated	Not stated	Not stated
87	NotSstated	Not stated	Not stated	Not stated
88	Not stated	Flying disc (not actually described as being of this shape)	Not stated	Not stated
89	Silvery	Round disc shaped object	30-50 ft. diameter	Not stated
90	Reflected light	Uniform with no protuberances such as wings of an airplane	Not stated	Not stated
91	Light	Not stated	Not stated	None
92	Silver	Not stated	Small	Not stated
93	Bluish center with red on its edges	Appeared to be a disc	Resembled a shooting star; however, observers not certain	Not stated
94	Not stated	Not stated	Not stated	Not stated
95	Not stated	Not stated	Not stated	Not stated
96	Not stated	Not stated	Not stated	Not stated
97	Flash of light	Not stated	Not stated	Not stated
98	Bright light	Almost round or perhaps oval or saucer-shaped	26-30 miles diameter	Not stated
99	Shining	Brightly shining object with long tail	Not stated	Not stated
100	Shining	Not stated	Not stated	Not stated

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Incident No.	Exhaust Trail	Heading	Altitude Ft.	Speed	Effect on Clouds
1	None	320°	1000-8000 ft.	300 mph	Not stated
1a					
1b					
1c	Not stated	Northwest	7500-8000 ft.	350-400 mph	Not stated
1d	Not stated	Northwest	7000-8000 ft.	300-400 mph	Not stated
1e	Not stated	Northwest	8000 ft.	300-400 mph	Not stated
2	Not stated	Not stated	From very near the ground to very high	Not stated	Not stated
3	Not stated	West to east	10000-12000 ft.	200-225 mph	Not stated
4	Not stated	North of due east	Under 20000 ft.	Slower than maximum speed of P-80	Not stated
5	Not stated	Two flying south - 3 flying east	Not stated	Great speed	Not stated
6	Not stated	Northwesterly	Undetermined	Terrific	Not stated
7	None	Southwest	30000 ft.	Terrific - faster than any object ever seen by him	Not stated
8	None-	South	40000 ft.	Terrific	Not stated
8a	None	South	40000 ft.	Terrific	Not stated
9	Not stated	South	High over Globe Mills	Terrific	Not stated
10	None	Northwest	Not stated	Cruised for 45 min. at conventional airline speed (180 mph) then rapidly disappeared	Not stated
11	Not stated	Over north end of Lake Washington	Not stated	Not stated	Not stated

CONFIDENTIAL

Incident No.	Exhaust Trail	Heading	Altitude Ft.	Speed	Effect on Clouds
12	Not stated	Not stated	Not stated	Not stated	Not stated
13	Not stated	3 west to east. 1 north	Did not appear very high	Traveling so fast they were out of sight in east in 2-4 seconds	Not stated
14	Not stated	Not stated	Not stated	Moving slowly over sandy district	Not stated
15	Not stated	1 headed southeast. 2 headed northeast	High	Not stated	Not stated
16	Not stated	Not stated	Not stated	Not stated	Not stated
17	Not stated	north to south about 170°	9500 ft.	Not stated	Not stated
18	Trail streaming out behind like vapor trail behind airplane on misty day	Seen over westend of Toronto	Not stated	Not stated	Not stated
19	Like slight trace of steam. Disappeared immediately.	West to east	One mile high	Very fast	Not stated
20	Not stated	Southwest	About 1500 ft.	Fast	Not stated
21	Not stated	N.N.W.	1200 ft.	About 300 mph	Not stated
22	Not stated	S.W. of S.	7000 ft.	Slower than two-motored army plane	Not stated
23	Not stated	Not stated	3000 ft.	Not stated	Not stated
24	Cloud-like vapor - retained shape and persisted for over an hour	Southeast	Very high	Very fast	Not stated

Incident No.	Exhaust Trail	Heading	Altitude Ft.	Speed	Effect on Clouds
25	Not stated	East	High	Fast	Not stated
26	Bluish-black	Not stated	Not stated	Not stated	Cut a clear path through clouds
27	Bluish-black 15 mi. long	Not stated	10000 ft.	Fast	Seemed to cut clouds open
28	Not stated	Not stated	Not stated	Did not move. Seemed to go below horizon with rotation of earth	Not stated
29	Not stated	10 flying north; on reverse course there were only 7	High	300-400 mph	Not stated
30	None (appeared to have bluish streaks out from sides	West	3000	Slow	Not stated
30a	Five times length of object	120°	From very near ground to 1000 ft.	500 mph after it started to leave vicinity	Not stated
30b	Small streak trailing object	S.S.W.	2000-3000 ft.	Exceeding 500 mph	Not stated
30c	Not stated	Not stated	different altitudes	Motionless	Not stated
31	White, heavy	West to east	20000-50000 ft.	600±200 mph	Not stated
32	None	Stationary	3000 ft.	Stationary	None
33	None	None visible	Unknown	none visible	None
33a	None	210° from Godman Field	Extremely high	Stationary	None
33b	None	Not stated	Not stated	Not stated	Not stated

Incident No.	Exhaust Trail	Heading	Altitude Ft.	Speed	Effect on Clouds
33c	Not seen	Appeared to be stationary.	Very high.	Appeared to be stationary.	None
33d	None	210° from Godman Fld.	Uncertain-very high.	Stationary.	Could be seen through cirrus
33e	None	210° from Godman Fld.	25000 ft.	Stationary.	None
33f	Not stated	Approx. 210° from Godman Fld.	15000 ft.	500 mph	Not stated
33g	Not stated	Southwest	4 miles	10 mph	Not stated
34	None	West to east	Not stated	Speed of a meteor or falling star.	None
35	Stream of fire.	Northwesterly	Not stated	700-900 mph	Not stated
36	Not stated	Northeast	Not stated	Not stated	Not stated
37	Not stated	Northeast	8000-10000 ft.	350 mph	Not stated
38	Not stated	Not stated	Not stated	Not stated	Not stated
39	None	East	30000 ft.	Very fast	Not stated
40	Not stated	Appeared from northeast.	5000 ft.	400-600 mph	Not stated
41	Not stated	South	Not stated	Great	Not stated
42	Not stated	Northwest	1500	100 mph	Not stated
43	Not stated	First group S S/E, second group N/W.	1200	300 mph	Not stated
44	Not stated	South	Not stated	Fast	Not stated
45	Not stated	Not stated	Not stated	Not stated	Not stated
46	Not stated	Northwesterly	1000	Faster than an air-plane.	Not stated
47	Not stated	Southwesterly	10000	Faster than any aircraft he had ever seen.	Not stated
48	Gaseous green mist.	S/W when it left the vicinity.	Not stated	Gained and lost altit-ude at a terrific rate.	Not stated

Incident No.	Exhaust Trail	Heading	Altitude Ft.	Speed	Effect on Clouds
48a	Very faint exhaust trail when moving.	S/W when it left the vicinity.	Not stated	Left vicinity at very high speed.	Not stated
48b	Greenish mist when descending.	S/W when it left the vicinity.	Not stated	Not stated	Not stated
48c	Not stated	210 degrees when it left the vicinity.	15000-20000	Not stated	Not stated
48d	None	Approximately due west when it left the vicinity.	From 4000 to very high.	Slow	Not stated
49	Long trail of smoke.	West	Very high	Not stated	Not stated
50	Not stated	Shoreward	Not stated but said to be quite close.	Slow until over land then higher speed while leaving.	Not stated
51	Not stated	Not stated	High	Not stated	Not stated
52	None	Southward	8000-10000	Made a P-80 look like it was motionless in the air.	Not stated
52a	Not stated	120°	6000	Approximately 750 mph.	Not stated
53	Not stated	120°	6000	285 mph.	Not stated
54	Not stated	North Sea to Norfolk	22000	Equal to or greater than a British Mosquito.	Not stated
55	Not stated	NNE	10000	High velocity, stated to be faster than conventional airplane.	Not stated
56	Not stated	South East	2000 ft	500-600 mph.	Not stated

Incident No.	Exhaust Trail	Heading	Altitude Ft.	Speed	Effect on Clouds
57	Not stated	NNE (30° E of true North on horizonal plane.	30° off the horizon at an estimated 1/4 mile range.	High velocity, stated to be faster than a tracer bullet.	Not stated
58	Not stated	N/W	1000	510 mph.	Not stated
59	Not stated	350° later changed to 109°.	9500-10000	1000 knots	Not stated
60	Light flame color.	From N/W heading Eastward.	6000	Very high velocity.	Not stated
61	Not stated	Northern	2000-3000	Faster than birds.	Not stated
62	Not stated	Not stated	Several thousand ft.	High rate of speed.	Not stated
63	Not stated	Northeasterly	3000	Tremendous Speed.	Not stated
64	Not stated	Northeasterly	Not stated	Terrific	Not stated
65	Not stated	West to East	1000	1000-1200mph	Not stated
66	Long straight white streak similar to the streak left by a tracer bullet.	North to South	Low	Required 3-4 seconds to travel 70° arc.	Not stated
67	White trail of smoke.	Not stated	500-1000	Terrific	Not stated
68	Not stated	Southeasterly	6000	Not stated	Not stated
69	Thin streak of greyish color.	South	Not stated	Very fast.	Not stated
70	Either smoke or condensation lasting 2 seconds.	NE to SW	1000-3000	400-500	Not stated
71	May have been smoke or vapor from intense speed, was almost white.	Southeast then turned and went west.	Not stated	7000800	Not stated

Incident No.	Exhaust Trail	Heading	Altitiude Ft.	Speed	Effect on Clouds
72	None	South	Below 10000	Tremendous	Not stated
73	None	Easterly approximately 110° magnetic.	7000	175 mph	Not stated
74	Not stated	Not stated	Not stated	Greater than any-thing ever witnessed.	Not Stated
75	None	East to west	75	Not stated	Not stated
76	Not stated	Not stated	4000-6000	Not stated	Not stated
77	Not stated	Northwest(True)	Not stated	600-1200	Not stated
78	Not stated	Straight down.	Decreasing from approximately 25000.	Inconceivable	Not stated
79	Not stated	East to West	Less than 15000	Not stated	Not stated
80	None	Southeast	Less than 500	Computed at 1350 mph, however ap-peared to move with the speed of a jet aircraft.	Not stated
81	Not stated	Northwest	6000	Not stated	Not stated
82	None	350°	10000-18000	Three times that of a jet aircraft.	Not stated
83	Not stated	Not stated	11000	Not stated	Not stated
84	Not stated	Northeast	7500	Not stated	Not stated
85	Not stated	North	8500	350 mph	Not stated
86	Not stated	Northward	Not stated	Not stated	Not stated
87	Not stated	Not stated	from 5000	Not stated	Not stated
88	Not stated	Not stated	200 yards	moving rap-pidly	Not stated
89	Not stated	East	11000	210 mph	Not stated

Incident No.	Exhaust Trail	Heading	Altitude Ft.	Speed	Effect on Clouds
90	One witness thought he saw vapor trails	Northerly	8000-10000	Not stated	Not stated
91	Not stated	Disappeared in the south-west	Great height	High rate of speed	Not stated
92	Not stated	West	Above 1000	Great speed	Not stated
93	None	Dropped from sight on north side of Mt. Tom near Holyoke, Mass.	Not stated	Very high velocity	Not stated
94	Green and blue flames	Descending ver-tically	From 13000	Very high rate of speed	Not stated
95	Several colors of flames - red and green predominating	Eastward	Low	Very high rate of speed	Not stated
96	Not stated	Not stated	1200-1300	Not stated	Not stated
97	Not stated	Not stated	Not stated	Not stated	Not stated
98	Not stated	Not stated	Not stated	Not stated	Not stated
99	Not stated	West to east	Not stated	Not stated	Not stated
100	Grey streaks were left in sky	North to south	Not stated	Not stated	Not stated

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NOTE: Incident #18

It has now been definitely determined that both the photograph and story were a hoax, perpetrated for publicity and money.

Incident #84

The person making the report on this incident was determined to be an excitable person, very talkative, and possessing an exaggerated imagination and inclined to impress people with his continuous chatter.

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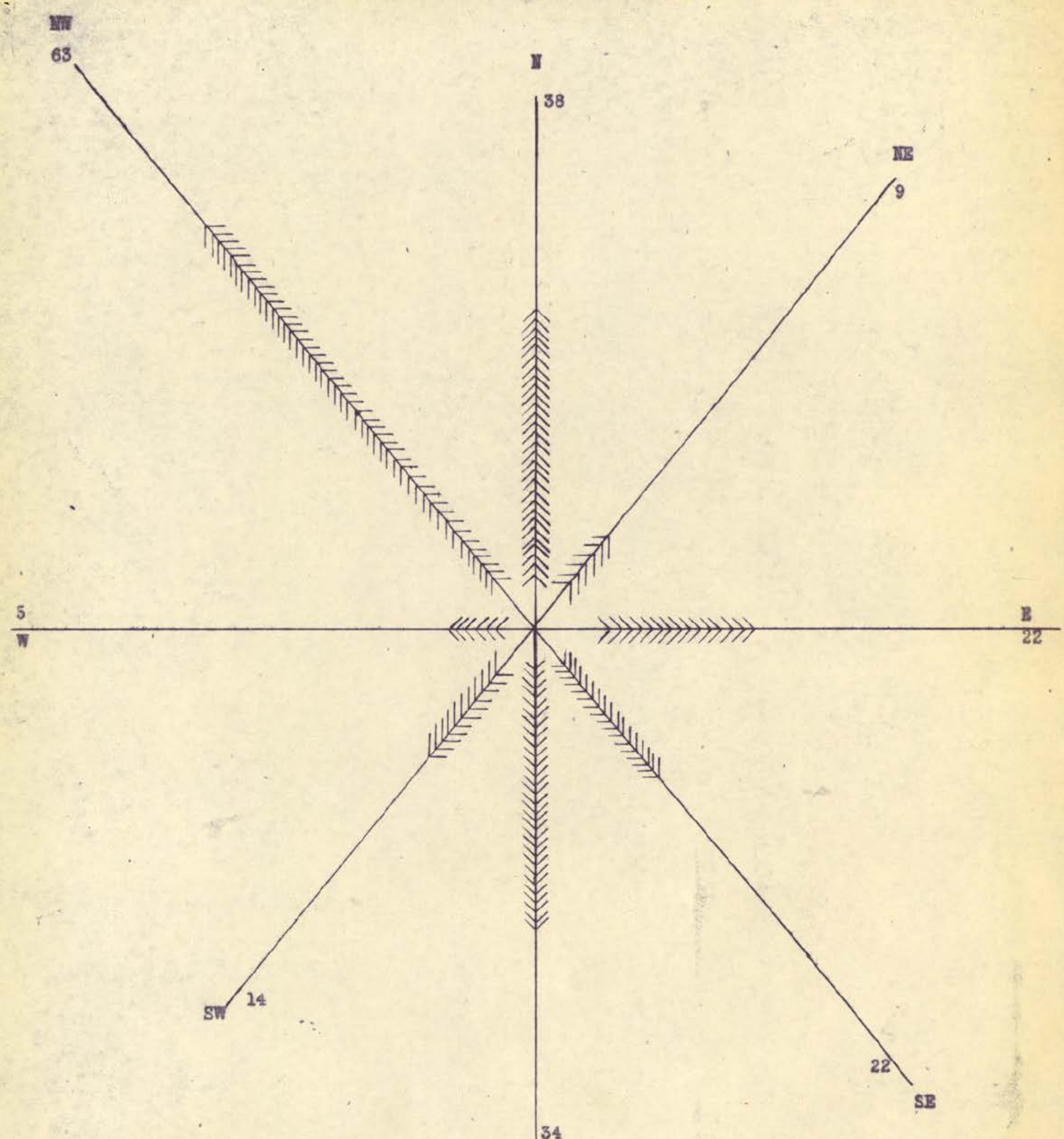
REPORTED DIRECTIONS OF FLIGHT



Circling 15
Straight down 3
Direction Indefinite 64
Direction Not Stated 61

Where an undetermined number of objects were reported the minimum number of objects are plotted. Same object reported by different people only shown once.

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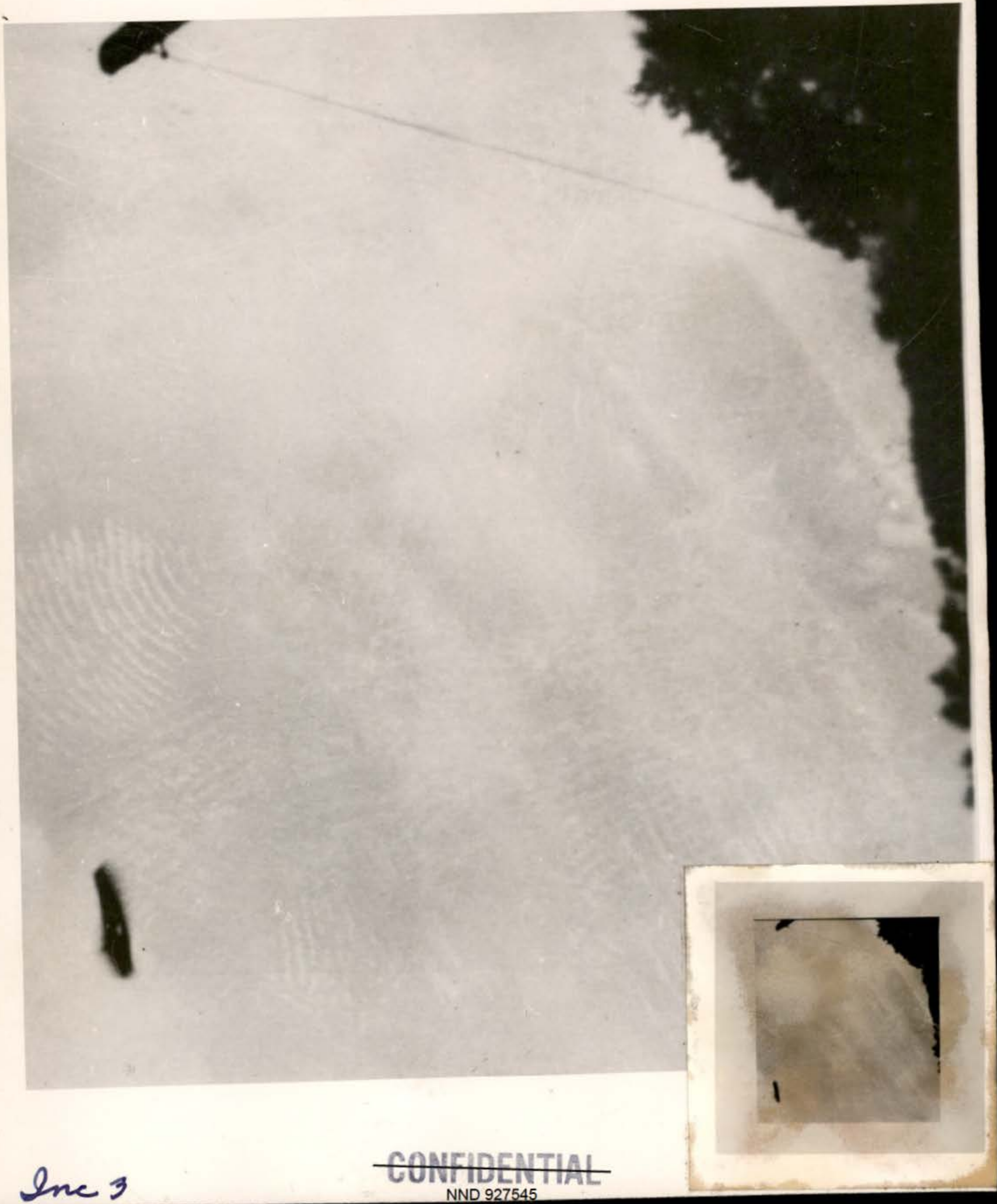
Inc 2

CONFIDENTIAL



Inc 3

Identification of Subject Matter (as per sample)

MCIA MCIT 19 Feb 48 1

1. Reference is made to the films taken by Mr. Rhoades (Incident #40) which were forwarded for examination. The following data were derived from a study of the specimen:

a. It is concluded that the image is of true photographic nature, and is not due to imperfections in the emulsion, or lack of development in the section in question. The image exhibits a "tail" indicating the proper type of distortion due to the type of shutter used, the speed of the object and the fixed speed of the shutter. This trailing off conforms to the general information given in the report.

b. The report states the object was seen at approximately 2000 feet at the time of exposure. The observer also reports being able to see clearly a canopy of enclosure. The visual acuity of an average person would allow for this perception, but certainly not much further as the subject had low visual contrast, being gray against a gray sky. If we can establish the distance from camera to subject, we will have quantity #1. The report states that a 620 camera was used, indicating several possibilities, since the 620 is nomenclature for the spooling and width of the film we may have negatives $2\frac{1}{4}$ x $2\frac{1}{4}$", $2\frac{1}{4}$ x $3\frac{1}{4}$" and $2\frac{1}{4}$ x $4\frac{1}{4}$". The sample submitted had been cut and it was not possible to establish the exact frame size. The $2\frac{1}{4}$ x $2\frac{1}{4}$" size was ruled out, leaving $2\frac{1}{4}$ x $3\frac{1}{4}$" and $2\frac{1}{4}$ x $4\frac{1}{4}$". If it were the former, then the focal length of the lens would be 4", and using 2000 feet as the approximate subject distance and the image size at 7/64", we have an approximate size of 44 feet as the diagonal of the object. Now if we choose the latter value of 5" for focal length, we have an approximate value of 55' for the diagonal. Points of measurement are indicated from x to x on Exhibit "A".

Inc 4

~~CONFIDENTIAL~~

Exhibit "A"

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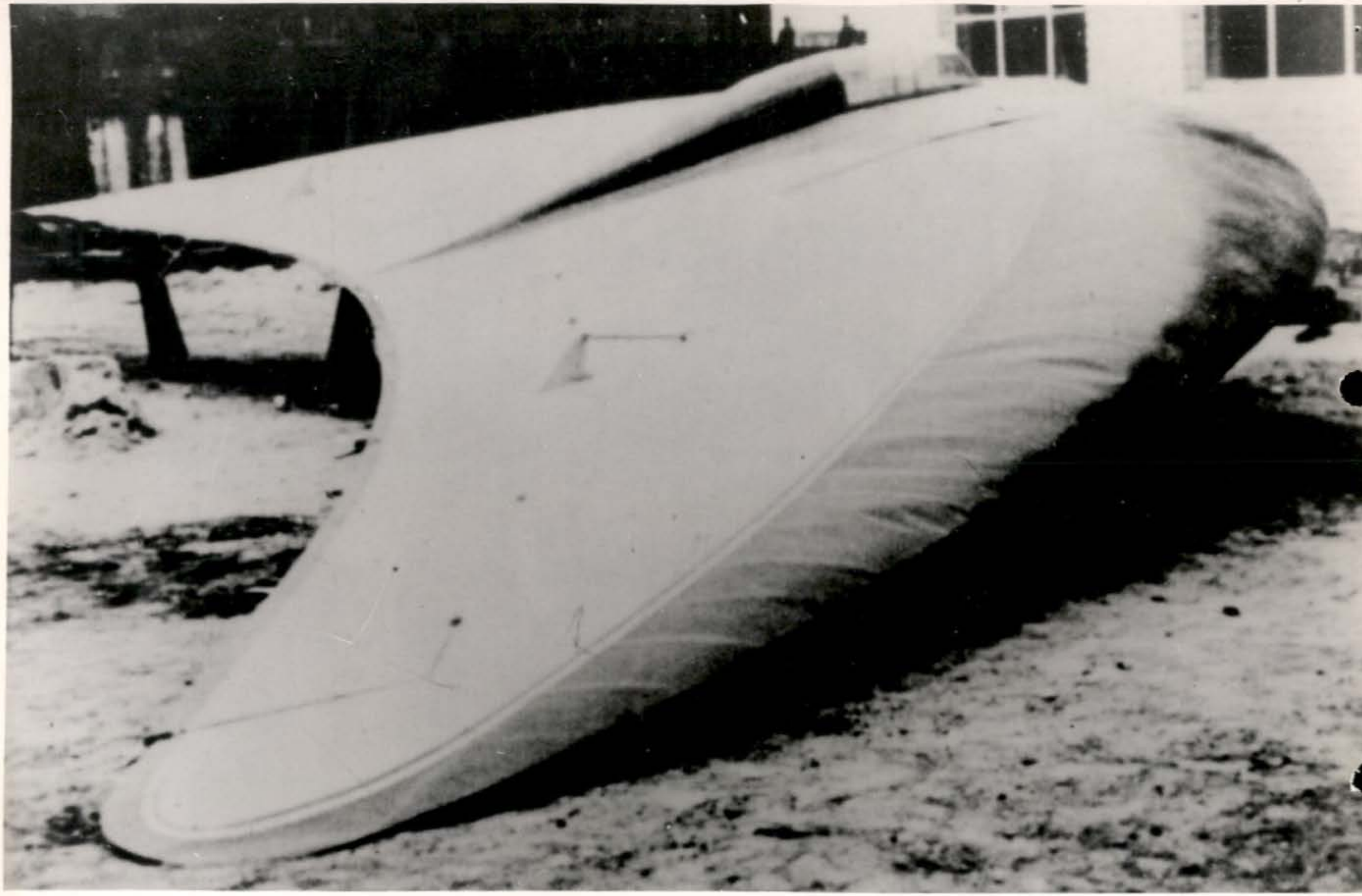
Inc 5



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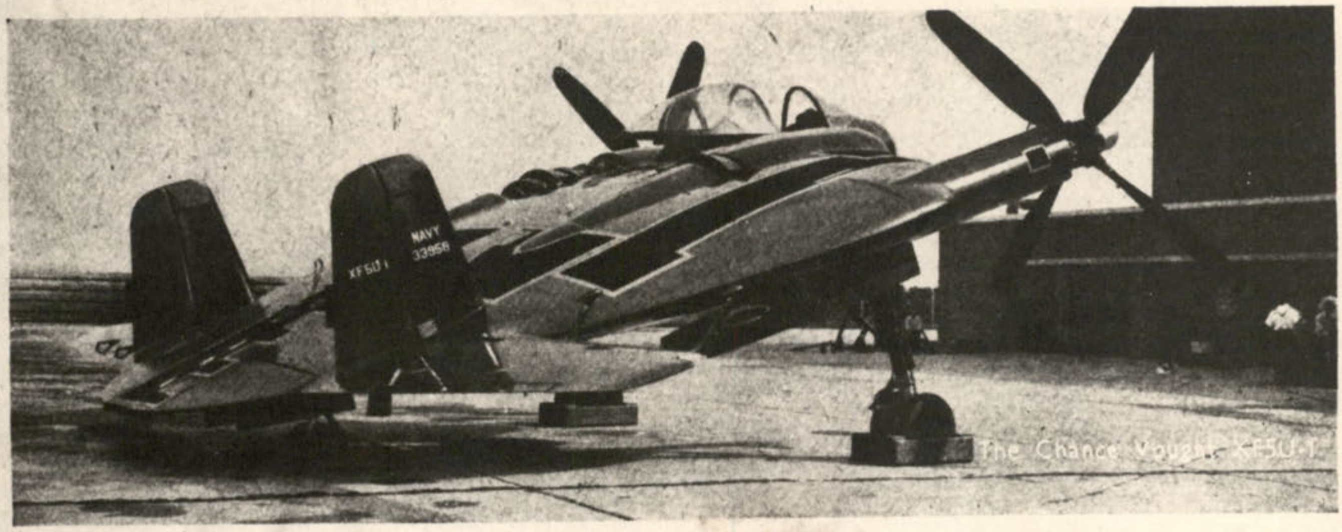
NND 927545

The Biology of the Flying Saucer—I

The Story of Low Aspect Ratio Aircraft

By A. R. Weyl, A.F.R.Ae.S.



SEVERAL MONTHS AGO people on both sides of the Atlantic rushed into print with claims of having observed queer saucer-shaped aircraft which flew very fast. Some maintained, indeed, that they had seen squadrons of such mysterious objects; others described vividly how these celestial saucers were able to descend vertically. All agreed on the saucer-like shape.

Sceptics considered that, for non-aeronautical people living far from the former playgrounds of V.1, V.2, and all the rest of Hitler's "civilizatory" practices, flying saucers might indeed constitute phenomena of threatening aspect, from their experience of domestic disagreements. Doctors, however, hastened to assure the World that saucer-shaped or lenticular objects could well be nothing more than specks in the lenses of the eyes of the observers—the so-called *musae volantes* associated with high blood pressure. Teetotallers blamed the sorry consequences of imbibing intoxicating liquors for the observations. On the other hand, the U.S. Air Force considered the matter serious enough to warrant investigations into the incidents which had been reported.

In the meantime, the occurrence of Flying Saucers has ceased to be news. Presumably, they have all landed. [A new crop was reported in THE AEROPLANE for January 16 last under the heading "Tuppence Coloured."—ED.]

Aeronautical Antiquities and Iniquities

As a matter of fact, saucer-shaped aeroplanes are not quite as new as some people have tried to make out. (Fig. 1.) Quite a number of aircraft have been constructed and flown with wings of the ring or disc type which could well have been mistaken for saucers, hat-brims, spades, doughnuts, diamonds, Greek letters, pancakes, flat-fish, geometrical symbols, dinner plates, and other entirely non-aeronautical commodities.

Moreover, it is quite true, and not even a minor secret, that, at present, aeronautical engineers are paying increased attention to such queer wing shapes; disc wings, for instance, permit certain disadvantages of conventional wings to be overcome. It is even thought that such shapes have been neglected too long.

The blame for their neglect can be ascribed to the doctrine of the induced drag. When the Lanchester-Prandtl aerofoil theory became recognized nearly 30 years ago, and when the sailplane movement proved that slender wings were a necessity for soaring, designers began striving after "good" aspect ratios. The theory blinded their eyes against the possibilities of other than conventional wings. This, however, was not the fault of the theory, as Prandtl soon showed its restrictions.

We have now come to reconsider the matter of wing shape in an objective way, as it is quite possible that aircraft design is approaching a cul-de-sac so long as it retains its bias in

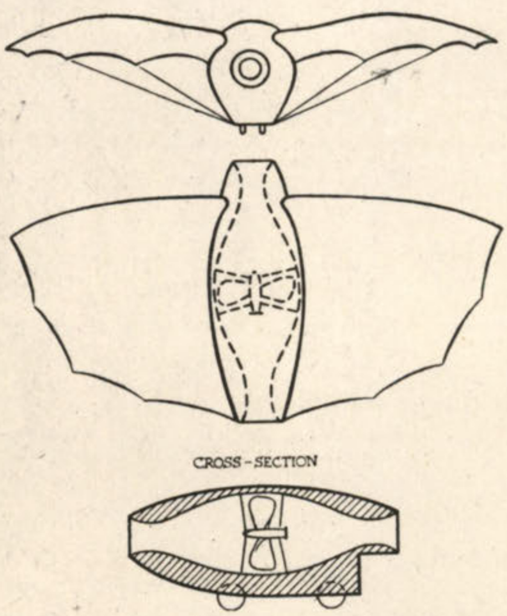


Fig. 1.—"Turbine flying machine" (project) of the Munich engineer Gustave Koch, 1893/1894. Tailless monoplane of low aspect ratio, propelled by a ducted fan. A 50 h.p. steam engine was deemed sufficient for this flying motor car. The design of the duct shows intelligent anticipation.

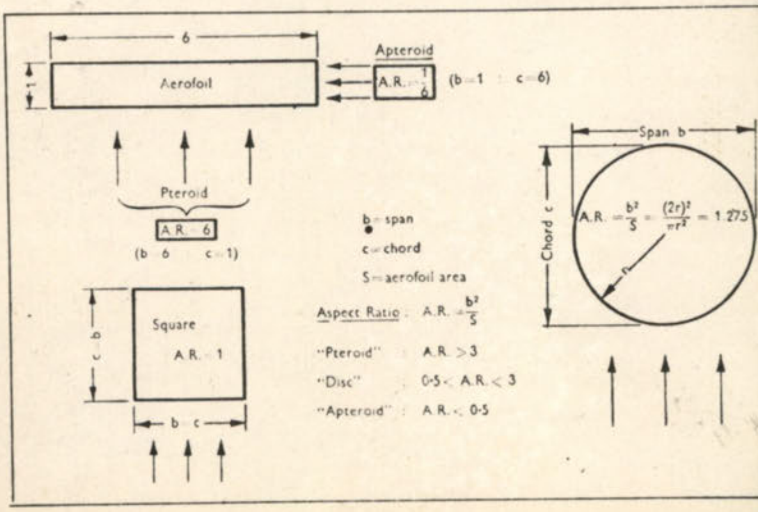


Fig. 2 (Right).—Definition of the aspect ratio of an aerofoil. The arrows signify the direction of the air flow against the wing. The terms pteroid (feather-like) and apteroid have been introduced by F. W. Lanchester.

Inc 6

favour of the "well-tried" convention of "normal" wings. For these reasons, a study of the history of the use of low aspect ratios in wing design will be of interest.

Spiritually, the fathers of such aeronautical exhibits were Englishmen. They were people of good reputation and by no means suspect of aerodynamic perversion.

F. W. Lanchester was undoubtedly the first aerodynamicist to give thought to aeroplane wings of circular or square shape. In his book published in 1907, he referred expressively to such "apteroid" wing shapes (Fig. 2) and advanced the view that Newton's law was valid for these. The correctness of this view was experimentally proved 30 years later.

In a previous article on "Stalling Characteristics of Tailless Aeroplanes" (THE AEROPLANE for August 15, 1947), the early interest taken by F. (now Sir Frederick) Handley Page in the stalling qualities of wings of low aspect ratio was mentioned. He showed, in a paper read in April, 1911, that marginal vortices and pressure-equalizing flow around the tips were responsible for the delay of flow separation which had been observed at high incidences.

He stated, in this connection:—"... With planes of high aspect ratio (i.e., with slender wings of normal span/chord ratio), there is not the same facility for the "feeding in" of fresh air at the plane sides (i.e., at the wing tips) to act as a link between the plane and the live stream, and therefore the live stream leaves the plane's back at an earlier stage than in the case of the plane of lower aspect ratio. . . ." He then showed some experimental evidence for the delay of flow separation with decrease of the aspect ratio and for the greater maximum lift of such wings.

When Lanchester published his book, man was just beginning to spread his wings, and in order to fly with a minimum expenditure in power, wings of fair aspect ratio were a necessity. Nevertheless, there were a few early aeroplanes, notably the little "Demoiselle" monoplane of Santos Dumont (1909-1910), which had an aspect ratio of only 2 and proved to be quite successful.

One of the earliest attempts at a genuine "apteroid" aeroplane was an experiment by a German architect, Flick-Reinig (1910). It had a span of 7½ ft., and performed in hops only.

Annular Aerodynamics

A simple experiment with some paper and a pair of scissors shows that the sinking speed of a circular disc loaded with a paper clip is decreased when a hole of sufficient diameter is cut out in the centre (Fig. 3). This justifies the development from the circular disc wing to the annular aerofoil. The theory of the phenomenon is still somewhat obscure.

(Having tried this experiment, we can confirm that the characteristics of an annular aerofoil are certainly very different from those of the plain disc aerofoil. Our own experiments were admittedly somewhat limited in scope and we were unable to form more than an impression of the relative sinking speeds; it did, however, appear to be less with the annular aerofoil. Our main conclusions were that cutting a 2.25-in. diameter hole in a 5.375-in. diameter disc, resulted in a much flatter glide; the stall was not so abrupt, and the stability in the glide was improved. We were so fascinated with the experiment that we hope to repeat it at a later date on a more scientific level.—ED.)

The conventional aeroplane is constituted of two basic aerofoils: a wing (which supplies the lift) and a tail (which balances and stabilizes the wing). We know that such an arrangement of the two aerofoil components is by no means the only possible one. The balancing and stabilizing aerofoil (tailplane) need not to be aft of the lifting wing as a tail. It can be arranged anywhere in relation to the wing, e.g., above it, below it, or in front of it.

If the balancing aerofoil is in front of the main wing, the aeroplane is of the tail-first type, and if it is attached to the main wing, the tailless aeroplane is created. For all these arrangements, the condition is that, in the case of a wing comprised of normal (unstable) aerofoil sections, the stabilizing aerofoil exerts a certain leverage in relation to the centre of gravity of the aircraft.

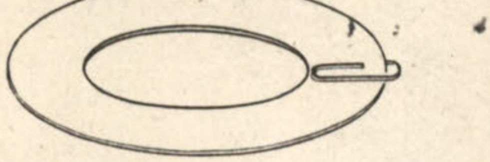


Fig. 3.—A simple experiment in annular aerofoils.

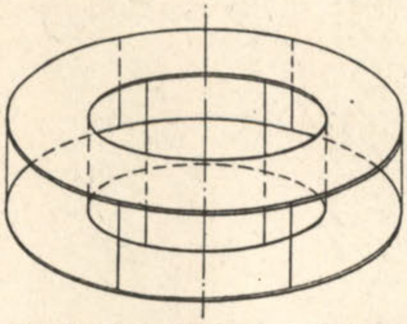


Fig. 4.—Principle of the Huth annular-biplane system.

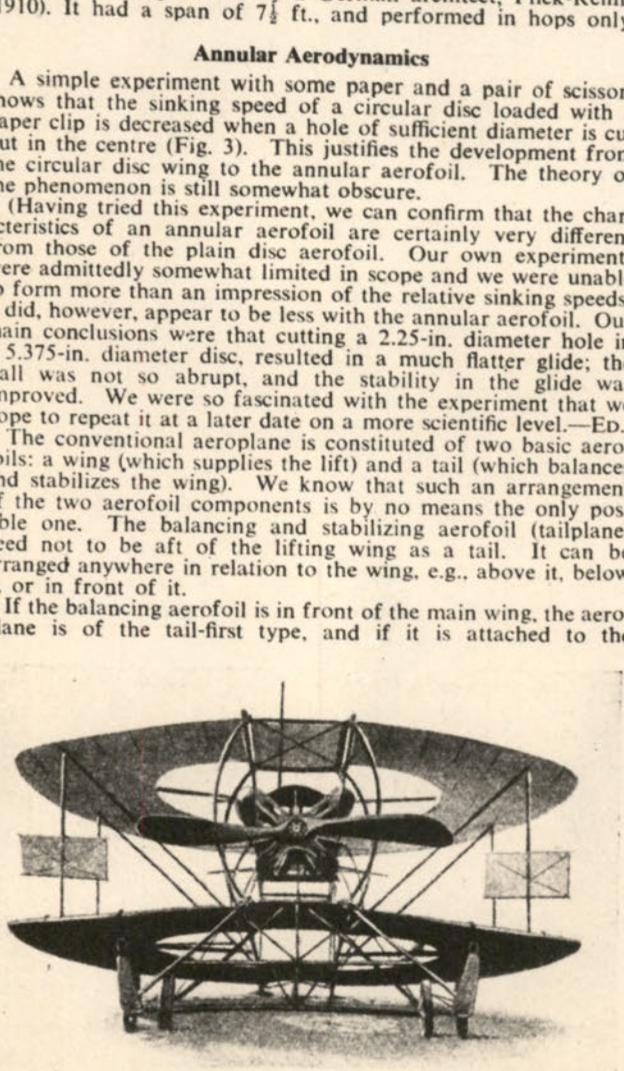


Fig. 5. Kitchen's doughnut of 1911.

Another possibility is to combine two lifting wings so that they will stabilize and balance each other. For this purpose, all that is required is that the front wing shall possess, at all incidences of flight, a greater effective incidence than the rear wing. In other words, the centre of gravity must be nearer to the leading wing than to the trailing wing, and the whole arrangement must be balanced accordingly. In this way, we arrive at the conception of a stable tandem aeroplane.

If we now take such a tandem arrangement and sweep the leading wing back and the trailing wing correspondingly forward so that the tips of both wings merge into each other, we obtain an annular or ring-shaped wing system. Aerodynamically, it is of minor importance if the shape is actually circular or oval, or if triangular or quadrangular shapes constitute the wing. For simplicity's sake, in all such cases considered here, the term "annular" is applied.

As mentioned, the aerodynamics of such shapes cannot yet be considered as fully established. But it is proved that longitudinally stable wing systems can be obtained with such shapes. Some types relying on such wings have shown quite remarkable flying qualities. It is also possible that, with annular wings, the induced drag is less than with conventional wings of equivalent aspect ratio.

In common with circular wings, annular wings have the remarkable property that the lift force steadily increases with incidence up to fairly high values without a stall. For all known arrangements the maximum lift seems to occur at incidences exceeding 30 degrees. As such high angles of incidence are not likely to be reached in flight unintentionally, it is obvious why annular wings have become renowned for their good-natured flying characteristics.

Another property of annular wings (first established by Tilghman Richards) is that the centre of pressure of such wing systems is nearly stationary in flight, or that a travel of the centre of pressure can be obtained which is positively stable until incidences of the order of 18 degrees are reached. In fact, no case of longitudinal instability has ever been reported with an annular wing, although the centre of gravity has often been located dangerously far back.

The first annular-wing aeroplane dates back to 1908. It had little success. Two types were constructed in succession to the designs of a capable German aeronautical engineer, Fritz Huth, who was by profession a teacher at a technical school (Figs. 4 and 6). The second type, which had a less elaborate airscrew drive, flew in May, 1910; it was, however, so devoid of performance, in spite of a 50 b.h.p. engine, that it was soon afterwards discarded as a hopeless proposition.

Britain's First Doughnut

The British conception of the idea has been far more successful. As it is constituted, until now, the best tried representative, its history may be given somewhat more extensively.

The original idea for an annular-wing aeroplane came from G. A. Kitchen, in about 1910; he constructed a biplane with ring-shaped wings, but made no progress with it. The stable flight of Kitchen's models, however, convinced Cedric Lee that an aeroplane of such design would be a success, and late in 1910 he acquired the patents. At the same time, G. Tilghman Richards, who was a qualified aeronautical engineer, became sufficiently interested in the matter to give up a budding engineering bureau in order to join Cedric Lee and to devote his energy to the idea of a "safety" aeroplane.

Tilghman Richards began with systematic experiments on models and on large gliders. Later, careful wind-tunnel tests (including the observation of the pressure distribution) were made by him in a 2-ft. tunnel he had constructed at East London College and also in tunnels of the National Physical Laboratory. The preparation of the design was, therefore, uncommonly careful for this early period of 1911-1914.

In order to appreciate the intentions for the development, the following quotation from a paper read by Tilghman Richards in about 1912 is illuminating:—

". . . The very fact of high lift occurring at small angles means the provision of large area for landing speed resulting in an inefficient attitude of the plane at high speed; and the inherent instability of curved aerofoils means a continual dependence on extraneous controls carried at some distance from the wing by heavy and redundant structure. . . . High lift at small angles is useless, likewise high lift/drag ratio at small angles, and what is required is the reversal of the normal type of lift curve giving little lift at small angles with low value of the lift/drag ratio for landing. . . ."

Seen from our present state of knowledge and development, and facing the burning problems of personal aircraft for the man in the street, it would seem that this opinion is a very good argument for further experimentation along the lines indicated.

The experience with powered aeroplanes was at first beset with disappointments. Famine Point, Heysham, was apparently not a spot from which aeronautical experimenters could derive any comfort.

The original Kitchen biplane with a 50 b.h.p. rotary engine was wrecked by a gale, during 1911, before flight tests could be made. After reconstruction some flights were performed with it at Shoreham during 1911-12; yet it never gave any proof of superior qualities. The biplane had ailerons of the original Farman variety between the wings. Very soon the biplane arrangement was given up in favour of the monoplane.

A subsequent experimental monoplane was nicknamed the "Secret-Circle Plane" or "Doughnut," the experiments being shrouded against publicity (much against the interests of the development). This annular-wing aeroplane (Fig. 7) was equipped with an 80 b.h.p. rotary and test-flown by Gordon England on November 23, 1912, at Shoreham. The flight was remarkable and lucky for the pilot, but unlucky for the precious craft. After having flown a large circuit on the first attempt, the pilot noticed, when coming in to land, that the aeroplane was exceedingly tail-heavy and getting out of control, the elevator being insufficient. At about 150 ft. above the ground the inevitable stall took place; but the pilot managed somehow to drop his mount upside down on to telegraph wires and escaped without personal injury.

With the reconstructed and improved monoplane many successful flights were made by Gordon England, N. S. Percival

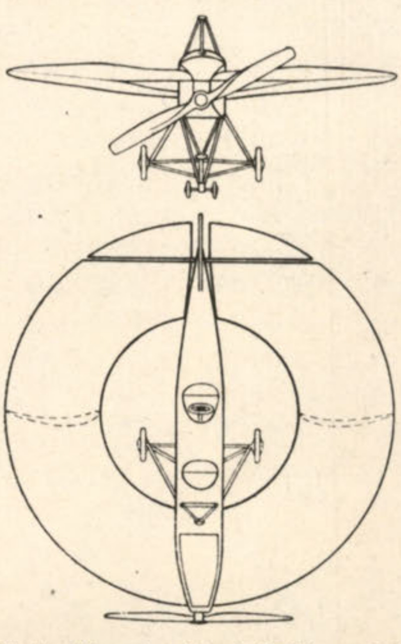


Fig. 7.—Cedric Lee Monoplane No. 1 of Tilghman Richards, 1912.

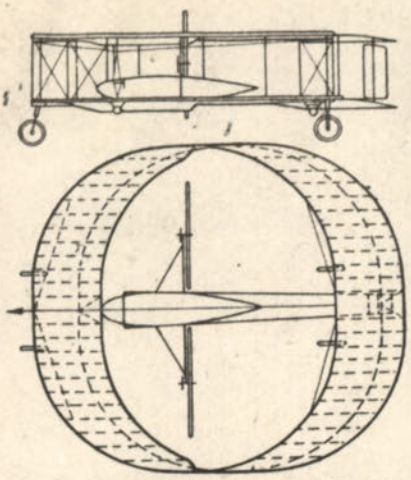


Fig. 6.—Huth annular biplane of 1909.

and Gordon Bell. Finally it came to grief when flown by Cedric Lee himself without previous training. After a good flight he managed to put it into a river.

Another incident happened with a subsequent annular monoplane: the elevator jammed and broke in flight. The aeroplane merely pancaked to the ground, again preserving the health of its pilot, E. C. Gordon England.

These types in their final form had lateral control effected by differential deflection of the elevators. It was realized that this elevon control was not very effective for lateral manœuvres, yet the lateral stability of the wing proved so great that the provision of ailerons seemed superfluous. The longitudinal stability was always satisfactory, once the centre of gravity was properly located. Because of the great inherent fore-and-aft stability, a separate elevator was, at one time, located on top of the vertical fin and permitted the fitting of special ailerons. For directional control a vertical rudder was attached to the stern of the fuselage at the trailing edge of the wing. A form of tricycle undercarriage was employed.

In respect of performance, the wind-tunnel tests indicated that a better lift/drag ratio could be expected than with a comparable conventional aeroplane. However, no conclusive evidence for this has, as yet, been presented.

The third British monoplane of this type also had an 80 b.h.p. rotary engine, but this time it was located aft and, further, drove the airscrew by means of an extension shaft. Unlike its predecessors, no dihedral was provided, and because of this the flying qualities were found to have been greatly improved. From early in 1914 until the outbreak of the 1914-18 War this unconventional aeroplane was frequently flown (mostly by Gordon Bell); it was demonstrated before Winston Churchill in the hope of securing orders from the Admiralty.

Altogether, 11,000 miles were flown in about 128 hours, and even people not previously trained as pilots were able to fly it. In May, 1914, two such aeroplanes were being designed for participation in the Gordon-Bennett Race of 1915. When the 1914-1918 War terminated the work, it had clearly grown far beyond the stage of an untried project and could have well been termed a successful experiment with every prospect of becoming a practical proposition.

In 1919-20 Tilghman Richards succeeded in persuading the Air Ministry to place an order for a further experimental aeroplane. But a week after communicating this decision Major-General Bagnall-Wild, the promoter of the idea, retired, and red tape killed an intelligent intention.

It is only fair to record that aeronautical progress has suffered from the failure to have this development continued. As Tilghman Richards stated many years ago:—

"There is nothing mysterious about the annular plane. It affords high lift at large angles, has no burble point, and has a good lift/drag ratio for wings with a body. The machine was very fast in flight, for its day, and extremely slow in landing; and there being three distinct regions of lift, one apteroid and two pterygoid on each half-wing, the movement of the centre of pressure was a resultant of three distinct regional movements; and with slight modifications could be made to move in any desired manner without affecting the general efficiency of the plane."

As mentioned, the circular shape for the wing is not in itself a decisive characteristic. Previously, in 1908, A. H. Edwards invented the ring-type wing with rhomboidal or triangular shape (Brit. Pat. Spec. No. 4519 of February, 1908). An experimental aeroplane of this type, "The Rhomboidal," was constructed and tested at Brooklands. It was not successful.

(To be continued.)

The Biology of the Flying Saucer—II

By A. R. Weyl, A.F.R.Ae.S.

In this series of articles the history of low-aspect-ratio aircraft is recounted and technical aspects of their design discussed, leading up to their use for supersonic flight.

(Continued from page 185, February 13 last.)

THE SECRET-CIRCLE "CONSPIRACY," mentioned previously in connection with circular-aerofoil aeroplanes, did not lack congenially inventive spirits. Early in 1913 an engineer in Dijon, M. Bourgoin, made experiments with an annular-wing aeroplane. The tests were unsatisfactory. One feature of this design was the provision made for varying the wing incidence in flight.

More recently, a similar idea was suggested by N. H. Warren and Th. R. Young (Fig. 8). In 1937 they secured a patent (Brit. Pat. Spec. No. 508,022 of December, 1937) for a non-stallable monoplane of rhomboidal shape (i.e., leading wing swept back and trailing wing swept forwards with the wing tips merged together). This was provided with a conventional tail at the stern of a long fuselage and a number of advantages

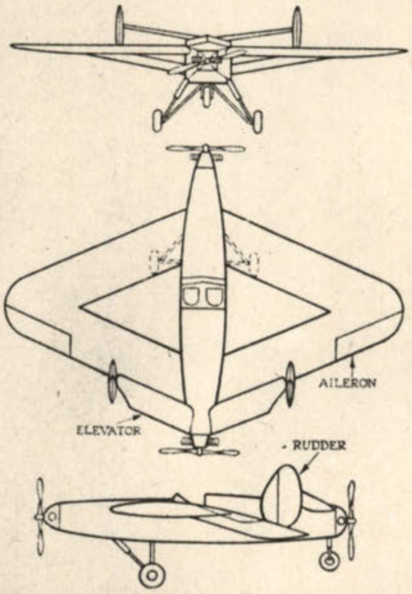


Fig. 8.—Project by Warren and Young for a light twin-engined two-seater of 90 h.p. (1937). The elevator is fitted between fin and fuselage. There is no tailplane.

were claimed. In 1943 a model for a two-seater fighter with tail turret showed the separate tail omitted; special emphasis was laid on the triangular shape of each wing and the effect of sweep was relied upon. Nothing more has become known since, however, but it is worth noting that the project had been based on sound aerodynamic considerations.

In 1933, the annular wing of the German sculptor Antes created a mild sensation because of the good performance of models made to this conception (Fig. 9).

Somewhat peculiar was the aerodynamic conception of the rhomboidal annular aeroplane of P. Nesbitt Willoughby, a qualified aeronautical engineer (Fig. 10). The Willoughby Delta Co. of London had taken up the development of this idea in 1931 and sufficient means were available to make rather extensive tests.

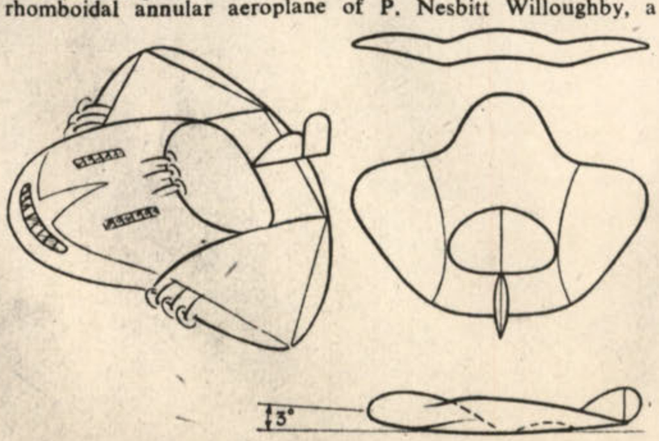


Fig. 9.—Model of the "annular wing" of Antes, 1933.

The principle is best described as a tandem monoplane with two aerofoil-shaped parts connecting the leading wing with the trailing wing near the tips. The "side wings" had aerofoil shape not only in their longitudinal cross-section (i.e., in the direction of flight), but also laterally. This was considered a characteristic feature and subject to patents. It was claimed that the vortex distribution induced by such shape gave an unusually high aerodynamic efficiency in spite of the small span of the aeroplane. In addition, it was pointed out that the maximum lift was shifted to very high incidences. Moreover, the "side wings" should reduce the drag of engine nacelles fitted underneath them.

All this was said to be proved by extensive wind-tunnel experimentation here and abroad. Designs of passenger transport aircraft reaching weights of 40,000 lb. were prepared on the basis of model tests made at the National Physical Laboratory and elsewhere. The results must have been so encouraging that an experimental monoplane with two 125 b.h.p. Menasco engines and weighing 2,540 lb. was constructed late in 1938 (Fig. 11). This aeroplane flew indeed and was even publicly demonstrated (including one-engine flight) at a Garden Party in May, 1939. Shortly afterwards the experimenter was killed in an unexplained crash during a flight test.

From pressure plots over the "side planes" which have been published, apparently trim changes could be expected at various incidences. These components were thus capable of producing longitudinal instability and it is not improbable that this and poor control efficiency may have contributed to the accident. There was also evidence of a stall at normal incidences, although of a very mild character and with little apparent decrease in the lift coefficient (which, however, would not exclude the presence of fluctuating lift forces).

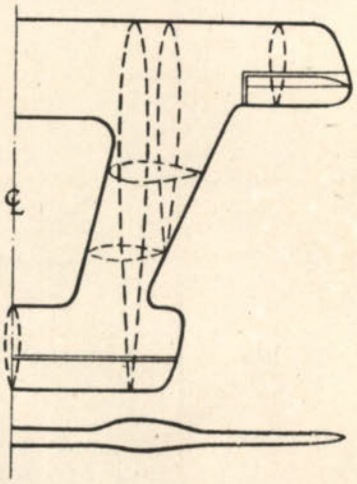


Fig. 10.—Principle of the Willoughby Delta design.

Another suggestion for an annular wing was made by L. Peel, in 1944. This, however, was concerned less with the aerodynamic properties of such wing systems than with the arrangement of two engines facing each other with their airscrews, in order to overcome the torque reaction.

A phenomenon of which aerodynamic experimenters were always well aware, but which aircraft designers failed to utilize, was that wind-tunnel tests clearly proved good-natured stalling properties of wings having very small aspect ratios. Yet even in the very early days when centres of gravity were far too far back on the old box-kites, the square shape of tailplanes, then unaccountably in vogue, may have saved the pilot's bacon more than once by its refusal to stall under extreme provocation. Later on science came and proved that a tailplane of "good" aspect ratio was more efficient. It was, but it made the stall worse when the centre of gravity happened to be rather aft.

The interesting thing is that aerofoils of circular or square shape were tested in the early days at incidences up to 90 degrees, while on normal aerofoils tests were restricted to rather small incidences only, generally excluding the range of stall.

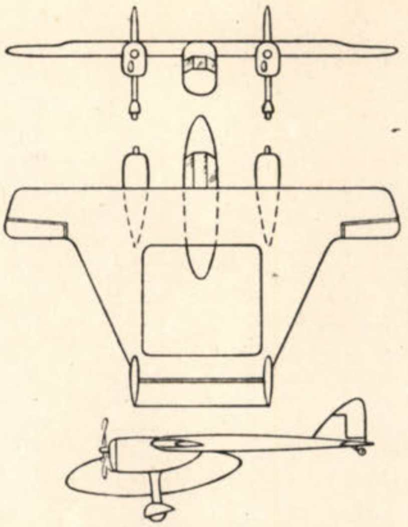


Fig. 11.—Willoughby's "Delta 8" experimental monoplane of 1938.

Thus, an observant student of laboratory tests could have noticed the extraordinary capacity of circular or square shapes to give a very gradual, innocent stall, and that at very high incidences. Yet, apart from a few broad-minded experimenters, no designer drew the conclusion that wings of such shapes promised safety in flight, though it was known from early practical experience that flying in the "second regime," i.e., at the stall, was positively dangerous.

It is true that spinning—Parker's "Spiral Dive"—was attributed, in those days, to high incidences, and that most of the lightly loaded rectangular wings used at that period rendered the stall relatively innocuous. However, accidental stalling was then, as now, the cause of the majority of all crashes. And the nose dive following inadvertent stalls was well known to be of the most serious consequences.

Eiffel, Riabouchinsky, Dines, Prandtl, etc., began their laboratory experiments on aerofoils of very small aspect ratio and the results were generously published (how closely secret they would be kept to-day!). Eiffel showed that the ratio of the resultant forces reached maxima for small aspect ratios and that slender wings gave the greatest drag at 90 degrees incidence, whilst disc wings had then the least resistance of all. Riabouchinsky proved that the maximum lift with disc wings was reached at incidences of the order of 40 degrees, whilst with normal aspect ratios (exceeding a value of 4) the maximum lift took place at incidences of 12 to 14 degrees only. Beyond their critical incidence disc wings gave a gradual decrease of the lift force, whereas wings of normal aspect ratio gave a very abrupt and unsteady one. The tests by Dines on flat plates in natural wind confirmed this information and that the observation applied to cambered aerofoils as well was also proved (by Riabouchinsky). O. Foeppl showed from systematic wind-tunnel tests that a square aerofoil behaves, in respect of its lift curve, in a remarkably different manner from one having an aspect ratio of 1.5, although wall interference and Reynolds Number may have somewhat affected the results of the tests.

Later, Prandtl was eager to point out that his aerofoil theory did not hold for very small aspect ratios, and that, in fact, the induced drag of disc wings was less than the theory suggested. In spite of this, however, nobody seems to have heeded the possibilities implied and the "Battle of the Aspect Ratios" was decided in favour of slender wings.

To be fair, it must be pointed out that there was one serious argument against disc wings. The best aerofoil sections in use prior to about 1925 had a plain camber which implies travel of the centre of pressure when the incidence varies; the length of such travel is linked up with the wing chord. Hence the change in trim or stability is, with such aerofoil sections, greater with large-chord wings. On this consideration of fore-and-aft stability and control, designers had some justification for their decision against experimenting with disc wings. Yet quite useful aerofoil sections had already been used in flight which had practically no travel of the centre of pressure and hence did not suffer from this disadvantage of the disc wing.

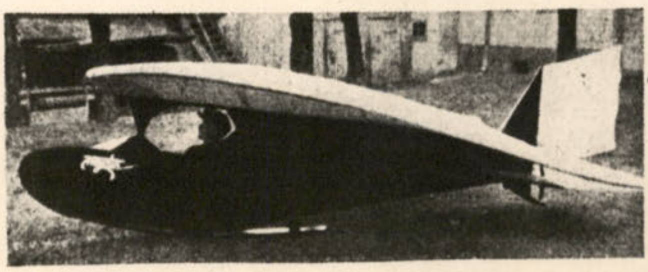


Fig. 12.—Experimental Hayden glider, 1925. Span, 19.7 ft.; length, 13·85 ft.; wing area, 173 sq. ft. All-up weight, 310 lb. No lateral control.

The whole argument, however, lost its importance immediately M. M. Munk proved that very efficient aerofoil sections could be designed with a completely (or nearly so) stationary centre of pressure. It is, therefore, right to say that from that time all conditions existed for a practical evolution of disc-wing aeroplanes.

F. Handley Page converted an aerofoil, leaving an aspect ratio of 6.25, into six square-aerofoil portions by five slots, each parallel to the chord of the wing. By so doing he hoped to have the low drag of a normal wing combined with the high stalling angle of the disc-type wing. Although a very slight improvement was claimed, the principle was that of eating the cake and having it too: the induced drag is responsible for the stalling properties of the disc wing and you cannot have the benefits of the high drag without suffering its disadvantages. Moreover, in order to have the effect of the disc wing, the provision of mere slots is insufficient. Marginal vortices need room to deploy.

On the whole, however, the idea proves that at least one practical aircraft designer had realized that there was something in wings of abnormally small aspect ratio.

There were other, although not quite as well thought out, antecedents of the disc-wing aeroplane. In the first soaring-flight competition on the Rhoen (1920), Friedrich Richter, a burly naval pilot of 20 stone or so, performed on a triplane glider with wings having an individual aspect ratio of far less than three. H. Hayden secured, in 1922, a patent for a rhomboidal wing with an aspect ratio of nearly unity, claiming for such a shape high lift and good flying qualities.

In 1925 he constructed a glider with a wing having an aspect ratio of only 2.25. The wing was nearly triangular in shape, with its apex leading, and a pronounced wash-out towards the tips (Fig. 12); no lateral controls were fitted. The tailplane with the elevator was fitted underneath the trailing edge at the

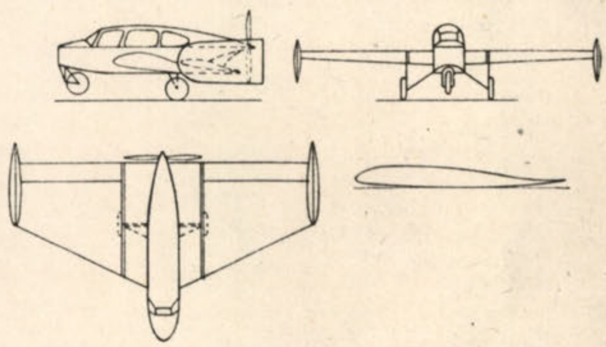


Fig. 13.—A French project of G. Abrial, 1929.

stern of a fuselage. Flying experiments in Styria were said to have proved satisfactory flying qualities.

Some early tailless aeroplanes, such as certain experimental types of Rene Arnoux, had rather stub wings and heavily reflexed (i.e., positively stable) aerofoil sections. A 1929 design of G. Abrial showed an aspect ratio of 2.88, with, however, substantial tip discs (which have the effect of increasing the aerodynamic aspect ratio) and wind-tunnel experiments indicated a creditable performance (Fig. 13). Russian attempts, in particular the parabola type of Tscheranowsky, too, were experiments with aspect ratios of three and even less (Figs. 14 and 15). Their resemblance in shape to the latest designs of super-sonic aeroplanes is remarkable.

A Modern Pioneer

Further interest in the aerodynamics of disc wings was displayed by research workers with the arrival of Juan de la Cierva's Autogiro. This was indeed something like a circular wing, and performance estimates were based on the properties of such wings. Yet the question of stalling stability did not arise, because of the rotor properties.

The real pioneer of the disc wing was a very able American research engineer of the National Advisory Committee for Aeronautics (N.A.C.A.), who proved capable of following independent lines of development. In about 1930 Charles H. Zimmermann subjected the properties of disc wings to

Fig. 14.—A Russian 'parabola' glider of 1924.

extensive wind-tunnel investigation and the published reports still form the basis of present development. In places, the results confirm, qualitatively, the experiments made 20 years before. But, as mentioned earlier, these experiments had been practically forgotten.

Zimmermann's target has been the development of a really fool-proof aeroplane for amateur pilots. It is no use hiding the fact that in nearly all accidents in which blame is attributed to an "error of judgment" on the part of the pilot, the aeroplane is actually at fault. The most common causes are the consequences of inadvertent stalling. Once this is completely remedied, the overwhelming majority of accidents will become mere incidents or just fun, and instead of coroners and hospitals, aircraft manufacturers and repair shops will have the benefit.

On such very sound lines (which seem to be generally acknowledged, but still far too often ignored), Zimmermann directed his main attention to the stalling problem. He proved that small variations in the aspect ratio made profound differences and that the shape of the wing tips also had a great influence.

At the same time he confirmed that the induced drag of circular or square wings is by no means as prohibitive as the simple theory of the "horseshoe" vortex line would indicate. He also proved that it was simply the induced drag due to the predominant influence of the marginal vortices which brought about the behaviour at high incidences; the idea that the provision of oblique slots might help in this connection proved, however, abortive.

An advantage which Zimmermann's research brought to light was that disc wings gave less profile drag at small incidences (high-speed flight), because of the reduction of the relative thickness of the aerofoil sections. This drag reduction has indeed become one of the main reasons for disc wings being adopted for aeroplanes capable of flying at speeds at which the compressibility of the air needs to be considered. For supersonic flight disc wings seem, at present, to be a necessity. Alternatively, for a given aerofoil thickness ratio, the height available for structure and storage (power plants) is greatest within a disc wing; this makes for light and stiff

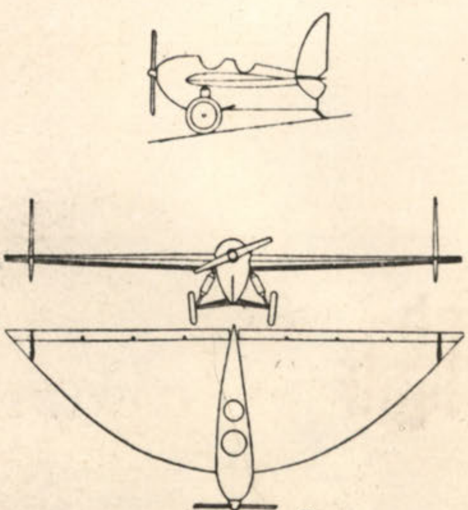


Fig. 15.—A 'parabola' aircraft by B. I. Tscheranowsky.

wing structures as well as for the possibility of housing everything within a wing.

Hence there are very real design reasons for the preference of disc wings, quite apart from the eased accommodation of short-span aeroplanes.

Some Remarkable Results

Zimmermann established that the optimum aspect ratio was found between the values of 0.75 and 1.5. These values include both square and circular wing shapes. For a given wing section (Clark Y) the latter gave the highest lift coefficient, 1.85 at 45 degrees incidence, compared with a value of 1.24 at 14 degrees incidence for an aspect ratio of six.

Furthermore, an important result was evidence that at an aspect ratio of unity (square or elliptical wings), and at an aspect ratio of 0.9 (wing with faired tips), no tendency to autorotation could be found. A circular wing (aspect ratio of 1.27) indicated the possibility of autorotation (i.e., spinning) at incidences below that of maximum lift. The possibility of spinning before the actual stall is reached is, indeed, extraordinary. All these results refer to tests with the Clark Y aerofoil section.

Less established was the contention that disc wings would give improved lateral and longitudinal stability at low incidences. This seems still to be a moot point of the Flying Saucer.

In Fig. 16, Fig. 17, and Fig. 18 some characteristic results of

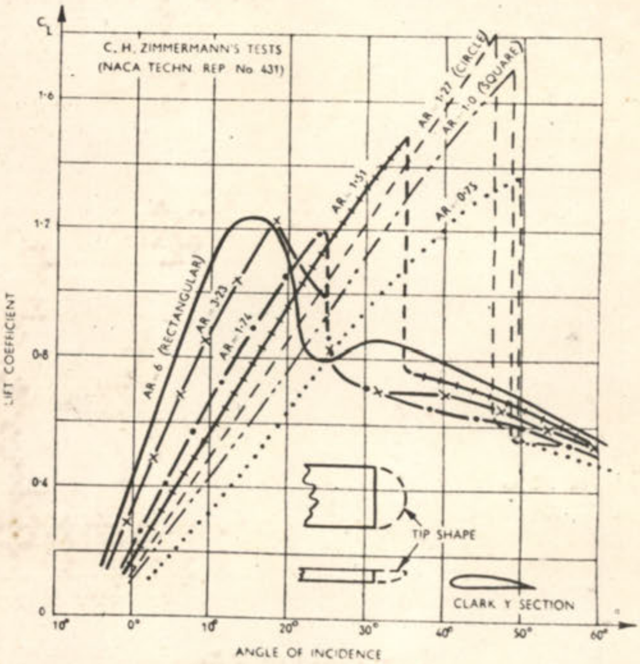


Fig. 16.—N.A.C.A. tests by C. H. Zimmermann which prove the extraordinary stalling qualities of disc wings.

Zimmermann's wind-tunnel experiments of 1932 are given. It is seen from Fig. 18 that the difference between the incidence of maximum lift and the gliding angle at maximum lift ($\alpha_{max} - \epsilon_{\alpha\,max}$) remains fairly independent of aspect ratio, and of the order of 9 to 13 degrees. This would mean that the attitude of the disc-type aeroplane, when flattening out, would not greatly differ from that of conventional aeroplanes. In particular, there would be no need to provide high undercarriages for disc aeroplanes as their gliding path is steep. This is an important difference from wings with leading-edge slots.

In practice, however, the landing of disc-wing aeroplanes gives rise to undercarriage problems. As the induced drag increases rapidly with the reduction of flying speed, when the aeroplane flattens out prior to touching-down, the gliding angle steepens abruptly. This is particularly true of tailless designs, and the result is a strong tendency to pancake to the ground as soon as the pilot flattens out. Thus to avoid the necessity of fitting undercarriages able to stand the strain of abnormally high sinking speeds, it has been found practical to land with power on.

For a tailless aeroplane with an aspect ratio of three, M. B. Morgan found that, without flaps, the trimmed gliding angle at 160 m.p.h. was three degrees; it increased to 17 degrees at 126 m.p.h., while the stalling speed was 115 m.p.h. This pronounced steepening of the gliding angle makes a merger between the aeroplane and the helicopter an attractive proposition.

Another peculiarity of the disc wing established by Zimmermann was its sensitivity to the shape of the wing-tips and pseudo-circular and pseudo-square wings thus exhibit significant differences. This also applies to the ground effect, i.e., the landing qualities. The provision of oblique nozzle-shaped slots at the tips yielded no useful results. In any case, square-cut tips were found to be a disadvantage, with respect to drag, as well as to other qualities.

Later N.A.C.A. research by F. E. Weick and Robert Saunders referred to aspect ratios of the order of 3 in connection with slotted auxiliary Vevions flaps for the trim of tailless aeroplanes. This constituted the first investigation of what has become known to-day as the "Delta Wing," i.e., the combination of sweep-back with low aspect ratio. Such shapes are of special interest for aeroplanes capable of flying through the trans-sonic region.

Pancakes á la Zimmermann

The results of Zimmermann's research were so convincing that a number of otherwise quite respectable designers were tempted into experimentation with disc-wing aeroplanes. In accordance with Zimmermann's views, all these designs were intended to be of the safety-first type of privately owned aircraft. This distinguishes the early phase from the more recent interest in Flying Saucers.

In 1934 Farman was stimulated into experimenting with a wing with an aspect ratio of only 1.9. This was seen in his F-1020 monoplane which otherwise had a long fuselage with a conventional tail. It was said to have proved very stable in flight, but was not further heard of. An experimental parasol monoplane with a completely circular wing, a camber flap in the trailing edge and severely skewed ailerons was tested in the U.S.A. (in 1934), with indifferent results. It was shown in flight in news reels.

At about the same time Raoul J. Hoffmann, of St. Petersburgh, Florida, an eminent aeronautical engineer of Austrian origin (known as the first to prove—in 1913—that the ratio C_L^3/C_D^2 governs optimum climb and glide with minimum sinking speed, took up development of the disc-wing aeroplane.

Hoffmann's Flying Saucer was a tailless aircraft with an aspect ratio of slightly over 2. The first type was an ultra-light single-seater with 36 b.h.p. Later a side-by-side two-seater with an 85 b.h.p. Cirrus engine was constructed and flew well; the wing tips served as ailerons and the elevators formed part of the trailing edge. The aerofoil sections employed were N.A.C.A. M.6 basically, with N.A.C.A. M.1 at the tips. Both are sections designed by M. M. Munk. The former is a reflexed-camber section with a practically stationary centre of pressure; the latter is symmetrical

The central structure of the wing, the fuselage and the fin was of welded-steel tube; the wing had three spars. This little two-seater was stated to fly well and to exhibit very good stability. It seems, however, that the controllability, in particular directionally, was not satisfactory. The vision from the cockpit must have been very restricted—a moot point with all these designs. A speed range from 28 m.p.h. to 135 m.p.h. was claimed. The empty weight was given as 900 lb., and the wing loading was 5.5 lb./sq. ft.

One remarkable characteristic observed during the flying tests of Hoffmann's aircraft was that, when coming in to land, the approach was steep; yet prior to the flattening out and just before touching down, the glide flattened. This would

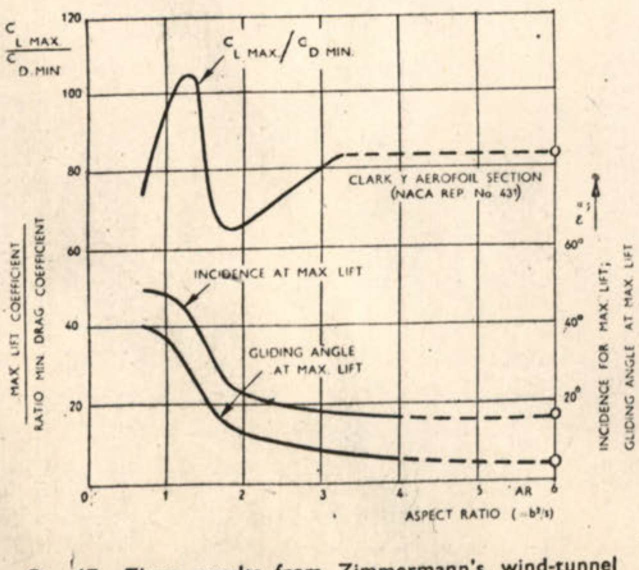
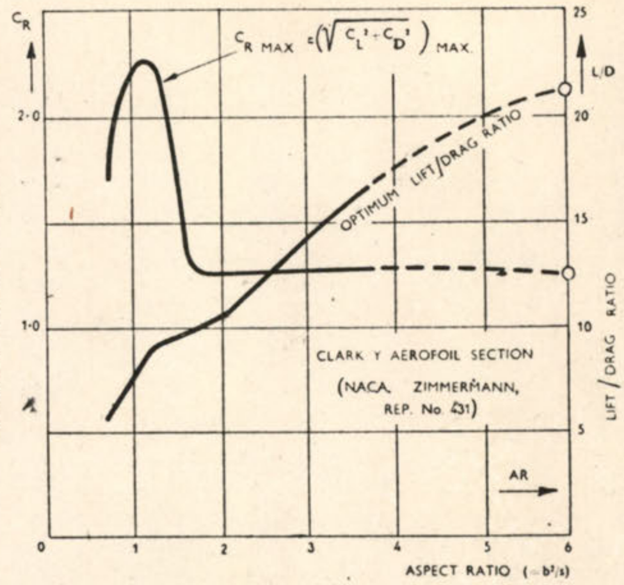


Fig. 17.—These results from Zimmermann's wind-tunnel tests on disc wings (1932) clearly show the characteristics of low aspect ratio aerofoils.



18.—Further results from Zimmermann's tests shown here also indicate the advantages to be gained from disc wings.

seem to contradict the experience referred to above, and it was attributed to a ground effect arising from the rake of the wing-tips. It is indeed reasonable to expect that the presence of the ground would affect the formation of the marginal vortices to an extent which may markedly influence the behaviour of disc wings during take-off and landing. Hoffmann projected a pusher and a twin-engined version, but these types did not materialize.

A further development was the Arup monoplane of R. J. Hoffmann and C. L. Snyder at South Bend, Indiana. The wing shape was very similar. It resembled a semi-circle flying with its straight side as the leading edge; to this wing, ailerons were added as special tips. The aspect ratio practically corresponded to that of the previous Hoffmann types. Again, aerofoils with little centre-of-pressure travel were used.

The latest type had its tailplane and elevator separately located over the wing trailing edge (similar to the "Elytroplane" of De Rougé). It seems that the longitudinal control at certain incidences was not satisfactory. The ailerons which formed part of the wing shape and reduced the aspect ratio to a value of 1.75 had a triangular shape and were greatly skewed (taking into account the oblique flow over the wing tips). The engine was a 70 b.h.p. Le Blond radial; a tricycle undercarriage was fitted.

With the pilot alone, a gliding speed of 23.5 m.p.h. was recorded (the wing loading was about 3.3 lb./sq. ft.) and a gliding angle of 21 degrees was measured, with a sinking speed of 12.3 ft. per second, which can be accommodated by a sturdy undercarriage without flattening out of the glide. The maximum speed was 86 m.p.h., and the take-off was stated to require 5 secs. in zero wind.

Several more Arup types seem to have been constructed and flown during 1935. The flying qualities were praised—gliding angles of 1 : 2.6 being quoted—and the published performance figures sounded extremely good. Yet, for reasons never disclosed, the production stage was not reached and the development ceased abruptly. It is worth noting that Charles Zimmermann himself has taken no part in this development, but he was an interested spectator at demonstration flights with an Arup monoplane at Langley Field.

An Italian "Tortellino"

At the time of the Arup development (1934), F. Piana Canova, an Italian, began to embark on a development for a tailless aeroplane with a low aspect ratio. In May, 1935, he secured patents for a rhomboidal wing, one diagonal of which coincided with the direction of flight. The ailerons were to be located at the lateral apices, elevator and rudder at the rear apex, while the airscrew was in front of the leading apex. Another patent related to bi-convex aerofoils with ducts and control valves for the pilot, enabling the latter to neutralize the negative pressure on the forward ventral surface when at negative incidences. The latter patent was, apparently, never submitted to flight experiments.

(To be continued.)

The Biology of the Flying Saucer—III

By A. R. Weyl, A.F.R.Ae.S.

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WIND-TUNNEL TESTS were made in Turin and at Rome of five Canova projects (described in the previous instalment of this article). It is interesting to note that the Canova disc-wing types did not make use of reflexed-camber aerofoils. Stability and trim could, therefore, be secured only by an upwards deflection of enlarged elevators.

Early in 1935, an open glider of the "Zoegling" type was constructed by a Milan firm and M. A. Garbell made fairly successful flights with it. He reported that the longitudinal stability (with the enlarged elevator) was good and that parachute-like landings could be performed. The lateral stability characteristic, however, proved deficient, since a "Dutch-roll" motion was experienced; turns were of questionable steadiness. In this respect, insufficient damping in roll and yaw are mentioned. With winch-launching, this glider reached altitudes of 600 ft.

On the basis of this design, a light aeroplane was developed and the Italian Government financed the construction of two larger experimental aeroplanes, including one with 130 b.h.p. Gipsy engine. A fatal accident described as "not necessarily reflecting on the technical merits of the design," caused the authorities to change their minds and to terminate this development.

A Return to Childish Things

Aeroplanes with a long, deep tail affixed to a small-span wing form a development of the low-aspect wing in another direction. Although the overall aspect ratio is low with such an arrangement, the wing system is not that of a disc. It is more akin to primitive kites or, better, to the paper dart of our school days which, as we may be able to remember with some mental effort, exhibited quite remarkable flying qualities and made better use of our school books than we ever expected.

A representative of this aboriginal type is shown in Fig. 19. It crashed during the first tests (which would not seem very surprising in view of the arrangement of engines and airscrews).

Another less eccentric arrangement was the French Payen single-seat racer of 1935. This was a daring experimental type with a 400 b.h.p. radial engine. An improved type, this time more reasonable—a 70 b.h.p. light aeroplane—was constructed in 1936. To a very small, conventionally tapered wing, a large triangular tail was fitted; the wing alone had dihedral, and the overall aspect ratio was about 1.76. No flights have been reported of one of these Payen aeroplanes, but take-off attempts with the second type seem to have suggested that with the small span the torque reaction of the airscrew cannot be adequately dealt with.

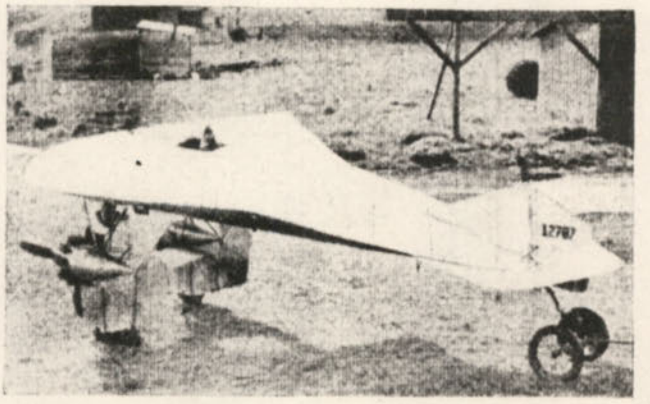

Fig. 19.—An American "Flying Flapjack" with two engines. It crashed while under test (1938).

A third design (in 1938) the "Flêchair" single-seat fighter project, therefore, incorporated two coaxial counter-rotating airscrews driven by two 100 b.h.p. engines mounted in tandem in the long fuselage. The pilot's cockpit was located at the root of the fin, and a single-track undercarriage was adopted. There were, however, far too many untried features in this unusual design to make it a serious proposition. Nothing more has been heard of Payen's efforts.

The modern phase of the Flying Saucer aeroplane is characterized by two distinct developments. One is the helicopter-aeroplane, the other is the trans-sonic or supersonic aeroplane. Both have become—unfortunately—essentially military developments; the progress is hence shrouded in the usual pretentious secrecy (which implies that the potential enemy knows everything) while the work is gravely hampered by elaborate security precautions.

The helicopter-aeroplane is not a novel idea. Many years ago, for instance, Nicola Tesla (famous for his electrical experiments with high-frequency phenomena) secured a patent for a tailless aeroplane equipped with a large lifting airscrew permitting a vertical ascent.

In 1921 Claud Dornier secured a patent for a conventional

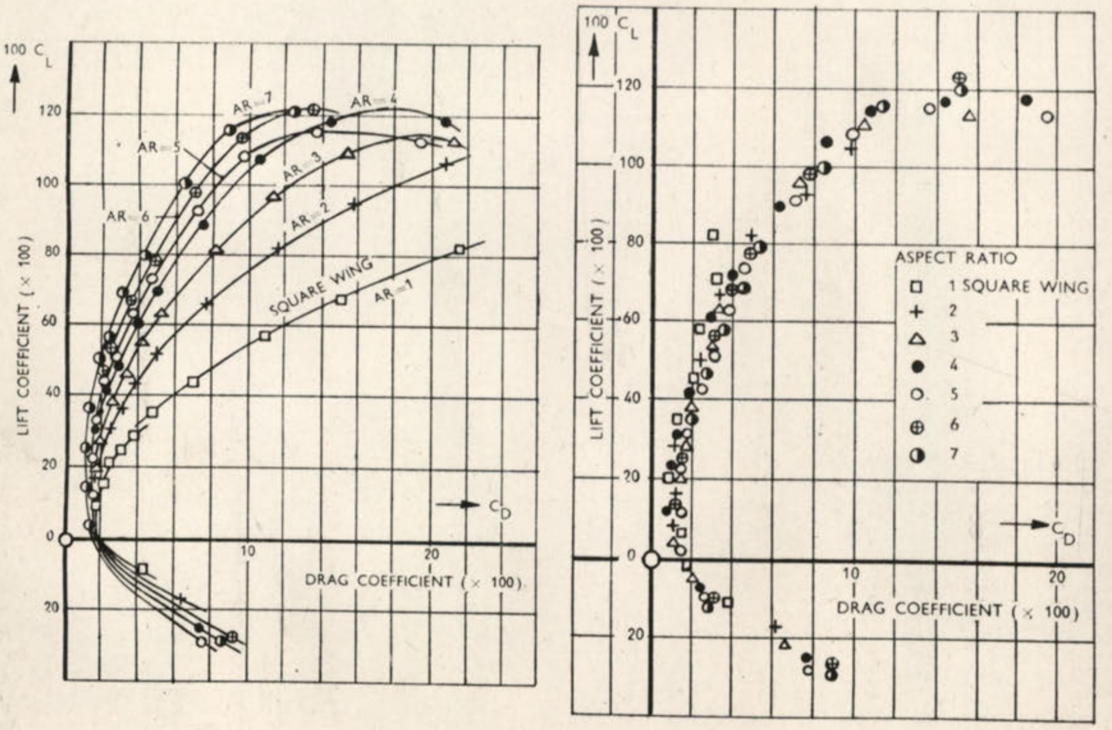

Fig. 20.—Lift and drag of wings of different aspect ratio. (Left) Wind-tunnel results obtained at Goettingen, in 1920; Goettingen 389 aerofoil with 10 per cent. thickness and square wing tips. (Right) A reduction of the results to an aspect ratio of five, by the Prandtl Aerofoil Theory of the induced drag, shows that a square aerofoil (aspect ratio of one) does not follow the theory. Its induced drag is less than predicted by the "horse-shoe vortex" assumption.

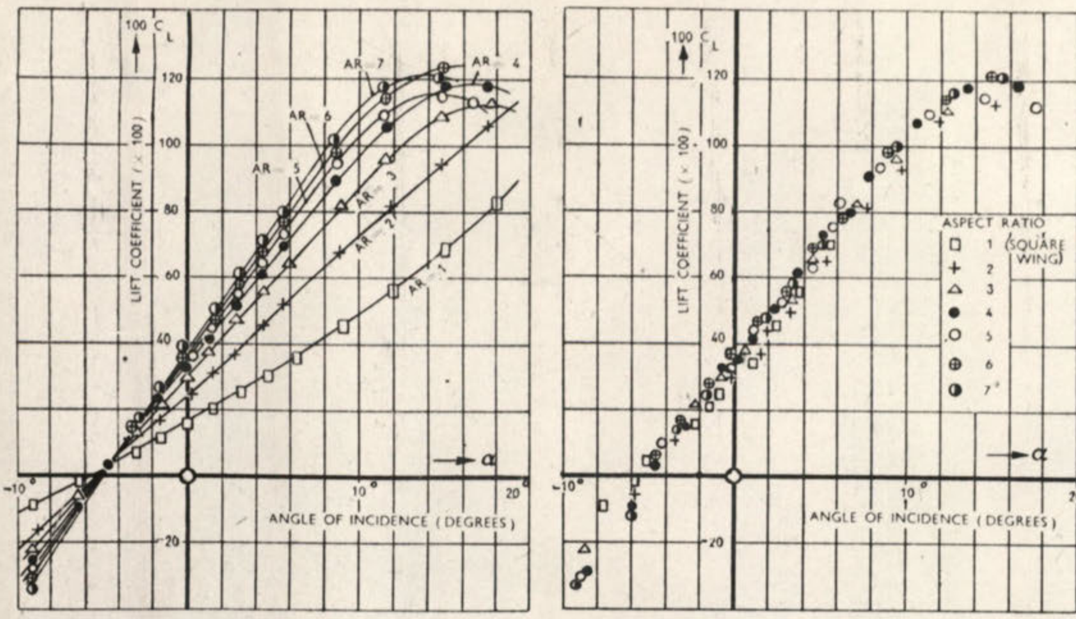

Fig. 21. — Lift curves of aerofoils of different aspect ratios. (Left) Wind-tunnel results obtained, in 1920, at Goettingen, with Goettingen 389 aerofoil and square tips. The absence of stall at normal incidence is in evidence, for aspect ratios up to a value of two. (Right) Reducing the values, by the Prandtl theory, to an aspect ratio of five, shows that wings of very small aspect ratio do not follow the theory in respect of the induced-incidence correction.

aeroplane with take-off as helicopter (Brit. Pat. Spec. No.161,948). Earlier still (in 1916), the German, F. Bendemann, a noted research worker on airscrews, conducted a secret development of an aeroplane with a large tilting airscrew capable of rising and descending as a helicopter. The development of this air observation post was later discontinued in view of the Austrian helicopter experiments by Th. v. Karman and Petroczy.

From his early experiments with lifting airscrews, F. Bendemann found that hovering without forward movement could be achieved—when the power loading of the aircraft was less than about 9 lb./b.h.p. With fighter aeroplanes, such low power loadings were already then being approached, and operational experience had indeed shown that certain single-seaters could, under favourable conditions, be held in attitudes approaching that of hovering (later the Fokker D.VII biplane, with a large airscrew, became renowned for this trick in air combat on the Western Front). Attempts to revive the project at a later date failed, and with the suicide of its promoter (who had gone into the Civil Service), all interest in the development ceased.

Charles W. Zimmermann, mentioned earlier as stimulator of the disc wing, approached the conception of the helicopter aeroplane on the basis of his results with low aspect ratio wings. He secured basic patents and constructed during 1934-35, in the cellar of his home, a man-carrying aircraft of his design. This had a wing of only 7-ft. span, with two airscrews driven by two 25 b.h.p. engines. Due to persistent engine trouble, no flights were made; the little aircraft showed, however, all the essential features of the present types.

In 1937 he granted a licence for his patents to the Chance-Vought Aircraft Division of the United Aircraft Corporation in Stratfort, Connecticut, and joined this firm for the further development of his ideas. It is possible that the public conception of the mysterious "Flying Saucers" has originated from this development.

Zimmermann's intention may have been the development of a safety-first aeroplane for the private owner. The U.S. Navy, however, took an interest in the possibilities of the helicopter-aeroplane, and the work done at present is purely for military purposes. In 1942 a low-powered piloted scale model type V-173 was constructed. This wooden aircraft made many flights and proved that the ideas underlying the design were practical.

The principle is that, at high speed and when cruising, the aircraft shall fly as an aeroplane, while for slow speed and hovering it flies as a helicopter. Hence the airscrews are at the same time rotors and must have a rather large diameter. With the V-173 the problem of the prone position for the pilot was studied, and there is reason to believe that the latest types have adopted this feature.

A further step towards the realization of a naval gun-spotter and a fighter for use from aircraft carriers has been the Chance-Vought XF5U-1 single-seater (1946), for which a speed range from 40 m.p.h. landing speed to over 425 m.p.h. has been claimed; in general, it follows the V-173 model. *(See p. 185, February 13.)*

The aspect ratio of the wing is less than unity. Strictly speaking, however, it is not a genuine tailless aeroplane because of the attachment of a trimming elevator to both sides of the wing. The reason for such excrescences is the need to locate control organs directly in the slipstream of the paddle-like airscrew rotors. The twin rudders, too, are in the slipstream. Unlike the V-173 type, the XF-5U-1 has an all-moving tail surface and the undercarriage is retractable.

This interesting hybrid has a modern metal structure. Two Pratt and Whitney R-2000-2 engines of 1,350 b.h.p. each (at 2,700 r.p.m.) are mounted within the wing, entirely buried and cooled by forced draught. Water injection for temporarily boosting the power is one of the engine features.

A special problem was the design of a transmission gear which allows both rotors to be driven from either of the engines —this is a necessity in case of an engine failure. The four-bladed rotors are contra-rotating so that there is no residual torque and are geared down to about one-fifth of the engine speed, hence their substantial diameter. The wing loading is rather high, reaching the order of 40 lb./sq. ft.

The Real Flying Saucer?

Since this experimental type was produced, further progress has been made in the development. It seems that axial-flow gas turbines have been installed, and it is quite possible that a combined propulsion with thermal jet and airscrew rotor is already under test. With this, for slow flight (take-off, climb and landing) the rotors are driven by the gas turbines, while at high speed the rotors are declutched and feathered and pure jet propulsion is used. This would, incidentally,

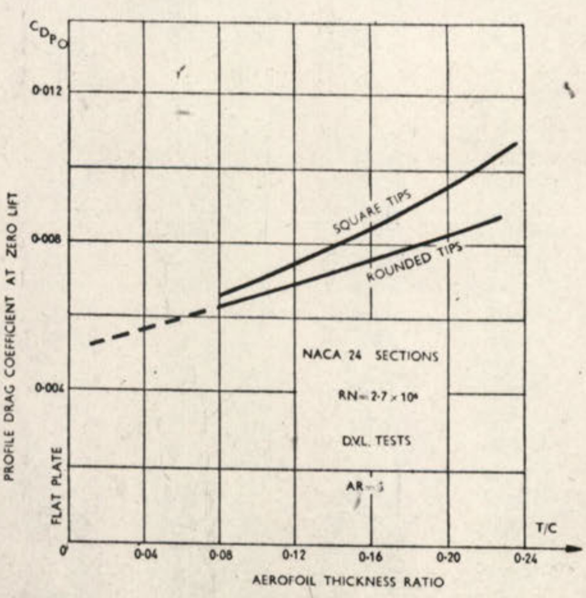

Fig. 22.—Increase of profile drag with section thickness, at zero lift. The importance of the tip shape is obvious. The data refer to an aspect ratio of five (From D.V.L. wind-tunnel tests at low turbulence).

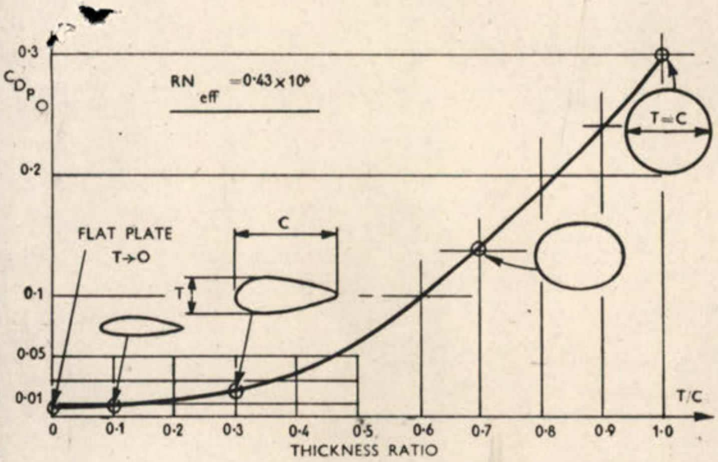

Fig. 23.—Increase of zero lift profile drag with thickness ratio of symmetrical aerofoil section. The saving in profile drag is one of the advantages of disc wings because of their thinner aerofoil section. (Data from Gerber, Zurich Report No. 6).

explain the extraordinary ability of the reported "Flying Saucers" to be able to fly very fast and high, and also to hover, ascend and descend with practically no forward speed. No other aircraft is known to do that. On the other hand, it is inconceivable that whole squadrons of such unconventional aircraft could already be observed at air exercises. It is rare for military developments to progress as quickly as all that.

For operation with gas turbines a speed range from zero (i.e., hovering flight) to more than 500 m.p.h. has been claimed for the Chance-Vought-Zimmermann helicopter-aeroplane. Technically, there is little reason to doubt that such an amazing speed range can be attained with the combination power plant mentioned.

Incidentally, as there is not as yet a standard term for the combination of an aeroplane with an helicopter, the name "helicoplane" is tentatively suggested.

The other line of engineering approach which has led to the disc-wing aeroplane of near-saucer appearance derives from the trend towards very high flying speeds within the sonic range of velocities, and in particular, at great altitudes. As now commonly realized, the compressibility of the gaseous medium sets a speed limit for conventional aeroplanes. This limit is reached when the speed of flight approaches sufficiently to the velocity at which sound is propagated through the air. This "acoustic velocity" depends solely on the air temperature, and is, therefore, lower at altitude. Hence, compressibility effects begin to be felt at lower speeds when flying at altitude.

When the "shock stall," due to the compressibility of the air, sets in, the lift is catastrophically decreased (hence the justification for the expression "shock stall"), the drag rises to enormous values, and the longitudinal stability is grossly impaired by a rapid backwards shift of the aerodynamic centre as well as by fluctuations in the flow pattern at the wing. The experience of phenomena of such distressing nature has given rise to two distinct aims in aeronautical research. One is to delay the onset of the phenomena to higher Mach Numbers; the other aim is to find wings which would permit flight within or through the trans-sonic regime. The alternative, "within or through," is still a necessary impediment of definition, since we do not know yet if stable, steady flight will be at all possible within the trans-sonic regime (extending from about 0.8 to 1.2 Mach Number) while there is certainly that beyond this trans-sonic regime, i.e., within the supersonic regime, stable, steady flight can be predicted.

Two simple means have become known which delay the occurrence of the "shock stall" until much higher (but still subsonic) flying speeds are attained. One is sweep of the leading edge of the wing, either as sweep back or as sweep forward. The other—a Farnborough discovery of nearly 30 years ago, when high top speeds of airscrews were investigated—is the adoption of very thin aerofoil sections. The latter leads, as we have pointed out already, straight to aerofoils of low aspect ratio when, for reasons of structural stiffness, a certain wing thickness is required.

In the discussion of the "Stalling Characteristics of Tailless Aeroplanes" (THE AEROPLANE for April 25, 1947), it was shown that at low speeds, i.e., during take-off and landing, swept-back wings suffer from the disadvantage of instability at the stall. With pronounced sweep-back, swept-back wings of normal aspect ratios exhibit the vice of "self-stalling," due to premature tip stall. It was also shown that this vice can be remedied by reducing the aspect ratio, and a curve based on extensive wind-tunnel tests (THE AEROPLANE for July 11, 1947, p. 47, Fig. 8) proved that there is a distinct relation between aspect ratio and angle of sweep-back in this connection.

M. B. Morgan has recently communicated the following values for the limit of stability at the stall from this graph:—

Upper limit of the Angle of Sweep-back (referred to the ¼ chord) beyond which self-stall can be expected	Aspect Ratio Required
Degrees	
65	1
54	2
46	3
38	4
25	6
14	8
5	10

It is thus advisable to combine sweep-back with low-aspect ratio when safe stalling is required.

Considerations of high speed lead to a similar combination, since both features tend to delay the shock stall. We have, as a result, the rare case of two quite different aspects of an engineering problem pointing to an identical solution.

The inevitable result has been the development of arrow-shaped, more or less triangular, disc wings, termed "Delta-Wings," for flight at speeds which are trespassing into the trans-sonic velocity régime. Another advantage of such wings is that when the shock stall occurs, the backward shift of the centre of pressure is less than with normal wings. The induced drag does not count quantitatively at these high speeds.

Development of such abnormal aeroplane types began in Germany during the War, following the progress accomplished in jet and rocket propulsion since 1937, which had shown that flight at sonic velocity was a practical proposition. A few experimental delta-wing types had been brought to initial flying tests when the War came to a close.

The German development had two distinct aims, resulting in two separate lines of approach. The immediate target necessitated by the Allied bombing raids, was the creation of very fast jet fighters or fighter-bombers which could surpass in speed even the Me 262. Secondly, there was the long-term development of a supersonic aeroplane capable of flying over very long distances, such as from Europe to America and back, and dropping a bomb or two on the way. It is perhaps not too fantastic to surmise that this development had some connection with the research on atomic bombs and bacteriological warfare instituted by the Hitler Gang.

For the immediate target, orders for interceptor-fighters were placed with enterprising firms, notably with the Horten brothers and Messerschmitt (both pets of the Reichsluftministerium), with the Gotha Works, Henschel, Junkers, Heinkel and Arado (a Government enterprise), etc. In order to facilitate experiments with rather unusual aircraft types and to enable an exchange of ideas and experiences, a special research aerodrome was built at Oranienburg (near Berlin) with all facilities for flight testing (in particular, very long wide runways and workshops for repairs and modifications were provided). This was placed under the command of a capable technician, Lt.-Col. Knemeyer.

On this aerodrome, all the initial and development tests with novel prototypes had to be made. When the Russians collected the aerodrome, they were agreeably surprised to discover some of the most progressive aircraft ever constructed. It has since become certain that they have made intelligent use of this aeronautical treasure as well as of the technicians collected then and afterwards. Of the German firms interested in the development, at least one, the well-known Junkers works at Dessau, has been completely transferred to Russia, lock, stock and barrel. Most of the scientists and designers were urged to volunteer for development work in Russia. Few could afford to refuse.

According to reliable information, among the interceptor prototypes at Oranienburg, at the time of the Occupation, were the following:—One Horten tailless delta-wing, which had been damaged during tests and was undergoing repair; another Horten tailless jet-fighter was just ready for its first tests. There was also the latest version of the Lippisch-Junkers' development of the Me 163-C; another advanced Junkers design; an experimental Gotha, and several research gliders.

Hitler's Last Secret Weapon

The German long-term development of an aeroplane capable of reaching truly supersonic speeds discarded the gas-turbine jet engine. It was based on the ram-jet or aerodynamic propulsive duct ("Athodyd")—the simplest engine ever invented.

The ram-jet, a widely discussed invention by the genial René Lorin in 1912, had been experimented with in Germany, notably by the Austrian Eugen Saenger (for whom a special laboratory had been built by the German authorities in 1938), by Otto Pabst, of Focke-Wulf, and by others. Following a suggestion made by Alexander Lippisch (formerly known as an eminent sailplane designer and research worker on tailless aeroplanes), progress had been made with the combustion of solid fuel in ram-jets. Such fuel took the form of solid blocks of specially prepared coal which lined the walls of the duct. This development had been perfected by the German Research Institute for Soaring Flight.

(To be continued.)