PENALTY FOR PRIVATE USE TO AVOID
PAYMENT OF POSTAGE, $300

James, E. C.
Sergeant, R.A.F.

NAVY DEPARTMENT
U. S. NAVAL AIR STATION
PENSACOLA, FLA.

OFFICIAL BUSINESS

Aircraft No:................ Date:..................

TYPICAL WEIGHT SHEET SUMMARY

CATALINA I AIRCRAFT

Maximum All up Weight permissable = 34,000 lbs.	LBS.	LBS.
(a) Weight Empty = This weight includes the following: -		16,970
1. Airframe and Engines..........................		
2. All fixed component parts		
3. Armour plating	225	
4. Anchor and cable	48	
5. Hoisting Sling	24	
6. Bilge pump hose	32	
7. Entrance ladder	7	
8. Heating System	145	
9. Internal Bomb Racks	108	
10. Main radio and Interphone	143	
100 Watt Radio	250	
Loop instalation	68	
Antenna, etc.	11	
11. Navigation Equipment	55	
12. Aluminum Suitcases (9)	74	
13. Items in Gear Locker	50	
14. Boat Hook and two sea anchors	16	
15. Emergency Rations	20	
16. First Air Kits	4	
17. Distiller	25	
(b) Items Normally Carried		
1. Work Platforms (2)	35	
2. Bomb Loading Platforms (2)	53	
3. Engine changing tackle	78	
4. Airscrew changing tackle	19	
5. Surface Control Lock (1)	3	
6. Engine Covers (2)	31	
7. Pilots' coupe cover	15	
8. Airscrew covers (2)	3	
9. Waist gun shield covers (2)	19	
10. Dinghy, Type "D"	63	
11. Dinghy, Type "M"	32	
TOTAL		
Total Weight Empty, including (a) and (b) =		17,321
(c) Variable Items to be checked before take off: - Pyrotechnics		
1. Aluminum Sea Markers (13 lbs. each) No: 10	130	
2. Parachute Flares (20 lbs. each) No: 5	100	
3. Flame Floats (11 lbs. each) No: 15	165	
4. Camera (if carried, 40 lbs)	—	
5. Food (Variable)	105	
6. Water (10 lbs. per gallon) 10½ galls		
7. Bombsight (if carried 28 lbs.)	30	
8. Aldis Lamp Very Pistol & Cartridges........	100	
9. Oxygen equipment..............................		
10...		
11...		
12...		
(d) Special Items: -		
1. Overload fuel tanks and accessories	200	
2. Beaching gear: - Main Wheel and Strut assembly (2) less water	650	
Tail wheel assembly (1)	~~650~~ 64	

Carried Forward	~~LBS~~ LBS	LBS.
3. External Bomb Racks (......lbs each)) Number...........Total.......		
4. Guns .303" (........lbs. each) Number...........Total.......		
5. Guns .50" (........lbs. each) Number...........Total.......		
(e) <u>Crew and Baggage</u>		
1. Number of persons...7.........Total wt:.......	1112	
2. Parachutes (20 lbs. each) Total wt:.......	140	
3. Flying Gear (wt. per person......) Total wt.....	105	
4. Baggage (wt. per person.....) Total Wt:........	280	
Note: For rapid calculation, 250 lbs per crew member will include individual weight and flying gear plus parachute plus 40 lbs of baggage.	67	
(f) <u>Oil:</u> (8.9 lbs/Imp. Gall. - 7.42 lbs / U.S. gall.) ....94.....Imp. Galls. Total....... ...........U.S. Galls. Total.......	837.	
(g) <u>Freight</u> (description of items and weights to be listed) 1.................... 2. .... 3. .... 4. .... 5.	120. (food)	
TOTAL		20.803.
Maximum all up weight:		34,00[illegible]
(h) <u>Weight available for fuel, bombs and ammunition:</u>		
1. ....Bombs Type Total:		
2. ....Rounds .303" ammunition Total:		
3. ....Rounds .50" ammuntion Total:		
<u>Fuel:</u> (100 octane....lbs/Imp. gall. ...lbs/U.S.gall) 4. ...1470...Imp. Galls. Total.10090.... ........U.S. Galls. Total........		
Total Weight for take-off: -		33.830

Tank capacity 735 galls possibly overload to 760 galls.

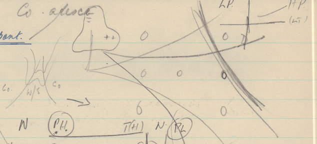
Signature..............................

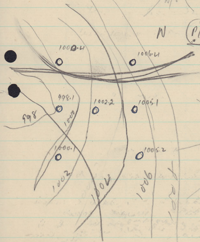
Captain of Aircraft

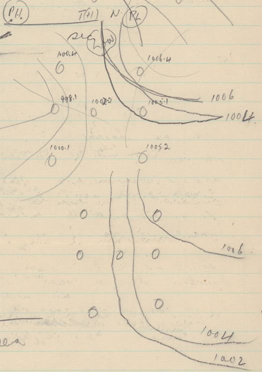
R.A.F. Training Office
Pensacola, Florida.
May 23,1942

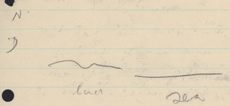
1st Sighting Report.

NR1-0-G-GR5









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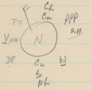
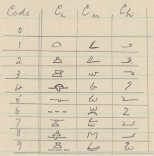
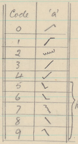






U	20°	30°	40°	50°	60°	70°
0	1	1	1	1	1	1
9	2	2	2	2	2	2
8	3	3	4	4	5	5
7	6	6	7	8	8	8
6	9	9	10	11	12	12
5	14	13	14	15	16	17

Temp.

Code	N.
0	No cloud cover
1	Trace of cloud
2	1/10 cloud cover
3	2/10 or 3/10 cloud cover
4	4/10 or 5/10 " "
5	7/10 or 8/10 " "
6	9/10 " "
7	9/10 + when sky completely covered except for small areas
8	10/10 cloud cover.
9	10/10 by fog or dust storm.

W (Red)

0	unclouded sky	8	▽ showers
1	Variable sky	9	Thunderstorm
2	Mainly overcast		
3	sand or dust storm		
4	≡ Fog		
5	drizzle		
6	• Rain		
7	✱ Sleet or snow		

Catalina I   Two Pratt & Whitney 1250 ~~1250~~ H.P. 14 cyl. in two banks of seven
Take off full load   Bendix induction carburettor
(1) M.P. 48"   2700 RPM - 2750 RPM
Never use more power than necessary for safe flight.
P. & Whit. engine flies 600 before major overhaul.
As soon as leave water throttle back to
(2) M.P. 35" — 2350 RPM   [2400 - 2650 RPM] Vibration range, do not use if possible
After 200/500 altitude, depending on surrounding hills etc close back to
(3) M.P. 30" — 2000/2150 RPM. May be used for any length of period

(4) Full load cruising 28" - 1900 RPM } (100 K T.A.S)
Light load   25" - 1600 RPM }
Fuel consumption - 60 gals per hour.

Power output roughly the multiplication of Boost & RPM
Cylinder Head Temp.
Max. for continuous operation should not exceed 230°C
Desirable for continuous automatic lean should not exceed 205°C
Oil pressure   Max 105 lbs min. 80 lbs
Min at cruising 65 lbs

530

Extra fuel tanks fixed as near C.G. as possible + special pump to pump gas to wing tanks.

Beaching gear - tyres filled with H_2O to make it easier for them to sink below water when beaching.

1 Imp gallon = 6/5 U.S. galls.
1 Imp gall of oil = 9 lbs per gallon
1 gallon of fuel = 7 lbs per gallon
1 gallon of water = 10 lbs.

Fuel tanks in centre section of wing
Each top tank carries 735 Imp galls.
Tank in hull to hold 320 galls
Each man, luggage + flight gear: 250 lbs approx.
Approx. 19000 / lbs ready for flight less Crew Bombs + Fuel.

If flying with max. load, better to have nose slightly heavy.

PBY @ 33000 lb load stalling speed: 75 K.

Trim tab should seldom be more than 5° one way or other.

Mixture Controls Catalina I – Bendix injection Carburetor

4 positions, eg 1 Full rich 2 Automatic rich 3 Auto. Lean
4 Idle cut off

Full Rich.

1. Used for prolonged excessive Power.

2. In event of failure to automatic carburator.

3. When starting to give richer mixture after spitting.

Aut Rich

1. Can be used under all condition of flight

2. Take off.

3. Level flight

Auto. Lean

1. ~~below 28" boost provided boost less than 28"~~

Used for cruising provided boost less than 28" & RPM less than 2250 & cylinder head temp. does not exceed

205°C

If used must be used slowly.

Idle cut off.

When ~~engine~~ stopping engine & when engine is stopped.

E. E. James
R.A.F.

THEORY OF BOMBING

1. THE THEORY OF A FALLING BOMB

In studying the theory of bombing we discover firstly what woul happen to a bomb that is unaffected by air resistance, and secondly what effects air resistance has on a real bomb. With the first set information as a base and the second set applicable to any type of bomb, a sight can be constructed for any set conditions.

2. THE UNRESISTED FALL OF THE BOMB

This simplified treatment of the problem was usually referred to as the "Vacuum Fall Theory", as it could only be in the entire absenc of air that a real bomb would fall in the manner to be discussed.

When, however, the theory of aiming comes to be considered it is necessary to take account of the wind, and it is difficult to think of a wind in a vacuum. Again, it will be found convenient to study the actual motion of a real bomb by comparing its behaviour during fall with that of an unresisted one's fall beside it.

It is found convenient, therefore, to discard the idea of the vacuum and substitute for it the motion through air of an "ideal bomb"

This "ideal bomb" must be presumed to be perfectly smooth, perfectly streamlined and incapable of setting up pressure waves as it moves through the air, thus encountering no real resistence. It need hardly be remarked that such an ideal bomb could not be manufactured, but for the successful understanding of the above theory, it must be imagined.

3. RELATIONSHIP OF BOMB, AIRCRAFT AND GROUND

The fall of a bomb, either real or ideal, must always be considered relative to the aircraft and not relative to the ground.

Wind must be visualised as a column of air moving relative to t ground. This column of air has the aircraft and bomb moving in it.

When bomb sighting in a wind is considered, the problem consists of find the point in this column of air, moving over the ground, at which to release the bomb so that it will hit the target.

4. THE TRAJECTORY OF AN IDEAL BOMB

When an ideal bomb is released from an aircraft there are two factors effecting its flight to earth:-

(i) Gravity: Starting at zero and giving it an acceleration downwards at 32 ft/sec^2 approximately.

(ii) Initial Velocity: Imparted by the aircraft in the direction of its flight through the air.

As this bomb is not affected by air resistance, it will maintain this velocity until the moment of impact with the ground. Assuming the aircraft maintains its own velocity and direction the bomb will be vertically beneath it at any moment of its flight.

Para. 4 (contd.)

If the time of fall is known then the distance forward through the air that the bomb fell can be ascertained by multiplying the time of fall "T" seconds by the air speed of the aircraft "V" ft/sec., i.e. V x T ft. The time of fall of an ideal bomb is found by the formula for constant acceleration.

Where s = Distance; a = Acceleration; u = Initial Speed,

and t = time;

$$s = ut + \tfrac{1}{2} a t^2$$

To calculate the time in seconds for an ideal bomb to fall through H feet; $H = uT + \tfrac{1}{2} = T^2$. But the velocity downwards is zero at the moment of release, so

$$q = \tfrac{1}{2} a T^2 = \tfrac{1}{2} gT^2 \text{ where } g = 32 \text{ ft/sec}^2$$

$$H = 16\ T^2$$

$$T^2 = \frac{H}{16}$$

$$\therefore T = \frac{H}{\sqrt{16}} \qquad \therefore T = \tfrac{1}{4}\sqrt{H}$$

Therefore the distance an ideal bomb moves forward through the air after release is $\tfrac{1}{4}\sqrt{H}$ secs x airspeed in ft/sec.

Air speed will now be referred to as "V" ft/sec.

Data: 100 m.p.h. = 147 ft/sec approximately.

Conversion factor $\frac{22}{15}$ for m.p.h. to ft/sec.

The trajectory of an ideal bomb is shown in Fig. I (see Page 3) by plotting H ft. against $\tfrac{1}{4}\sqrt{H}$ x Vft. at varying heights.

5. BOMBING ANGLE

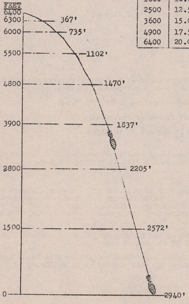
In fig. IA an ideal bomb is released at 'O' from an aircraft vertically over the point A. It falls through H feet and travels forward V x T feet through the air before striking the ground at M. At the moment of release the point M is at an angle to the aircraft from the vertical, angle A.O.M.

This angle is known as the Bombing Angle and is contained in a triangle of sides H and VT ft. set at right angles.

Any triangle having the same sides proportional to these lengths will automatically produce the same bombing angle θ (Theta) as the triangles are similar.

TRAJECTORY OF AN IDEAL BOMB.

H	1/4 √H	V ft/sec	V×T
100	2.5	147	367
400	5.0	147	735
900	7.5	147	1102
1600	10.0	147	1470
2500	12.5	147	1837
3600	15.0	147	2205
4900	17.5	147	2572
6400	20.0	147	2940



AN IDEAL BOMB RELEASED FROM AN AIRCRAFT AT

6,400 ft., TRAVELLING AT AIR SPEED OF 400 M.P.H.

FIG. 1.

BOMBING ANGLE – NO WIND

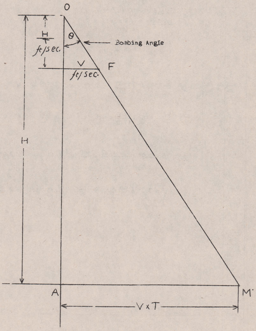


FIG. 1a ELEVATION

A SIMPLE BOMBSIGHT.

SCALE 60 ft/sec. 1"
HEIGHT 6,400 ft.
4,900 ft.

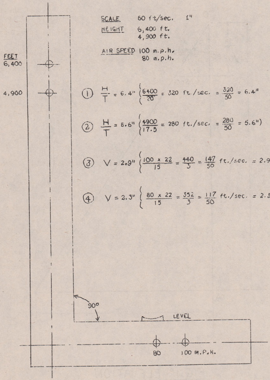
AIR SPEED 100 m.p.h.
80 m.p.h.

(1) $\frac{H}{T} = 6.4'' \left(\frac{6400}{20} = 320 \text{ ft./sec.} = \frac{320}{50} = 6.4'' \right)$

(2) $\frac{H}{T} = 5.6'' \left(\frac{4900}{17.5} = 280 \text{ ft./sec.} = \frac{280}{50} = 5.6'' \right)$

(3) $V = 2.9'' \left(\frac{100 \times 22}{15} = \frac{440}{3} = \frac{147}{50} \text{ ft./sec.} = 2.9'' \right)$

(4) $V = 2.3'' \left(\frac{80 \times 22}{15} = \frac{352}{3} = \frac{117}{50} \text{ ft./sec.} = 2.3'' \right)$



Para. 5 (contd.)

Thus a miniature triangle can be placed in the aircraft, which, if provided with fore and aft levels, will serve to give the correct bombing angle.

When, however, we come to graduate these sights so that the fore and back sights can be set for attacks at varying heights and speeds it is found that the horizontal side of the triangle is proportional to the product of two variable V and T. It would be inconvenient to arrive at these two settings in the air.

By graduating the sides of the miniature triangle proportional to speeds instead of distances, a correct bombing angle can be produced of sides $\frac{H}{T}$ ft/sec. (The average speed of fall of the bomb in ft/sec.) and V ft/sec. (the average speed of the aircraft in ft/sec.)

Since both sides have been divided by T and reproduced to some suitable scale - such as 1 inch equals 50 ft/sec., the graduations on the vertical and the horizontal sides are now only dependent on height and air speed respectively.

6. DRIFT ANGLE

Bombing in a Wind with an Ideal Bomb

In Fig. II a bomb is released vertically over the point A from an aircraft heading along AM.

During the time of fall the aircraft and the bomb would move forward through the air to M, a distance of VT feet.

There is, however, a wind W ft/sec. blowing in the direction of A - A' over the ground.

Thus, at the moment of impact of the bomb, the column of air through which the aircraft has flown will have moved W x T ft. to the position A'M'.

The aircraft has therefore tracked over the ground from A to M', and this distance divided by T will give the speed of the aircraft relative to the ground, i.e. Ground Speed.

Thus, AM' equals G x T feet and a triangle of sides V X T feet and G x T feet will include an angle M A M' which is known as the angle of drift. The problem of bombing in a wind is to determine:-

(1) In what direction the aircraft should be headed in order that it will track over the target.

(2) The correct point G x T feet from the target at which the bomb should be released. In other words to determine the drift and bombing angles.

Provision may now be made accordingly. As it has been decided to graduate the sight in proportion to speeds, we have only to fix the the base of the height bar a miniature triangle of velocities A B F proportional to the triangle of distances covered A M M'. Thus the side AB is proportional to the distance AM and will represent the airspeed "V" ft/sec. The side BF is proportional to the distance MM' and will represent the wind speed "W" ft/sec.

/Page 7 - Drg. Drift Angle.
/Page 8 - Drg. Bombing Angle in a Wind.
/Page 9 - Para. 6 (contd.)

BOMBING ANGLE IN A WIND.

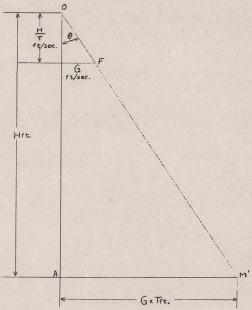


FIG. 3. ELEVATION.

Para. 6 (contd.)

The third side AF will be determined automatically both in length and direction and will be proportional to the distance AM' and will represent ground speed "G" ft/sec. and track.

The foresight will be situated at the Point F.

The bombing angle thus produced in a wind is shown in Fig. III.

7. THE EFFECTS OF AIR RESISTANCE

When a real bomb is dropped it is subject to air resistance and will:-

1. Take longer to fall;

2. Be unable to maintain its initial horizontal velocity after release.

Its trajectory will therefore be behind that of an ideal bomb and at any moment during its fall the real bomb will not have fallen as far as the ideal bomb.

8. TIME LAG

Time lag is the difference in times of fall of a real and an ideal bomb dropped simultaneously from the same uniformly moving aircraft. It is denoted by the symbol "t". Thus the time of fall of a real bomb is (T + t) seconds.

9. AIR LAG

Air lag is the horizontal distance at any given height between the trajectories of a real and an ideal bomb released simultaneously from the same uniformly moving aircraft. It is denoted by the symbol "l". Fig. IV shows the trajectories of a real and an ideal bomb released from the same uniformly moving aircraft when vertically over the point A, and shows the relative positions of the bomb and the aircraft after T + t seconds. At the moment of impact of the ideal bomb at I, the aircraft is vertically above it at O', but the real bomb is at some point R' and must still fall for "t" seconds (time lag) before hitting the ground at R.

During the time "t" seconds the aircraft will move forward through the air at a distance of V x t Feet. Thus, at the moment of impact of the real bomb, the aircraft is vertically over the point M' which is (l + Vt) feet ahead of the point of impact of the real bomb, parallel to heading. When viewed from the aircraft the real bomb appears to trail behind.

10. TRAIL ANGLE

Trail Angle is the angle between a vertical dropped from an air craft and a line from the bomb to the aircraft at any given moment during its fall, assuming that the aircraft is moving at a constant airspeed and direction.

The angle is denoted by symbol λ (Lambda). In work connected with bombing problems it is often necessary to deal with triangles one angle of which is very small.

/Page 10 - Drg. Trail Angle.
/Page 11 - Para. 10 (contd.)

TRAIL ANGLE.

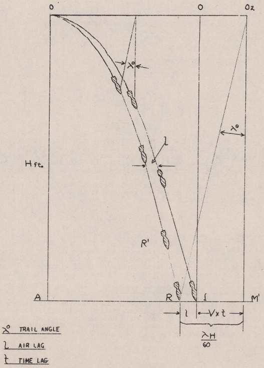
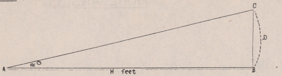


FIG. IV.

Para. 10 (Contd.)



It will be seen from the foregoing figure that the chord BC approximates very closely to the arc BDC. The whole circumference of a circle of radius H is given by the formula 2πH and the arc BDC is to the whole circumference as the angle α is to 360° or $\frac{BDC}{2\pi H} = \frac{\alpha}{360}$

when α is measured in degrees.

$$\text{Hence BDC} = \frac{\alpha}{360} \times 2\pi H$$

$$= \frac{\alpha\pi H}{180}$$

$$= \frac{\alpha H}{57.3}$$

In a bombing problem it is required to know length of BC, and since it is very nearly identical in length with the arc BDC, the above expression would give sufficient accurate results for practical purposes. In order to facilitate working the denominator is taken as 60 instead of 57.3. The expression thus becomes $\frac{\alpha H}{60}$. This approximation for the solution of a triangle with one very small angle will be used where appropriate. For example - if AB were 14,000 ft. and were 2° then the line BC would be

$$\frac{2 \times 14,000}{60} = 467 \text{ feet in length.}$$

11. TRAIL DISTANCE

Trail distance is the horizontal distance a bomb trails behind a vertical dropped from a uniformly moving aircraft. This distance is back along a line parallel to heading. Trail distance = 1+ Vt tan H α° or as an approximation $\frac{\alpha^{\circ} H}{60}$ and air lag = 1 = (α°H) - Vt.

12. DROPPING A REAL BOMB IN A WIND

In Fig. V an ideal and a real bomb are released simultaneously from the same uniformly moving aircraft when vertically over the point A, heading along AM. At the end of T seconds it has been previously shown that the ideal bomb landed at the point I vertically under the aircraft tracking along AM'.

The real bomb will now take a further t seconds to fall; during this time:

/Page 12 - Drg. Bombing in a Wing with a Real Bomb.
/Page 13 - Para. 12 (1).

BOMBING IN A WIND WITH A REAL BOMB.

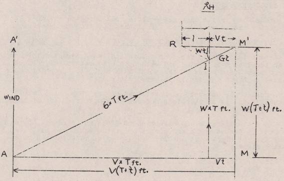


FIG. V. PLAN

Para. 12 (Contd.)

(1) The aircraft will move through the air a distance of V x t feet.

(2) The air and the trajectories will move over the ground a distance of G x t feet, arriving over M' at the moment of impact of the real bomb at R. The real bomb strikes at R (i.e. 1 + Vt) feet behing M' parallel to heading. Thus RI the distance the two bombs will fall apart. RI being the third side of a triangle having 1 and WT as its other sides

$$\overleftarrow{RI} = \overleftarrow{1 + Wt}$$

13. GROUND LAG

Ground lag is the distance apart a real bomb and an ideal bomb fall on the ground when dropped simultaneously from the same aircraft

14. CONSTRUCTION OF A BOMBSIGHT FOR USE WITH A REAL BOMB.

A bombsight has so far been theoretically constructed for dropping an ideal bomb in a wind and with such a bombsight the correct line of sight terminates at the point I in Fig. VI, the point where an ideal bomb would burst if it were released at Point A.

A real bomb, however, when released at the same point, would strike at R and it is therefore necessary to move the line of sight to that point.

Since the distance and direction of RI is not constant, being dependent on the strength and direction of the wind, the alteration of the line of sight must involve two stages of modification to the existing sight.

Firstly, the height bar is graduated proportional to the average speed of fall of the real bomb, i.e. $\frac{H}{(T+t)}$ ft/sec. thus projecting the line of sight to M' which point is vertically beneath the aircraft after (T + t) seconds.

Secondly, since the real bomb trails behind the point M' a distance of $\frac{\lambda H}{60}$ feet parallel to the line of heading, the backsight must be moved forward a proportionate distance in the same direction, bring the backsight vertically over the point B, and thus projecting the line of sight from B through F to R.

This movement of the backsight is effected by tilting the height bar forward about the point A and parallel to the air speed bar. It will be seen that since the length of the height bar is already proportional to the height of the aircraft above the ground, and the distance RM' is subtended by the trail angle λ^{o} then, if the height bar can be tilted forward through λ^{o} the distance AB will be proportional to RM'.

/Page 14 - Drg. Construction of a B/Sight for use with a real bomb. (Elevation).
/Page 15 - As above (Plan).
/Page 16 - Para. 15.

CONSTRUCTION OF A BOMB-SIGHT FOR USE WITH A REAL BOMB

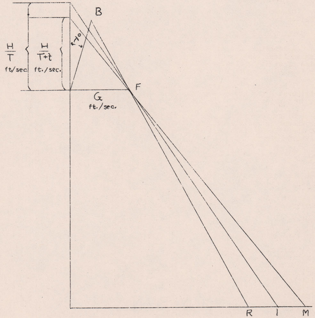


FIG. VI. ELEVATION

CONSTRUCTION OF A BOMB-SIGHT FOR USE WITH A REAL BOMB.

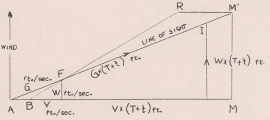


FIG. VI. PLAN.

15. PERFORMANCE OF BOMBS

We have now constructed a bomb sight for use with a real bomb; this construction consisted of modifying the sight, as used for an ideal bomb, by re-graduating the height bar so as to incorporate "t" and by tilting the height bar so as to incorporate λ. It has already been shown that the time lag "t", the air lag "l", the ground lag and the trail angle λ are inter-related. Since these values are dependent on air resistance it follows that the air speed at the moment of release, the height of release and the mass and shape of the particular bomb will alter them. Thus, it is necessary for each type of bomb and for each airspeed to place different settings on the sight. On the old typebomb sights an average time of fall of all real bombs was taken and one height bar graduated to this scale was fitted; a trail angle setting was provided and from a table the correct trail angle for each bomb at a number of different heights and air speeds could be ascertained and set on the bomb sight. This system has been improved upon in modern bomb sights, however, by the use of a single setting for the terminal velocity of the bomb, inter-connected with the air speed setting in such a way as to give the correct trail angle Separate heights scales are also issued for each type of bomb and can be clipped into position on the height bar.

The connection between trail angle and terminal velocity may not be apparent and is explained hereunder. When a real bomb falls it is as we have seen, subject to air resistance. Now the air resistance against a body which is travelling at a speed below the speed of sound, increases as the square of its own velocity. If this body is a bomb subject to the initial velocity of the aircraft, plus an acceleration of 32 ft/sec^2 due to gravity, then as the bomb's speed increases, the air resistance will increase as the square of its speed until a point is reached when the effect of air resistance will balance the forces of the acceleration due to gravity and the bomb will travel at a uniform speed. This is known as the terminal velocity, and is related to the ballistic characteristics of the bomb through the common factor of air resistance. Thus a bomb of good shape and smooth surface will have little air resistance, its T.V. will consequently be <u>high</u>, and its trail angle, air lag and time lag will be <u>low</u>.

A glance at the height scales for a bomb sight will show that a number of bombs are labelled as having a T.V. above the speed of sound (i.e. above 100 ft/sec). Unfortunately, the air resistance on a body travelling above the speed of sound does not follow the simple square law that is true for speeds below 1,100 ft/sec. It does in fact, become so complicated as to make calculation impracticable and the true T.V. of these bombs cannot be worked out. These bombs are therefore assumed to be subject to an air resistance equal to the square of their velocity throughout their fall. The T.V. so obtained is fictitious, but it nevertheless is a true indication of the ballistic qualities of the bomb and as such is used for sighting purposes.

16. THE CONSTRUCTION OF A FOURTH VECTOR SIGHT

(a) When bombing a moving target an allowance must be made for the distance the target will move during the time taken for the bomb to fall. It is also necessary to adjust the drift wires so that the line of approach of aircraft and moving target is indicated.

16. THE CONSTRUCTION OF A FOURTH VECTOR SIGHT (Contd.)

(b) It has been shown that the ground velocity is the resultant of air velocity and wind velocity. Similarly the velocity of approach is the resultant of the velocity of the aircraft over the ground and the velocity of the target over the ground. In Fig. I, the triangle ABE represents the three vector bomb sight and the line XY represents the enemy velocity. In order to build up a vector diagram it is necessary to consider all velocities relative to one object. Let us take the aircraft as our object, and stop the ship, then in order to get the same relative velocity between ship and aircraft we must apply to the aircraft the ship's velocity reversed. Thus, in building up the vector diagram, ED (the ship's velocity reversed) is added. Now if we join AD it will represent the resultant or the speed of approach of the aircraft and ship. Fig. IA shows the construction of the diagram when the ship's velocity is YX. Now if AB is the airspeed bar, BE the wind speed bar and AE the ground speed bar or drift wires on 3 vector sight, then it will be necessary to add a 4th bar ED to the end of the wind speed bar, capable of rotation through 360° and of adjustment to a length proportional to the ship's or enemy's speed. If the foresight is carried at D and the drift wires are also connected to this point instead of to the point E, then ED becomes the enemy speed bar and AD the speed of approach bar - or the drift wires. Such a sight was constructed and is shown in the photograph Fig. IB.

The mechanical disadvantages of this sight are obvious. It can be seen from Fig. II, however, that the same approach velocity can be reproduced if, instead of moving the foresight by mounting the enemy speed bar at E, we move the backsight in the opposite direction BY MOUNTING THE ENEMY SPEED BAR AT A and move the height bar and the rear anchorage of the drift wires. Incidentally, as we have to move the backsight in the opposite direction, the enemy speed bar is now in the same direction as the movement of the target. Fig. II.A shows the same construction as Fig. II with enemy speed in the opposite direction. The photograph Fig. II.B shows how the CSBS now in use takes up the position of the diagram, Fig. II.

(c) The bombing angle for an Ideal Bomb and Moving Target will be included in a triangle of sides H feet and S x T feet (where S is the speed of approach in ft/sec). This is shown in plan Fig. III and elevation Fig. IV. If an Ideal Bomb is released vertically over the point F, Fig. III, from an aircraft tracking FI, it will strike at the point I a distance of (G x T) feet from F. In order to register a hit, the target at the moment of release must be at E, a distance of (E x T) feet from I, and of (S x T) feet from F.

/Page 18 - Drg. The construction of a 4th Vector Sight, Fig. I.
/Page 19 - As above, Fig. II and Fig. II.A.
/Page 20 - Para. 16 (contd.)

THE CONSTRUCTION OF A FOURTH VECTOR SIGHT.

FIG. I.

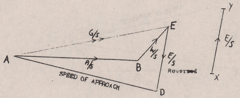
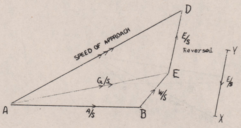


FIG. IA.



THE CONSTRUCTION OF A FOURTH VECTO SIGHT.

FIG. II.

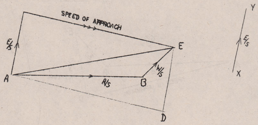
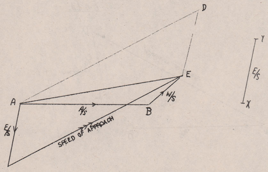


FIG. II A.



Para. 16 (Contd.)

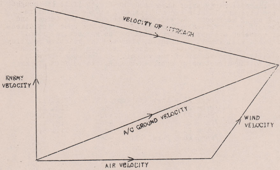
(d) The construction of a bombsight for a real bomb and moving target is shown in Fig. V. A real bomb is released vertically over the point F from an aircraft tracking F M'. Assuming that the aircraft maintans a constant velocity it will arrive at the point M' at the moment of impact of the bomb at R. A target moving along E'M' must be at the position E' (E x T x t) feet from M' and S x (T + t) feet from F at the moment of impact. The point E' therefore represents the termination of a line of sight with a height bar at A' graduated to a velocity scale of $\frac{H}{T + t}$ ft/sec., but with a zero trail angle setting. With a height bar tilted forward λ^{o} parallel to the air speed bar (position B') the line of sight is moved from E' to E, a distance equivalent to, and parallel to the trail distance, M'R. A target at E at the moment of release will therefore move a distance of E x (T + t) feet along E R and arrive at R at the moment of impact.

NOTE

Misconception may arise when studying Fig. V if it is thought since the aircraft is at F and the target E at the moment of release, F and E represent the relative positions of the target and the aircraft at a particular instant of time. The speed and direction of approach are entirely governed by the respective ground velocity and will remain unaffected, whatever the relative position of target and aircraft may be. Further, if the speed of approach bar (A'F) is a true vector of the velocity of approach, it will parallel to the direction of approach whether viewed from A'B or any other point.

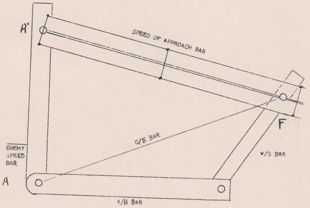
/Page 21 - Drg. 4th Vector Sight, Fig. 1.
/Page 22 - Drg. -do- Fig. 2.
/Page 23 - -do- Fig. 3.
/24 24 - -do- Fig. 4.
/Page 25 - -do- Fig. 5.
/Page 26 Para. 17. -do-

FIG. 1. VECTOR DIAGRAM



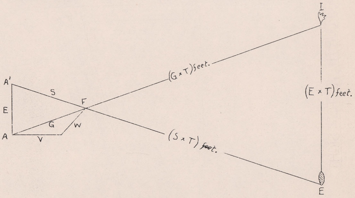
FOURTH VECTOR SIGHT.

FIG. 2. SPEED BARS.



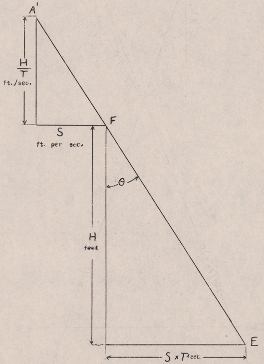
FOURTH VECTOR SIGHT.

FIG. 3. IDEAL BOMB.



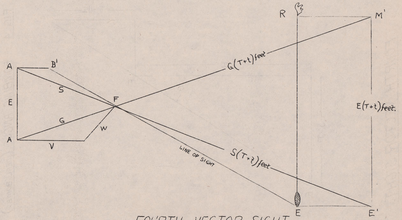
FOURTH VECTOR SIGHT.

FIG. 4. BOMBING ANGLE (IDEAL BOMB.)



FOURTH VECTOR SIGHT.

FIG. 5. REAL BOMB



FOURTH VECTOR SIGHT.

AZIMUTH BRACKET

1. The azimuth bracket and steering indicator has been introduced for use with the course setting bombsight, Mk.VII and IX, to enable the pilot of a bombing aeroplane to make use of banked turns in a bombing approach. The main advantage of the azimuth bracket is that long, straight approaches are unnecessary and major turns may be made within 40 seconds of the instant of bomb release. This means that the aeroplane is only flying on a straight course, suitable for anti-aircraft flying prediction, for about 20 seconds, with consequent decrease in vulnerability to anti-aircraft fire. The bracket has no definite advantage over the fixed spigot if long, straight approaches are made. In addition, a rapid change of course 70 to 30° may be made by a banked turn, when conditions of bad visibility occasions a late identification of the target.

DESCRIPTION

2. AZIMUTH BRACKET (See Fig. 1.)

The azimuth bracket consists of a main frame (1), in which a bombsight spigot (2) is pivoted about a vertical axis and is capable of rotation in azimuth, 30° left or right of a central zero, by relative movement of the bombsight. A pointer (3) attached to the vertical spindle (4), indicates on a scale (5), attached to the main frame. If an aeroplane has to be turned to pass over an objective, the actual angle measured at the start of the turn will be less than the final total change of course, due to the fact that the aeroplane cannot turn instantaneously, but must turn on a path of appreciable radius. If, therefore, the magnitude of the turn, as indicated by the azimuth bracket is slightly greater than the actual angle measured at the start of the turn, a close approximation to the total turn required is obtained. It is found, in practice, that the total turn required is about 1.2 times the actual angle measured at the start of the turn, and the scale (?) (Fig.3.) has been calibrated in accordance with this rule. The bombsight spigot is geared to a transmitter (6) which actuates a steering indicator described below. A clutch is provided whereby the stiffness of the spigot rotation in azimuth may be adjusted and is controlled by the knob (7). Rotation of the spigot in azimuth from the central position is normally prevented by a springlever (8), when it is required to rotate the course setting bomb-sight in azimuth to determine the angular offset of the target. The lever (8) may be maintained in the depressed position by a thumb-operated lever and locking pin on the side of the bracket. On releasing the locking pin, the course setting bombsight is automatically secur in the central position when the spring-loaded latch registers with the groove. The levelling adjustments are similar to tho. of the standard course setting bombsight levelling bracket and are controlled by the levelling screws (9) and (10). The lateral levelling screw (9) has a spring loaded handle which enables the handle to be positioned to give an unobstructed view of the scale without deranging the lateral levelling of the bombsight.

3. STEERING INDICATOR

The steering indicator (Fig. III) is an electro-magnetic device, which, in conjunction with the transmitter incorporated in the bracket, actuates a pointer (11) moving over a scale (12). The scale is calibrated and figured 35° left and right to coincide with the bracket scale readings. The indicator is designed so that in the event of a supply failure or when the supply is not

3. (contd.)

switched on, the pointer leaves the calibrated portion of the scale and points vertically downwards. Two lamps, behind red and green windows (13), are contained in the indicator and work in conjunction with the switch described in Para. 4. The lamps are readily replaceable in the event of failure, the lamp retaining plate being secured by a milled screw.

4. SWITCH

The switch (Fig.II) consists of two push buttons (14) coloured red and green respectively, arranged with a guard plate (15), in such a manner that the bomb-aimer may distinguish by touch only, which one to depress.

5. RESISTANCE UNITS

The equipment is normally for use with a 12 volt supply. When the equipment is to be used with a 24 volt supply, suitable resistance units must be inserted in the installation wiring. This must be done by signals personnel.

6. INSTALLATION

The azimuth bracket is interchangeable with the standard course setting bombsight levelling bracket. The alignment of the bombsight with the fore axis of the aeroplane should be checked with the bombsight set at zero drift and the pointer on the bracket registered in the zero position. Any necessary adjustment of installation should be made by the method normally employed when using a standard course setting bombsight levelling bracket.

7. PROCEDURE FOR USE.

(a) The bomb-aimer ensures that the bombsight spigot is located in the central position, and makes all the usual settings on the sight.

(b) As soon as the target is located, he switches on the electrical supply, disengages the lever (8) and rotates the bombsight in azimuth until the drift wires are on the target wit RED set on RED.

(c) The bomb-aimer depresses the red and green push-buttons (1 simultaneously to illuminate the lights on the steering inc cator. The indicator shows the angle of turn required, while the illumination of the lamps is the executive signal to the pilot to start the turn. The minimum possible time should elapse between the measurement of the angle and the executive signal.

(d) The pilot banks and turns the aeroplane through the angle indicated on his steering indicator by his directional gyro.

(e) During the turn, the bomb-aimer centralizes the sight. There is no need to re-set RED on RED as this has previously been done. (See Para. 7 (b). On completing the turn, he should find the target on or near the drift wires with RED still on RED. The locking lever will engage itself automatically when the sight is centralized.

7.(contd.)

(f) If subsequent small corrections are required, flat turning technique can be used. Steering corrections can be given on the steering indicator by red or green lights. Bombing crews should devise a simple code of signals to indicate the magnitude or urgency of the correction.

(g) If, after the first banked turn, the required correction is of such a magnitude that flat turning technique cannot be used, the procedure outlined in Para's. (b), (c) and (d) should be repeated. However, if the azimuth bracket and bombsight is used correctly there should be no reason for a major correction at this point.

(h) The bomb-aimer releases the bomb in the usual way when the target reaches the line of sight through the backsight and foresight.

NOTE

As an alternative to, or in the event of a failure in the steering indicator, the bomb-aimer can transmit verbally to the pilot the angle of turn required, after reading its magnitude on the scale (5). Other steering corrections may be relayed in similar fashion as for normal bombing.

DESCRIPTION OF THE MK.IX C.S.B.S.

There are two types:

Type	Height range	A/S range	W/S range	Enemy speed range.
Mk.IX.A	3000' to 20,000'	100 - 240 MPH	0 - 70 MPH	0 - 50 knots.
Mk.IX.C.	3000' to 20,000'	87 - 208 knots.	0 - 60 knots.	0 - 50 knots.

They are similar in most respects to the Mk.VII, but possess an extended range in speed settings to allow for the increased speeds of modern aircraft. To obviate any corresponding increase in the size of the bombsight, the scale of the speed and height bars has been reduced.

In addition to the extended range of speed, provision has also been made to facilitate the determination of Wind Speed and Direction by the incorporation of an Auxiliary Drift Bar and a Calibrated Wind Gauge Bar. A vertical extension to the drift wires also enables early corrections to be made at the commencement of a bombing run, and obviates the necessity for a longer drift bar.

For the purpose of description, the bombsight will be considered in three groups:

(a) The body, compass and internal mechanism.

(b) The height bar, enemy speed attachment and calibrated wind gauge bar.

(c) The air, ground and wind speed bars and auxiliary drift bar.

Key To Photographs of C.S.B.S. & Azimuth Bracket

1. Drift wire beads.
2. Drift Wires
3. Drift Bar
4. Foresights
5. Ground Speed Slider
6. Wind Speed Bar
7. Wind Speed Knob
8. Air Speed Bar
9. Enemy Speed Bar
10. Trail Setting Stop
11. Enemy Direction Knob
12. Air Speed Drum
13. Air Speed Knob
14. Terminal Velocity Lever
15. Terminal Velocity Scale
16. Bombsight Catch Knob
17. Terminal Velocity Knob
18. Drift Scale
19. Wind Arrow
20. Bearing Plate Clamp Lever
21. Compass Bowl Knob
22. Bearing Plate
23. Wind Gauge Bar
24. Cursor
25. Spirit Levels
26. Enemy Speed Bar.
27. Height Bar Slider
28. Height Bar Catch
29. Height Bar Knob
30. Height Bar
31. Height Bar Timing Scale (Red)
32. Backsights
33. Enemy Direction Arrow
34. Enemy Direction Ring
35. Auxiliary Drift Bar
36. Auxiliary Drift Wire
37. Auxiliary Drift Bar Pointer
38. Auxiliary Drift Scale
39. Spigot
40. Slots For Positioning Lugs
41. Pointer
42. Locking Lever
43. Locking Pin
44. Latch
45. Clutch
46. Lateral Levelling Control
47. Scale
48. Fore & Aft Levelling Control
49. Steering Indicator