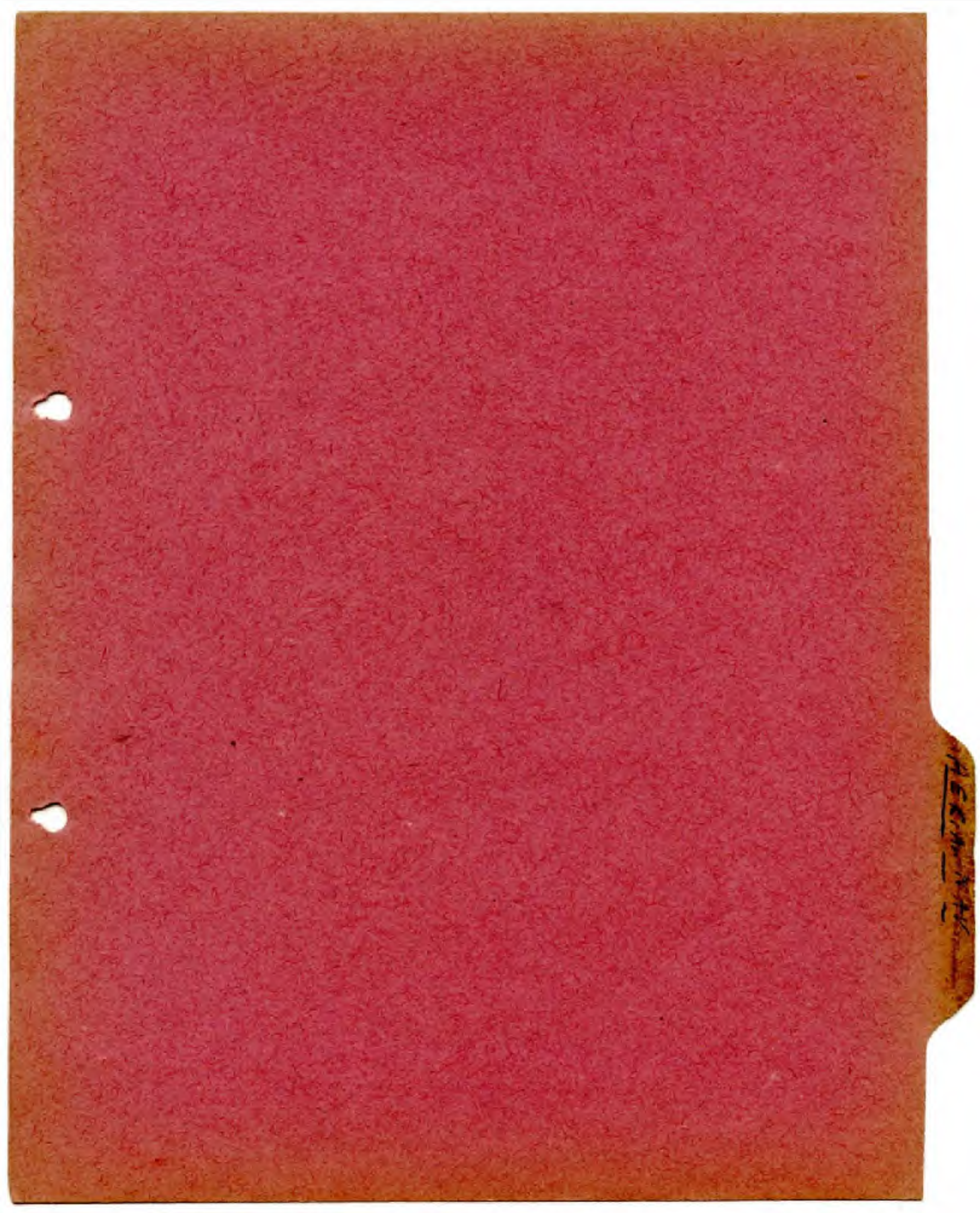
AERIAL NAVIGATION



AERIAL NAVIGATION

Aerial Navigation.

Compass: The compass has 4 cardinal points N.S.E.W & 32 points which are marked on the Mariners Compass.

The compass is divided into 360 equal parts called degrees. 1°= 60' & 1' = 60°. Bearings & courses are always measured clockwise 0° to 360°.

Lubber Line:- A white line marked on bowl of compass & co-incides with the fore & aft axis of machine.

1 mile = 5280'

1 sea mile = 6080'

7 sea miles = 8 land miles (approx)

1 knot is speed of 1 sea mile per hour.

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Illustration of compass]

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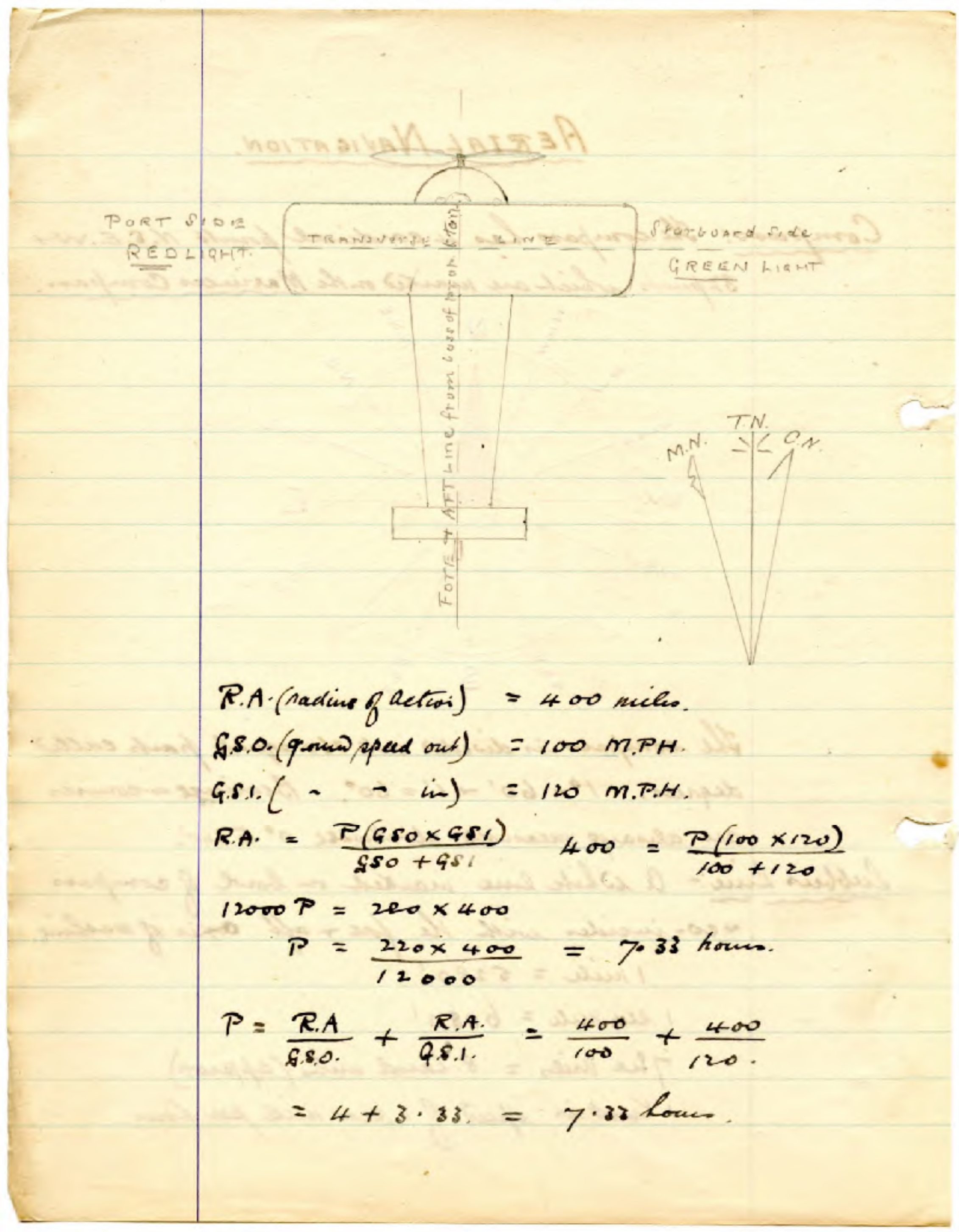


[Illustration of aircraft seen from above, indicating fore, aft & transverse lines]

R.A. (radius of action) = 400 miles
G.S.O. (ground speed out) = 100 M.P.H.
G.S.I. (" " in) = 120 M.P.H.

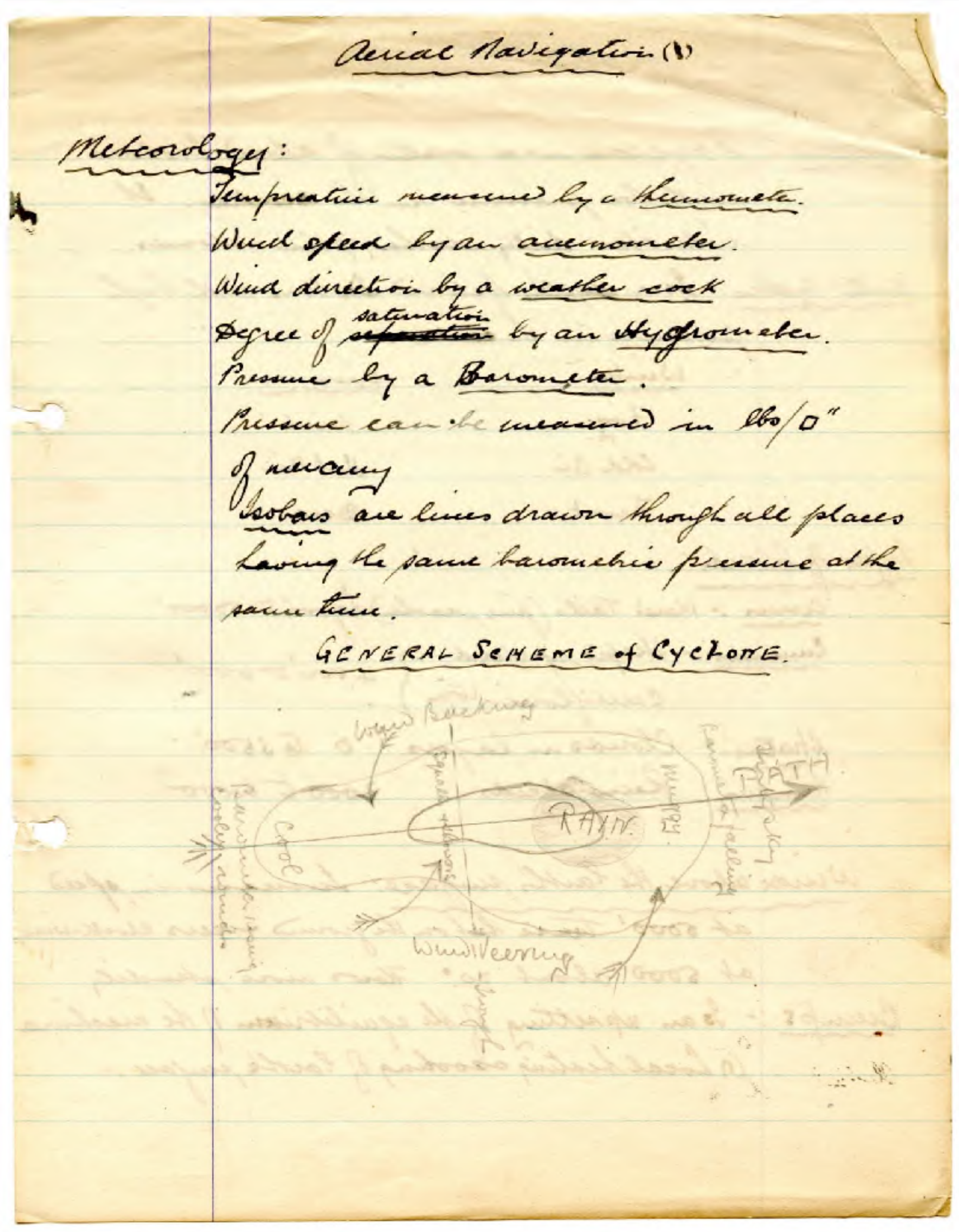
$$R.A. = \frac{P(GSO \times GSI}{GSO \text{ \& } GSI} \qquad 400 = \frac{P(100 \times 120)}{100 \text{ \& } 120}$$

12000 P = 220 x 400

$$P = \frac{220 \times 400}{12000} = 7.33 \text{ hours}$$

$$P = \frac{R.A}{G.S.O.} + \frac{R.A}{G.S.I.} = \frac{400}{100} + \frac{400}{120}$$

= 4 + 3.33 = 7.33 hours



Aerial Navigation (1)

Meteorology:

Temperature measured by a thermometer.
Wind speed by an anemometer.
Wind direction by a weather cock
Degree of ~~separation~~ saturation by an Hygrometer.
Pressure by a Barometer.
Pressure can be measured in lbs/□" of mercury
Isobars are lines drawn through all places having the same barometric pressure at the same time.

GENERAL SCHEME of CYCLONE.

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Pressure can be measured in lbs/sq " of mercury

Isobars are lines drawn through all places having the same barometric pressure at the same time.

GENERAL SCHEME OF CYCLONE

[Illustration of the same]

Cyclone: A cyclone is a system of closed Isobars with low pressure in the centre. It indicates dirty weather, rain & clouds.

Anti-Cyclone: Is a system of closed Isobars with high pressure in the centre.

Winter:	Summer
Fog.	Mist.
Cold air	Hot air
Frost.	Dew.

Types of Clouds:

Cirrus :- Mare's Tails (fine weather) 27000' to 50000'
Cumulus :- Heaped up cloud
Cauliflower tops } 4,500' to 6,000'
Stratus :- Clouds in layers 0 to 3600'.
Nimbus : Rain clouds 3000' to 6400'

Winds above the Earth's surface: Increase in speed at 5000' twice that on the ground & veers clock-wise, at 5000' about 20°. Flows more steadily

Bumps :- Is an upsetting of the equilibrium of the machine
(1) Local heating & cooling of Earth's surface.

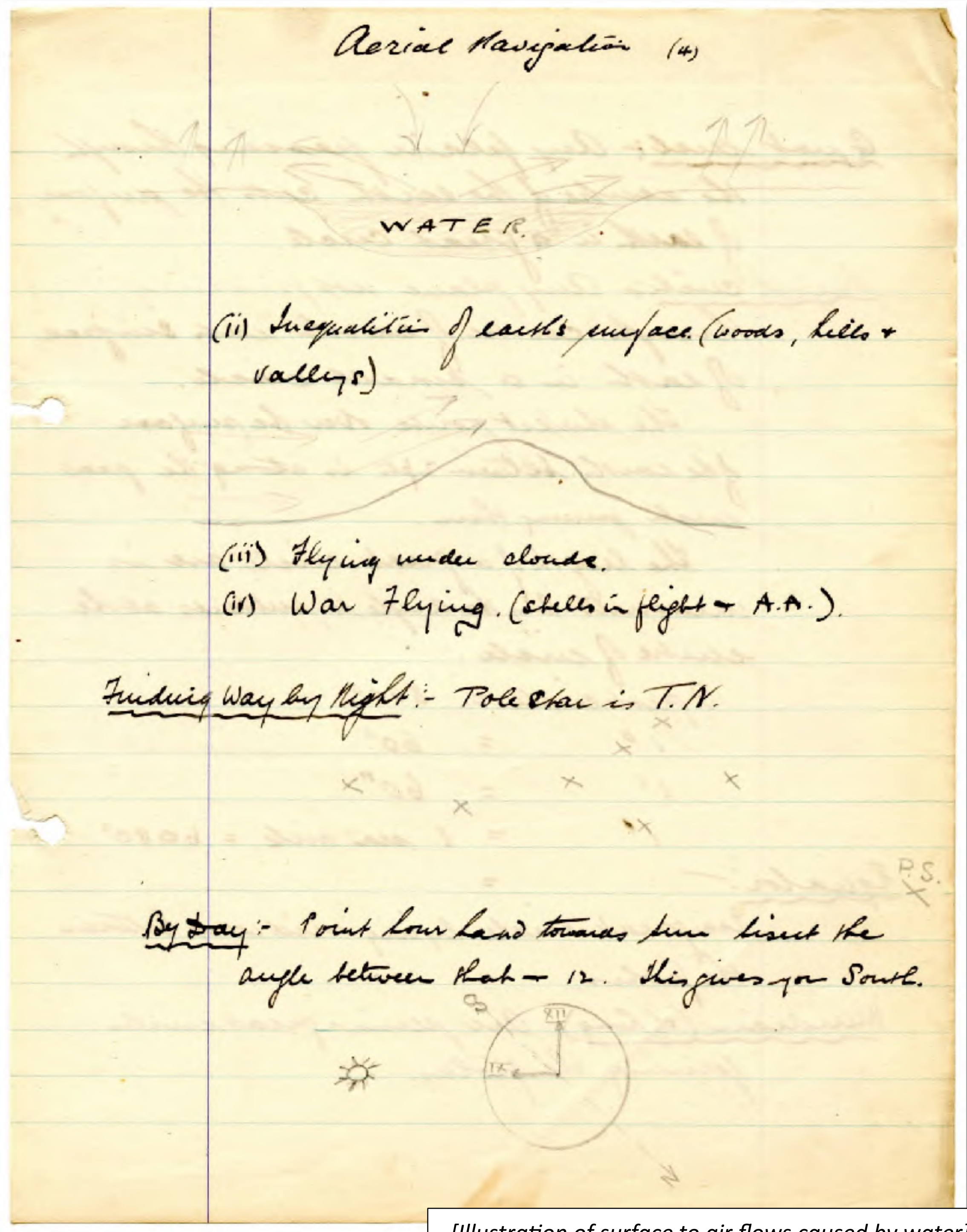
Cyclone:
A cyclone is a system of closed Isobars with low pressure in the centre. It indicates dirty weather, rain clouds.
Anti-cyclone:
Is a system of closed isobars with high pressure in the centre.

Winter	Summer
Fog	Mist
Cold air	Hot air
Frost	Dew

Types of cloud:
Cirrus: Mares' tails (fine weather) 27000' to 50000'
Cumulus: Heaped up cloud)
Cauliflower tops } 4,500' to 6,000'
Stratus: Clouds in layers 0' to 3500'
Nimbus: Rain clouds 3000' to 6400'

Winds above the earth's surface: Increase in speed at 5000' twice that on the ground & veers clock-wise, at 5000' above 20°. Flows move steadily.
Bumps: Is an upsetting of the equilibrium of the machine
(i) Local heating & cooling of the earth's surface.

Aerial Navigation (4)



Aerial Navigation (4)

WATER

(ii) Inequalities of earth's surface (woods, hills + valleys)

(iii) Flying under clouds.
(iv) War Flying. (shells in flight + A.A.).

Finding Way by Night:- Pole Star is T.N.

P.S.

By Day:- Point hour hand towards sun bisect the angle between that – 12. This gives you South.

[Illustration of surface to air flows caused by water]

(ii) Inequalities of earth's surface (woods, hills & valleys)

(Illustration of air flows over hills)

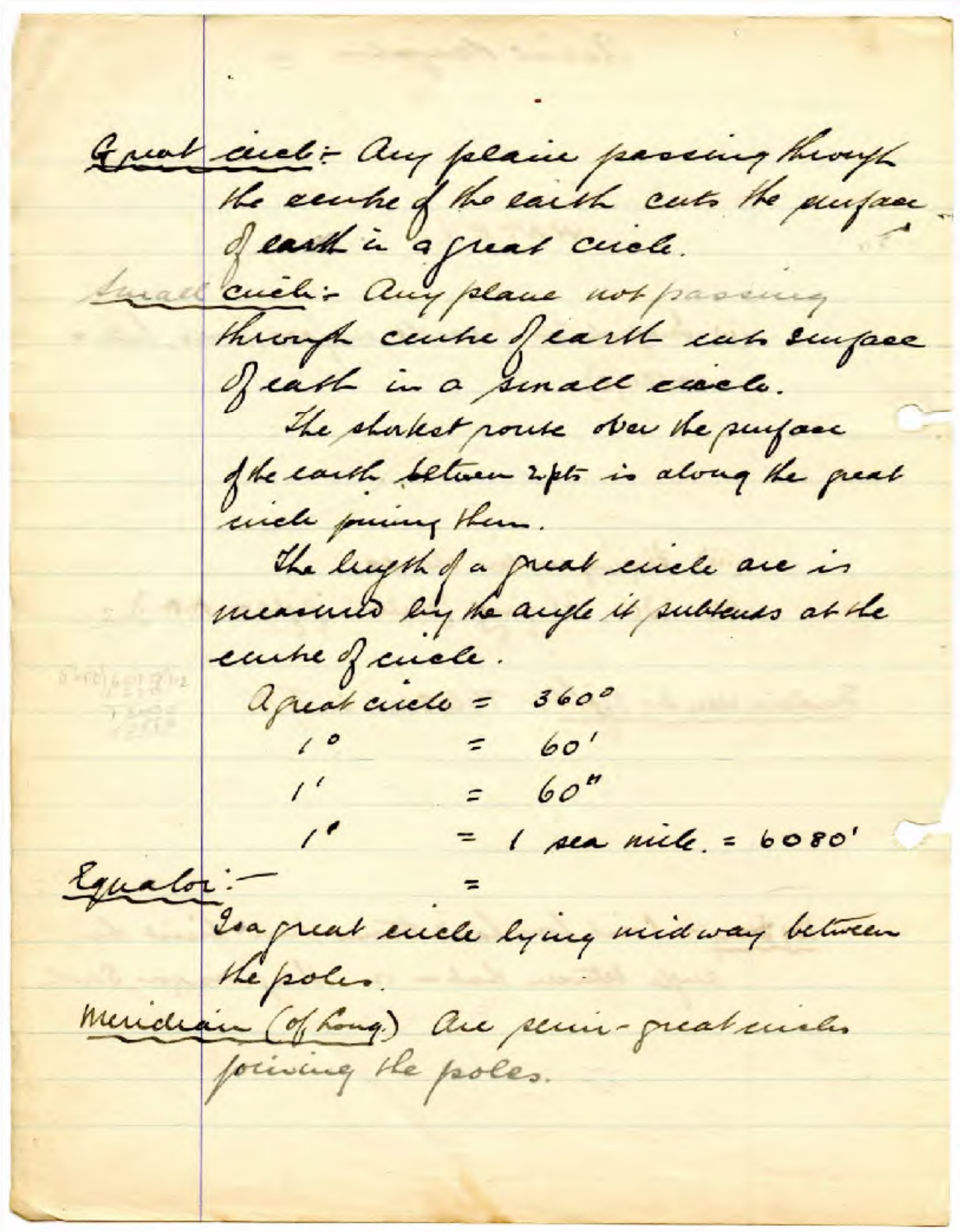
(iii) Flying under clouds
(iv) War Flying (shells in flight & A.A.)

Finding Way by Night: Pole Star is T.N.

(Illustration of position of Pole Star]

By Day: Point hour hand towards sun. Bisect the angle between that – 12. This gives you South.

(Illustration of how to calculate South)



Great circle:- Any plane passing through the centre of the earth cuts the surface of earth in a great circle.
Small circle:- Any plane not passing through centre of earth cuts surface of earth in a small circle.
The shortest route over the surface of the earth between 2 pts is along the great circle joining them.
The length of a great circle arc is measured by the angle it subtends at the centre of circle.
A great circle = 360°
1° = 60′
1′ = 60″
1′ = 1 sea mile = 6080′
Equator:—
Is a great circle lying midway between the poles.
Meridian (of Long.) Are semi-great circles joining the poles.

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Any place passing through the centre of the earth cuts the surface of earth in a great circle.
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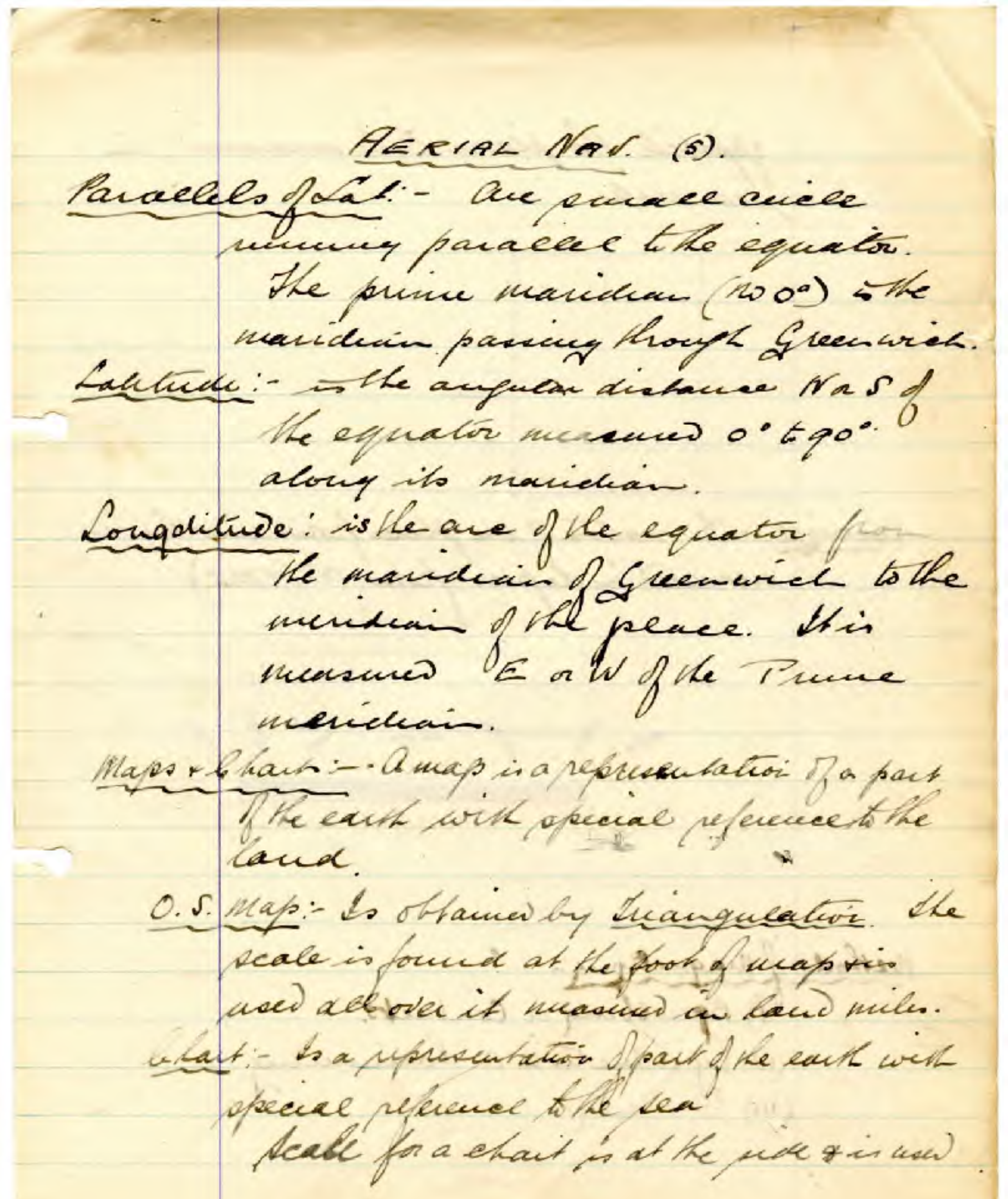
<u>AERIAL NAV (5)</u>



AERIAL NAV. (5).

Parallels of Lat:- Are small circle running parallel to the equator.
The prime maridian (No 0°) is the maridian passing through Greenwich.

Latitude:- is the angular distance N & S of the equator measured 0° to 90° along its maridian.

Longditude: is the arc of the equator from the maridian of Greenwich to the meridian of the place. It is measured E or W of the Prime meridian.

Maps & Charts:- A map is a representation of a part of the earth with special reference to the land.

O.S. Map:- Is obtained by Triangulation. The scale is found at the foot of map & is used all over it measured in land miles.

Chart:- Is a representation of part of the earth with special reference to the sea
Scale for a chart is at the side & is used

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Is the ace of the equator from the maridian [sic] of Greenwich to the meridian of the place. It is measured E or W of the Prime meridian.

<u>Maps & charts:</u>
A map is a representation of the earth with special reference to the land.
<u>O.S. Map:</u>
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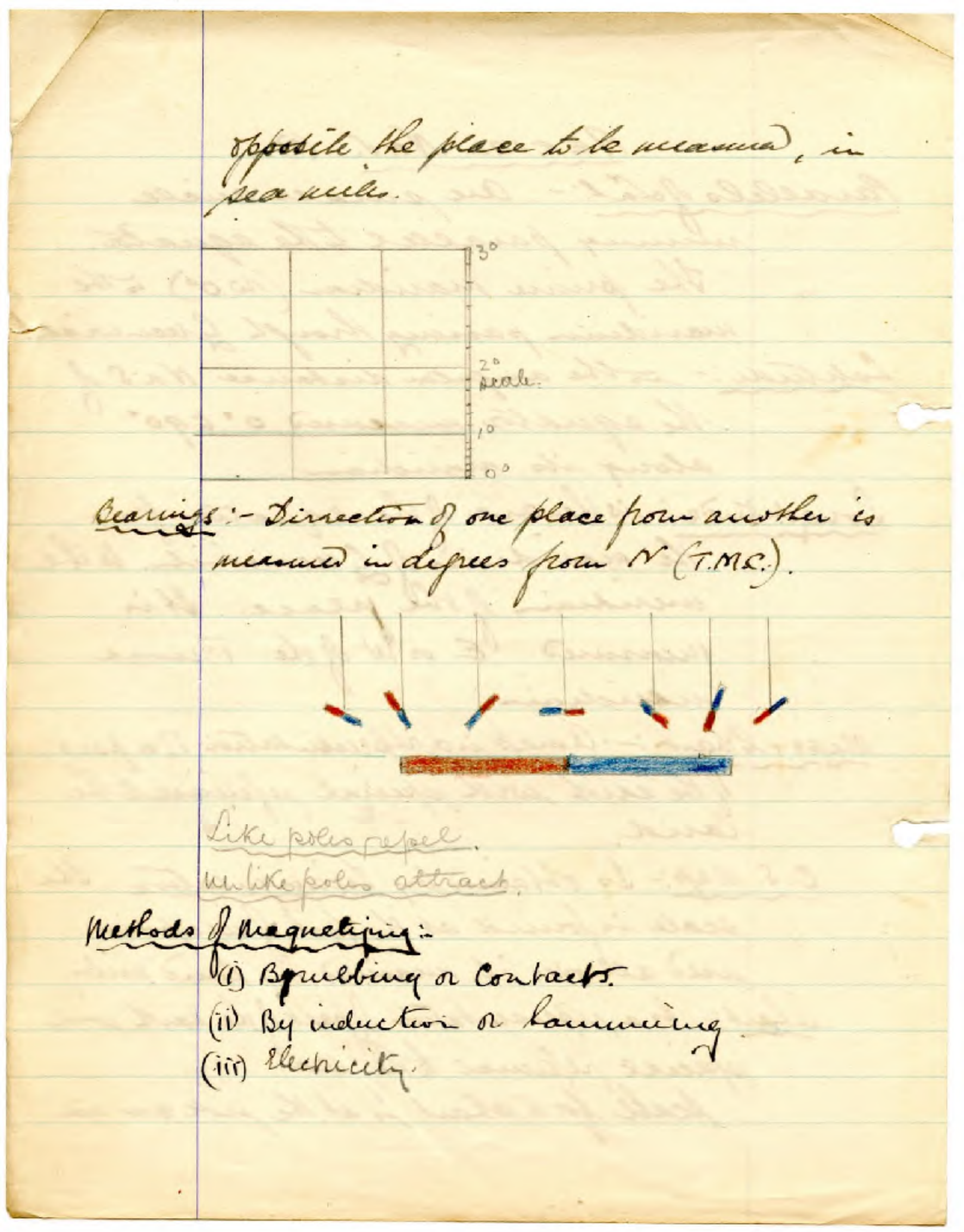
<u>Chart:</u>
Is a representation of part of the earth with special reference to the sea. Scale for a chart is at the side & is used . . .


opposite the place to be measured, in sea miles.

Bearings:- Direction of one place from another is measured in degrees from N (T.M.C.).

Like poles repel
unlike poles attract.

Methods of Magnetizing:-
(i) By rubbing or Contacts.
(ii) By induction or hammering
(iii) Electricity.

. . . opposite the place to be measured, in sea miles.

(Illustration of chart)

<u>Bearings:</u>
Direction of one place from another is measured in degrees from N (T.M.C.)

(Iillustration of bearings)

<u>Like poles repel</u>
<u>Opposite poles attract</u>

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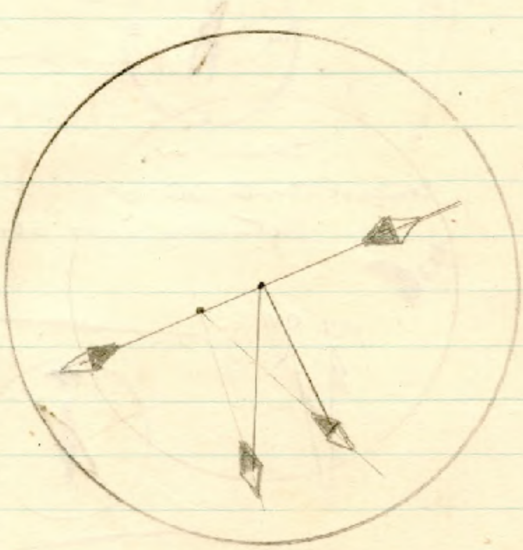
AERIAL NAV (6)

AERIAL NAV. 6.

The M.N. is situated in N. Canada about 1400 miles from Geographical N Pole.

Variation:- Is the horizontal angle between the magnetic meridian + the true meridian, measured E or W of the true meridian.



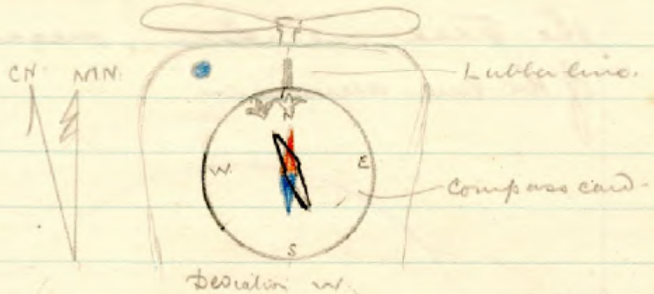
The M.N. is situated in N. Canada about 1400 miles from Geographical N Pole.

Variation: is the horizontal angle between the magnetic meridian & the true meridian, measured E or W of the true meridian.

(Drawing of Variation)

Deviation:- Is the angle between M.N. & C.N. it is measured from MN. & may be either E or W.

Effect of permanent magnetism in machine:-



Deviation W.

Compass should read 0°
Actually reads about 10°

Deviation E.

<u>Deviation:</u>
Is the angle between M.N. & C.N. It is measured from MN & may be either E or W.

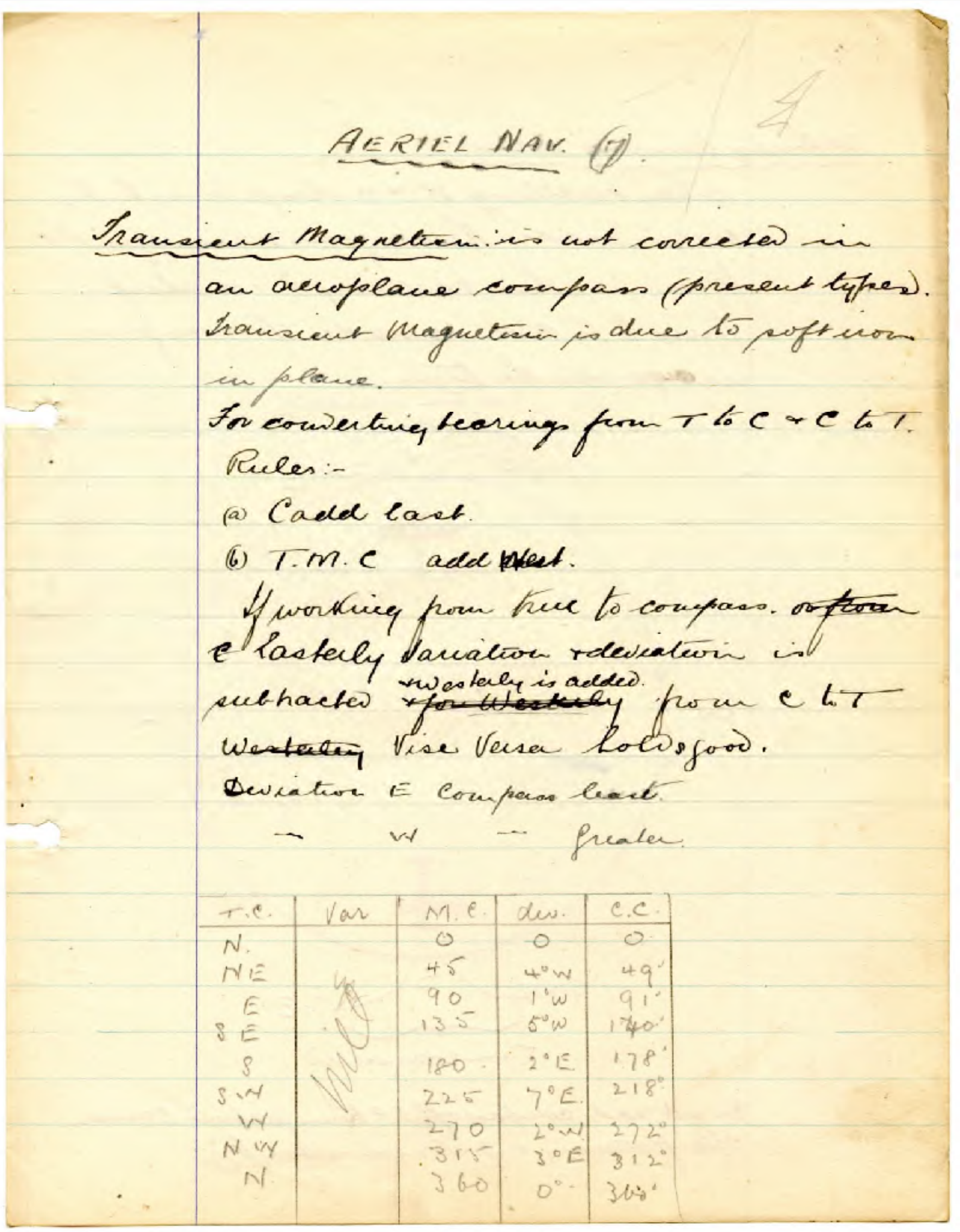
<u>Effect of permanent magnetism in machine:</u>

(First drawing of compass showing incorrect readings when flying north)

Compass should read 0º
Actually reads about 10º

(Second drawing of compass showing incorrect readings when flying East)

AERIAL NAV (7)



AERIEL NAV. (7)

Transient Magnetism is not corrected in an aeroplane compass (present types). Transient Magnetism is due to soft iron in plane.

For converting bearings from T to C & C to T.

Rules:-

(a) C add East.

(b) T.M.C add West.

If working from true to compass. Easterly variation & deviation is subtracted & westerly is added from C to T

Vise Versa holds good.

Deviation E Compass least.

" W " greater.

T.C.	Var	M.E.	dev.	C.C.
N.		0	0	0
NE		45	4°W	49°
E		90	1°W	91°
SE		135	5°W	140°
S		180	2°E	178°
SW		225	7°E	218°
W		270	2°W	272°
NW		315	3°E	312°
N		360	0°	360°

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For converting bearings from T to C & C to T.

Rules:

(a) C add East

(b) T.M.C. add West

If working from true to compass. Easterly variation & deviation is subtracted & westerly is added from C to T.

Vice versa holds good.

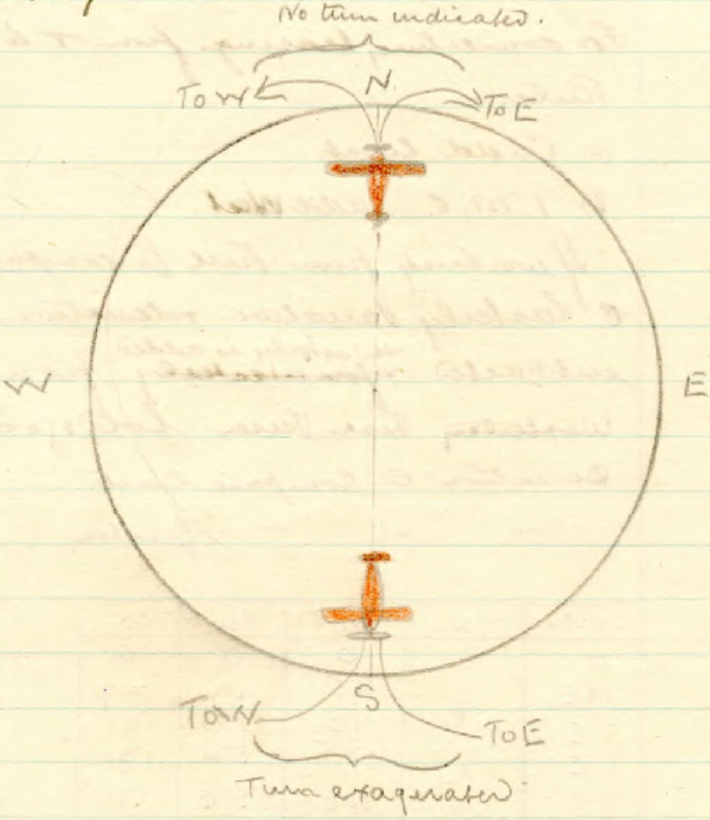
Deviation E Compass least.

" W " greater.

T.C.	Var	M.E.	Dev	C.C.
N		0	0°	0°
NE		45	1°W	49°
E		90	1°W	91°
SE		135	5°W	140°
S		180	2°E	178°
SW		225	7°E	218°
W		270	2°W	272°
NW		315	3°E	312°
N		360	0°	360°

<u>Northerly turning error:–</u>

When travelling N & a sharp turn to E or W is made the compass minimizes the turn. When travelling S & a sharp turn to E or W is made the compass exaggerates the turn.



Do not read compass aft. S.R. turn for about 30 secs. after flattening out. (12 secs with 5/17).

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When travelling N & a sharp turn to E or W is made the compass minimises the turn. When travelling S & a sharp turn to E or W is made the compass exaggerates the turn.

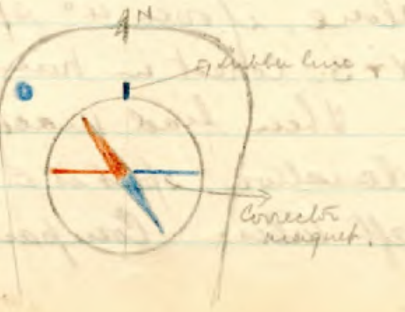
(illustration – effect of northerly tuning errors on compass)

Do not read compass aft. S.R. turn for about 30 secs. after flattening out. (12 secs with 5/17).

AERIAL NAV. (8)

Swinging for deviation:— With the aid of a land compass mark out the following magnetic directions N, NE, E, SE, S, SW, W, NW. N. seeing that no building is within 100 yds & no machine within 30 yds. The permanent magnetism is overcome by "corrector magnets", "tempory magnetism" is allowed for by marking out a deviation table. Wheel machine onto swinging base & pay attention to the following points:— (i) Machine in flying position (ii) Full war load. (iii) Compass O.K. (iv) No machine within 30 yds.

Head machine for M.N., note the reading, correct for deviation in transverse tubes.



Dev. W.

Swinging for deviation:

With the aid of a land compass mark out the following magnetic directions N, NE, E, SE, S, SW, W, NW, N. seeing that no building is within 100 yards & no machine within 30 yards. The permanent magnetism is overcome by corrector magnets, 'temporary magnetism' is allowed for by marking out a deviation table. Wheel machine onto swinging base & pay attention to the following points: (i) Machine in flying position (ii) Full war load (iii) Compass OK (iv) No machine within 30 yards.

Head machine for M.N., note the reading, correct for deviation in transverse tubes.

(Illustration of compass deviated W)

If deviation is W, red end of corrector magnet points W in the transverse tube. If deviation is E, red end of corrector magnet points E in transverse tube. Head machine M.E. note the reading, correct for deviation in fore & aft tubes.

If Deviation is W red end of corrector magnet points W in fore & aft tubes, if deviation is E red end of corrector magnet points E in 4 & aft tubes.
Next head machine to M.S. If deviation is under 4° E or W leave alone, if over 4° split the deviation N & S. Correct in transverse tubes.
Then head machine M.W., if over 4° deviation, split it E & W, correct in fore & aft tubes. Compass has now been

If deviation is W, red end of corrector magnet points W in the transverse tube. If deviation is E, red end of corrector magnet points E in transverse tube. Head machine M.E. note the reading, correct for deviation in fore & aft tubes.

(Illustration of compass deviated E)

If deviation is W red end of corrector magnet points W in fore & aft tubes, if deviation is E red end of corrector magnet points E in 4 [sic] & aft tubes.
Next head machine to M.S. If deviation is under 4° E or W leave alone, if over 4° split the deviation N & S. Correct in transverse tubes.
Then head machine M.W., if over 4° deviation, split it E &W, correct in fore & aft tubes. Compass has now been . . .

corrected for permanent magnetism.
Head machine to 8 pts of compass respectively make out a deviation table.

<u>Course of Aeroplanes:-</u>

<u>Course steered:</u> is the horizontal angle from the meridian (T.M. or C) to the fore & aft line of machine, it is measured from the meridian clockwise.

<u>Air speed:</u>- is the speed with which an aeroplane cuts its way through the air.
N.B. This equals ground speed when there is no wind.

<u>Ground speed:</u>- is the speed of an aeroplane over the ground (or in relation to ground). It is found by noting the interval of time between passing over 2 ground objects of known distance apart. Or by ground speed indicator.

<u>Actual track:</u>- is the line on ground over which aeroplane actually flies.

<u>Track angle:</u>- is the angle from the meridian (T.M. or C) to the actual track.

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Head machine to 8 points on compass respectively & make out a deviation table.
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<u>Actual track:</u> is the line on ground over which aeroplane actually flies.

<u>Track angle:</u> is the angle from the meridian (T.M. or C) to the actual track.

it is measured clockwise.
Drift:- is the angle between fore & aft line of machine & actual track. It may be to port or starboard.
If track angle is greater than T.C drift is to starboard & vice-versa.

There is no drift when there is:-
(i) Flat calm
(ii) Following wind.
(iii) adverse wind.

Before an allowance for wind problem can be worked out the wind speed & direction for the height at which you intend to fly must be found.

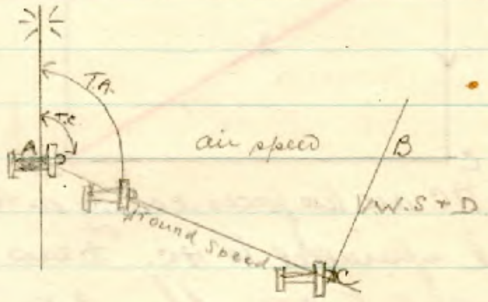
. . .it is measured clockwise.
Drift: is the angle between fore & aft line of machine & actual track. It may be to port or to starboard. If track angle is greater than T.C., drift is to starboard & vice versa.

(Illustration of track angles & drift)

There is no drift when there is:
(i) Flat calm
(ii) Following wind
(iii) Adverse wind

Before an allowance for wind problem can be worked out the wind speed & direction for the height at which you intend to fly must be found.

Four things to be found:- Air speed. steered Course
Ground speed. Actual track
Air speed is always measured along
T.C. Ground speed is always measured
along actual track. Wind blows from
T.C. to Track.

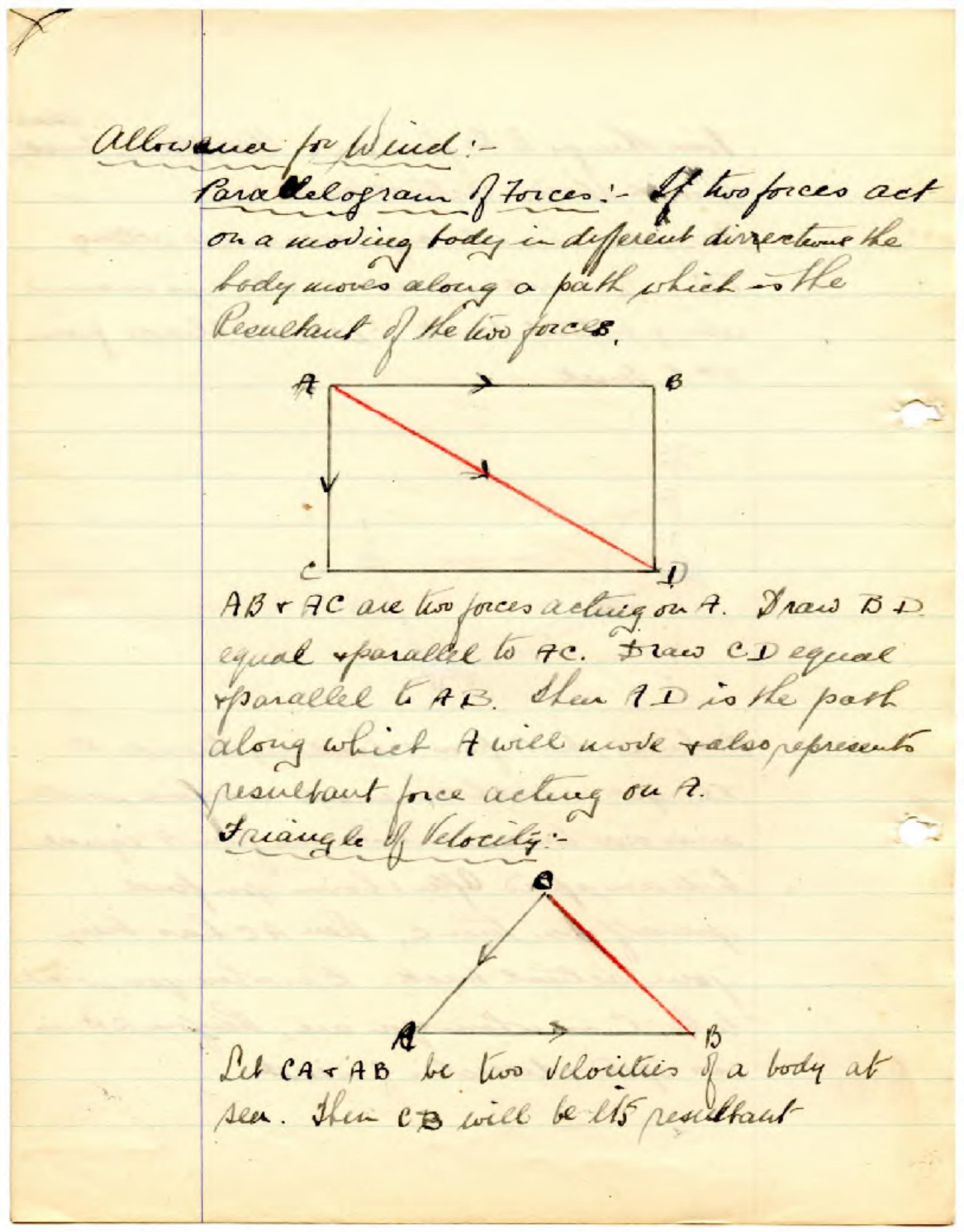


Machine starts from A heading towards B
T.C. 90°. With no wind machine would
arrive over town B a distance from A equal
to its air speed. After 1 hour you find
yourself over town C, then AC has been
your actual track. B is where you wish
to be, C is where you are, therefore B.C. is
is speed & direction of wind.

Four things to be found: Air speed. Steered course. Ground speed. Actual track.
Air speed is always measured along T.C. Ground speed is always measured along actual track. Wind blows from T.C. to track.

(Drawing – measuring air and ground speed)

Machine starts from A heading towards B T.C. 90°. With no wind machine would arrive over town B a distance from A equal to its airspeed. After 1 hour you find yourself over town C, then AC has been your actual track. B is where you wish to be, C is where you are, therefore B.C. is is [sic] speed & direction of wind.



Allowance for Wind:-
Parallelogram of Forces:- If two forces act on a moving body in different directions the body moves along a path which is the Resultant of the two forces.

A B C D

AB & AC are two forces acting on A. Draw BD equal & parallel to AC. Draw CD equal & parallel to AB. Then AD is the path along which A will move & also represents resultant force acting on A.

Triangle of Velocity:-

C A B

Let CA & AB be two velocities of a body at sea. Then CB will be its resultant

<u>Allowance for wind</u>:
<u>Parallelogram of Forces</u>: If two forces act on a moving body in different directions the body moves along a path which is the resultant of the two forces.

(Drawing – said parallelogram)

AB & AC are two forces acting on A. Draw BD equal & parallel to AC. Draw CD equal & parallel to AB. Then AD is the path along which A will move & also represents resultant force acting on A.

<u>Triangle of velocity</u>:

(Drawing – said triangle)

Let CA & AB be two velocities of a body at sea. Then CB will be its resultant . . .

Velocity in speed & direction. Let C = machine
CA = Air Speed. AB = Wind, then CB is
the ground speed & actual track

If no wind (flying from Bristol to London) all that is necessary is to measure T.C. from map, convert it into C.C. & fly on that course.

Note:- Always some wind: If directly directly against or with you course would be same, but ground speed would be greater or less. If blowing from any other direction, machine would be blown sideways over the country. Therefore to get to London it would be necessary to point nose of machine into wind at an angle to the Bristol-London line in order that the combined effect of Air speed & wind would make your machine move crab-wise over the ground directly over the Bristol-London line.

Given desired track, wind speed &

. . . velocity in speed & direction. Let C = machine, CA = Air Speed. AB = Wind, then CB is the ground speed & actual track.

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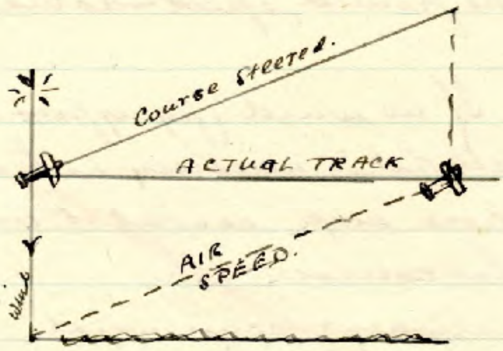
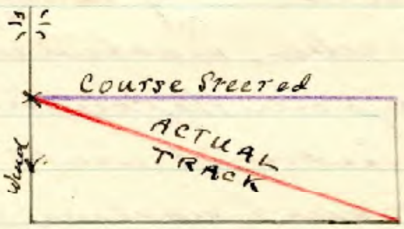
direction & Air speed, find T.C to steer & ground speed.



Given Course steered, Air speed, Wind speed & direction, find A.T & G.S.



An aeroplane sets out from A to bomb a town B which is 250 miles from A on a T.B. of 45°
Wind is blowing from 340° T. at 30 M.P.H.
Air speed of machine 95 M.P.H. Variation 15° W: Deviation <u>out</u> 2° E Dev <u>in</u> 5° W.

. . . direction & air speed, find T.C. to steer & ground speed.

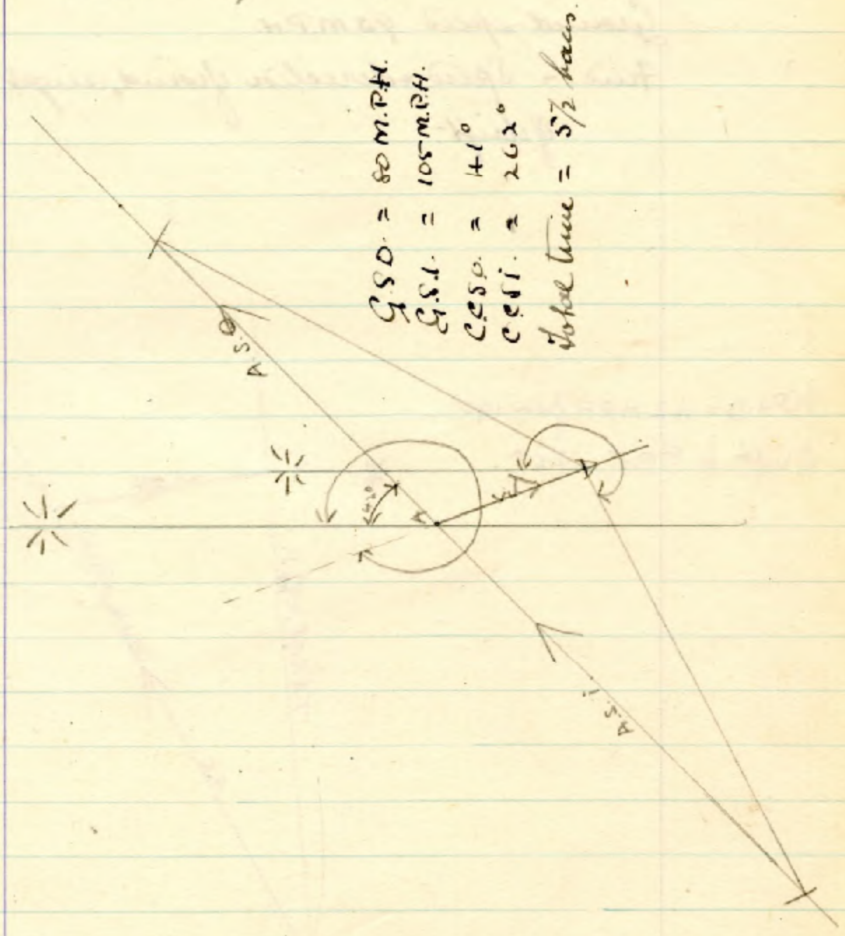
(Illustration of crabbed track)

Given course steered, Air speed, Wind speed & direction, find A.T. & G.S.

(Illustration of deviated actual track)

An aeroplane sets out from A to bomb a town B which is 250 miles from A on a T.B. of 45°.Wind is blowing from 340° T at 30 M.P.H. Air speeds of machine 95 M.P.H. Variation 15° W: Deviation <u>out</u> 2° E. Dev in 5° W.

Find ground speed out (G.S.O.) & ground speed in (G.S.I.) C.C. steered out & in. Time to complete journey.

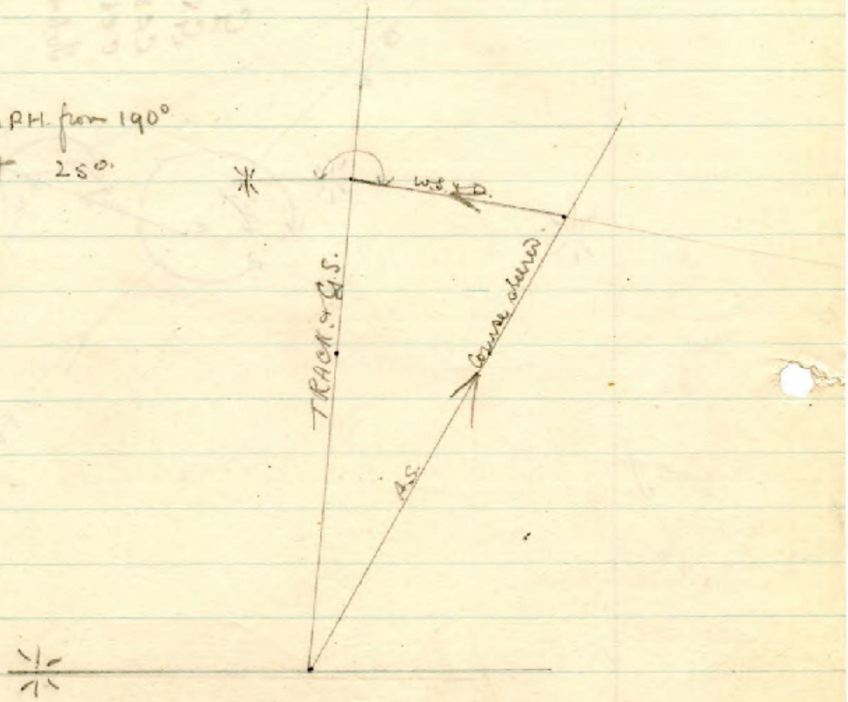


Find ground speed out (G.S.O.) &ground speed in (G.S.I.) C.C. steered out & in. Time to complete journey.

(Illustration – calculation of speed and journey time)

GSO	= 80 M.P.H.
GSI	= 105 M.P.H.
CCSO	= 41°
CCSI	= 262°
Total Time	= 51/2 hours

True course steered 120°
Actual track angle 95°.
Air speed 100 M.P.H.
Ground speed 95 M.P.H.
Find:- Speed & direction of wind, angle & direction of drift.

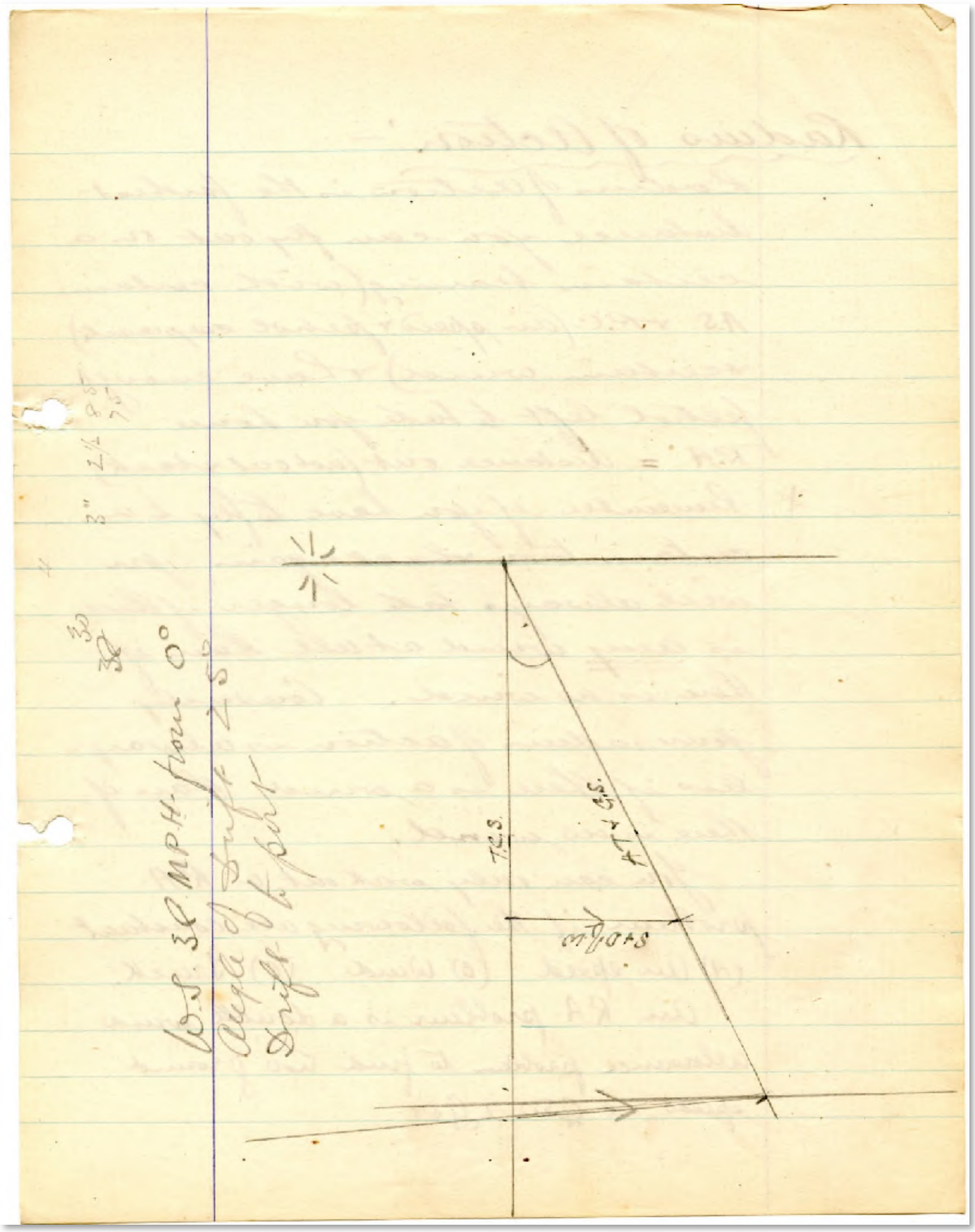


W.S.+D. = 42 M.P.H. from 190°
Drift to Port 25°.

True course steered 120°
Actual track angle 95°
Air speed 100 M.P.H.
Ground speed 95 M.P.H.
Find: Speed & direction of wind, angle & direction of drift

(Illustration – calculation of drift)

WS & D = 42M.P.H. from 190°
Drift to Port 25°



W.S 38 M.P.H. from 0°
Angle of Drift 25°
Drift to Port

(Full page illustration of drift to port)

Radius of Action:—

Radius of action is the farthest distance you can fly out on a certain bearing (with certain A.S. & P.C. (air speed & petrol capacity) & certain wind) & have enough petrol left to take you home
R.A. = distance out (not out & back)

* Remember if you have to fly to a certain town & back again you will always take longer if there is <u>any</u> wind at all than if there is no wind. Conversely your radius of action is always less if there is a wind than if there is no wind.

You can only work out a R.A. problem if the following are constant
(A) Air speed (B) Wind (C) Track.

An R.A. problem is a double wind allowance problem to find two ground speeds i.e. G.S.O. & G.S.I.

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You are to fly to a place, 300 [187.5 M] Kilometres from your aerodrome on a T.B. of 185°. Wind is blowing from 40° T at 25 [28.6] Knots. A.S. 90 [103] Knots
Find. G.S.O. & G.S.I. in M.P.H.
" T.C. Steered out & in.
" Time to reach place.

You fly out to a place on a T.B. of 185° 250 miles away. A.S. = 100 MPH Wind blowing from 300° T.B. at 25 M.P.H. On returning from B. wind veers 12° & increases to 30 M.P.H. Find G.S.O., G.S.I. T.C. steered O & I. Time to complete journey.

You are to fly to a place, 300 [note - added in pencil: 187.5 M] Kilometres from your aerodrome on a T.B. of 185°. Wind is blowing from 40° T at 25 [note – added in pencil: 28.6] Knots. A.S. 90 [note – added in pencil: 103] Knots.
Find. G.S.O. & G.S.I. in M.P.H.
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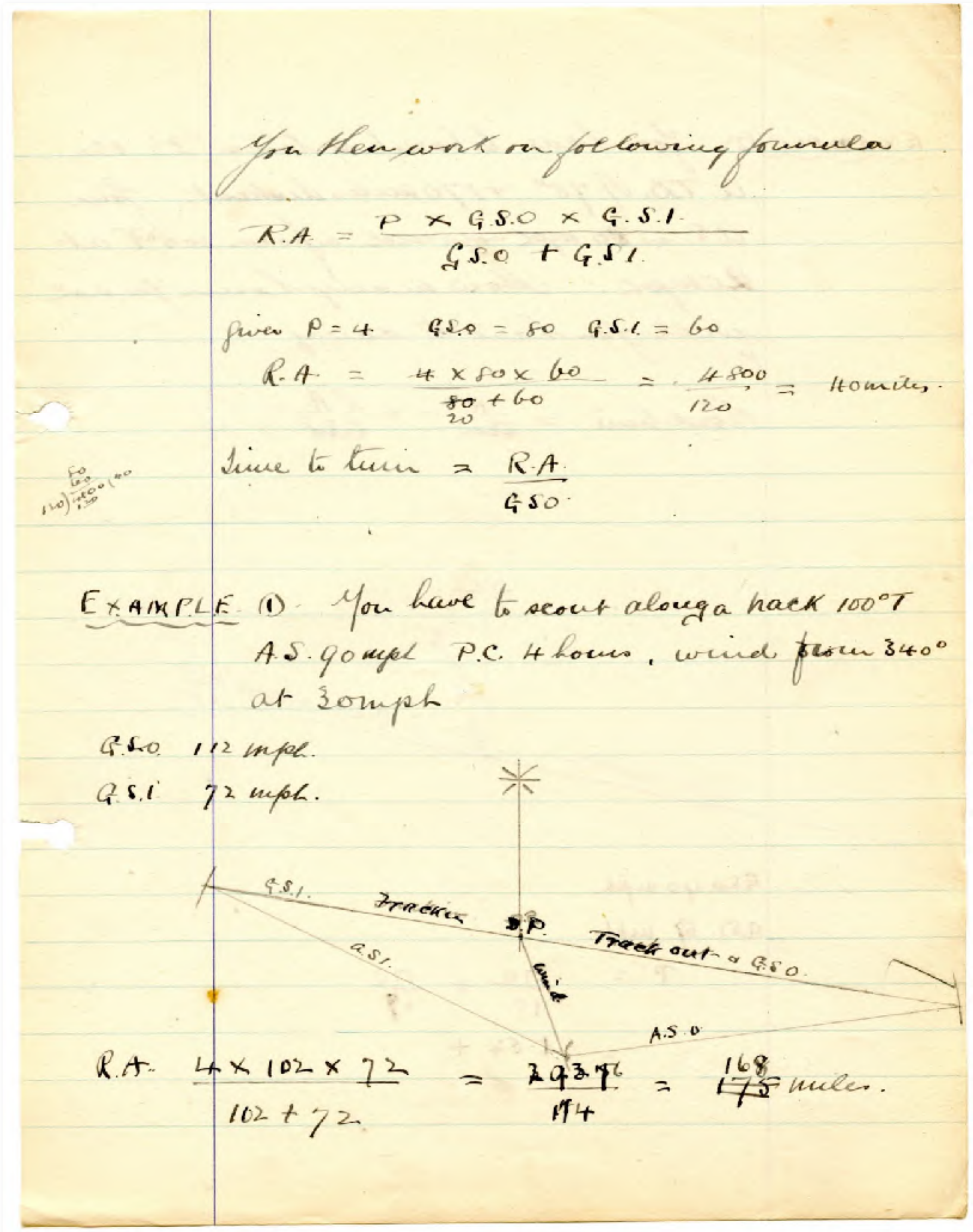

You then work on following formula

$$R.A = \frac{P \times G.S.O \times G.S.I}{G.S.O + G.S.I}$$

given P = 4 G.S.O = 80 G.S.I = 60

$$R.A = \frac{4 \times 80 \times 60}{\cancel{80}\,20 + 60} = \frac{4800}{120} = 40 \text{ miles.}$$

$$\text{Time to turn} = \frac{R.A}{GSO}$$

EXAMPLE (1) You have to scout along a track 100°T A.S. 90 mph P.C. 4 hours, wind from 340° at 30mph

G.S.O 112 mph.
G.S.I 72 mph.

$$R.A. \frac{4 \times 102 \times 72}{102 + 72} = \frac{29376}{174} = \cancel{175}\ 168 \text{ miles.}$$

You then work on following formula

$$R.A. = \frac{P \times GSO \times GSI}{GSO + GSI}$$

Given P = 4 GSO = 80 GSI = 60

$$R.A = \frac{4 \times 80 \times 60}{\cancel{80}\ 20 + 60}$$

$$\text{Time to timer} = \frac{R.A.}{GSO}$$

EXAMPLE

(1) You have to scout along a track 100° T
A.S. 90 mph P.C. 4 hours, wind from 340° at 30 mph

G.S.O. 112 mph
G.S.I. 72 mph

(Insert illustration of calculation and diagram)

EXAMPLE (2) You have to bomb a town B on a T.B. of 78° & 170 miles distant. Your A.S. is 80 mph & wind is from 200°T at 20mph. How many hours petrol will you have to carry

Petrol time $= \frac{R.A.}{G.S.O.} + \frac{R.A.}{G.S.I.}$

G.S.O. 90 mph.

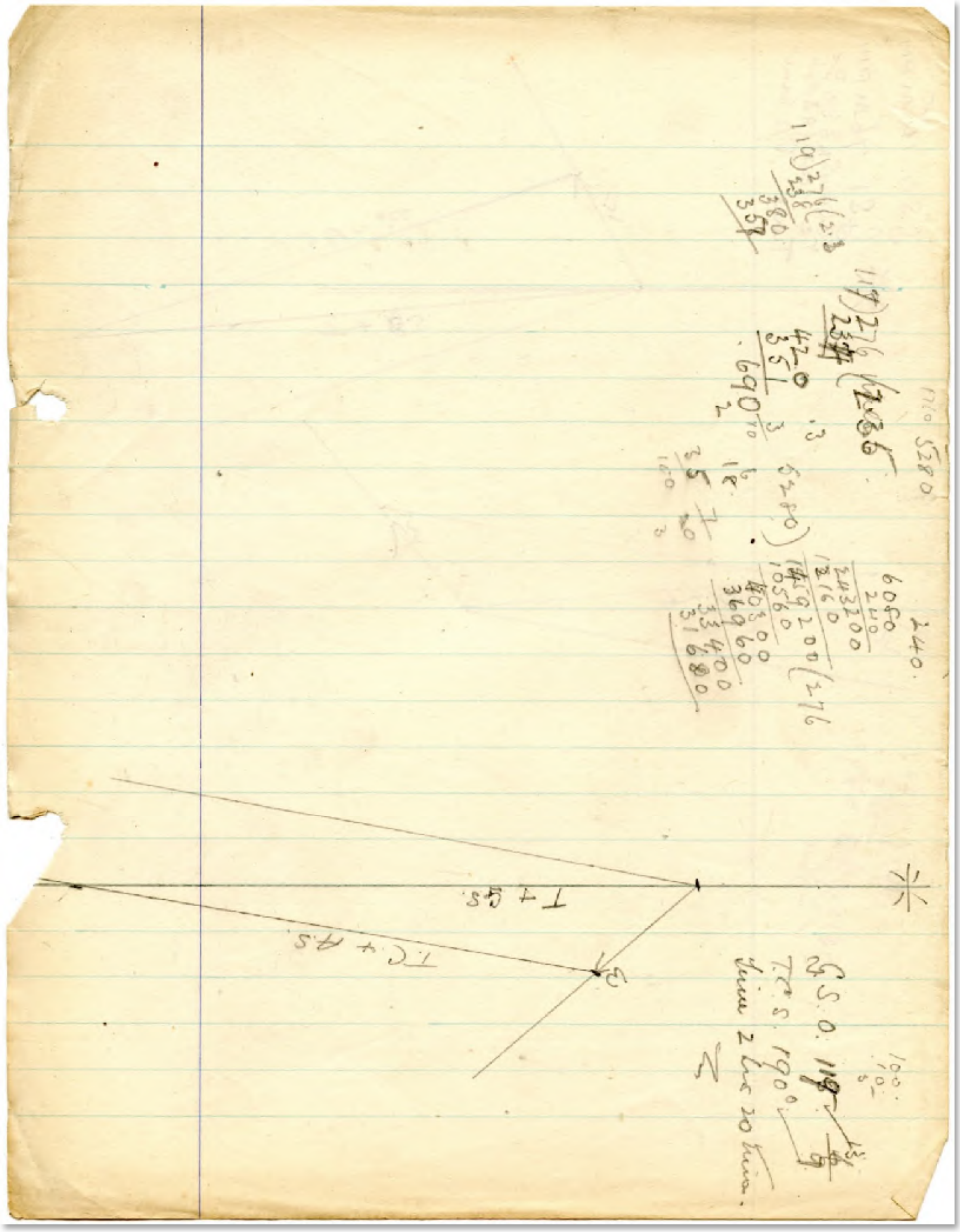
G.S.I. 67 mph.

$T = \frac{170}{90} + \frac{170}{67}$

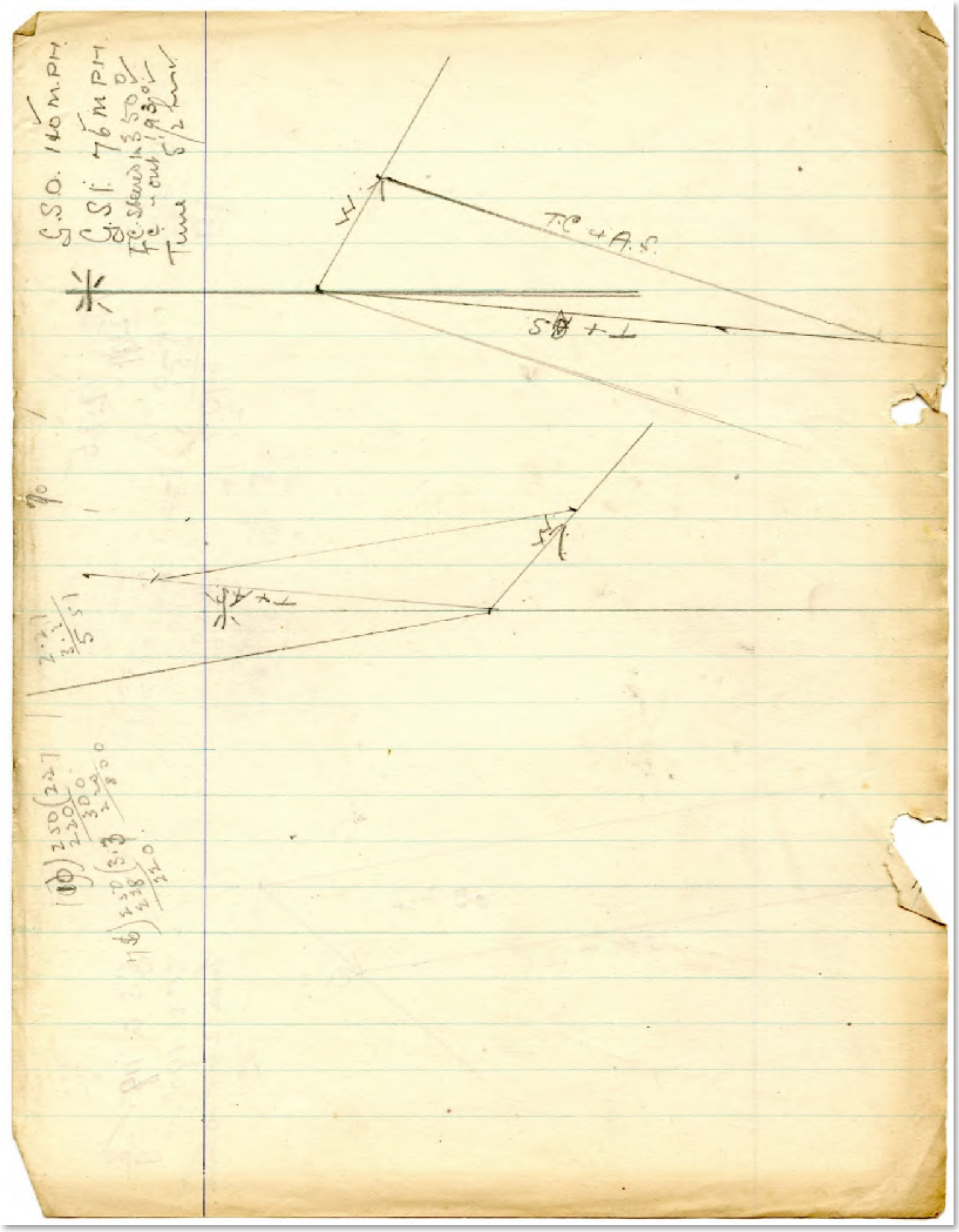
$= 4.54 +$

EXAMPLE (2)
You have to bomb a town B on a T.B. of 78° & 170 miles distant. Your A.S. is 80 mph & wind is from 200° T at 20mph. How many hours petrol will you have to carry.

(Insert illustration of calculations and diagram)



(Full page of calculations and diagram)



(Full page of calculations and diagram)

W. A. Seymour.
No 2 Squad
"A" Squadron.

Beardmore

(1). No 1 stroke Plunger ascends uncovering oil inlet & permitting oil to flow in

" 2 " This plunger remains stationary & No 2 plunger ascends sucking oil into the barrel.

" 3 " First plunger decends covering inlet pipe while second plunger remains stationary.

" 4 " Second plunder decends forcing oil to bearing surfaces while first plunger is stationary

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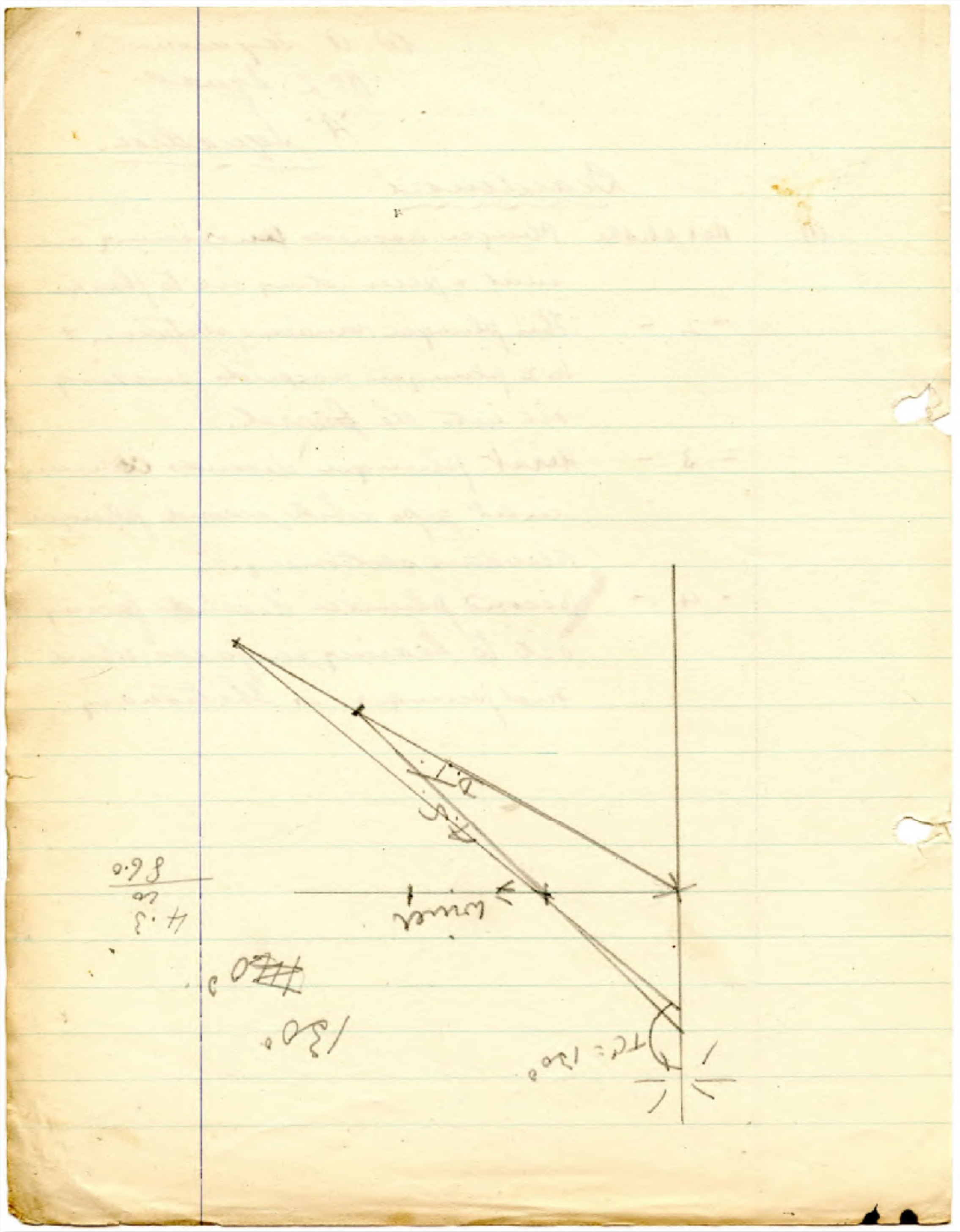
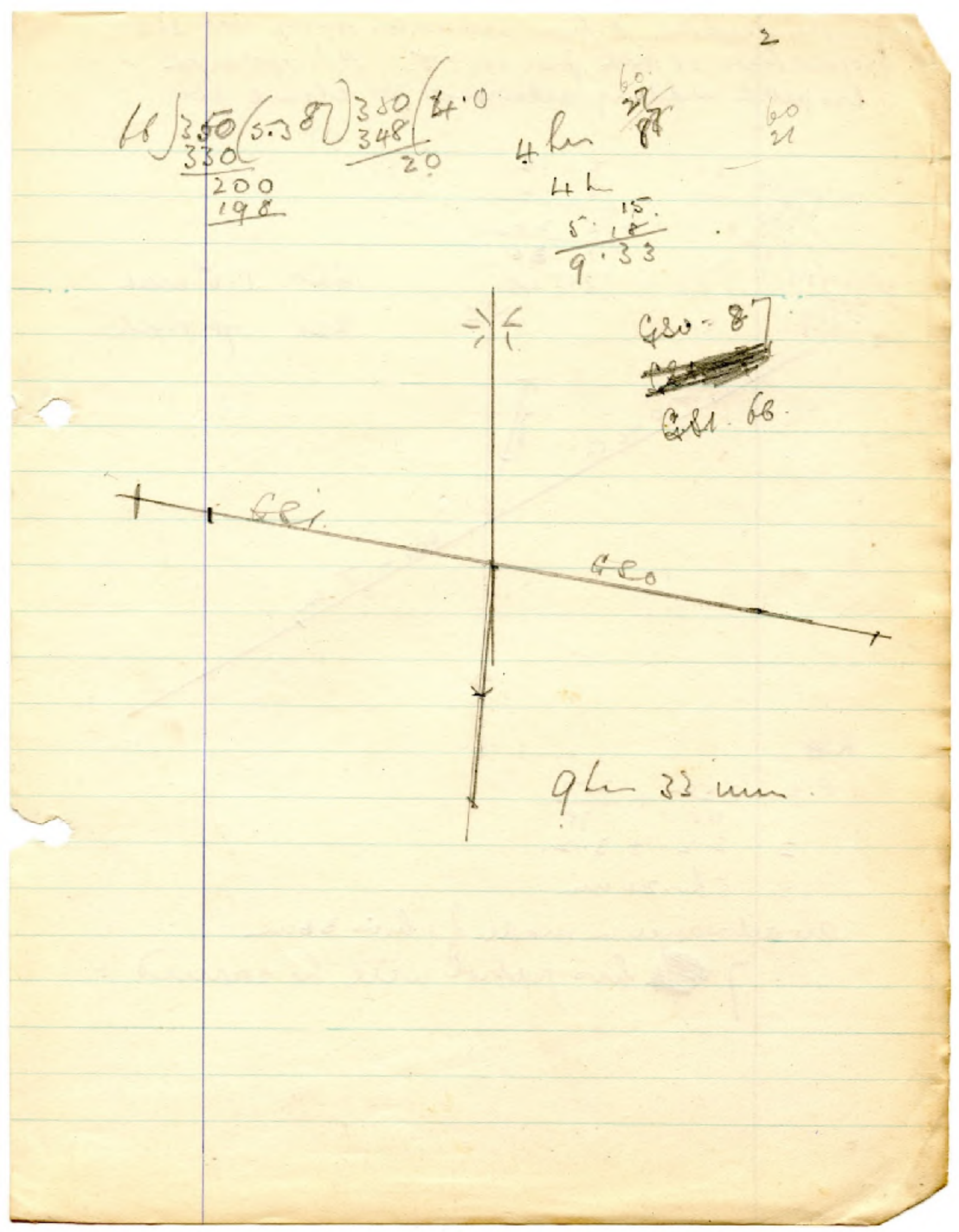
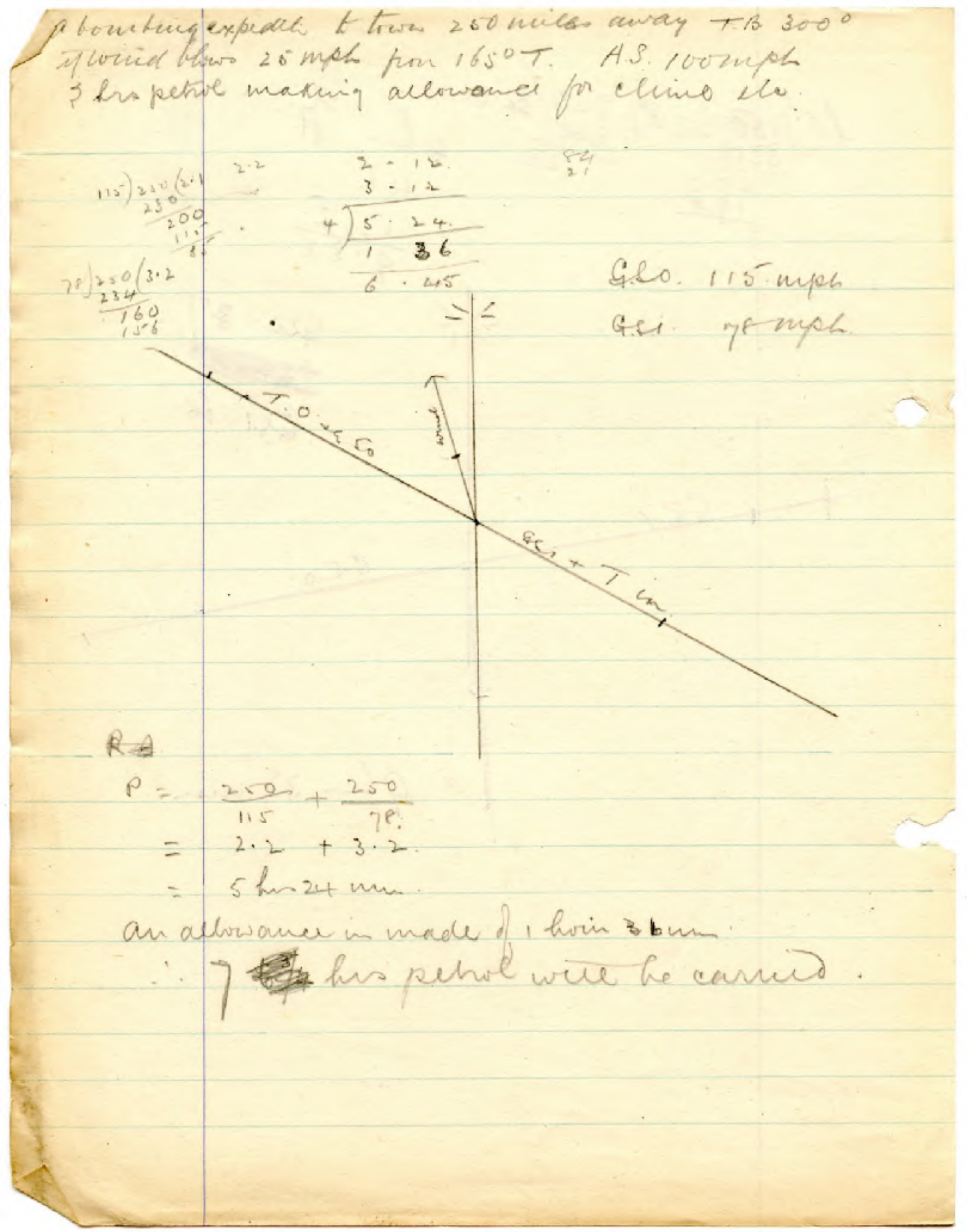


(Full page diagram of calculation of windspeed and drift)



(Full page diagram of calculation of time to get to target)



A bombing expedition to town 250 miles away T.B. 300°
If wind blows 25 mph from 165° T A.S. 100 mph
? hrs petrol making allowance for climbs etc.

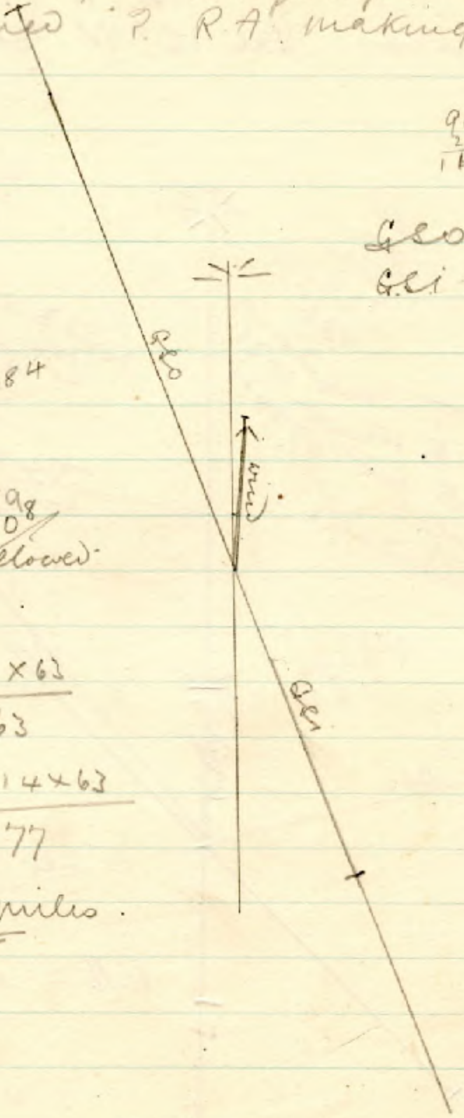
(Illustration of calculations and diagram)

An allowance is made of 1 hour 31 mins
7 hrs of petrol will be carried.

Aeroplane sent out along a track 340° T wind from 185° T @ 30 mph A.S. 90 mph. 6 hrs of petrol are carried ? R.A. making allowance

$$\begin{array}{r} 90 \\ 24 \\ \hline 114 \end{array}$$

G.S.o 114 mph
G.S.i 63 mph



1½ hrs petrol is allowed

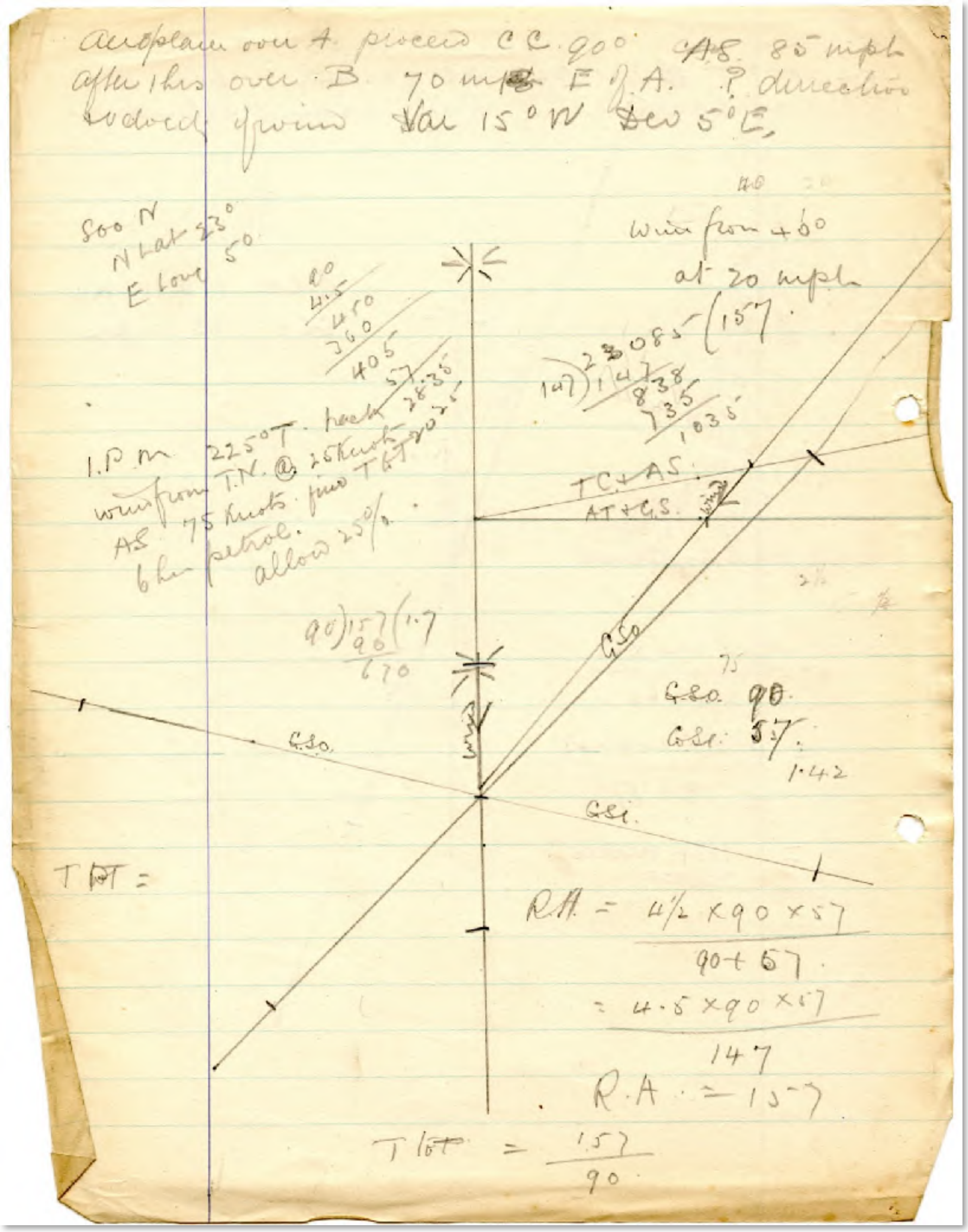
$$RA = \frac{4½ \times 114 \times 63}{114 + 63}$$

$$= \frac{4.5 \times 114 \times 63}{177}$$

$$= \underline{184 \text{ miles}}.$$

Aeroplane sent out along a track 340° T wind from 185° T 30 mph. A.S. 90mph. 6hrs of petrol is carried ? R.A. making allowance

(Illustration of calculations and diagram)



Aeroplane over A. Proceed C.C. 90° A.S. 85mph
After 1 hrs over B. 70 m E of A. ? direction &
velocity of wind Var 15° W Dev 5° E

(Illustration of calculations and diagram)

Bombing:–

From Nancy to:–

Cologne	160 miles
Coblenz	120 "
Darmstadt	140 "
Mayence	130 "
Strasburg	70 "
Mannheim	120 "
Frankfort	150 "
Karlsruhe	104 "

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