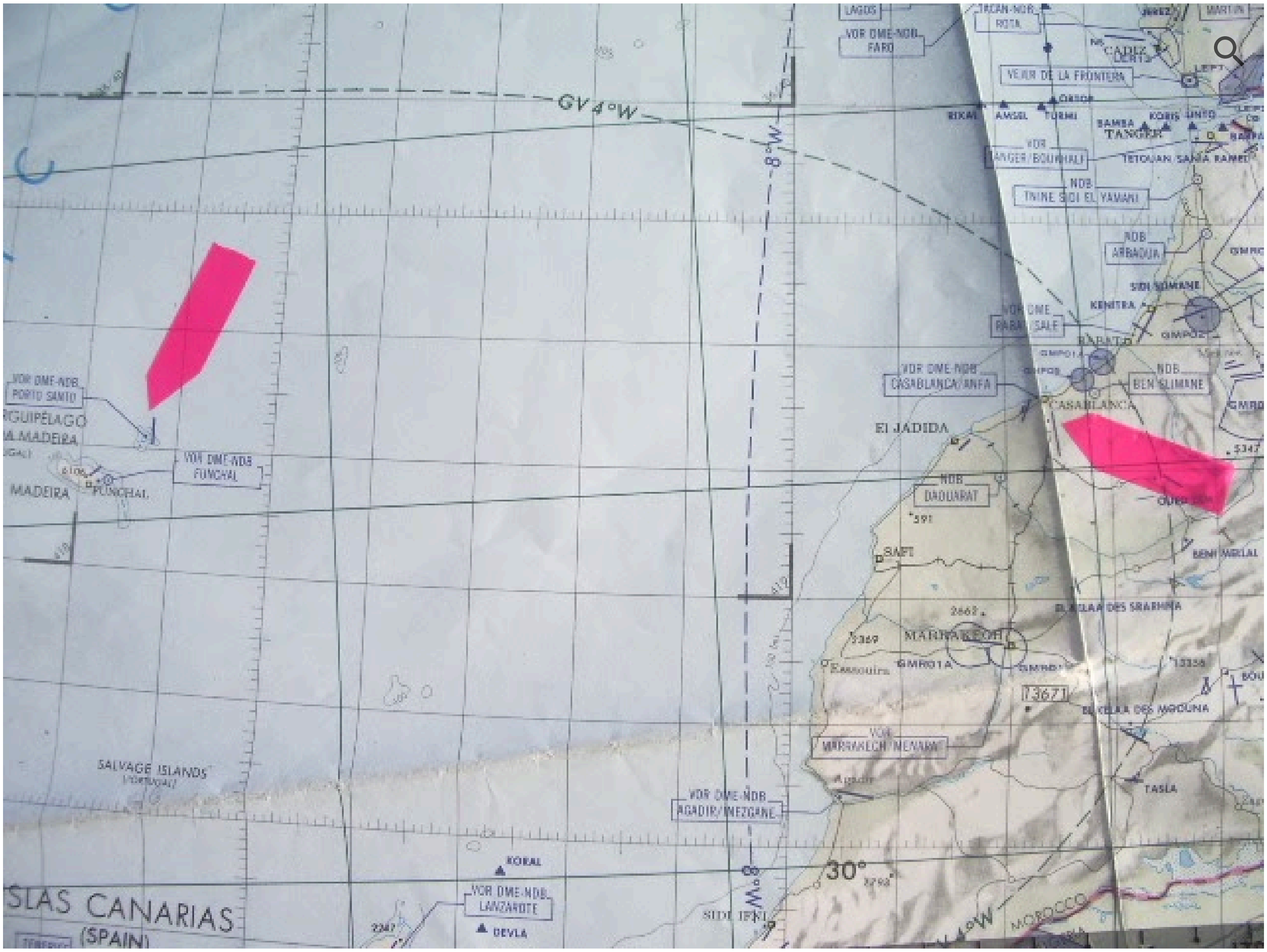
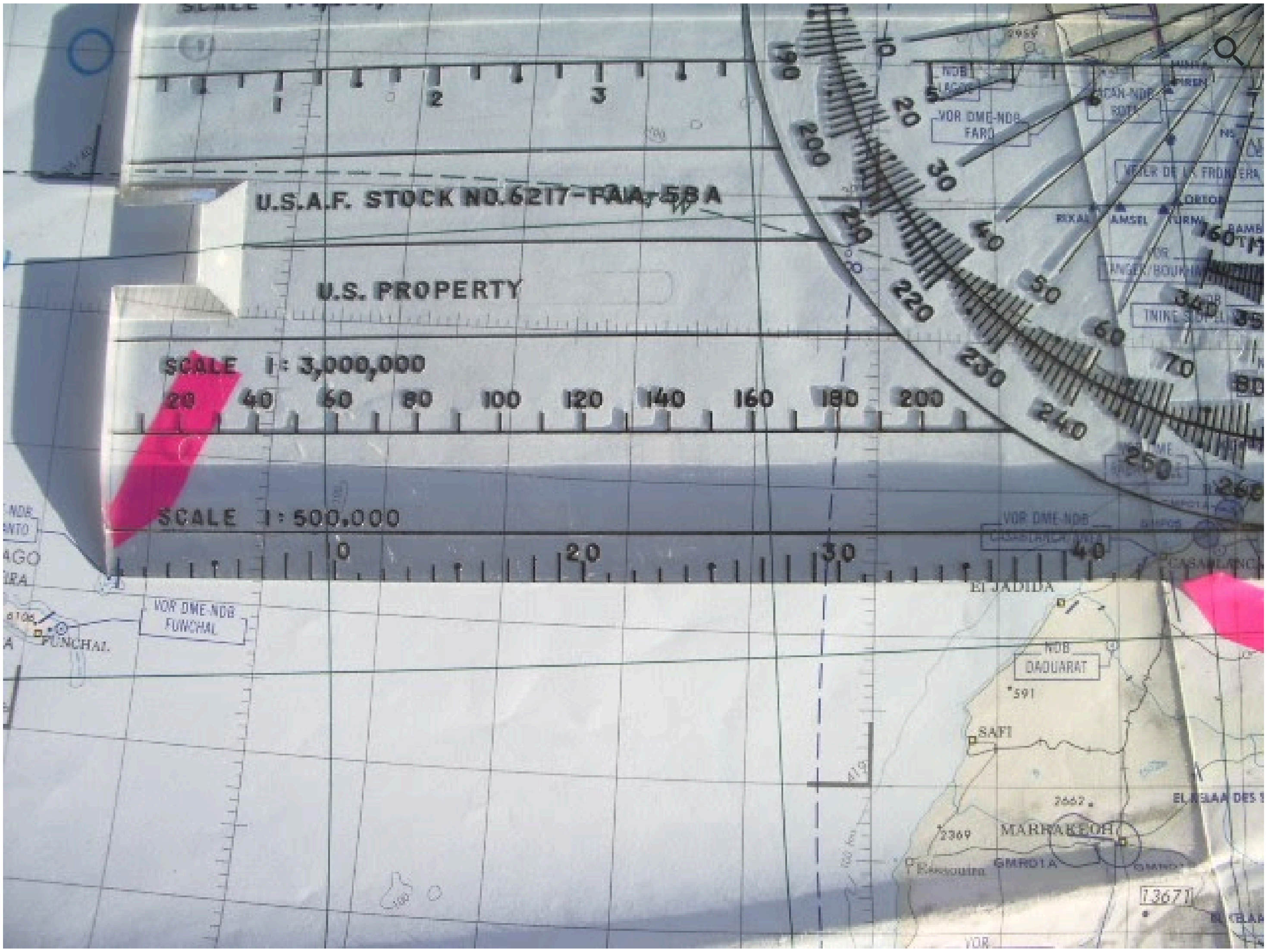
Example of in flight celestial navigation

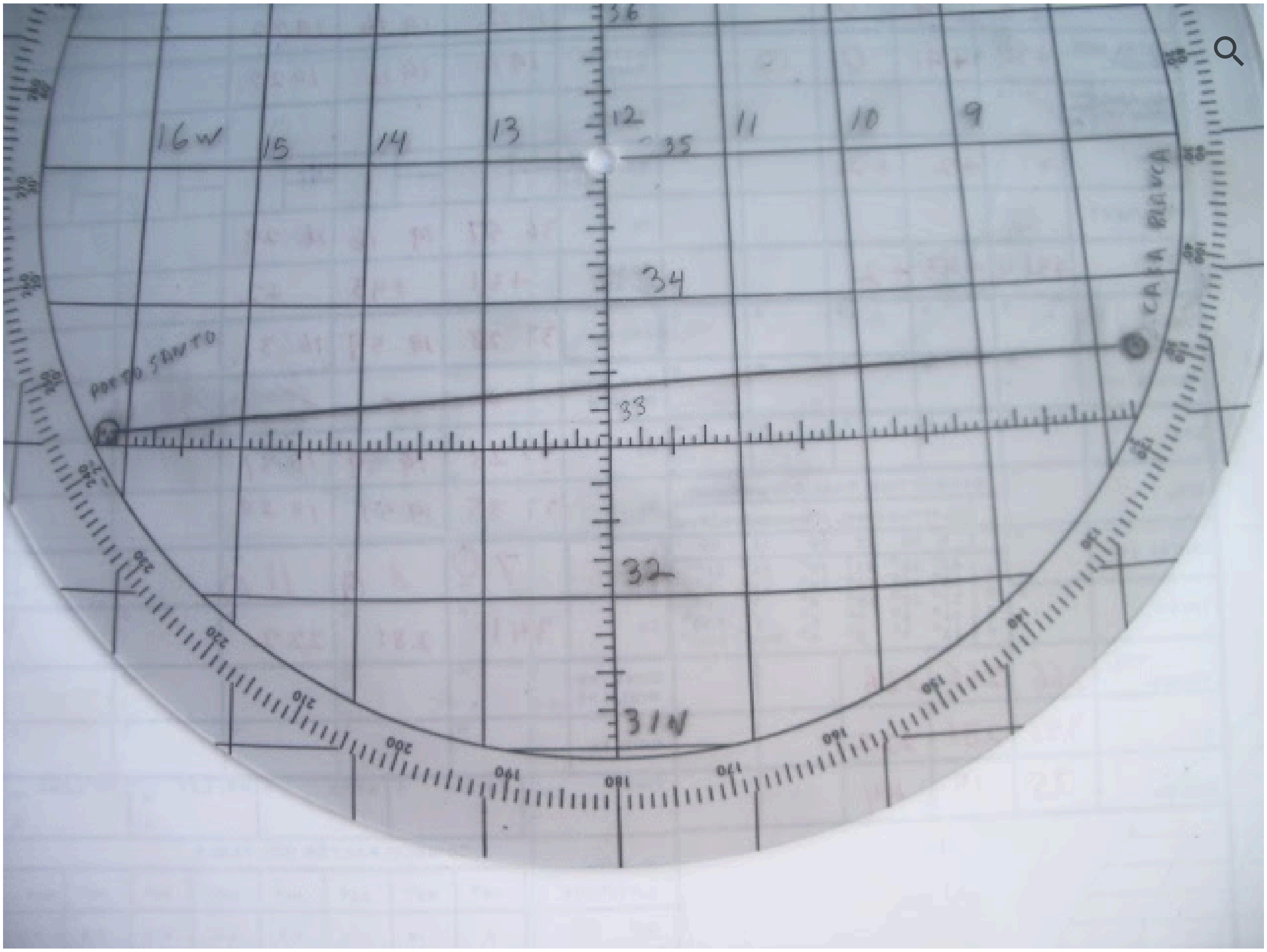
Now that we have discussed the technique of flight navigation we can look at an example of how it is actually done. I will use the Polhemus computer to illustrate this process which will also show how handy this device is but it can also be done on a plotting sheet though not so conveniently. (If your have not already read Working the celestial sight in flight you should do that before reading this page.)

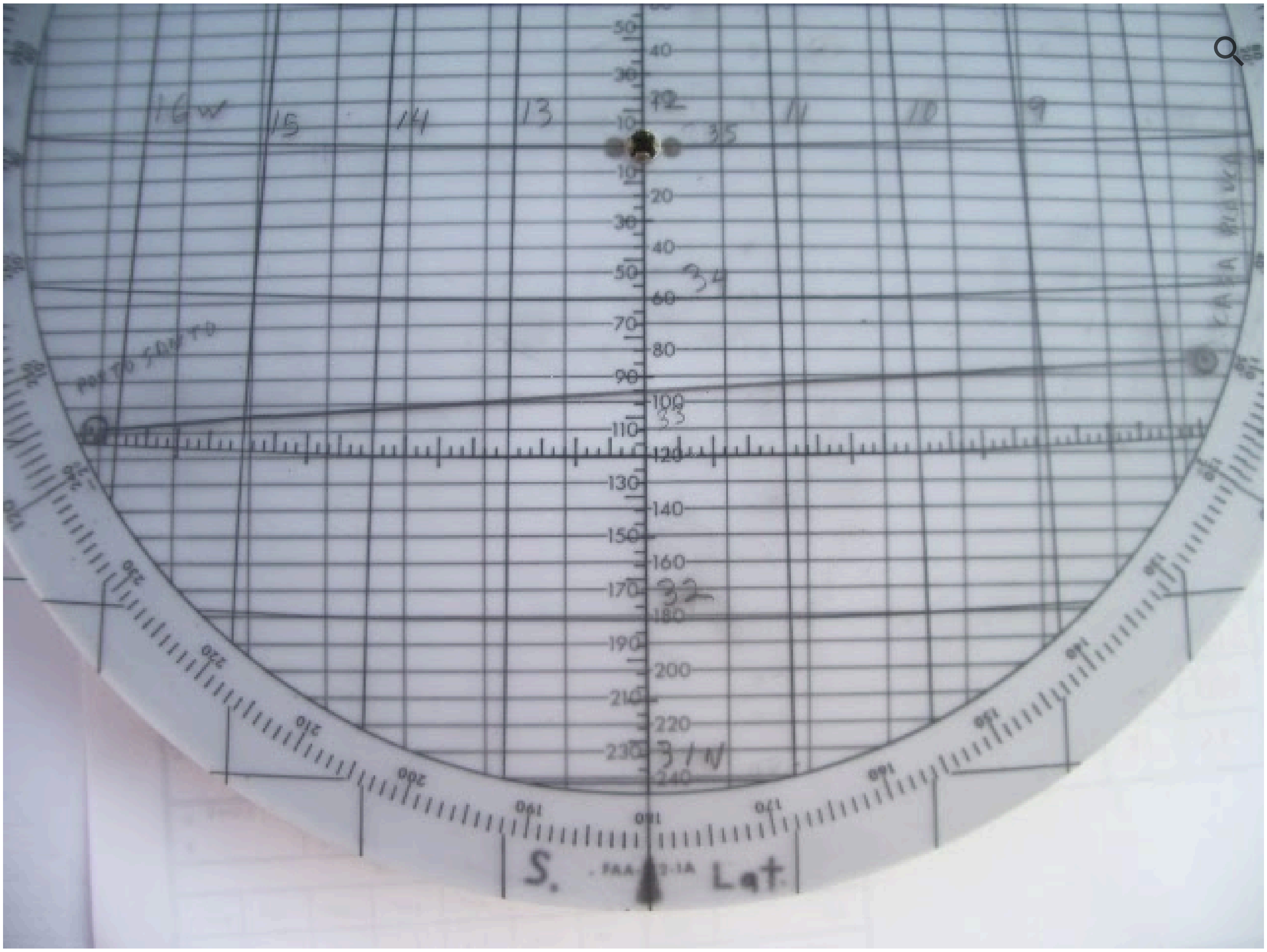
We are ferrying a 1978 Cessna Skyhawk (Cessna 172) from Casablanca Morocco to Porto Santo Island in the Madeira Islands on October 4, 2008 (1.jpg and 2.jpg.) We will be using a Kollsman MA-2 hand held sextant which has a two minute averager but the same procedures would be followed with any bubble sextant.


GV 4°W
8°W
VOR DME-NDB
PORTO SANTO
MADEIRA
FUNCHAL
VOR DME-NDB
FUNCHAL
SALVAGE ISLANDS
SLAS CANARIAS
(SPAIN)
KORAL
VOR DME-NDB
LANZAROTE
DEVLA
VOR DME-NDB
AGADIR/INEZGANE
30°
SIDI IFNI
VOR
MARRAKECH/MENARA
Essaouira
MARRAKECH
SAFI
El JADIDA
NDB
DAOUARAT
VOR DME-NDB
CASABLANCA/ANFA
CASABLANCA
NDB
BEN SLIMANE
VOR DME
RABAT/SALE
RABAT
NDB
ARBAOUA
SIDI SLIMANE
KENITRA
NDB
TNINE SIDI EL YAMANI
VOR
TANGER/BOUKHALF
TANGER
TETOUAN SANIA RAMEL
VEJER DE LA FRONTERA
VOR DME-NDB
FARO
LAGOS
TACAN-NDB
ROTA
CADIZ
BENI MELLAL
TASLA
MOROCCO

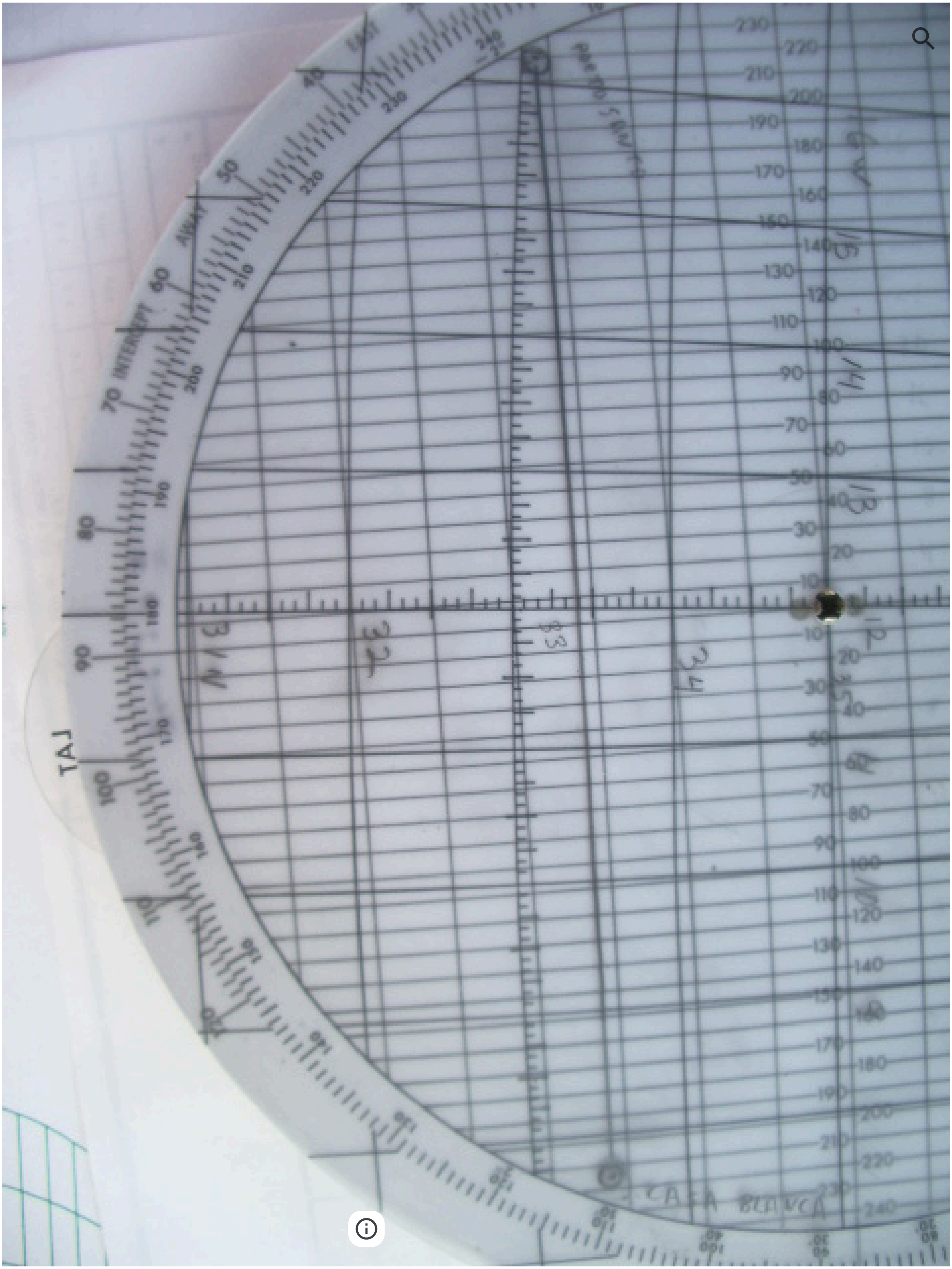


The coordinates of the departure airport are 33° 33' north, 7° 40' west. The destination airport is at 33° 04' north, 16° 21 west. Using the 35° latitude disk we label the graticle and we then plot the locations of both airports and draw a course line between them (3.jpg) then we place the disk on the base (4.jpg.)

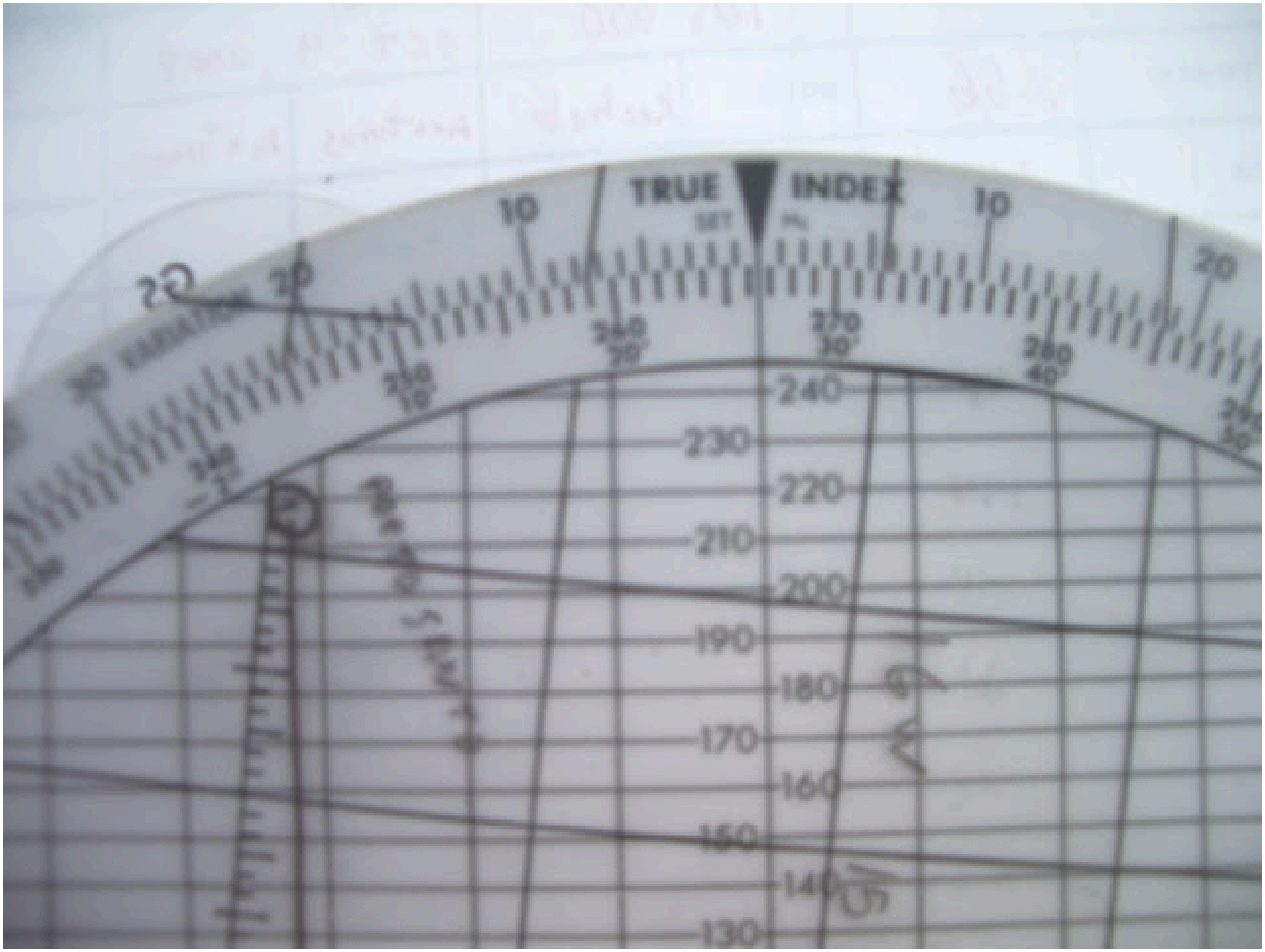

36
16W
15
14
13
12
11
10
9
35
34
33
32
31N
PORTO SANTO
CASA BLANCA



Now, by rotating the disk so that the destination is directly above the departure, we can read out the distance by counting the grid lines between the departure and the destination. Departure is down from the center at minus 215 (visually interpolating between 210 and 220) and destination is up from the center at plus 219 for a total distance of 434 NM (5.jpg.)


INTERCEPT
AWAY
TAJ
CASA BLANCA

We can also read out the true course at the "TRUE INDEX" which is 266.5°, which we will round to 266° (6.jpg.)



Looking at the aircraft flight manual climb schedule (7.jpg), we see that we will climb at an airspeed of about 70 knots and that it will take 21 minutes to climb to our planned cruising altitude of 10,000 feet (Flight Level 100, FL100) using 3.7 gallons of fuel in the climb and covering 27 NM. Since we also used 1.1 gallons taxiing we will have used up 4.8 gallons by the time we level off FL100. After we have leveled off at the top of the climb (TOC) we adjust our throttle to make 2500 rpm and lean the mixture control.

TIME, FUEL, AND DISTANCE TO CLIMB

MAXIMUM RATE OF CLIMB

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

NOTES:
1. Add 1.1 gallons of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10°C above standard temperature.
4. Distances shown are based on zero wind.

WEIGHT LBS	PRESSURE ALTITUDE FT	TEMP °C	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
					TIME MIN	FUEL USED GALLONS	DISTANCE NM
2300	S.L.	15	73	770	0	0.0	0
	1000	13	73	725	1	0.3	2
	2000	11	72	675	3	0.6	3
	3000	9	72	630	4	0.9	5
	4000	7	71	580	6	1.2	8
	5000	5	71	535	8	1.6	10
	6000	3	70	485	10	1.9	12
	7000	1	69	440	12	2.3	15
	8000	-1	69	390	15	2.7	19
	9000	-3	68	345	17	3.2	22
	10,000	-5	68	295	21	3.7	27
	11,000	-7	67	250	24	4.2	32
	12,000	-9	67	200	29	4.9	38

Figure 5-6. Time, Fuel, and Distance to Climb

5-15

Since the air temperature is about standard (15° C at sea level and cooling off about 2° C per thousand feet) this power setting will produce 61% power which will give us a true airspeed of 114 knots and a fuel flow rate of 6.8 gallons per hour (8.jpg.)

CRUISE PERFORMANCE

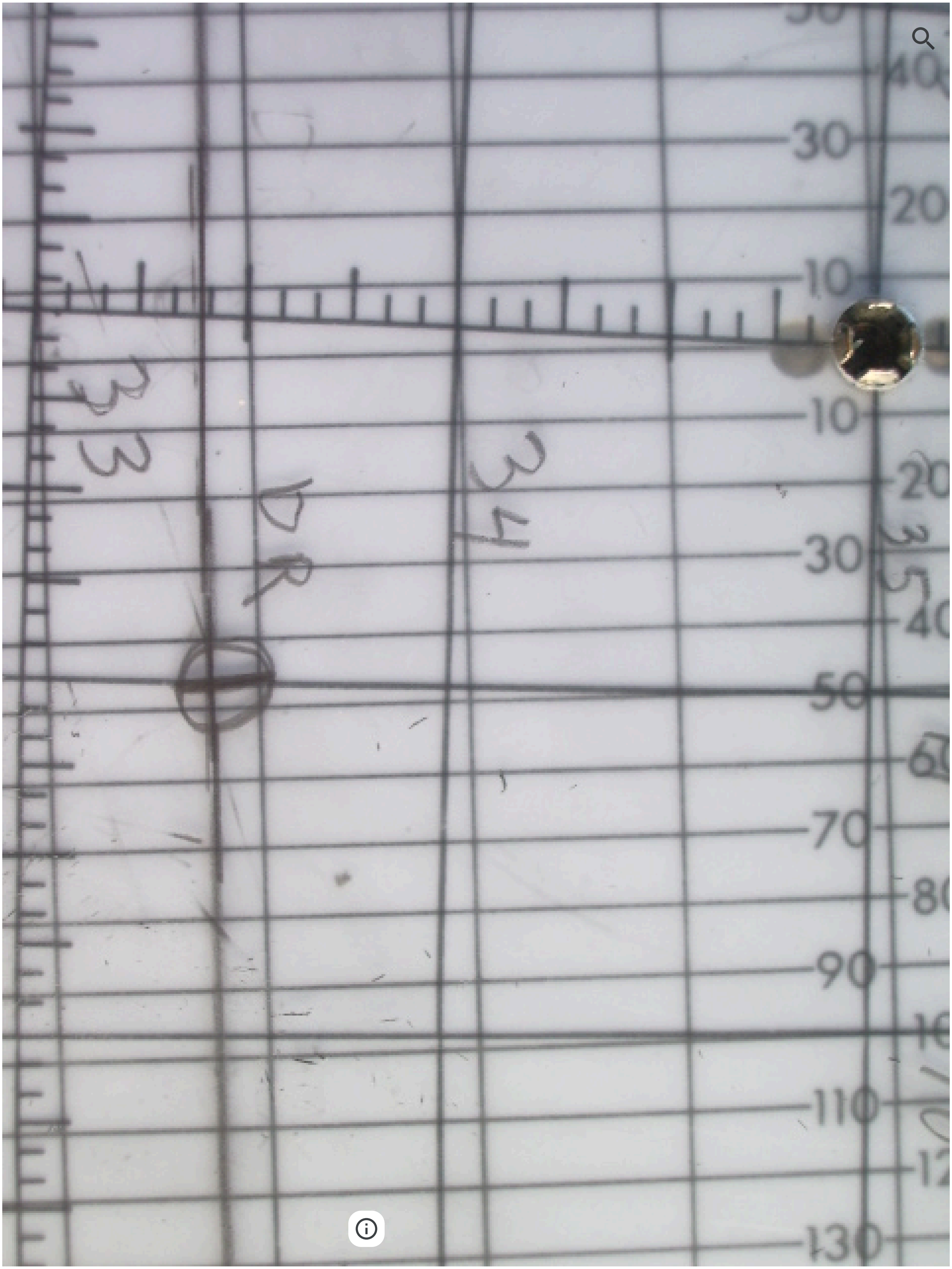
CONDITIONS:
2300 Pounds
Recommended Lean Mixture

PRESSURE ALTITUDE FT	RPM	20°C BELOW STANDARD TEMP			STANDARD TEMPERATURE			20°C ABOVE STANDARD TEMP		
		% BHP	KTAS	GPH	% BHP	KTAS	GPH	% BHP	KTAS	GPH
2000	2500	---	---	---	75	116	8.4	71	115	7.9
	2400	72	111	8.0	67	111	7.5	63	110	7.1
	2300	64	106	7.1	60	105	6.7	56	105	6.3
	2200	56	101	6.3	53	100	6.1	50	99	5.8
	2100	50	95	5.8	47	94	5.6	45	93	5.4
4000	2550	---	---	---	75	118	8.4	71	118	7.9
	2500	76	116	8.5	71	115	8.0	67	115	7.5
	2400	68	111	7.6	64	110	7.1	60	109	6.7
	2300	60	105	6.8	57	105	6.4	54	104	6.1
	2200	54	100	6.1	51	99	5.9	48	98	5.7
	2100	48	94	5.6	46	93	5.5	44	92	5.3
6000	2600	---	---	---	75	120	8.4	71	120	7.9
	2500	72	116	8.1	67	115	7.6	64	114	7.1
	2400	64	110	7.2	60	109	6.8	57	109	6.4
	2300	57	105	6.5	54	104	6.2	52	103	5.9
	2200	51	99	5.9	49	98	5.7	47	97	5.5
	2100	46	93	5.5	44	92	5.4	42	91	5.2
8000	2650	---	---	---	75	122	8.4	71	122	7.9
	2600	76	120	8.6	71	120	8.0	67	119	7.5
	2500	68	115	7.7	64	114	7.2	60	113	6.8
	2400	61	110	6.9	58	109	6.5	55	108	6.2
	2300	55	104	6.2	52	103	6.0	50	102	5.8
	2200	49	98	5.7	47	97	5.5	45	96	5.4
10,000	2650	76	122	8.5	71	122	8.0	67	121	7.5
	2600	72	120	8.1	68	119	7.6	64	118	7.1
	2500	65	114	7.3	61	114	6.8	58	112	6.5
	2400	58	109	6.5	55	108	6.2	52	107	6.0
	2300	52	103	6.0	50	102	5.8	48	101	5.6
	2200	47	97	5.6	45	96	5.4	44	95	5.3
12,000	2600	68	119	7.7	64	118	7.2	61	117	6.8
	2500	62	114	6.9	58	113	6.5	55	111	6.2
	2400	56	108	6.3	53	107	6.0	51	106	5.8
	2300	50	102	5.8	48	101	5.6	46	100	5.5
	2200	46	96	5.5	44	95	5.4	43	94	5.3

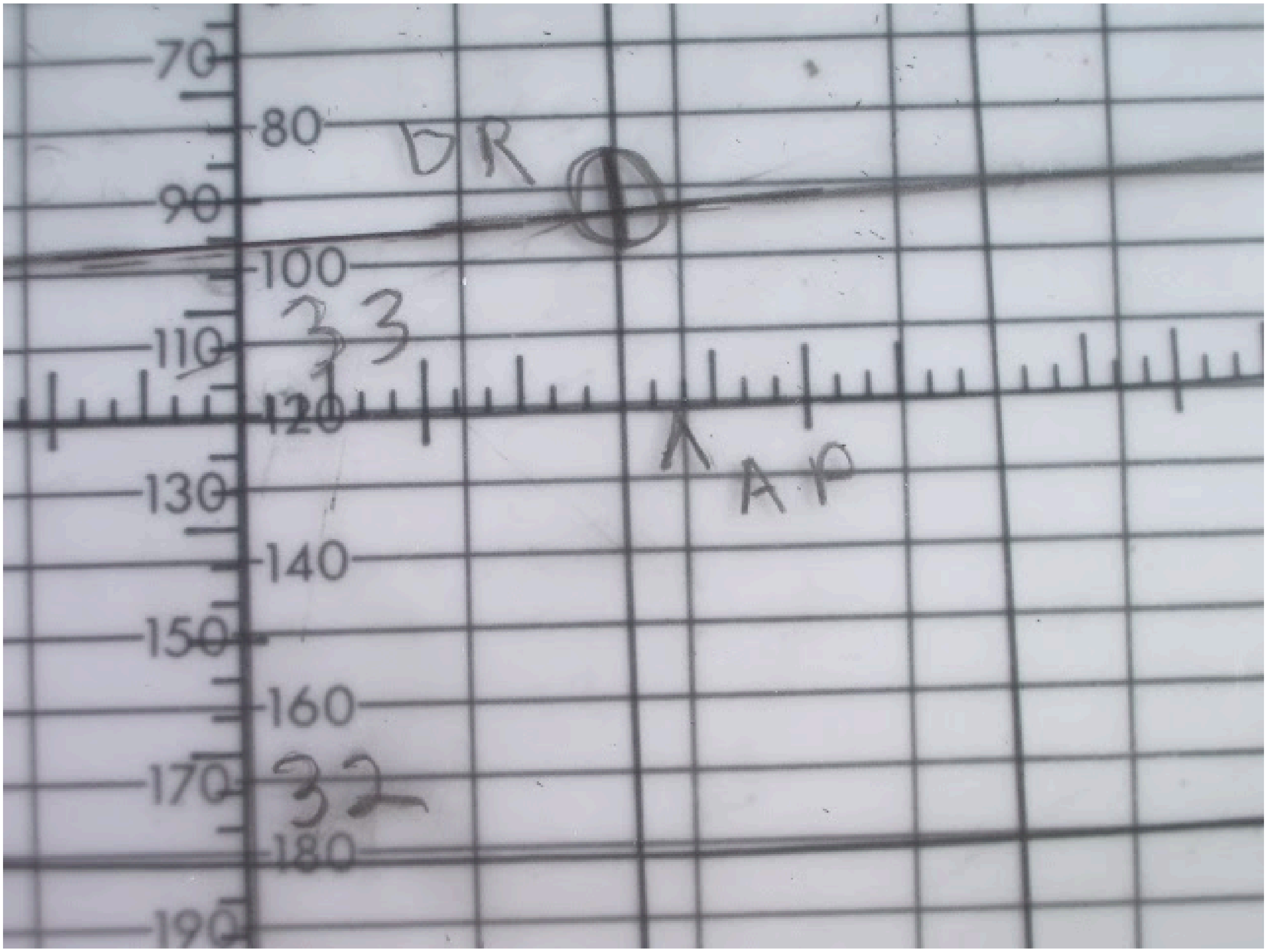
Figure 5-7. Cruise Performance

Since we have covered 27 NM in the climb we will have an additional 407 NM to cover in cruise after we reach the TOC. Winds are forecast "light and variable" so using our true airspeed of 114 knots we compute that it will take an additional 3 hours +34 minutes for the enroute phase of the flight for a total flight time of 3+55. We will burn 24.3 gallons in cruise plus the climb and taxi fuel means we will burn a total of 29.1 gallons out of our total fuel on board of 50 gallons leaving us a comfortable 20.9 gallons fuel reserve.

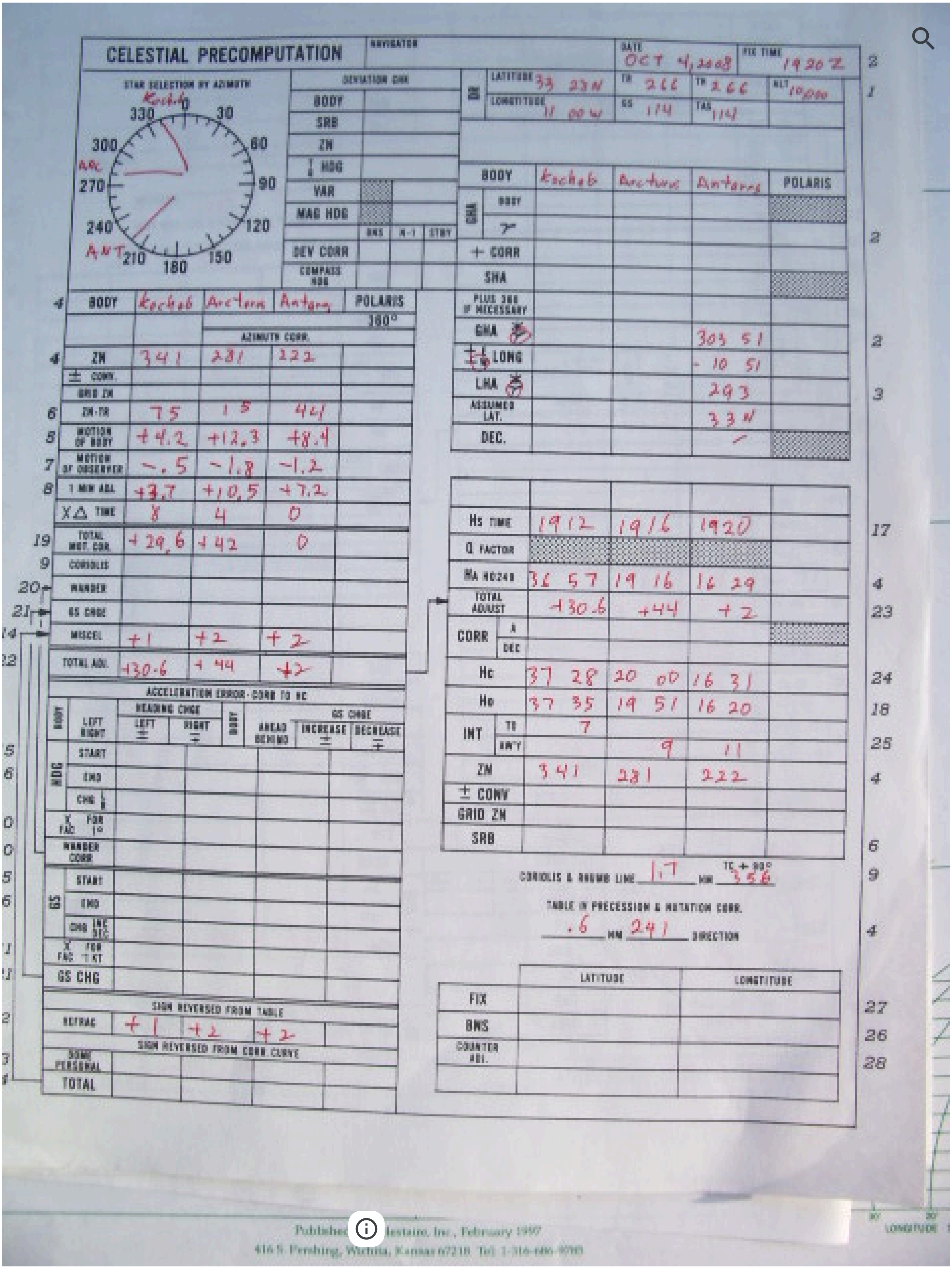
We take off at 1745Z and climb on course on a true heading of 266° and level off 21 minutes later at FL100 at 1806Z and set the power and auto pilot. Our ETA is 2140Z, 3+55 after takeoff. We plan on taking a celestial fix at 1920Z to allow for an enroute leg longer than one hour so as to allow for the determination of an accurate wind vector. We will cover 140 NM during the 1+14 minute cruise from TOC at 1806Z to 1920Z fix time. Since we covered 27 NM in the climb we will be 167 NM from departure at the planned fix time. To plot the 1920Z DR we count up 167 NM on the grid from the departure. Since the departure was at minus 215 on the Polhemus grid we simply subtract 167 from 215 and place a mark on our course line at the minus 48 grid line, visually interpolating between 40 and 50 (9.jpg.)


33
34
DR
30
20
10
10
20
30
40
50
70
90
110
130

Rotating the grid to north up by placing 360° at the True Index we can read out the coordinates of our 1920Z DR of 33° 27' north, 11° 00' west (15.jpg.)



About a half hour before the fix time we start planning our fix. It only takes about ten minutes to do the actual pre-computations for a three star fix but, since we must start shooting the first star nine minutes prior to fix time, we don't want to cut it too close, we want to leave some time for contingencies. We will be using H.O 249 Volume 1, Selected Stars, since it is the most convenient. First we look in the Air Almanac for 1920Z, October 4, 2008 and take out the GHA of Aries without interpolation, 303° 51' (10.pdf.) We select an AP of 33° 00' north and 10° 51' west so that the LHA Aries will be 293° exactly. We use only one AP since we are using H.O. 249 vol. 1 and we are accounting for motion of the observer (MOO) and the motion of the body (MOB) mathematically, not advancing the earlier LOPs to the fix time. We then look at the 33° north page of H.O 249, vol. 1 and looking at 293° LHA Aries we see that the selected stars are Alpheratz, Enif, Altair, Antares, Arcturus, Alkaid and Kochab (11.pdf.) Because the visibility is limited in a Cessna 172 by its high wing we must choose, not the three recommended stars, but Kochab, Arctures and Antares. We take out the Hc's and Zn's for the three bodies, 36° 57' and 341° for Kochab; 19° 16' and 281° for Arcturus; 16° 29' and 222° for Antares. We will shoot Kochab first since it is nearly on the wing tip and so advancing its LOP the most to the fix time will have little effect on its accuracy. We plan our shooting schedule, Kochab at 1912Z (eight minutes before fix time), Arcturus at 1916Z (four minutes early) and Antares at 1920Z. We enter this data our the Celestial Precomputation form (12.jpg,)



CELESTIAL PRECOMPUTATION	NAVIGATOR	DATE OCT 4, 2008	FIX TIME 1920 Z

DR				
LATITUDE 33 23N	TH 266	TR 266	ALT 10,000
LONGITUDE 11 00 W	GS 114	TAS 114	

STAR SELECTION BY AZIMUTH

Kochab, ARC, ANT

DEVIATION CHK			
BODY			
SRB			
ZN			
T HDG			
VAR			
MAG HDG			
	BNS	N-1	STBY
DEV CORR			
COMPASS HDG			

BODY		Kochab	Arcturus	Antares	POLARIS
GHA	BODY				
	γ				
+ CORR					
SHA					
PLUS 360 IF NECESSARY					
GHA				303 51	
± LONG				- 10 51	
LHA				293	
ASSUMED LAT.				33 N	
DEC.					

BODY	Kochab	Arcturus	Antares	POLARIS
		AZIMUTH CORR.		180°
ZN	341	281	222	
± CONV.				
GRID ZN				
ZN-TR	75	15	44	
MOTION OF BODY	+4.2	+12.3	+8.4	
MOTION OF OBSERVER	-.5	-1.8	-1.2	
1 MIN ADJ.	+3.7	+10.5	+7.2	
X Δ TIME	8	4	0	
TOTAL MOT. COR.	+29.6	+42	0	
CORIOLIS				
WANDER				
GS CHGE				
MISCEL	+1	+2	+2	
TOTAL ADJ.	+30.6	+44	+2	

ACCELERATION ERROR - CORR TO HC

	BODY LEFT RIGHT	HEADING CHGE LEFT ±	HEADING CHGE RIGHT ∓	BODY AHEAD BEHIND	GS CHGE INCREASE ±	GS CHGE DECREASE ∓
HDG	START					
	END					
	CHG L/R					
	X FAC FOR 1°					
	WANDER CORR					
GS	START					
	END					
	CHG INC/DEC					
	X FAC FOR 1 KT					
	GS CHG					

SIGN REVERSED FROM TABLE

REFRAC	+1	+2	+2	

SIGN REVERSED FROM CORR. CURVE

SOME PERSONAL				
TOTAL				

Hs TIME		1912	1916	1920	
Q FACTOR					
Ha HO249		36 57	19 16	16 29	
TOTAL ADJUST		+30.6	+44	+2	
CORR	A				
	DEC				
Hc		37 28	20 00	16 31	
Ho		37 35	19 51	16 20	
INT	TO	7			
	AW'Y		9	11	
ZN		341	281	222	
± CONV					
GRID ZN					
SRB					

CORIOLIS & RHUMB LINE 1.7 NM TC + 90° 356

TABLE IN PRECESSION & NUTATION CORR.

.6 NM 241 DIRECTION

	LATITUDE	LONGITUDE
FIX		
BNS		
COUNTER ADJ.		

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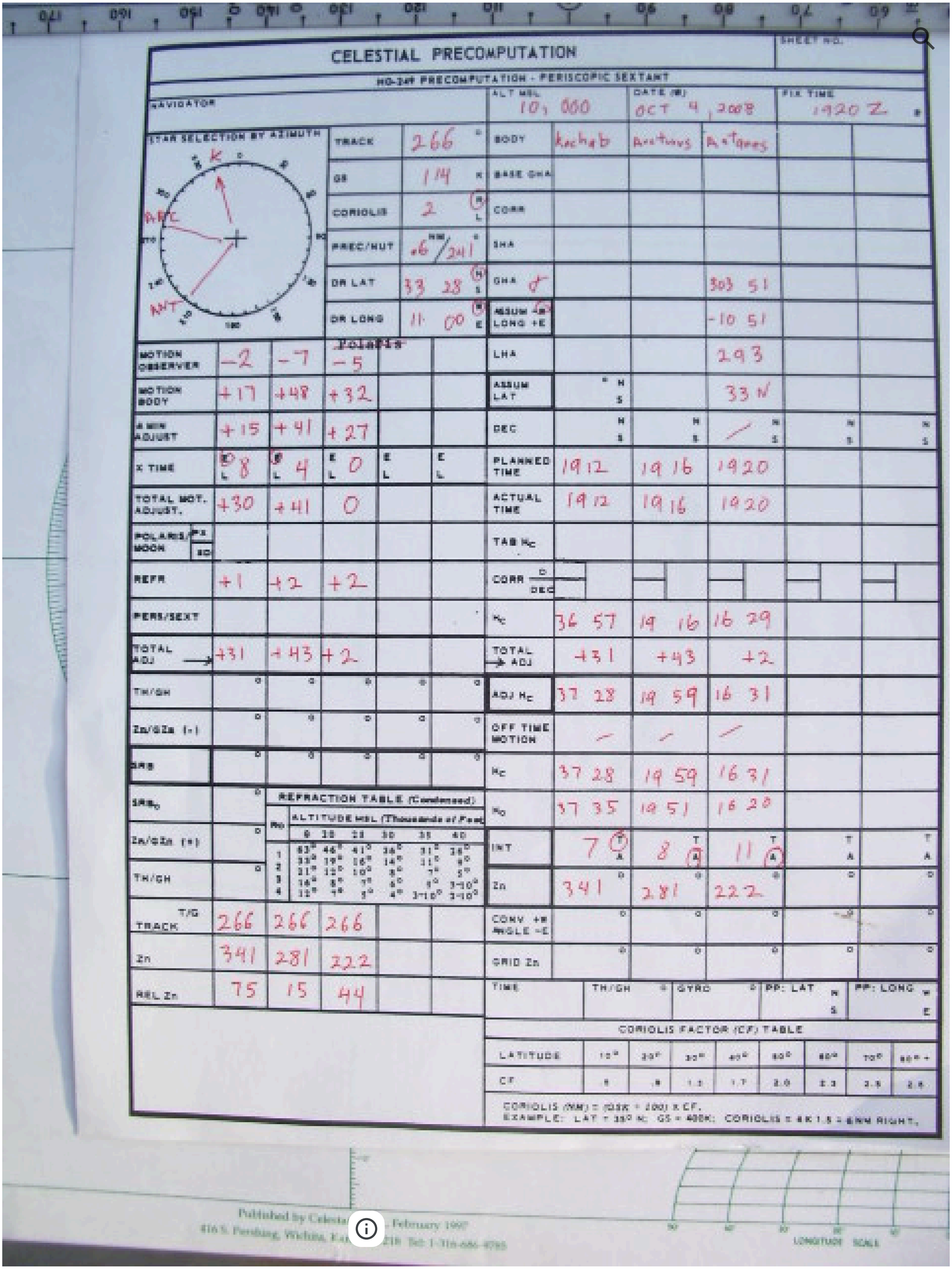
if using the Polhemus computer or the 1 minute adjustment tables from H.O 249 or (13.jpg)



CELESTIAL PRECOMPUTATION — SHEET NO.

HO-249 PRECOMPUTATION - PERISCOPIC SEXTANT

NAVIGATOR	ALT MSL	DATE (Z)	FIX TIME
	10,000	OCT 4, 2008	1920 Z

STAR SELECTION BY AZIMUTH (K, ARC, ANT)

TRACK	266°	BODY	Kochab / Arcturus / Antares
GS	114 K	BASE GHA	
CORIOLIS	2 (R) L	CORR	
PREC/NUT	.6 NM / 241°	SHA	
DR LAT	33 28 (N) S	GHA ♈	303 51 (Antares)
DR LONG	11 00 (W) E	ASSUM -W LONG +E	-10 51 (Antares)

	Kochab	Arcturus	~~Polaris~~		
MOTION OBSERVER	-2	-7	-5		
MOTION BODY	+17	+48	+32		
4 MIN ADJUST	+15	+41	+27		
X TIME	(E) 8	(E) 4	0		
TOTAL MOT. ADJUST.	+30	+41	0		
POLARIS/MOON					
REFR	+1	+2	+2		
PERS/SEXT					
TOTAL ADJ →	+31	+43	+2		
TH/GH					
Zn/GZn (-)					
GRS					
GRS₀					
Zn/GZn (+)					
TH/GH					
T/G TRACK	266	266	266		
Zn	341	281	222		
REL Zn	75	15	44		

REFRACTION TABLE (Condensed)

Ro	ALTITUDE MSL (Thousands of Feet) 5	10	20	30	35	40
0	63°	46°	41°	36°	31°	26°
1	33°	19°	16°	14°	11°	8°
2	21°	12°	10°	8°	7°	5°
3	16°	8°	7°	6°	5°	3-10°
4	12°	7°	5°	4°	3-10°	3-10°

BODY	Kochab	Arcturus	Antares		
LHA			293		
ASSUM LAT			33 N		
DEC			/		
PLANNED TIME	1912	1916	1920		
ACTUAL TIME	1912	1916	1920		
TAB Hc					
CORR D/DEC					
Hc	36 57	19 16	16 29		
TOTAL ADJ	+31	+43	+2		
ADJ Hc	37 28	19 59	16 31		
OFF TIME MOTION	–	–	–		
Hc	37 28	19 59	16 31		
Ho	37 35	19 51	16 20		
INT	7 (T)	8 (A)	11 (A)	T A	T A
Zn	341	281	222		
CONV +W ANGLE -E					
GRID Zn					

TIME	TH/GH	GYRO	PP: LAT N/S	PP: LONG W/E

CORIOLIS FACTOR (CF) TABLE

LATITUDE	10°	20°	30°	40°	50°	60°	70°	80°+
CF	.5	.9	1.3	1.7	2.0	2.3	2.5	2.6

CORIOLIS (NM) = (GSK ÷ 100) X CF.
EXAMPLE: LAT = 35° N; GS = 400K; CORIOLIS = 4 X 1.5 = 6NM RIGHT.

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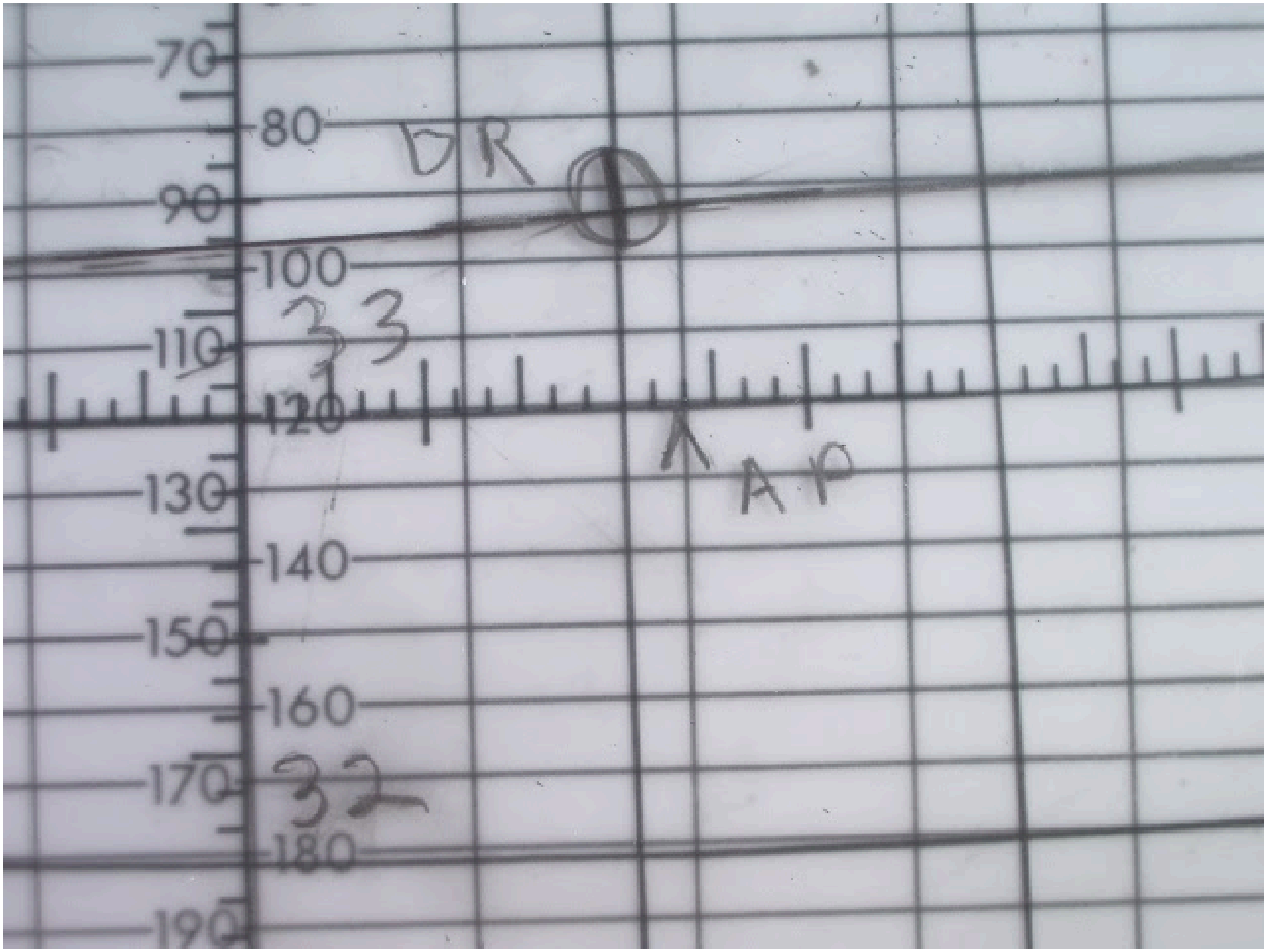
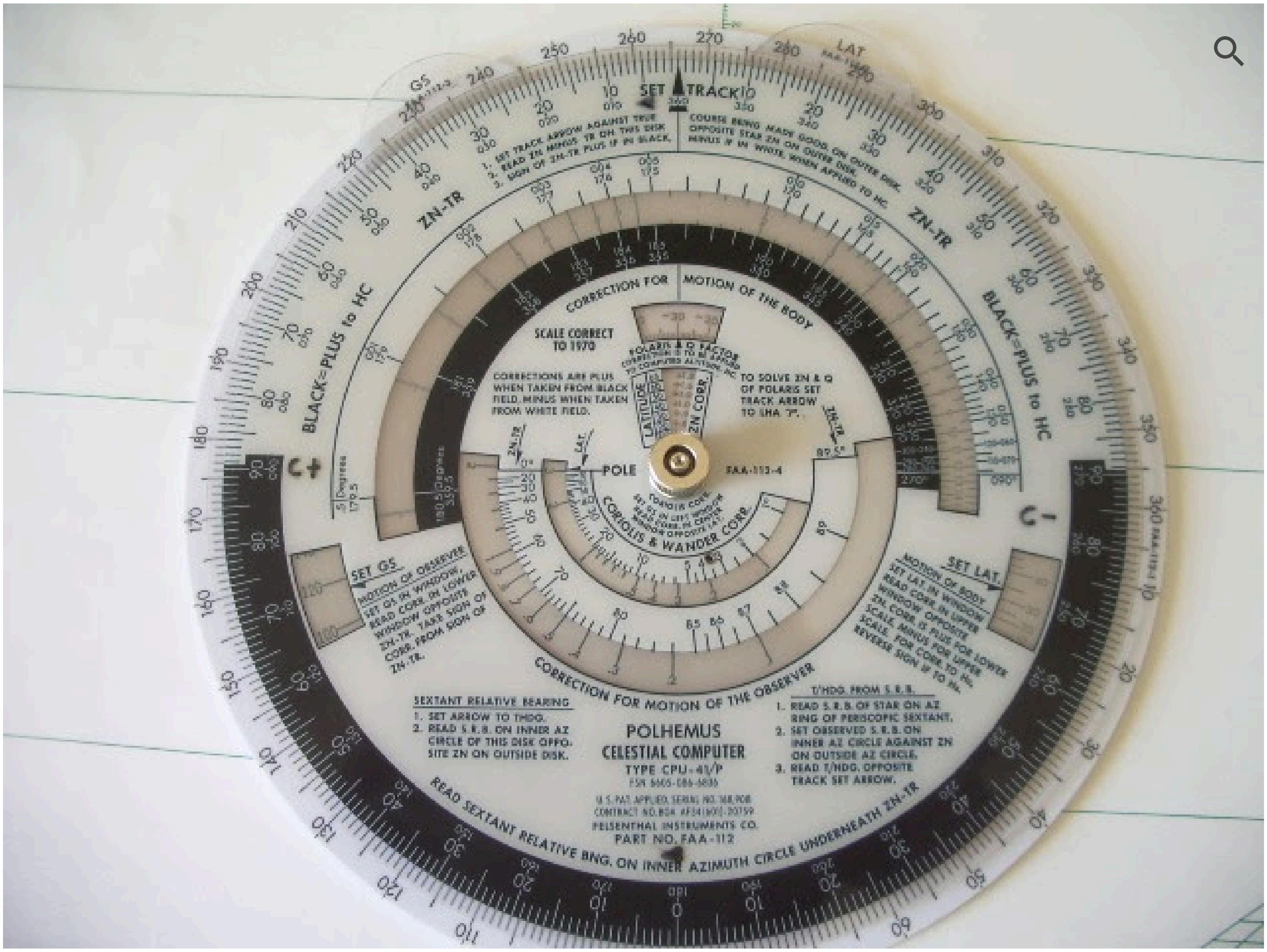
LONGITUDE SCALE

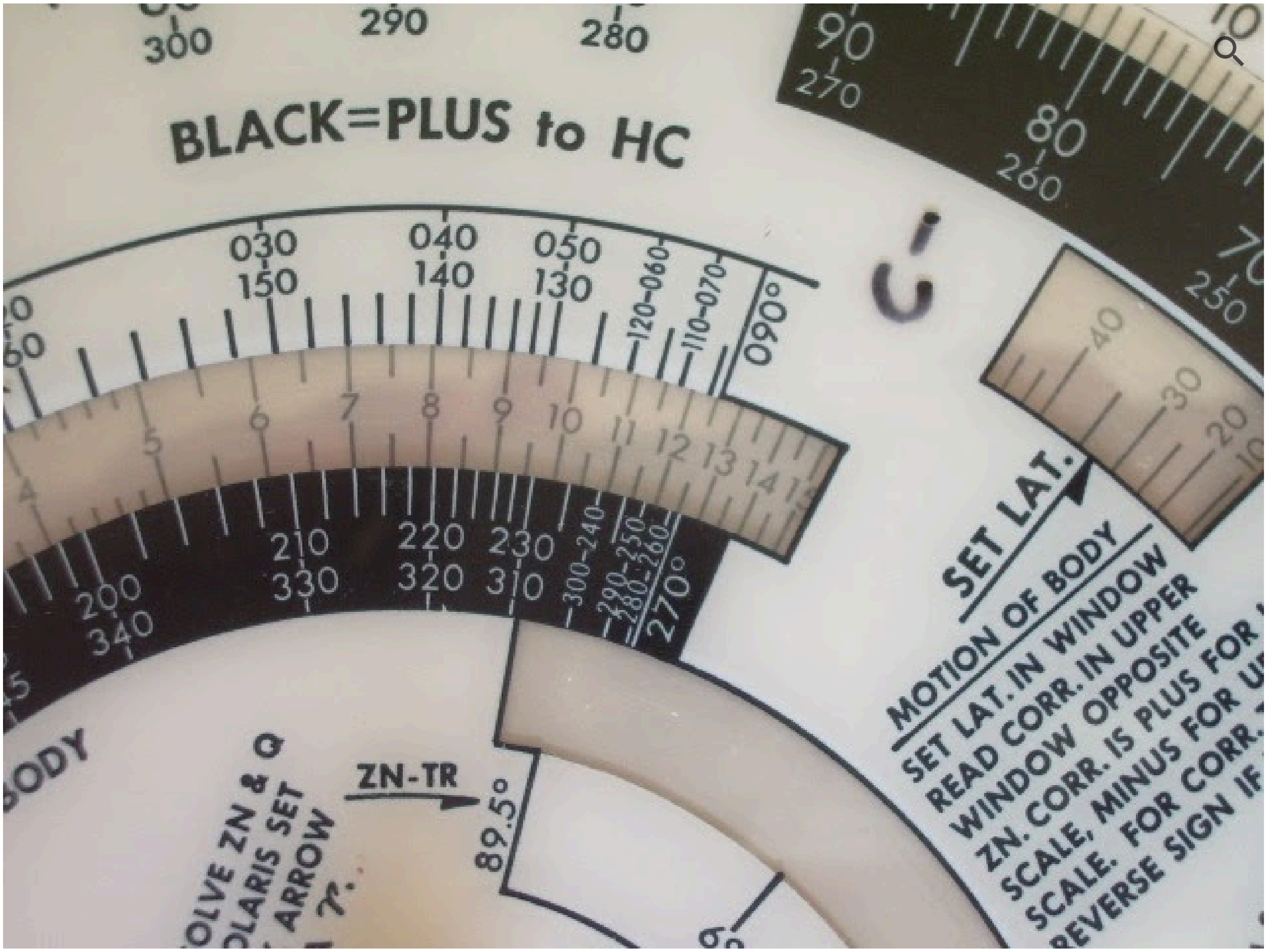
if using the 4 minute adjustment tables from H.O. 249. We only compute LHA for the the fix time shot but we use the same LHA, 293° to take out the Hc's for all three bodies and enter this data on the form in the row labeled "HA HO 249" and enter the Zn's in the same columns and also on the left side of the form for computation of the motions adjustments. We also take out the "Precession and Nutation" correction for 2008 for LHA Aries of 293° and for a latitude of 33° north, either visually interpolating or simply taking the nearest tabulated value since they are all small, we'll use .6 NM at 241° and enter it on the appropriate form (14.pdf.) We will use this to adjust the fix position. We plot the AP (an upside down "V") on the Polhemus grid at 33° 00' north, 10° 51' west, visually interpolating (15.jpg.)



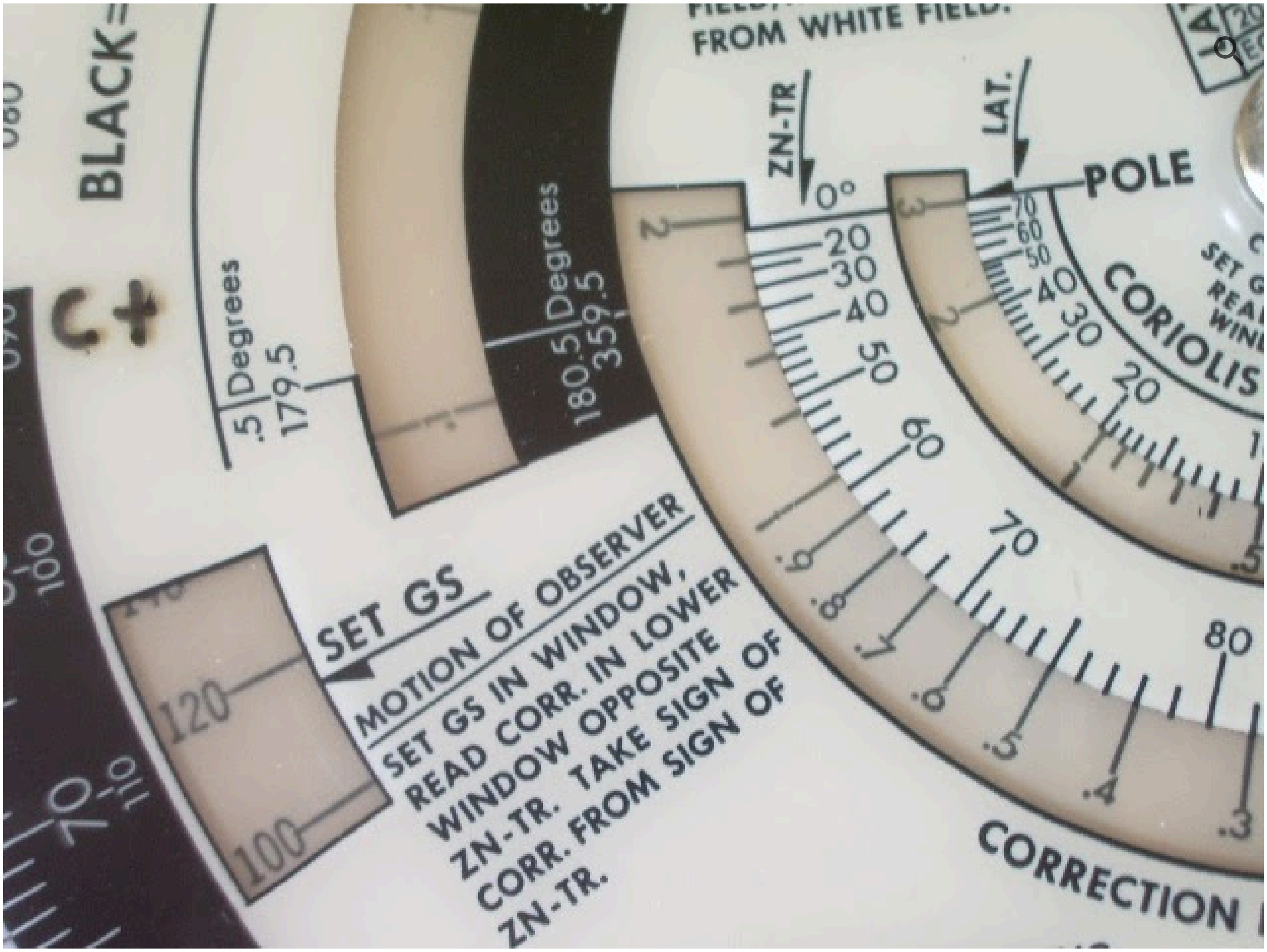
Now set the front of the Polhemus "SET TRACK" pointer to 266°, the "SET GS" (ground speed) to 114 knots and the "SET LAT" to 33° and then tighten the nut to keep the settings from changing (16.jpg.) (We could also do the same adjustments using the MOB and MOO tables from H.O 249.)



Looking around the outside edge for the Zn's of each body we find the relative Zn's (ZN-TR) and enter them on the form, 75° for Kochab, 15° for Arcturus and 44° for Antares. Using each body's Zn look in the "CORRECTION FOR MOTION OF THE BODY" window and take out the MOB one minute correction and enter it in the appropriate blank (17.jpg , 18.pdf. and 19.pdf.)

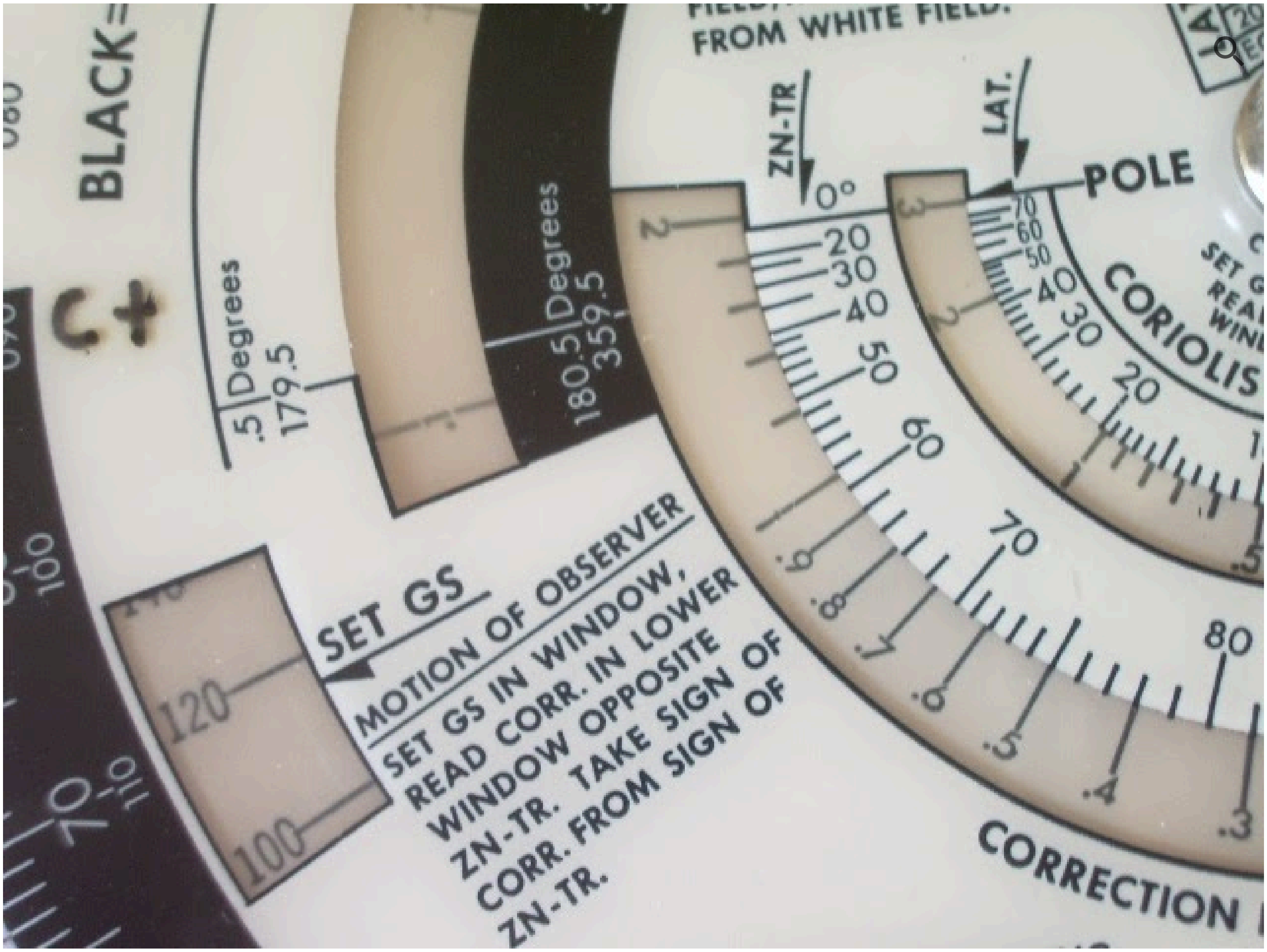


Since all three Zn's are to the west they are all found on the black scale so the signs are all plus. Next, using the relative Zn's (ZN-TR) look in the "CORRECTION FOR MOTION OF THE OBSERVER" window and take out the one minute corrections for MOO (20.jpg , 21.pdf and 22.pdf.)



Since all of the relative Zns are ahead of the plane they are all found on the white scale making all of their signs negative. We sum the MOB and MOO adjustments to the "ONE MINUTE ADJ." line keeping track of the signs. Since we are planning the first shot 8 minutes early, the second shot 4 minutes early and the last shot on time, we multiply the one minute adjustments by the time intervals to produce the total motions adjustments. (We get identical values if we use the one minute MOB and MOO tables. If we are using the 4 minute adjustment tables we multiply by 2 and 1 adjustment periods respectively and get the same values.) We look at the refraction table (23.pdf) in the 10,000 foot altitude column and take out the refraction correction for each body and enter it on the form with a plus sign and carry them to the "MISCEL" line. Add the total motion adjustment to the MISCEL line to arrive at "TOTAL ADJ." and carry to the right side of the form into the appropriate columns. Combine the "HA" from H.O. 249 with the total adj. to arrive at precomputed altitude (Hp.)

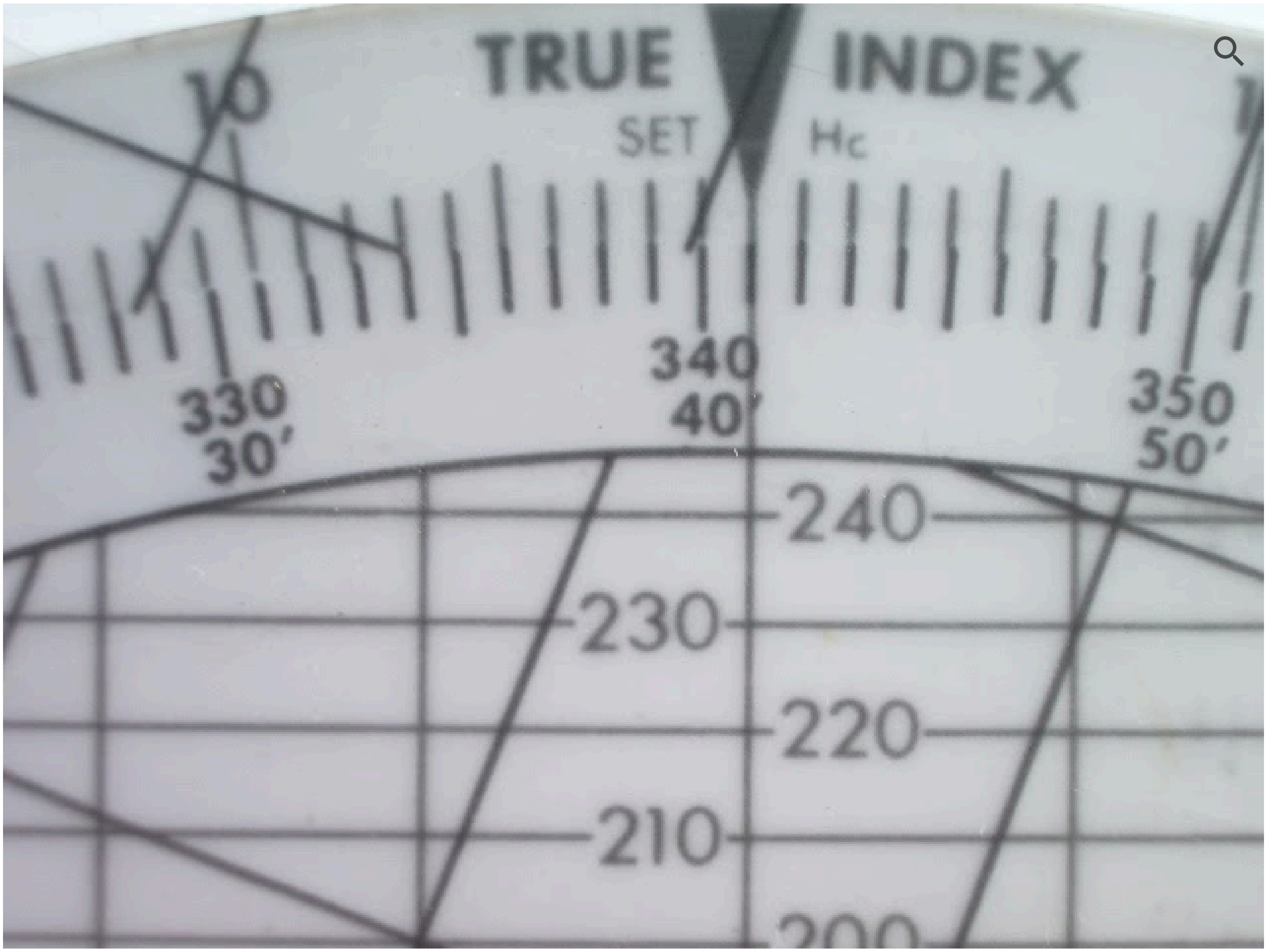
The last bit of information we take from the Polhemus is the Coriolis correction which is found in the "CORIOLIS & WANDER CORR." window. Look at the latitude, 33°, and take out the coriolis correction of 1.7 NM (20.jpg),

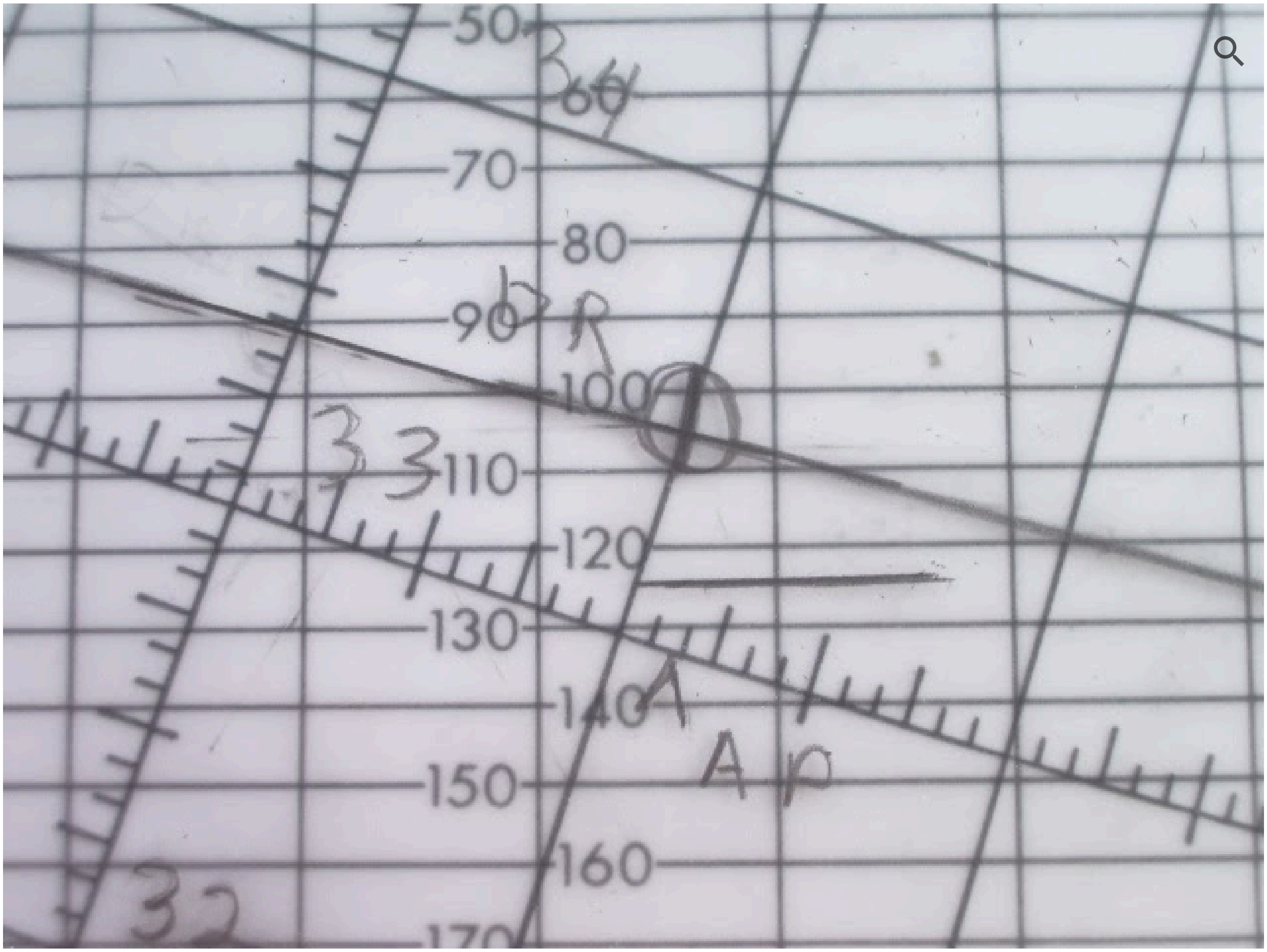

FROM WHITE FIELD.
BLACK=
.5 Degrees 179.5
180.5 Degrees 359.5
ZN-TR
LAT.
0°
POLE
CORIOLIS
SET GS
MOTION OF OBSERVER
SET GS IN WINDOW,
READ CORR. IN LOWER
WINDOW OPPOSITE
ZN-TR. TAKE SIGN OF
CORR. FROM SIGN OF
ZN-TR.
CORRECTION

(2 NM if taken from the H.O. 249 table 23.pdf .) We will use this to move the plotted fix 1.7 NM in direction 356° , 90° to the right of the track to account for Coriolis. (Alternatively we could make the same adjustment to to the AP prior to plotting the LOP's, dealers choice. We could also use the Polhemus to derive a Coriolis correction to be applied to each Hp mathematically but that is a needless complication especially at low air speeds.)

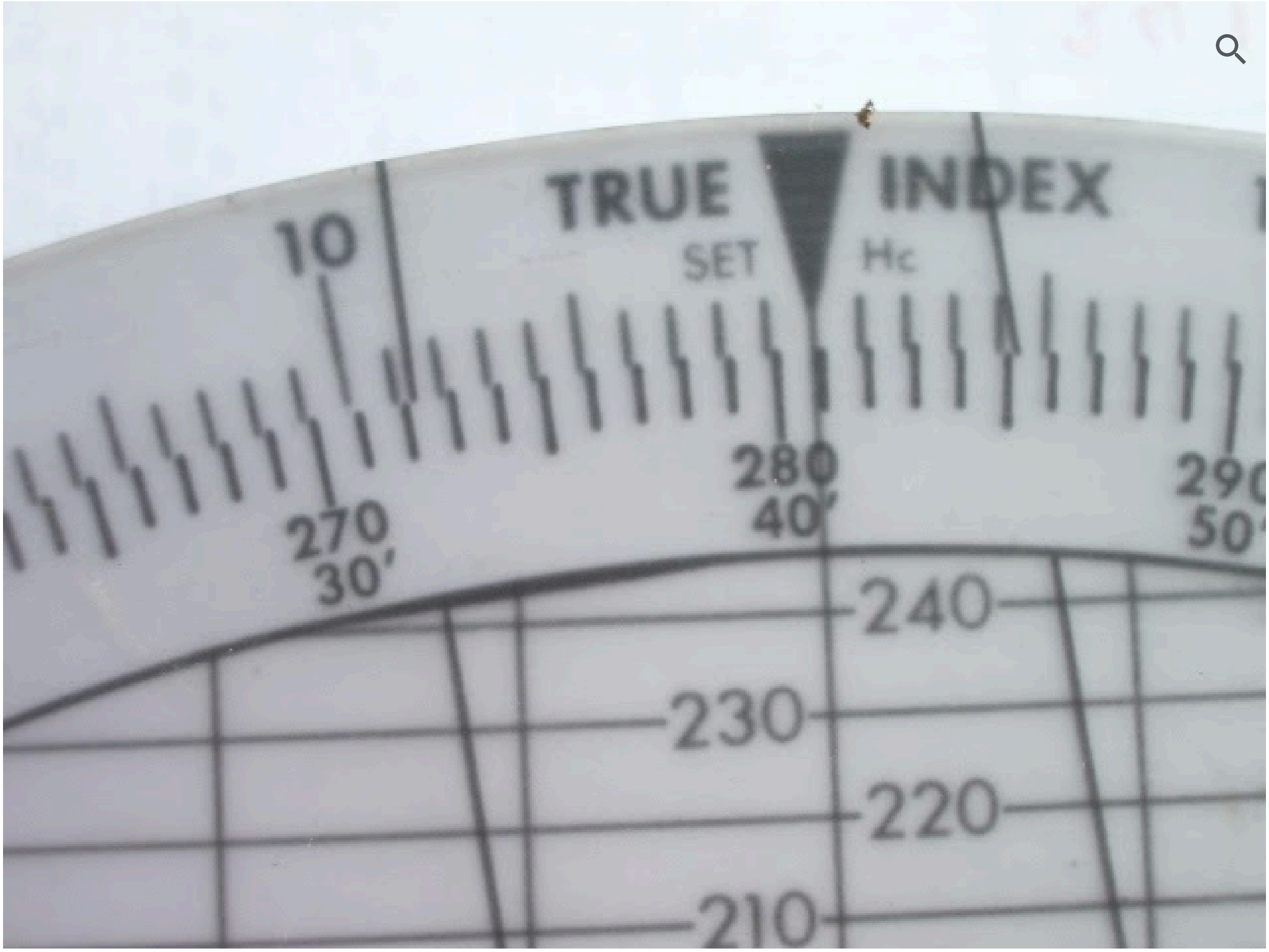
We are now done with the precomputations and can relax until time to shoot Kochab. About 1908Z we get the sextant ready, illumination on, bubble formed, averager set and altitude set to about 37°. We also make sure that the directional gyro is set and that the autopilot is set to heading mode. We look out the window, locate Kochab and bring it into the center of the bubble. At 1911Z we trigger the averager and continually adjust the altitude knob to keep Kochab centered in the bubble. Two minutes later the shutter on the sextant automatically closes ending the two minute shooting period and the average time of the shot is 1912Z. (If using an A-10A and some other sextants you must keep track of the progress of the shot and stop at the two minute mark.) The sextant altitude of Kochab is 37° 35'. We enter this in the form, compare it to the already adjusted and corrected Hp and determine that the intercept is 7 NM TOWARD Kochab, Zn 341°. (No need to correct Hs for refraction as this was already taken care of by applying the refraction correction with reversed sign to adjusted Hp.)

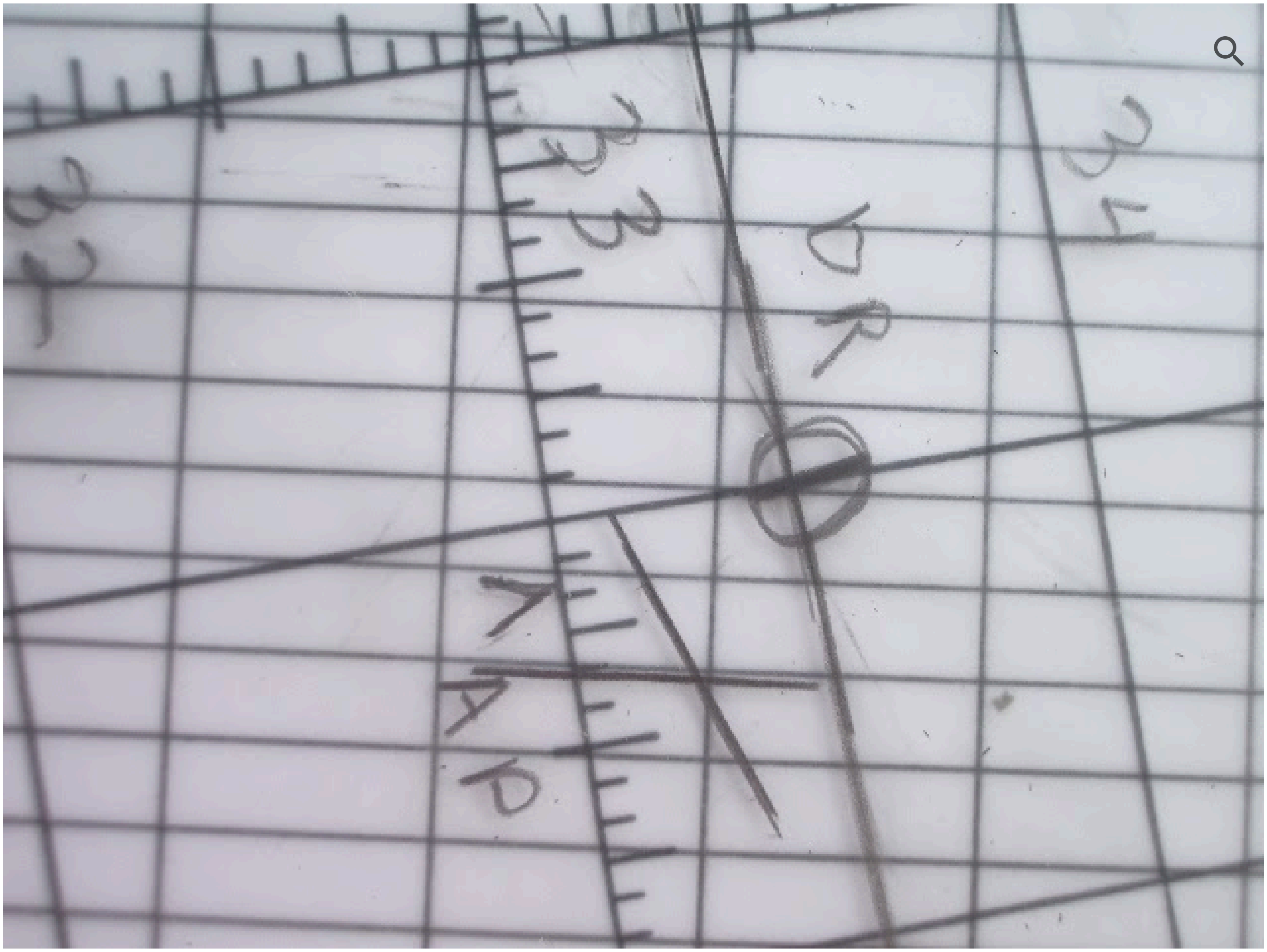
We complete the same steps with Arcturus and Antares and get an Hs of 19° 51' for Arcturus and an Hs of 16° 20' for Antares producing intercepts of 9 NM AWAY and 11 NM AWAY respectively. Using the Polhemus we plot the three LOPs. First we set the Zn of Kochab, 341°, at the TRUE INDEX and then measure up 7 NM from the A.P since this is a TOWARD intercept. and draw the Kochab LOP parallel to the right-left grid lines on the Polhemus base (24.jpg and 25.jpg .)

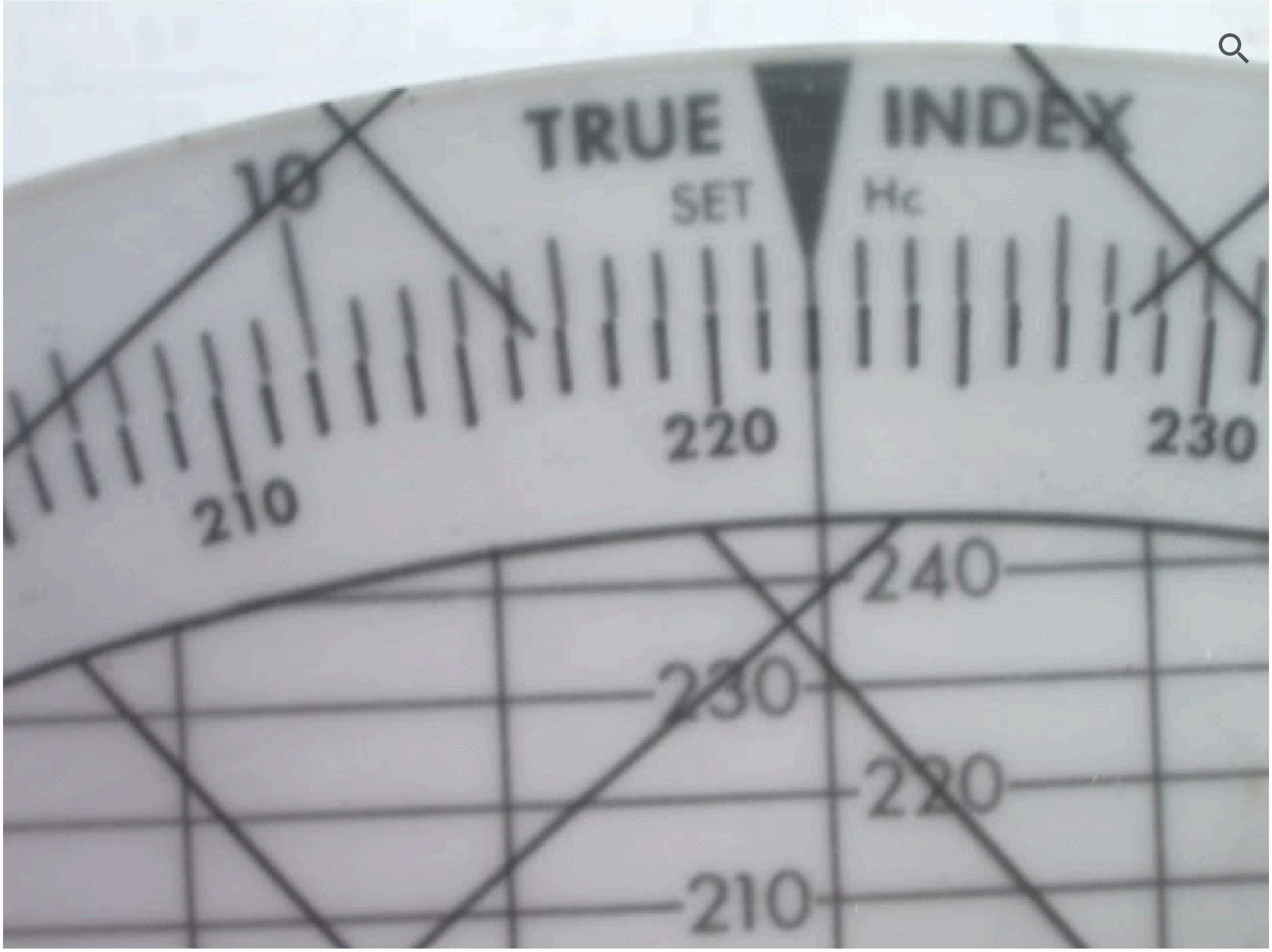

TRUE INDEX
SET
Hc
10
330
30′
340
40′
350
50′
240
230
220
210
200

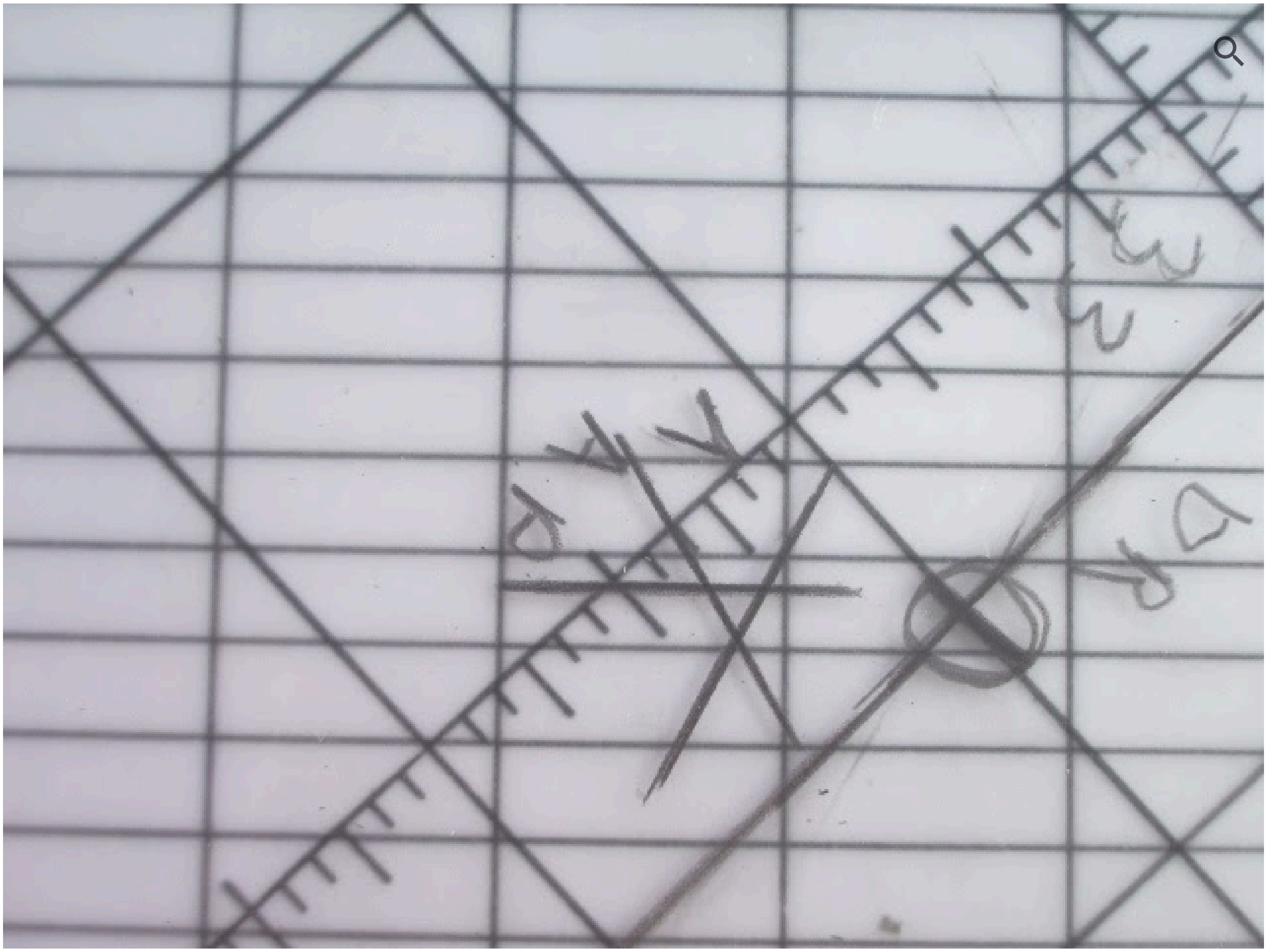


We do the same for the Arcturus and Antares LOP's remembering to measure down from the AP since these are AWAY intercepts 26.JPG , 27.JPG , 28.JPG and 29.JPG.)

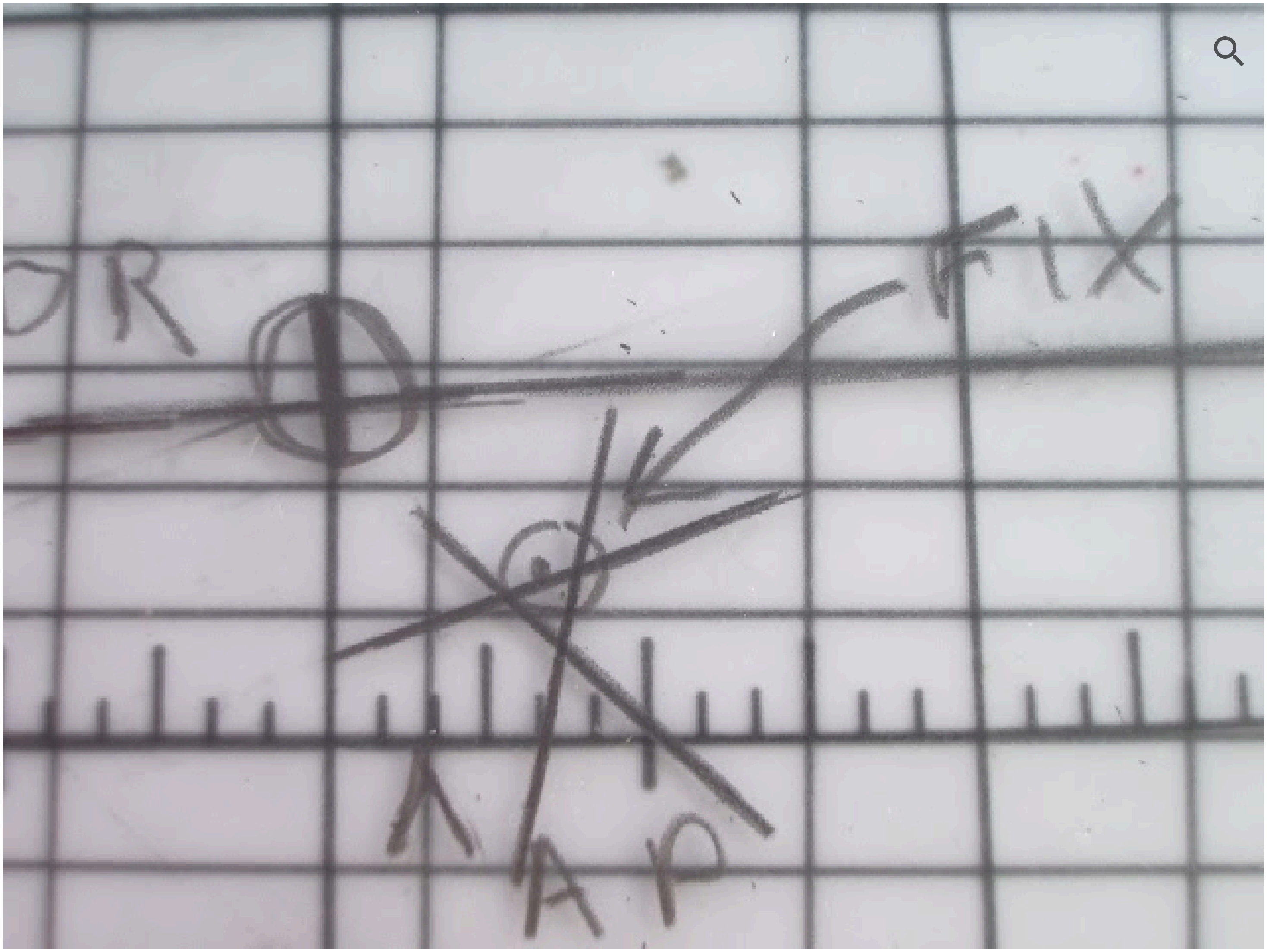

10
TRUE
SET
INDEX
Hc
270
30′
280
40′
290
50′
240
230
220
210


32
33
34
DR
AP


TRUE
INDEX
SET
Hc
10
210
220
230
240
230
220
210



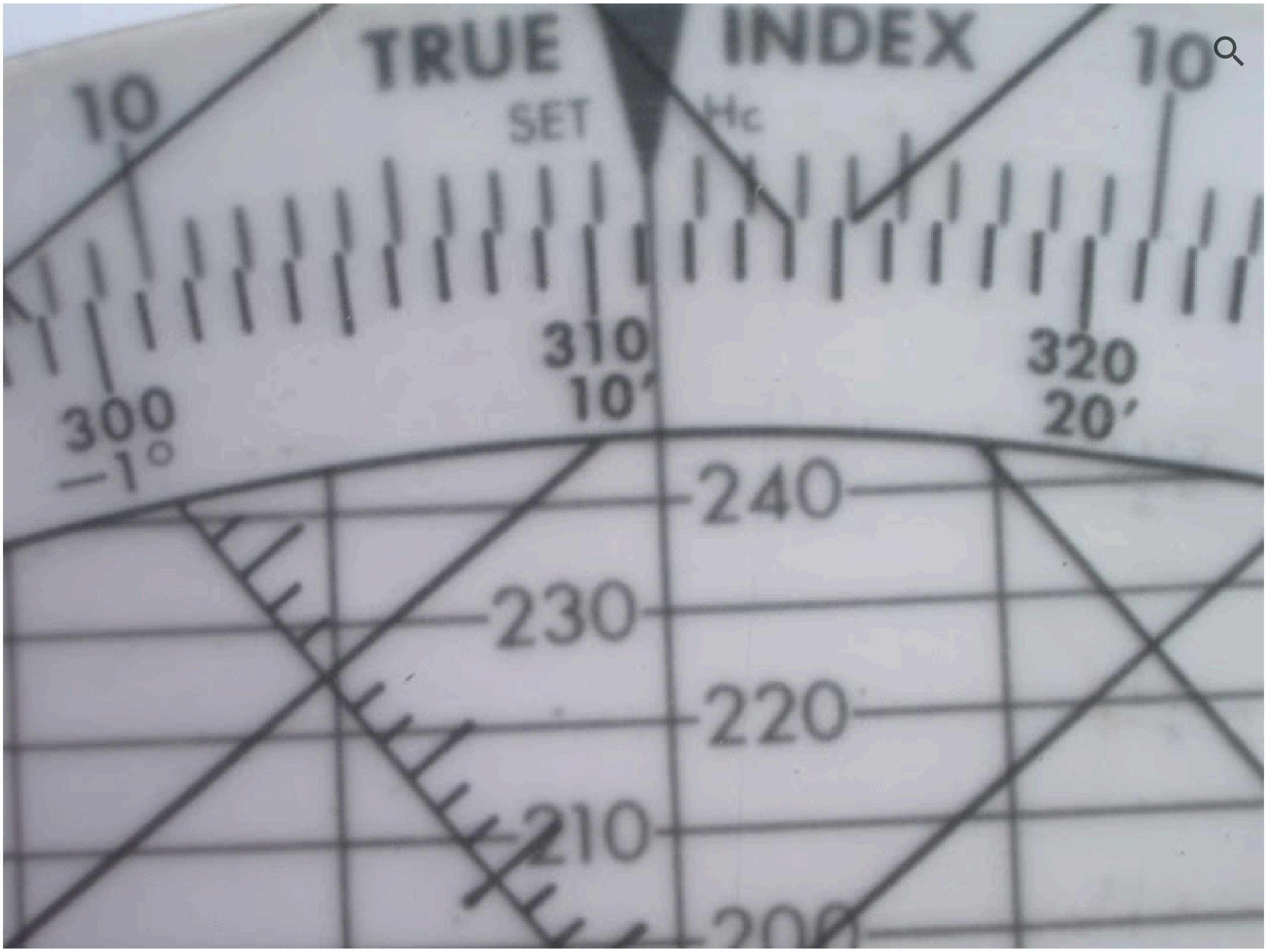
These three lines form the traditional "cocked hat" of a celestial fix. We then move the fix from the center of the cocked hat 1.7 (or 2) NM in direction 356° for Coriolis and then .6 NM in direction 241° for precession and nutation. We do this with visual interpolation since these are small values (30.jpg.)



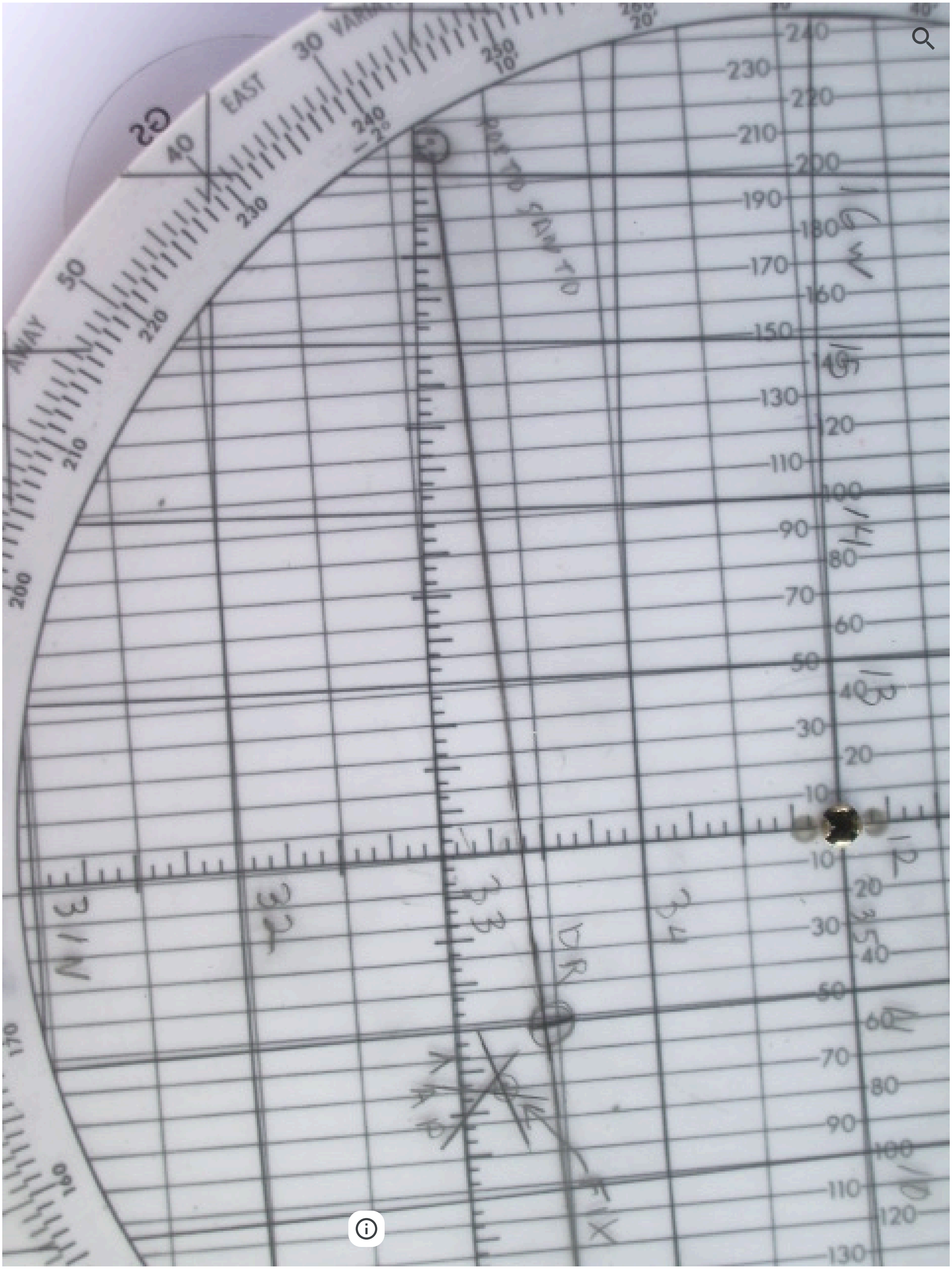
If larger, we would set the respective Zn's under the TRUE INDEX and measure up the appropriate amount for each of these corrections. The fix is 33° 13' north, 10° 41' west.

Showing the convenience of the Polhemus even more, we quickly find the wind encountered in flight and the new course and distance to the destination. Since our DR in this case is also our "no wind position" or "air position" where we would be if there were no wind, so any difference between the DR and the fix must be caused by the wind. We now rotate the disk to place the fix directly below the DR and read out the distance between the DR and the fix which shows how far the wind pushed the plane, in this case 21 NM (31.jpg.)

Since the plane flew for 1+14 in cruise we divide this 21 NM by this amount of time and find the wind speed of 17 knots. We now find the direction of true wind as it is already aligned with the "TRUE INDEX" which shows 311° (32.jpg.)



Now we can rotate the disk to place the destination directly above the fix and find the distance and true course to the destination of 284 NM (33.jpg), course 270° (34.jpg .)


EAST
AWAY
31 W
32
33
34
DR
FIX


10
TRUE
SET
INDEX
Hc
260
20'
270
30'
280
40'
240
230
220
210

Using this new course and the measured winds on our E-6B or MB-2A we calculate a new wind correction angle, new heading, new ground speed, new ETA and new fuel required. Wind correction angle will be 6° RIGHT making the new heading of 276° . The new ground speed will be 101 knots for the remaining distance of 284 NM which means it will take an additional 2+48 to arrive, making the new ETA of 2208Z. This means that we will arrive 28 minutes later than planned, using an extra 3.2 gallons reducing our fuel reserve to 17.7 gallons which is still a comfortable safety margin, more than two hours of extra fuel. We will plan on taking two more fixes at 2020Z and 2120Z to confirm that we are staying on course and maintaining our schedule to ensure having adequate fuel. We may omit the 2120Z fix if we are already receiving radio navigation guidance from the destination which should be only about 80 NM ahead at that time.

Although this is a fairly short flight it is still very useful to get the celestial fixes so that we can be sure we are not running into a strong headwind or getting blown far off course.

Celnav is done the same way in faster aircraft. Since most jets are flight planned at about .7 mach, about 450 knots, this just makes the adjustment for MOO and Coriolis larger but the same methods are used. Using the Polhemus it takes only 40 seconds to plot the three LOP's, about 13 seconds each, and just 30 seconds total to determine the wind speed and direction and the course and distance to destination. Then 25 seconds on the MB-2A gives you wind correction angle and ground speed and another 30 seconds gives you time to destination and fuel required. So by doing precomputations and by using the Polhemus you can have the fix and the new heading, ETA and fuel required, only two minutes after finishing the last shot. Try that with other other computation and plotting method!

TITLE	LAST MODIFIED
1.JPG	2/8/23 Gary LaPook
10.pdf	2/8/23 Gary LaPook
11.pdf	2/8/23 Gary LaPook
12.JPG	2/8/23 Gary LaPook
13.JPG	2/8/23 Gary LaPook
14.pdf	2/8/23 Gary LaPook
15.JPG	2/8/23 Gary LaPook
16.JPG	2/8/23 Gary LaPook
17.JPG	2/8/23 Gary LaPook
18.pdf	2/8/23 Gary LaPook
19.pdf	2/8/23 Gary LaPook
2.JPG	2/8/23 Gary LaPook
20.JPG	2/8/23 Gary LaPook
21.pdf	2/8/23 Gary LaPook
22.pdf	2/8/23 Gary LaPook
23.pdf	2/8/23 Gary LaPook