

**CAMBRIDGE AERO INSTRUMENTS, INC.**

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**Cambridge M-NAV System  
Installation and Operation Manual**

**Manual Revision 3  
March 1988**

**This manual is for  
revisions 16 and above  
of the M-NAV ROM only.**

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This manual covers the installation and use of the Cambridge M-NAV soaring navigation computer. The M-NAV system consists of a Variometer, Audio, and a Final Glide and Distance NAV computer.

M-NAV features:

NAV Section

- Speed Command Indicator
- 20-Second Averager
- Full Function Audio, Integral Speaker
- Full Final-Glide Computer
- Full Distance-Flown Computer
- Bug Polars
- Adjustable Wing Loadings
- Airspeed Based Automatic Climb/Cruise Switching

Variometer Section

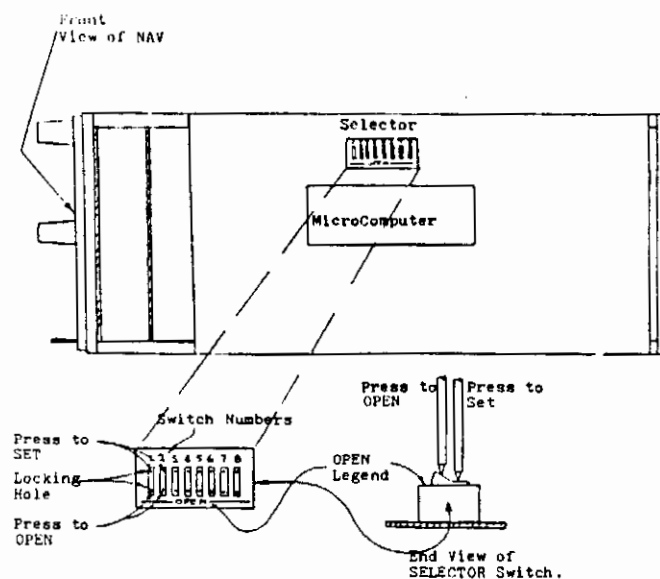
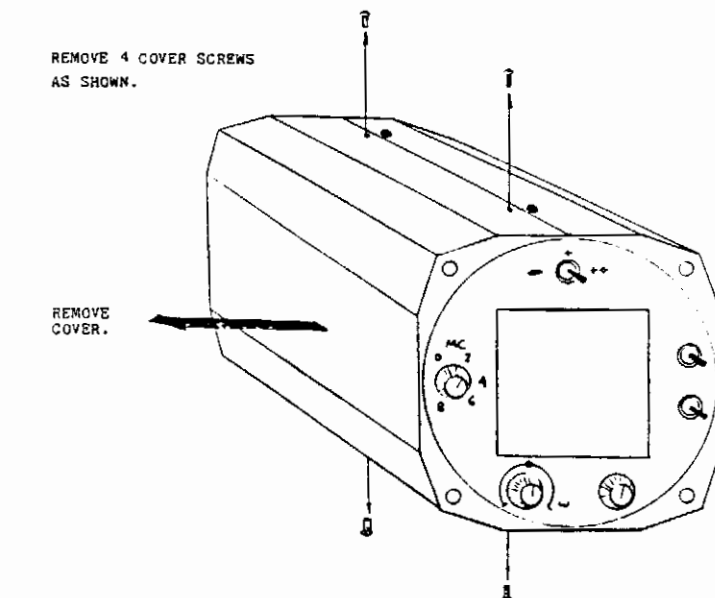
- Readout available in either 80mm or 58mm sizes
- Dual Range (5/10kts), Dual Damping (1.5 & 3 secs.)
- Relative Vario, selectable
- Altitude compensation
- TE probe compensation
- External flask required (supplied)
- Second Seat Repeater available, 80mm or 58mm

## • M-NAV Installation

### • Selector Switch Access

To reach the Option and Polar Selector Switch, remove the left hand (as viewed from the front) cover by removing the 4 cover screws.

To SET or OPEN a selector switch, use a ballpoint pen. SET or OPEN is selected by pressing the switch down on the appropriate side. Only a little force is required to snap the switch into its new position.



• **Polar Selection**

Selector switches 1, 2, 3, and 4 select the sailplane polar according to the following table:

Polar #	Sailplane Type	Best L/D	Switch Positions				Other Sailplanes
			1	2	3	4	
1	Std. Cirrus	35	Set	Set	Set	Set	G-102, LS-1, ASK-21
2	ASW-19	38	Open	Set	Set	Set	
3	LS-4	40	Set	Open	Set	Set	ASW-24, LS-7
4	Discus	42	Open	Open	Set	Set	
5	LS-3	41	Set	Set	Open	Set	Mini Nimbus, P1k-20
6	ASW-20	43	Open	Set	Open	Set	
7	Ventus	44	Set	Open	Open	Set	Nimbus II, 604
8	LS-6	45	Open	Open	Open	Set	
9	ASW-17	48	Set	Set	Set	Open	ASH-25
10	ASW-22	60	Open	Set	Set	Open	
11	Nimbus III	60	Set	Open	Set	Open	Nimbus 3D
12	Janus C	43	Open	Open	Set	Open	
13	Grob 103	36	Set	Set	Open	Open	
14	Taifun 17	32	Open	Set	Open	Open	

• **Calibration Selection - Selector Switch #5**

With the Wing Loading/Bug Polar switch to the left, the ROM Revision number is displayed in the Distance Readout.

**REV 16 ROM (Metric)**

SET - Europe (M/S, Meters, Km)

OPEN - Australia (Knots, Feet, Km)

**REV 17 ROM (English)**

(Knots, Feet)

SET - Nautical Miles

OPEN - Statute Miles

• **Automatic Climb/Cruise Switching Selection**

**- Selector Switches 6 and 7**

Revisions 16 and 17 of the M-NAV ROM makes it possible to switch

automatically from climb to cruise based on airspeed. It works in the following way:

When the airspeed goes from below to above threshold speed (60 or 65 knots) for more than 7 seconds, the M-NAV switches to cruise mode (Speed Command shows and Distance accumulates). Similarly, when airspeed falls below threshold for 7 seconds, the M-NAV goes into climb mode. This makes the M-NAV work well for cross country flight without the use of manual or flap coupled switching between climb and cruise mode.

A manual switch is still required for overriding the automatic function. In "dolphin" style flight, cruise in lift often occurs at less than 60 knots. The Auto Climb/Cruise switch would switch to climb, and distance would no longer accumulate. A manual switch allows the function to be overridden.

Selector Switch settings:

A. Selector Switches 6 and 7 both open --- Manual Switching

External (manual or flap coupled)  
Climb/Cruise Switch

Open - Cruise  
Closed - Climb

B. Selector Switches 6 closed, 7 open

--- Auto Cruise @ 60 kts

External Climb/Cruise Switch

Open - Cruise Always  
Closed - Climb below 60 kts

C. Selector Switches 6 open, 7 closed

--- Auto Cruise @ 65 kts

External Climb/Cruise Switch

Open - Cruise Always  
Closed - Climb below 65 kts

Remember --- Keep the switch in Climb position unless you cruise below the threshold airspeed.

- **Relative Variometer ("Super-Netto") Selection**  
- **Selector Switch #8**

SET - Relative Variometer

OPEN - Standard, Non-Netto Variometer

The Relative Variometer combines the conventional variometer with a Netto variometer in a single unit without the need for manual switching.

The concept arose from several observations. The first was that when flying in high speed cruise, a conventional variometer tends to hide what the air mass is doing due to the high sink rate of the glider. The Netto (air mass) variometer was the first solution to this problem. A Netto variometer shows the movement of the air mass with the sink rate of the glider removed.

The second observation was that thermal circles were nearly always done below 60 knots with cruising above 60 knots.

The Relative Variometer concept relies on a transition, which takes place at approximately 60 knots. As long as the ship is below this speed, the M-NAV Variometer readout will be a standard TE-compensated variometer. As you fly faster, the M-NAV Variometer will give you the vario reading the glider would have if you slowed up to circle in the air mass being flown through. Additionally, an "R" indicator appears on the display of the M-NAV.

The transition to Relative is smooth because at the 60 knot transition point the Relative and conventional variometer readings are the same.

#### • **Installing the M-NAV in the Instrument Panel**

You can now replace the side cover and install the M-NAV in the instrument panel of your sailplane.

In sailplanes where the instrument panel cowling raises with the canopy (as in the ASW-20), it is a good idea to make sure that the canopy will close after you have put the M-NAV in the panel but before you attach any wiring or tubing connections.

For sailplanes which have problems with the length of the M-NAV, a Side Fitting Kit is available from Cambridge dealers. The Side Fitting Kit allows tubing connections to come out the on side of the M-NAV.

The M-NAV fits into a standard round 3 1/8" (80mm) panel opening. The Variometer readout fits into a 3 1/8" (80mm) or 2 1/4" (58mm) opening depending on the readout size you have.

The M-NAV and its Vario readout should be mounted in the instrument panel adjacent or close to each other. The M-NAV should be mounted as far away as possible from the radio and compass. Non-electrical and non-magnetic instruments such as the airspeed indicator, altimeter, or a mechanical variometer are good instruments to locate adjacent to the M-NAV system.

## • Tubing Connections and Power Wiring

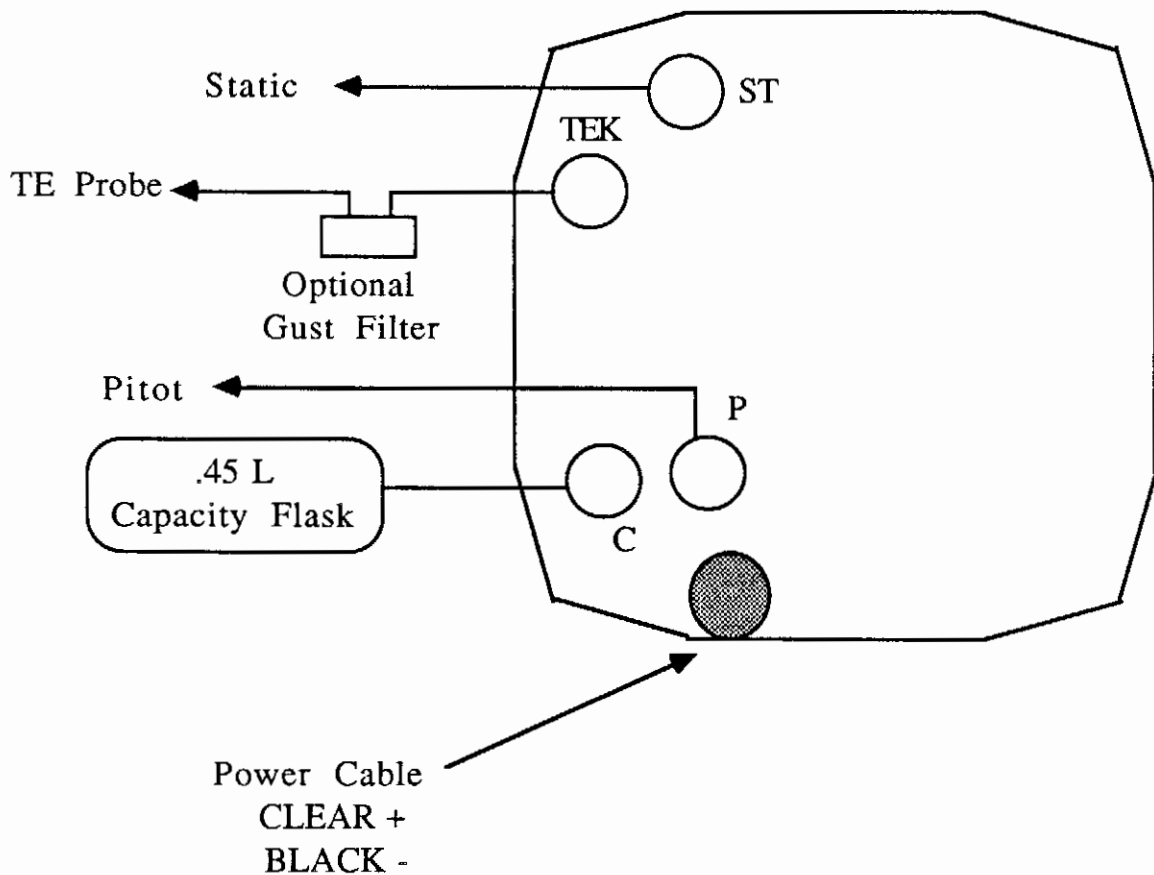
- You will probably need to use additional tubing and tee connectors to add the M-NAV to your sailplane's instrument system. Be sure that the primary instruments (Airspeed and Altimeter) still function correctly.

- The M-NAV must have its own capacity flask. It cannot share a flask with another variometer.

- Be sure that all tubing is free of kinks and leaks.

- A Cambridge gust filter is recommended where TE probe installation causes the vario needle and audio to jump around.

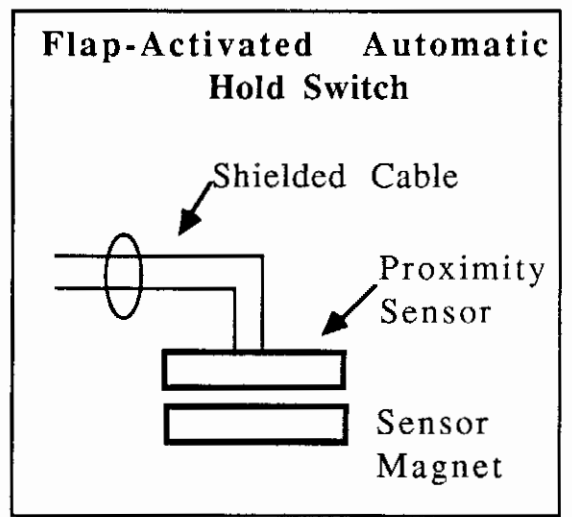
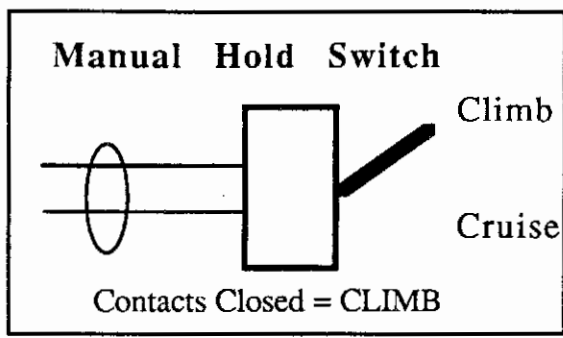
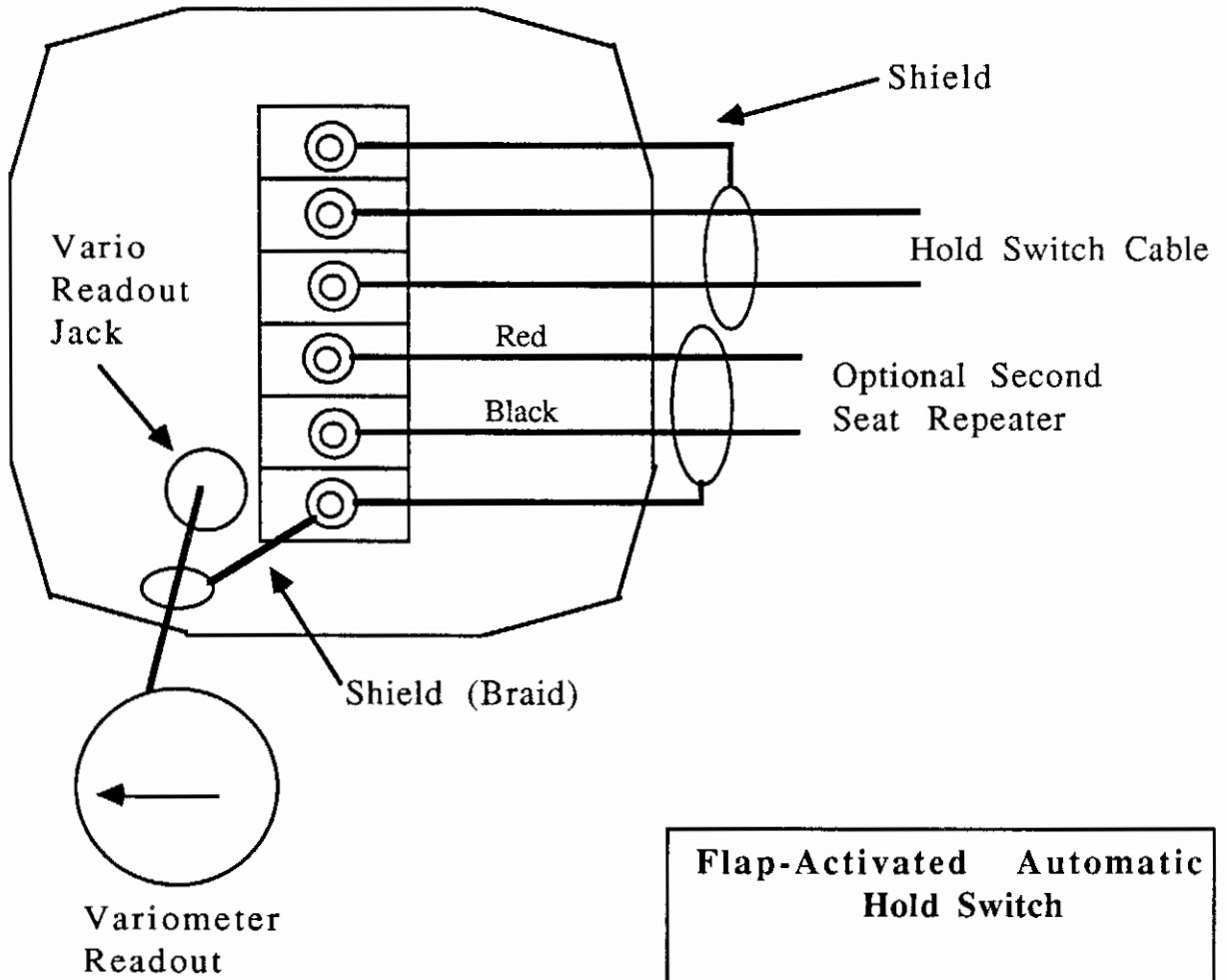
- The M-NAV system should be separately fused at the instrument panel with a 1 amp fuse.





• **Hold Switch and Variometer Wiring**

- On flapped sailplanes, install the proximity switches so that the switch is closed (the sensor and the magnet are next to each other) when the flaps are in climb position.
- On sailplanes without flaps, install the Manual Hold Switch where it can be easily reached in flight (such as on the control stick or the instrument panel).



## • Variometer Zero Adjustment

The Variometer Zero should be adjusted when you first install your M-NAV and about once per year or whenever you notice some drift in the reading.

The Variometer needle is zeroed with the screwdriver adjustment labeled ZV on the rear of the M-NAV. A small screwdriver should be used with care to avoid damaging the adjustment screw. The Wing Loading/Bug Polar switch must be in the middle when you make this adjustment.

With the M-NAV powered on, adjust ZV so that the Variometer needle points to zero.

Because of the sensitivity of the internal sensors, precise adjustment to the zero point may be impossible. Adjustment within a tenth of a knot of the zero point should be considered adequate.

This adjustment may be impossible if the air around the TE probe is turbulent or windy.

## • Airspeed Calibration

### - Zero Speed Adjustment

With the Wing Loading/Bug Polar switch in the Bug Polar position, the M-NAV distance readout shows twice the airspeed in Knots for Rev17 ROMs and in Kilometers Per Hour for Rev 16 ROMS.

With the sailplane on the ground and with no pressure into pitot, adjust the Airspeed Zero trim adjustment. This is labeled ZS on the rear of the M-NAV unit. As you adjust the ZS screw, the distance readout will make jumps in the number displayed. Leave the adjustment just on the high side of the 0 to 22 transition for Rev 17 ROMs or Rev 16 ROMs set for Australian display units and the 4 to 40 transition for Rev 16 ROMs set for European display units (determined by selector switch 5 inside the M-NAV).

### - Speed Calibration Fine Tune

The Speed Calibration is set at the factory and may need small adjustments because of variations in tubing connections in different gliders.

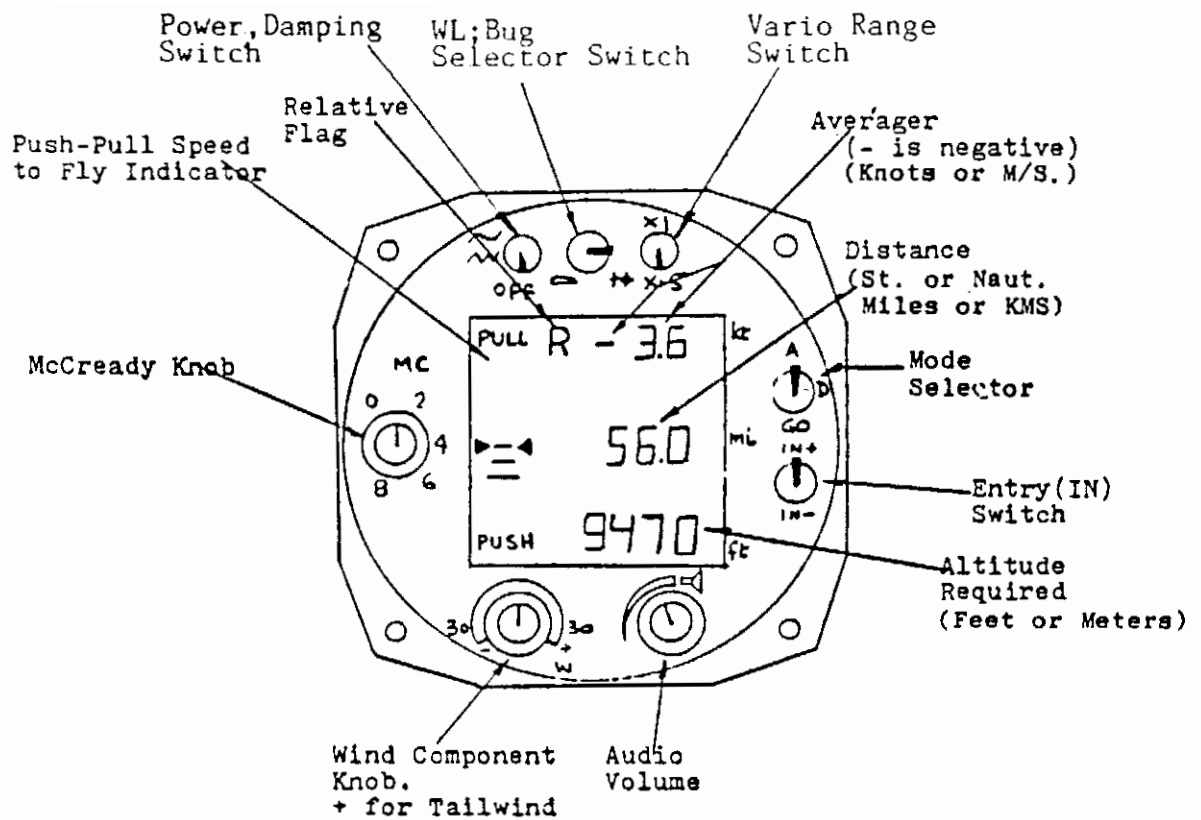
With the Wing Loading/Bug Polar switch in the Bug Polar position, the M-NAV distance readout should read twice the airspeed indicator within  $\pm 2$  knots over the range 50 to 90 knots. Above 110 knots the M-NAV display may read low by several knots.

If the Airspeed Calibration needs adjustment the following setup will allow you to make this adjustment on the ground:

- Connect the following together with tubing and Tee fittings:

1. The M-NAV pitot input.
2. The pitot input of a calibrated Airspeed indicator (ASI).
3. A flask (capacity) such as used with the M-NAV variometer. This stabilizes the pressure.
4. A tube so that you can pressurize the setup by mouth.

- Gently blow into the tubing and raise the pressure until the ASI reads 80 knots. Adjust the screw on the back of the M-NAV labeled CAL until the M-NAV distance readout reads 160 (twice the ASI). It is normal to have the pressure drop slowly. Check the calibration over the range of airspeeds mentioned above.



## • M-NAV Front Panel Controls and Display

### • Power Switch

- OFF - The M-NAV is powered off.
- The M-NAV Vario is in fast response (about 1.5 seconds).
- The M-NAV Vario is in slow response (about 3 seconds).

### • Variometer Range Switch

- X 1 - The Vario range is +/- 10 knots (5 m/s).
- X .5 - The Vario range is +/- 5 knots (2.5 m/s).

### • Audio

The M-NAV Audio gives Variometer and Speed Director information through your ears. This allows you to concentrate on traffic and on the soaring conditions instead of having to watch the cockpit instruments.

There are 4 different audio sounds:

- Interrupted Tone
- Continuous Tone
- Silence
- Alarm Tone
- rising in pitch with increasing climb
- falling in pitch with increasing sink
- quiet band for correct cruise speed
- a fast interrupted tone falling in pitch with increasing sink

Interpretation of the sounds produced by the M-NAV Audio depends on whether you are cruising or climbing. The Climb/Cruise Hold switch has no effect on the Audio.

	Climb Mode	Cruise Mode
<b>Interrupted Tone</b>	Climbing	Slow Up, Going Up!
<b>Continuous Tone</b>	Sinking	Slow Up
<b>Silent Band</b>	Sinking Faster	Correct Speed
<b>Alarm Tone</b>	Sinking Even Faster	Speed Up

• **The McCready Knob and the Speed Director**

The knob labeled MC on the left side of the M-NAV is the McCready setting for the Speed Director. According to "classic" McCready theory the MC setting should be what you expect the achieved rate of climb to be in the next thermal.

The Speed Director display on the left side of the screen gives you speed-to-fly advice based on the sailplane's polar, the current sink or lift conditions, and the McCready knob setting.

The first bars above and below the centerline are the limits of the Speed Director quiet band for Audio sound. When you are within this range the Audio is silent

**PULL**



**PULL**



**PULL**



**PUSH**

Flying  
Too Fast  
Slow Up

**PUSH**


Correct  
Speed

**PUSH**

Flying  
Too Slow  
Speed Up

## • Wing Loading and Bug Polars

### - Wing Loading

With the switch to the left in the  (airfoil) position, the top display (normally the averager) will show the current wing loading factor. This number is the percentage increase in wing loading based in the amount of water being carried. The Data Input (IN) switch is used to change this setting.

When you are flying a dry ship (no water carried) this number should be zero.

If, for example, your sailplane has a dry wing loading of 6 pounds per square foot and you add water to bring the wing loading up 7.5 pounds per square foot, 25 should be entered using the Data Input switch (7.5 is a 25 percent increase over 6).

During flight, if you drop water, the Wing Loading setting should be adjusted.

The maximum Wing Loading setting possible in the M-NAV is 99 percent increase over a dry ship.

## - Bug Polars

The Bug Polar setting with the switch in the right (++) position shows you the Bug Polar setting in the top display (normally the averager). This number is the percent reduction over optimum in the sailplane glide polar due to insect accumulation, dirt, or rain on the wings.

At the maximum "dirty" setting of 99% the polar performance will be degraded to approximately double the normal sink rate at minimum sink speed.

As with the Wing Loading setting, the Bug Polar setting can be changed at any time, even during GO mode. Nothing will be lost (the distance counter keeps counting), and the change in polar performance will immediately be reflected in the altitude required display.

**Note:** The Wing Loading and Bug Polar settings are reset to zero every time you turn the M-NAV on.

### • The Hold Switch

The Hold Switch (either as a manual toggle switch or a magnetic proximity switch mounted on the flap linkage) is only active in the GO mode. In the D or A Mode Selector switch positions it has no effect.

The Hold Switch should be On (Closed) when the ship is climbing. With a manual switch, the toggle should be flipped when starting to circle in a thermal. With the flap-mounted switch, as soon as the pilot drops the flaps into climb position the M-NAV will go into climb mode.

When the Hold Switch is On (in Climb position):

- The PUSH/PULL Speed Director display is blanked out.
- The M-NAV assumes that the ship is drifting with the wind, but making no forward progress in the air.

The M-NAV can show you when you are losing ground in strong headwinds. If you are trying to climb in weak lift and penetrate into a strong headwind, the M-NAV distance readout will increment as you circle in the weak lift and drift downwind, away from your destination. If the altitude required to fly back to the point where you started the climb is greater than altitude gained then you are losing more to the headwind than you are gaining from the lift!

## • **The M-NAV Final Glide and Distance Computer.**

The M-NAV Final Glide and Distance Computer is controlled with the Mode Selector and Data Entry switches.

To give you the Final Glide altitude required, the M-NAV uses the polar of the sailplane (as modified by the Wing Loading and Bug Polar settings), the Tail or Headwind component (entered with the Wind knob), the McCready setting (the MC knob), and the distance remaining (entered with the Data Entry switch and continuously updated by the Distance Computer).

### • **The Wind Knob**

The pilot's estimate of the head or tailwind component along the flight track is entered with the Wind knob. Headwind (-) and Tailwind (+) components of up to 30 knots are possible.

### • **The Mode Selector Switch**

The M-NAV operates in Static and GO modes.

- When the Mode Selector switch is in the A or D positions the M-NAV is in a Static display and Data Entry mode.

- In the GO mode the M-NAV constantly updates the Distance Remaining and Altitude Required readouts. This continually gives you a picture of where you are on your final glide slope.

### • **Data Entry**

- With the Mode Selector switch in the A position the Data Entry (IN) switch will set the Finish Altitude. The Finish Altitude is the elevation of the finish point plus your safety margin.

- With the Mode Selector switch in the D position the Data Entry switch will set the Distance-To-Go for the Final Glide computer.

- When the Mode selector is in the GO position, the Data Entry switch will change the Distance Remaining readout. This will change the Distance Remaining without affecting the Wind Effect Accumulator.



The Data Entry switch has 2 speeds of operation. After the switch is held in the IN- or IN+ position for about 3 seconds, the display begins to change rapidly. When you almost reach the desired number, release the Data Entry switch momentarily to go back into the slower rate of display change.

With only a little practice, the high and low speed modes of the Data Entry switch will become automatic and allow you to quickly enter distance and altitude settings.

#### • The Altitude Readout

- With the Mode Selector switch in the A position the Altitude Readout will show the Finish Altitude. This should be set using the Data Entry switch to the elevation of the finish point plus the height above it you want to have.

- With the Mode Selector switch in the D or GO positions, the Altitude Readout will show the Altitude Required to fly a final glide of the distance shown in the Distance Readout, if you follow Speed Director commands, and taking into account the MC and Wind settings.

Encountering greater than average amounts of sink may increase the Altitude Required: regular comparisons of the Altitude Readout and the ship's altimeter should be made. If the Altitude Required becomes greater than the actual altitude, you will either have to fly at a reduced McCready setting, or find some lift to climb in.

#### A note on the M-NAV Altitude Readout:

If the Altitude Readout is above 9990 feet, the altitude readout will show the height in multiples of 100 feet, preceded by a H.

For example:	12,800 feet would read H128
	14,300 feet would read H143

#### • The Distance Readout

The final glide Distance-To-Go is set with the Mode Selector switch in the D position. Putting the Mode Selector switch in the GO position starts the final glide.

## • Distance Count-Up Mode

A special use of the distance readout is Distance Count-Up Mode. If you start a final glide from a distance of 0 the M-NAV will count up the distance flown (subject to Wind estimate errors). EL20 is shown in the Altitude Readout when you are in count-up mode.

## • The M-NAV in Cold Weather

The electronics of the M-NAV will function quite normally in very cold conditions.

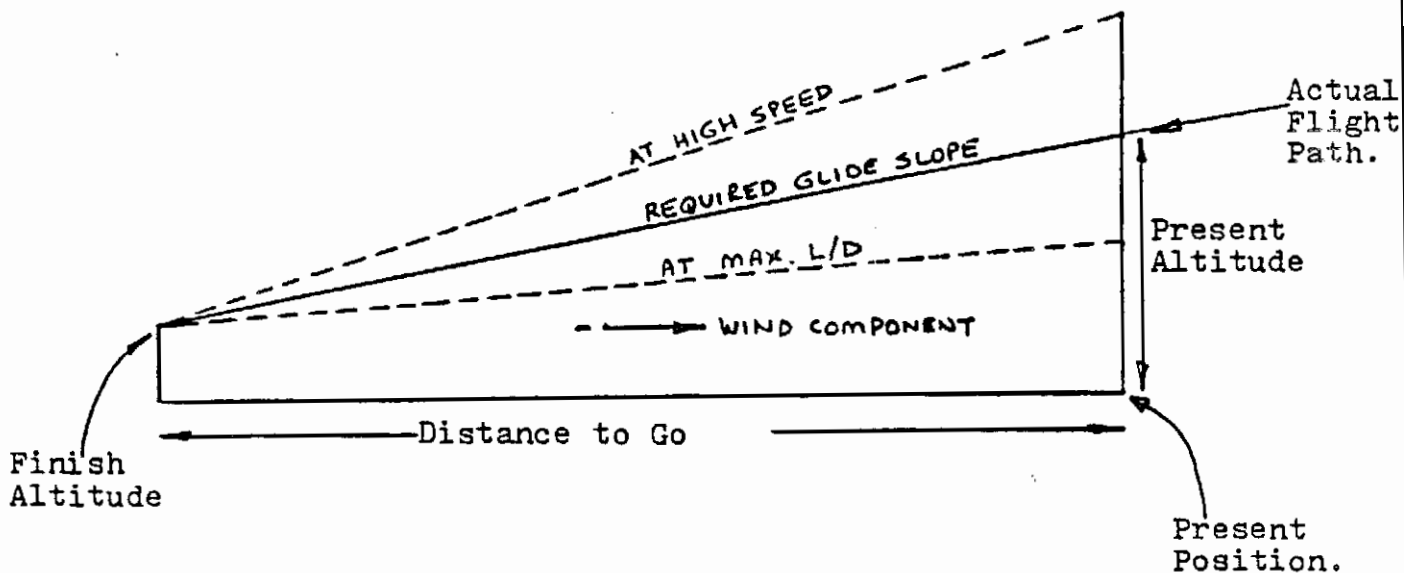
However, at temperatures below 32 degrees F (0 degrees C) you will notice that the display will change a little more slowly when setting numbers using the Data Entry switch.

This is because cold conditions increase the settling time for the LCD display screen.

## • Static Mode Calculations with the M-NAV

In Static Mode the M-NAV allows you to make what-if calculations for various final glide situations.

The diagram below shows some of the factors of a final glide:

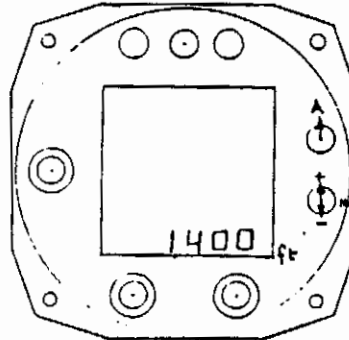


• **An Example Final Glide Calculation.**

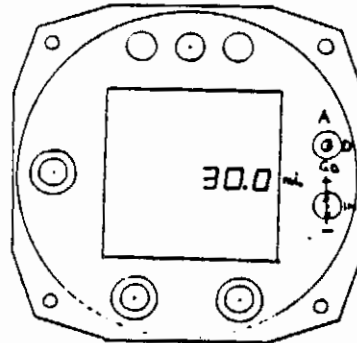
In this case you are 30 miles from home. Your current altitude is 7000 feet, and you Finish Altitude is 1400 feet (airport elevation plus safety margin). You are flying a 44/1 sailplane, and you have a headwind of 10 knots.

To determine the McCready setting for the final glide:

**STEP 1**  
Enter Finish Altitude  
using IN Switch  
This step may be  
done before Take-off

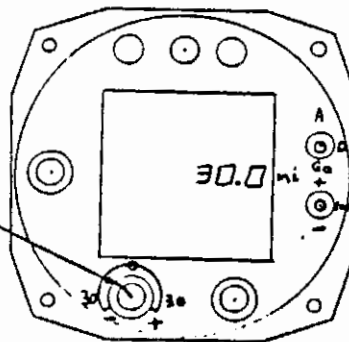


**STEP 2**  
Enter Distance-to-Go  
using IN Switch



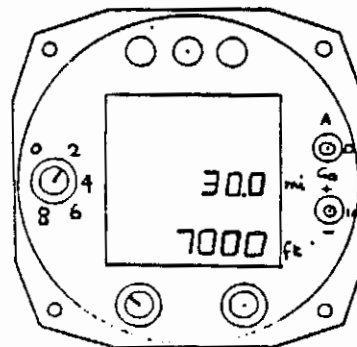
**STEP 3**  
Enter Wind Component  
Estimate

10Kts,  
Headwind



**STEP 4**  
Rotate MC Knob until  
ALTITUDE REQUIRED Readout  
equals your present  
Altitude on your Altimeter.  
(In this case 7000 ft.).

For 1:44 Ship, this should  
be at a MC Setting of  
about 2, under these  
conditions.



- What if you are not high enough?

If the Altitude Required readout at the MC setting of 0 (the Max L/D glideslope) is more than the height you have on your altimeter, then you will need to find a source of lift to climb to at least the height of the Max L/D glideslope.

- What if you are too high?

The Altitude Required, even at maximum MC setting, will be less than what you have on your altimeter. In this case fly as fast as you safely can, you may have height to spare at the end. Continue to cross-reference the Altitude Required and your Altimeter readouts to see if you descend to the M-NAV glideslope altitude. If you do, follow the M-NAV speed director commands.

• **Flying In GO Mode**

After you have entered the Distance-to-Go using the Data Entry switch and set the Wind and MC knobs, putting the Mode selector switch into the GO position starts the M-NAV distance counter. Using airspeed information and the wind estimate, the M-NAV continually updates the distance readout.

• **Monitoring the Final Glide.**

There are three primary sources of distance or altitude error when you are flying along on final glide. They are:

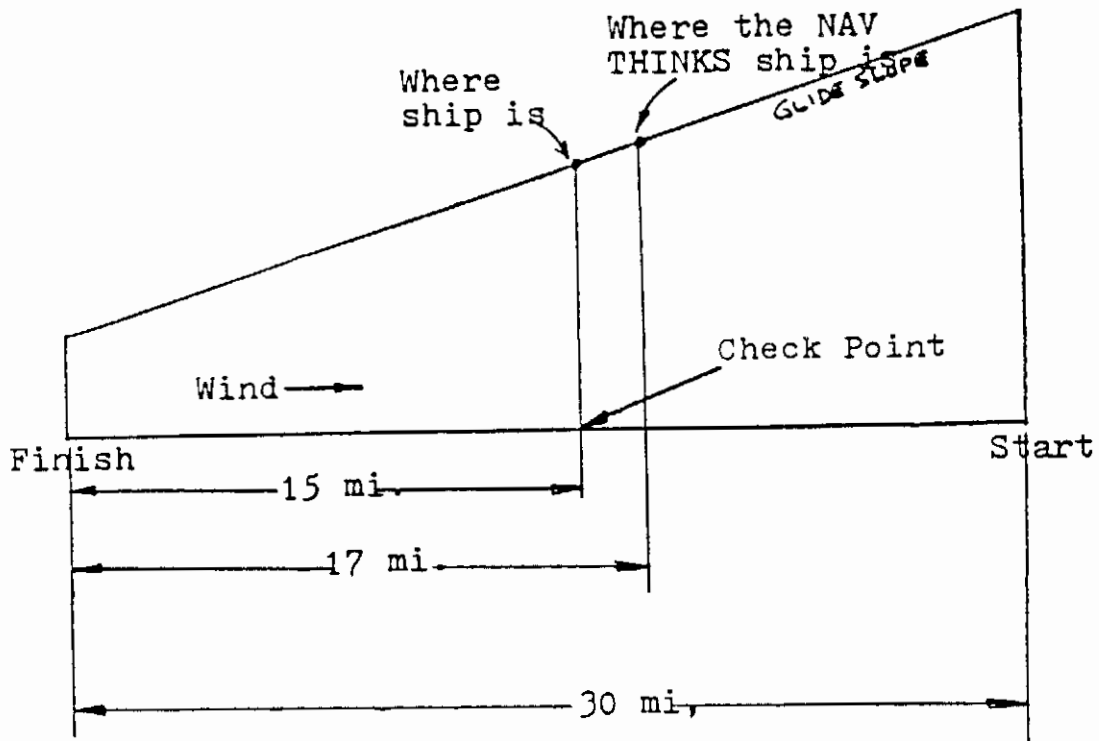
- An incorrect wind estimate.
- Airmass sink or lift along the way.
- Course deviations.

• **Correction for Wind**

Often your estimate of the Head or Tailwind will be a little bit incorrect. A checkpoint along the final glide should be used to compare the M-NAV's distance readout and the actual distance at the checkpoint.

In the example shown below the pilot started the final glide from 30 miles out. At a checkpoint 15 miles out, the M-NAV distance readout indicates 17 miles. Your Headwind estimate was too large.

At this point you should adjust the Wind knob (turning it clockwise) to decrease the Headwind. The Distance-To-Go readout will start changing. When the Distance-To-Go readout shows 15 miles, the Distance-To-Go is corrected and the correct Wind knob setting is established for the remainder of the glide.



• **Correction for Airmass Variations.**

During the glide, a ship may go above or below the correct glideslope. In the example below, the ship started from 30 miles out and flew below glideslope, perhaps either due to enroute sink, or the pilot flying too fast.

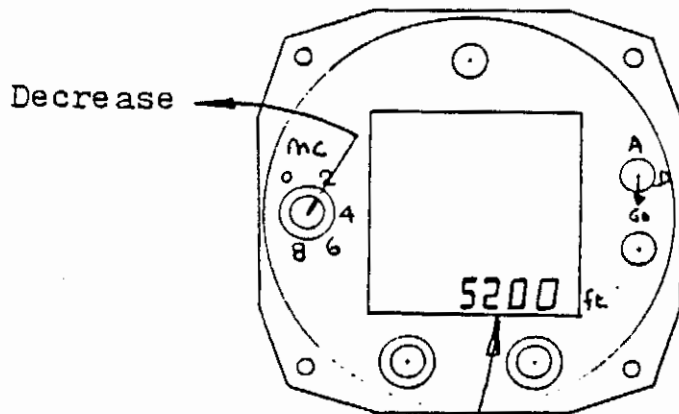
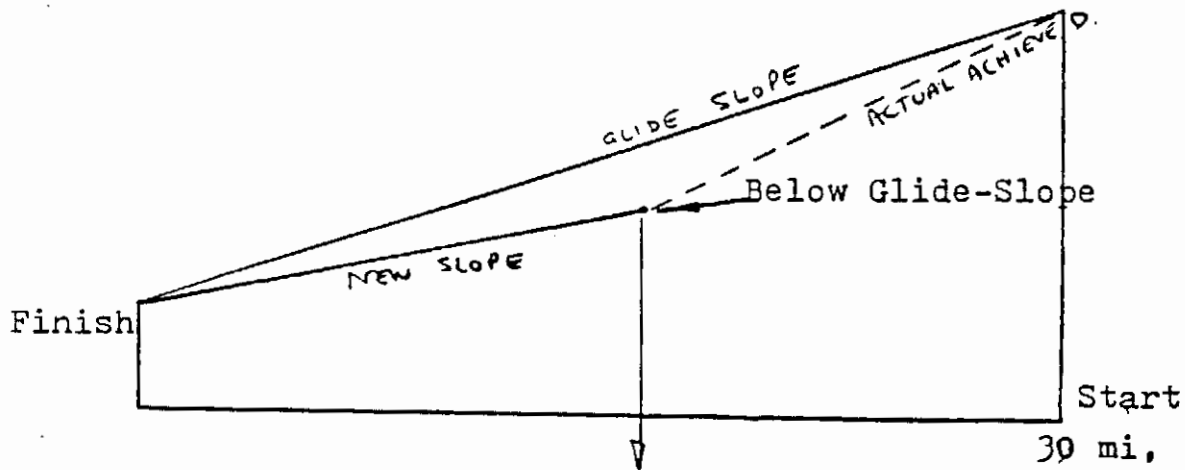
The Altitude Required readout shows 5200 feet while the Altimeter shows only 5000 feet. This means that more altitude is required than the ship actually has for this glideslope.

So, it is necessary to use a different glideslope. To do this rotate the MC knob until the Altitude Required readout agrees with the ship's Altimeter.

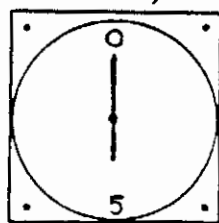
Now you can resume flying along the final glide course following the Speed Director's Push/Pull advice.

If, after setting the MC knob all the way to 0, the Altitude Required is less than what you have, you will have to find a source of lift and climb back up to at least an MC 0 glideslope.

Remember that the higher the McCready (MC) settings means faster cruise speeds but also requires more height. The lower the McCready setting, the flatter the glideslope.



Ship's  
Altimeter  
Reads 5000 ft.



## • Course Deviations

If you make a course deviation during final glide, perhaps to take advantage of a cloud street or to avoid a blue hole, you will create some error in the distance readout.

After making a course deviation, you should cross reference an aeronautical chart and ground landmarks to determine the actual distance remaining to the finish point. If the M-NAV distance readout differs from the actual distance remaining, a correction should be made.

In the case of a course deviation, make the Distance Remaining correction with the Mode Selector switch in the D position. The M-NAV will reset the effect of wind.

The M-NAV has an internal counter, called a Wind Effect Accumulator. It keeps track of the Wind knob setting and the distance flown. It allows you to correct errors in head or tailwind estimates and automatically update the distance remaining by simply changing the Wind knob setting.

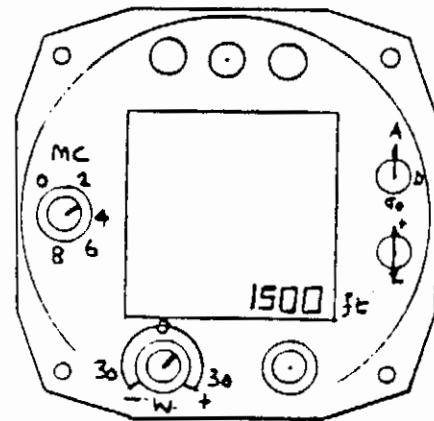
The Wind Effect Accumulator is reset whenever the Mode Selector switch is in the D position for more than about one second.

• **Some examples of other ways to use the M-NAV**

- How far out from cloudbase can you come in?

In this example you've been flying at a McCready setting of 3. Cloudbase is at 9000 feet. Finish Altitude is 1500 feet. There is a 10 knot tailwind.

Set MC to 3  
 Set Finish Altitude  
 to 1500 ft.  
 Set WIND to +10 kts.

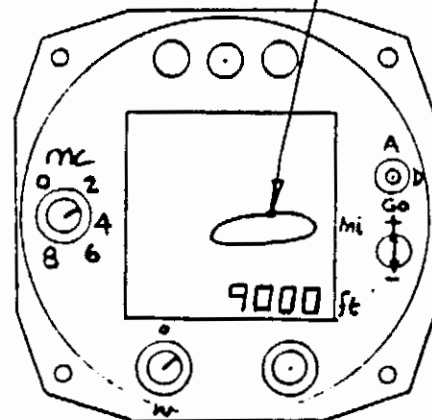


Now set MODE Switch to D  
 Enter a Distance-to go via  
 IN Switch, which is clearly  
 less than you could glide.

Start INCREASING distance  
 steadily, stopping  
 frequently to examine ALTI-  
 TUDE REQUIRED Readout.

When Altitude Required  
 Readout equals Cloudbase,  
 the DISTANCE Readout shows the  
 maximum distance you can  
 come in from, using MC = 3.

Distance-to-Go

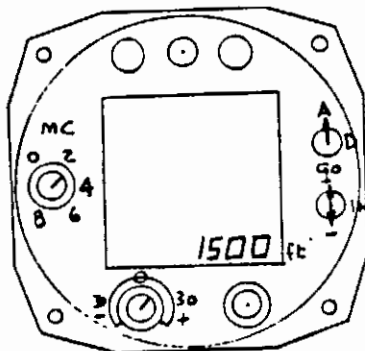




- Calculating the climb needed to reach final glideslope.

Your last turnpoint is 100 miles from home. How much altitude do you need and when will you intercept the glideslope for final glide?

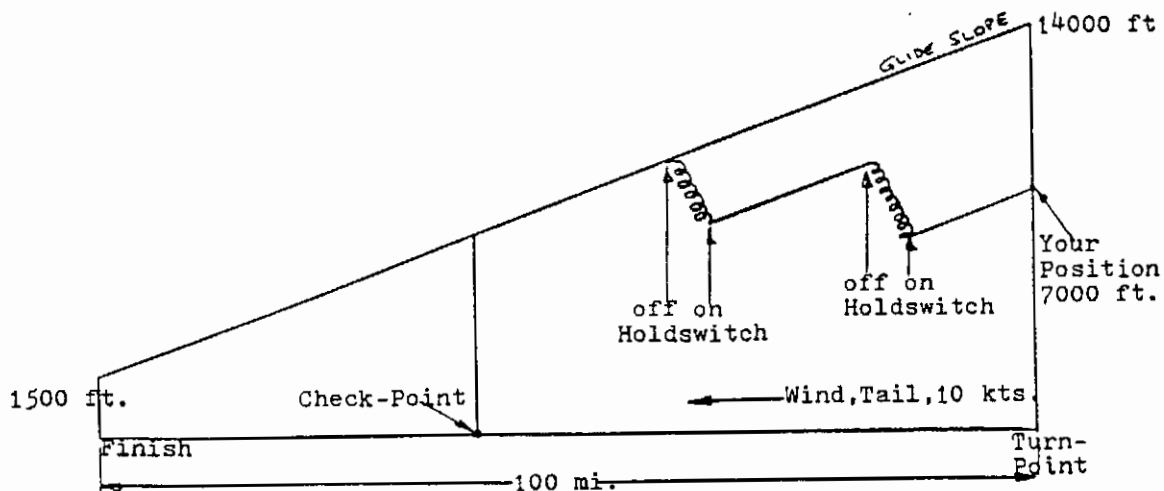
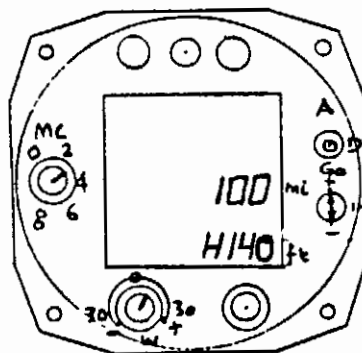
Set MC to 3  
 Set Wind to +10 kt.  
 Enter Finish  
 Altitude.  
 (Mode A, IN Switch)



Enter Distance-to-Go  
 (100 mi.) via Mode=D  
 and IN Switch.

Result: Altitude reqd.  
 =14000 ft.

This is for a typical  
 flapped 15m ship.



## M-NAV Specifications

### • Display and Control Unit

Voltage.....	11-15 Volts DC
Power Consumption.....	Approximately 180 ma.
Speed Command Readout.....	9 Segment LCD Bar Graph
Averager.....	2 Digits, 9.9 knots or M/S max.
Distance.....	4 Digits, 500 miles or 500 km.
Altitude.....	4 Digits, 9990 ft. or 9990 M max. Over-ranged H420 ft. = 42,000 ft. max.

Dimensions..... 3 1/8" X 3 1/8" X 8" long  
(plus tubing connections)  
Fits 3 1/8" (80mm) standard  
round panel opening.

Weight..... 1.75 pounds (800 grams).

### • Variometer Readout Unit

Available to fit either 3 1/8" (80mm) or 2 1/4" (58mm)  
panel openings.

15" connecting cable to M-NAV system unit.

3" (78mm) deep behind panel.