Most likely your radar has an unfortunately mislabeled control on it somewhere marked “GAIN.” Confusion results from the word’s etymology tracing to an old, old Germanic word having to do with the ratio of output to input (or maybe input to output). In modern times it’s become a word radar engineers put on certain radar knobs to flummox pilots.

What the GAIN control actually does, from a pilot’s perspective, is vary thresholds for the colors on the weather radar display. That is, with this control you can change red to green, as in the two accompanying photographs of the same echo. In the left photo the radar is calibrated; on the right is the same echo, but with GAIN reduced.

Thus, this particular control actually adjusts the radar’s calibration. The control can, therefore, cause echoes to appear either weaker or stronger than fact. For that reason, henceforth it should always be thought of and referred to as the CAL control.

It may help in better understanding the function of this control if you compare it to the volume control on your com radios. (And a radar is a two-way radio, after all.) Turn the “volume” up, sound increases; turn it down, the sound decreases. Regardless, the radio’s transmitter doesn’t change in the least.

The same is true for the CAL control, except you see the difference in “volumes” rather than hear them. Again, see the accompanying photos. In the left photo, with CAL at the calibrated position, the “volume” is normal and the echo appears intense; in the right photo the “volume” is turned down and the echo appears weak. Thus, a critical precaution about using the CAL control, it must always, always, be returned to the “calibrated” position. Otherwise the colors will lie and echoes may appear to be indicating only rain when in fact they are full of hail, microbursts, tornadoes and all those horrible things.

In their zeal to promote their equipment, radar manufacturers have created dense fogs of confusion around the actual location of the “calibrated” position by describing it variously as “PRE SET,” “MAX” and “AUTO.” Then on the Bendix, Bendix/King radars there is no label at all; rather the GAIN control is inert when those radars are in WX and WXA modes. To change their GAIN, it’s necessary to select the MAP mode.

(It’s amazing how many pilots have flown Bendix general aviation radars for years thinking their GAIN control is inop, but never noticed it does work in MAP.) This hodgepodge of acronyms allows each manufacturer to claim their radar has a feature the competition doesn’t. Nonsense. Hang any name you want on it, to a pilot it’s the CAL position of the calibration control.

The first radar on which the proper letters “CAL” appeared at the calibrated position was the Collins WXR-700, an airline class instrument introduced some 20 years ago. Even then the control itself was still called GAIN.

Another thing you must know about this control: On only a few modern systems can volume be increased beyond CAL, thereby making weather appear worse than fact. Why would you ever want to do that? Increasing CAL, in effect, makes the radar beam wider, which in turn makes proper TILT control less critical. It also enables the radar to detect lighter fringes of a storm, which should be avoided to ensure comfort and safety. In addition, an increase in CAL can be helpful in detecting storms at great distances, assuming the pilot is better than average at working the TILT knob.

On most radars, the control can be turned down from the CAL position, making echoes appear less reflective and smaller than fact. For what reasons would you ever want to do that? There are two. First, for those radars that do not have the fourth color, magenta, when approaching a mean looking red storm the CAL control can be used to determine if it’s just barely red or exceedingly red. That is, whether it’s only Level 3, and probably just a rain shower, or actually Level 5 or 6 with hail, microbursts, tornadoes and all that bad stuff. But, you may ask, what difference does it make? After all,
you're going to avoid all of it by at least the specified 20 nm... Right. Sure you are! Let's be real.

Every pilot likely to be flying with radar knows that's not possible. If each red echo were avoided by 20 nm, aviation would grind to a halt in the northern latitudes from March through September. As a realistic matter, what we need is a way to differentiate between little red rain showers, which we can skim by safely, and those big red monsters, which we must avoid by a long, long safe distance. That's simple to do with two semi-advanced radar operating techniques. TILT is one, followed closely by CAL.

After you've scoped out the reddest altitude of the cell with TILT, you begin to tweak the CAL control clockwise, down from the CAL position a tiny bit. If you still see red, tweak it again a tiny bit, then again. The more you have to tweak it before the red disappears the redder it is in fact. If you must tweak it down halfway to the bottom stop and red is still there, begin to think hail. More than halfway down, think hail for certain and maybe... well, you know — all that other bad stuff.

The reason for the halfway down position being important is because the "calibration" range from the CAL position (whatever it's called on your radar) to the bottom stop on most radars is about 20 units of radar reflectivity (called dBZ). That reduction actually works backward, elevating a red echo from a Level 3 or 4 to a Level 5 or 6, if any red is still showing. (Or, in modern ATC language, it tells you the echo is up out of the "Heavy" range and up into the "Extreme" range in reflectivity.) The accompanying pair of photographs illustrates this result.

For those who fly radars with the magenta fourth color, the same technique applies. When you see magenta in an echo, that's telling you it's at least Level 5, maybe 6. It's an "Extreme" weather system. Tweak the CAL control down, as before. The greater the tweak, the more likely it's Level 6, meaning hail, no doubt, and possibly other uglies. If the tweaking reaches the halfway point, it's most likely a supercell and full of bad news. Even 20 nm may be too close to avoid its hail and severe turbulence.

About now you may be thinking, "No way have I got time for all that knob tweaking when approaching the red at 450 knots!"

Understood, but all that tweaking is not necessary in every situation. All of the photos of weather in this article were shot with two identical CAL settings. Here's

At the beginning of the left to right sweep, the CAL control was at normal, TILT down painting ground. Then at about the one-third point in the sweep, the CAL control was rapidly reduced. Note the effect was to reduce the width of the ground paint from about 3.5 nm to about 1 nm. That smaller beam will bring up many details in the radar image not seen before. Of course, the colors are out of calibration, but that's OK when the objective is improved detail. This procedure is often not possible in a rapidly changing flight environment, but it can be very revealing when holding on the ramp with thunderstorms in the departure areas. If you wonder if they're really as bad as they look, crank the CAL control down and see what still shows.

On the left is a cluster of weather echoes as displayed at CAL. On the right is the same cluster with CAL reduced halfway to minimum. The remaining red indicates echoes are Level 5, and possibly Level 6, in hazard potential. To approach them closer than 20 nm would be an invitation for possible hail damage and/or an encounter with extreme turbulence. The risk of hail is up to 33%, severe turbulence as much as 50% and extreme turbulence (meaning loss of control) 33%. Those risks possibly extend out into the clear areas. If a terminal operation is contemplated, within red areas the expected per-hour rainfall rate will be 4 in. to 7 in. Visibility through the windshield will be zero and hydroplaning will be severe.

The left photo is an echo at CAL. On the right is the same echo with CAL reduced halfway. Since the only image remaining is the area that was red previously, the halfway reduction is confirmed. No red with CAL reduced indicates it's no more than Level 4 in hazard potential. The chance of severe turbulence in its vicinity is less than 33%. The per-hour rainfall rate within the echo boundaries is most likely to be 2 in. to 3 in., with up to 4.5 in. possible. Hail larger than 0.5 in. is unlikely.
Tips on Different CAL Controls

- Sorry to say, but if your aircraft is equipped with a multifunction display (MFD), it may be impossible to use the CAL control effectively. That’s because MFD designers are ignorant of the many things a radar will do in the hands of a savvy pilot. They seem to assume radar gets used only when storms are about. They don’t understand it can be used to back up VORs, GPS, GPWS, TAWS, aircraft attitude and even aircraft altitude agl.

As a result, controls for the radar get low consideration when an MFD is being designed. Since each MFD knob must serve many purposes, TILT and CAL are often combined on one and the pilot must alternate between them when making adjustments. But as noted in the main story, TILT and CAL must be tenderly worked, simultaneously, to coax all the detail — sometimes lifesaving detail — on to the display. That’s hard to do when one knob serves both.

My advice: When selecting an MFD, make certain it has separate, easy-to-use knobs for TILT and CAL.

- Quickly analyzing an echo on Bendix RDR or RDS series radars, plus the Bendix/King (now Honeywell) RDR 2000 and 2100 systems) cannot be done with CAL control in WX modes, since it’s alive only in MAP. So pilots should go to MAP when things are calm and adjust CAL to the midpoint. Then switch back to WX to watch for storms. When you detect one, switch quickly to MAP and CAL automatically drops to where you want it. If it was red before and after the switch, you’re probably as close as you dare get. Unfortunately, you can’t do the trick with magenta on those radars because that color drops out in MAP.

- Something you need to know when going to MAP is that color calibrations drop about a half shade on all radars. However, that change is irrelevant when using CAL reductions to check out an echo.

- On Honeywell’s Primus 450 through 880 series radars you must pull out the CAL knob to adjust it. Push it in and CAL automatically goes to calibrated. Pull it out and echoes drop back to where you left the control — CAL reduced. So you set reduced CAL once and just work the knob in and out to check out an echo. Easy and quick. Remember though, this only works within the STC range.

- On most versions of Rockwell Collins WXR-700 radars CAL cannot be reduced; it can only be increased. So, those are good radars if you can avoid all the red by 20 nm, but they’re not good if you want to know how much risk you would be taking in getting closer. Fortunately, the folks in Cedar Rapids, Iowa, corrected that restriction on their new, award-winning MultiScan radar.

how you do it. On a calm, CAVU day, tweak the CAL control a few times to find the halfway point. After that, anytime you’re wondering the true severity of the red up ahead, tweak the CAL knob to that halfway position. If you still see red, better reconsider the close encounter you planned for slipping by that echo.

Now, a critical caveat: The foregoing assumes the echo is within the radar’s STC range. We needn’t get into the nuts and bolts, but a rule of thumb for calculating STC range for all but the very oldest radars is to multiply the diameter of your antenna by 3.5 nm. So, for a 10-in. antenna, figure 35 nm; for 12 in., 42 nm; for 28 in., 98 nm. Again, those are rough estimates, but very close.

All weather echoes beyond the STC range will be depicted as weaker and smaller than fact. Some radars have “extended range STC,” which helps with the intensity indication, but not with size. Beyond the true STC range the echoes may appear just as reflective but may be smaller than fact.

CAL Versus Beam Diameter

A second vital use of the CAL control is for improving detail in weather echoes or when ground mapping. It does this because varying CAL also varies the beam’s diameter, as mentioned earlier. Turning it down causes the beam to narrow, as in the accompanying photo. In short, with CALs, you can reduce that big old wide beam (with a 12-in. antenna it’s 8 deg.; with a 28-in. antenna it’s 3.75 deg.) down to a width of 1 deg.

This is an extremely important action for highlighting detail in either a weather echo or ground map. (Follow Leonardo Da Vinci’s example; after all, he didn’t use a mop to paint the Mona Lisa.) You see the result in the second pair of photos.

Once more, there’s not always time to do a lot of tweaking, but you’ll be surprised at how quick and easy it is to do once you’ve practiced. It does take a lot of practice, but you can do that on CAVU days by ground mapping. In truth, the best and most-useful radar practice is ground mapping every chance you get. It takes tender tweaking of both TILT and CAL knobs simultaneously to become an expert radar operator. That’s because a radar cannot be “operated;” rather it must be fondled, if you wish to get the hoped for response from it.

Try it. You’ll be amazed at how much information your radar can deliver that you never knew was there. It’s all yours after just a bit of educated practice with that CAL control.