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Shoot the Moon!

—visual tracking for your EME array

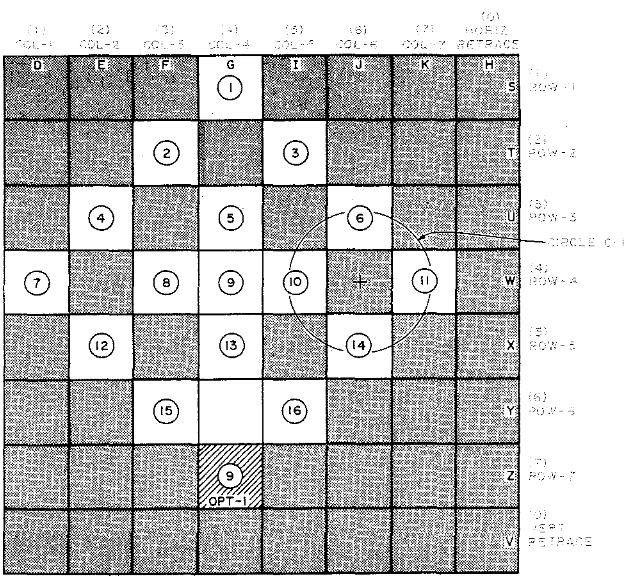

Fig. 1. Video monitor screen presentation. White squares with numbers are the maximum number of squares that can be lit. Dark areas are never lit. One possible moon image is shown by circle C-1. This would light squares 6, 10, 11, and 14. Adjust your lens or lenses for approximately this kind of spot size. The numbers correspond to the LDRs in Fig. 10.

Is your OSCAR or EME array all automated for tracking? Mine is, but I still wanted a means of visually tracking in a manual mode. This article details the simple "moon" camera I came up with to look at the moon while I stayed comfortably in my basement (Indiana winters get cold!). It also makes a fine motion detector or low-resolution surveillance camera.

Take a look at Fig. 1 for a moment. What I have is the screen of a TV set or, in my case, a video monitor. There is no reason why you can't feed the video output of my simple camera to one of the TV game modulators and pipe it into any TV set as rf on whatever channel the game modulator outputs on.

As shown, the spot or image of the moon has been concentrated into a round circle that just illuminates one or more of the photosensitive devices (more on them later). Whenever light shines on these devices, their resistance is greatly lowered and I sense that change to light a square on the monitor screen. In order to have the different positions on the screen represent different aiming positions of the antennas, there are two main requirements.

The first and easiest is that the camera be physically boresighted to the antenna. That's just a fancy way to say that it has to be aligned to look where the antenna is looking.

Secondly, the photo devices must be arranged in an array that duplicates what you want to see on the screen and then scanned in step with the monitor scanning. These last two requirements are met easily using the circuitry and board layouts provided by this article.

Since I have started you out at the photo-sensing end, let's begin there on the circuitry and boards. The first thing you will notice is all the boards are round instead of square or rectangular. This allows for mounting in a round enclosure (details later, under Mechanical Assembly). The first board to consider is the LDR Board, shown in Figs. 2 and 4. I used light-dependent resistors (LDRs) as photo devices; mine are about ¼″ in diameter at the light-input end. This allows the array of 16 LDRs you see the pattern for to fit easily on my round board.

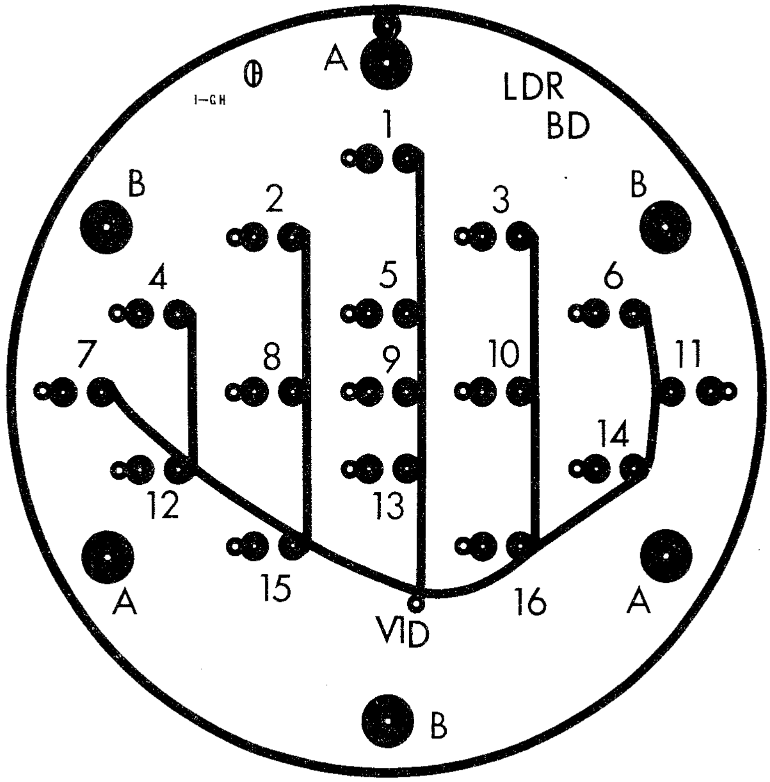

Fig. 2. Foil side of LDR board.

To mount the LDRs in the board, you need sockets of some kind. This avoids direct soldering and the possible altering of the resistive characteristics of the LDR. I highly recommend an item called a matrix pin by AMP, Inc.; it is their part number 380598-2. These are single-terminal push-in sockets and are sold by many parts houses and the magazine advertisers. Just drill out the circles to hold the sockets of your choice and load the board up as shown.

All leads come to the board from the copper side and pass through their holes, leaving a small amount of the stripped lead on the copper side to solder to. When this board is complete, there should be seventeen leads 4″ to 5″ long coming off the copper side. (Use different colors to avoid confusion.) 16 leads are to one side of each LDR, and one lead is common to all LDRs and is called the video lead (VID). There is really no easy way to test the board at this point, so set it aside and go to the counter chain schematic in Fig. 3. The corresponding foil and component sides are shown in Figs. 5 and 6.

The counter chain should go together quickly, and it can be checked out fully when completed—less any other boards. Load the board as shown and then check the test points using a frequency counter or oscilloscope at each test point against Table 1. The starting point is at the 555 IC, as this is the master clock. It should run at 122.88 kHz, and you adjust to that using the PC board thumbwheel pot, Ra. The set you use for a monitor will more than likely lock up (have steady sync) if the clock is from 122.0 to 123.5 kHz, but you may have something called flutter due to a difference between your divided-down vertical (59.57 to 60.3 Hz in the clock range just given) and the proper 60-Hz rate used to avoid beats against the power line 60 Hz.

The wide range of tolerance on most TV sets allows you a lot of leeway

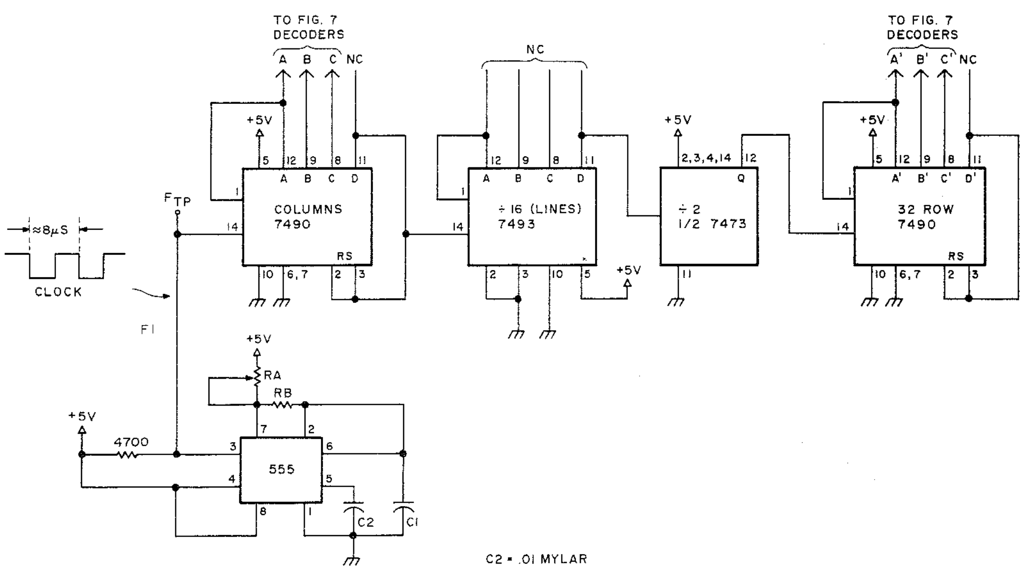

Fig. 3. Counter chain. Set for a frequency of 125 to 126 kHz at F_{TP} test point. For this application, C1 = 220 pF, Ra = 10k thumbwheel PC pot, Rb = 18k, ¼-W fixed resistor. General formula is: f = 1/T = (1.44)/Ra + 2Rb) × C.

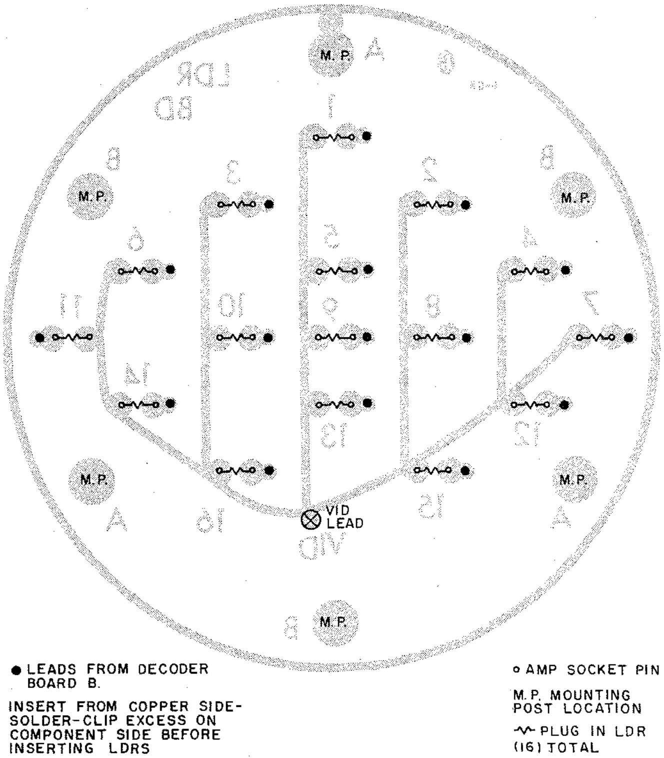

Fig. 4. Component side of LDR board. M.P. designates mounting post (threaded spacer) locations. Use alternate locations between any board pair, thus only three spacers looking like a triangle between any board pair. Small circles are socket pins for LDRs. Solid dots are leads from decoder board B and should be inserted and soldered from the copper side and excess lead on component side clipped off flush with board. Resistor symbols are LDR locations.

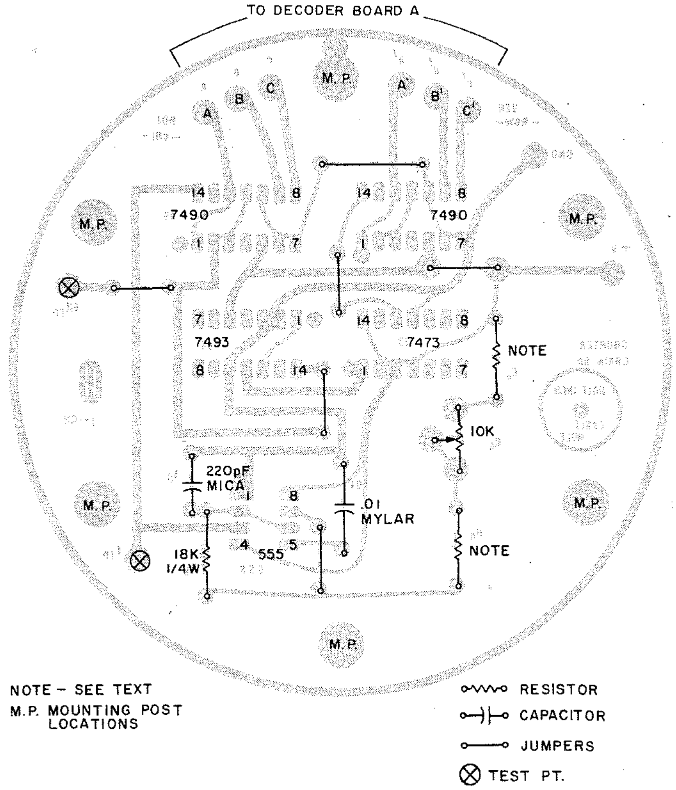

Fig. 6. Component side of counter chain board. Standard schematic symbols are used to show component mounting locations. Solid lines connecting dots indicate jumper leads. Circled x indicates test point.

in the setting of Ra where the set will lock up and look alright. If you can't get things as good as you want using a 10k pot for Ra and jumpers in the fixed Ra positions, a smaller pot can be used along with fixed resistor(s) to allow Ra to effectively tune slower. You would have to find the two extremes of Ra settings that create a locked-up picture, measure the resistance of Ra in each case, and use the difference as the new Ra value. Then fixed resistors make up the jumpers. Remember, the total must be 10k.

Example: If the set locked up alright on resistor Ra settings of 2500 Ohms to 7500 Ohms, use a new Ra of 5k and one fixed resistor of 2500 Ohms in either fixed Ra (jumper) position. Your new range then becomes 2500 to 7500 Ohms.

Ignoring the +V and ground leads needed by all boards except the LDR board, there are only six leads leaving the counter chain board (A, B, C, A', B', C'), and they all go to the points lettered the same on

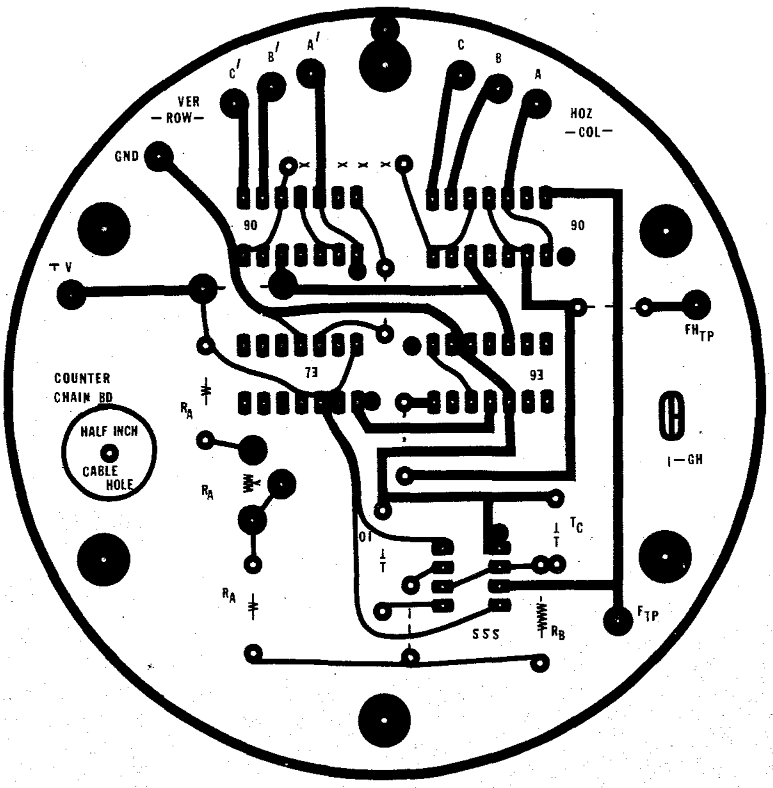

Fig. 5. Foil side of counter chain board.

decoder board A (Fig. 7). If these points are outputting according to Table 1, the 7442 decoders (IC1, IC2) will decode the BCD line codes into one of ten outputs. Since the D line is not used off the 7490s, the 7442 becomes a one-of-eight decoder. In IC1, positions 1 to 7 represent seven vertical columns across your monitor screen. Position 0 is left as horizontal retrace and is covered on the video/sync board. IC1 runs the sequence of 1 to 7, then 0, 32 times before any change occurs in the vertical scan decoder. This means 32 lines that are identical in vertical coding across the screen. This is accomplished by placing a fixed divide-by-32 chain between the horizontal and vertical counters.

In the case of the number 1 LDR, if light is shining on it each of the 32 lines will go white from a black screen as it scans over the column position 4 (center). When this happens 3 times, a white square is formed at the top center of your screen. When you have all your camera boards together but no optics or lenses over the LDRs, the monitor screen will light white squares in the same pattern as the LDRs are laid out on the board if

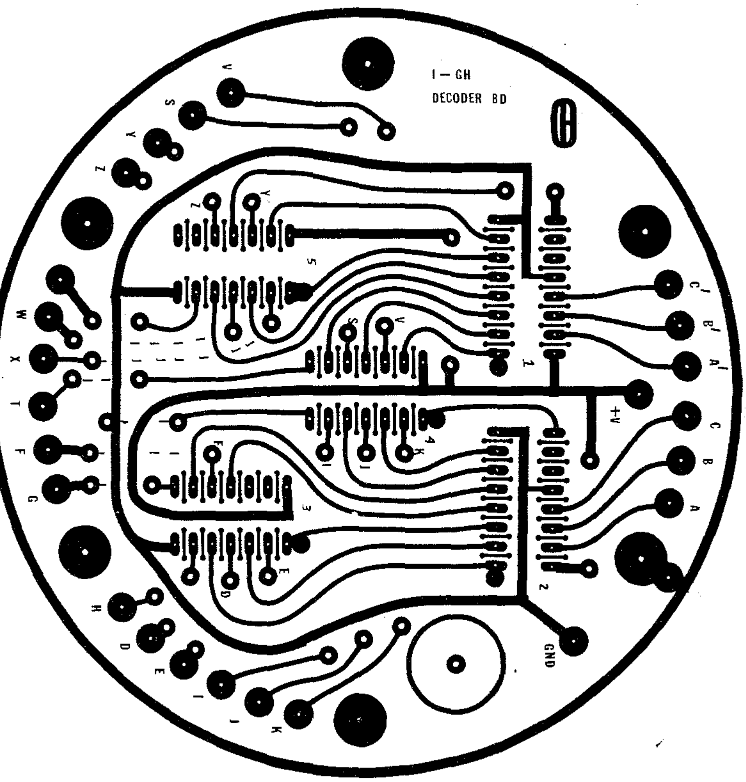

Fig. 8. Foil side of decoder board A.

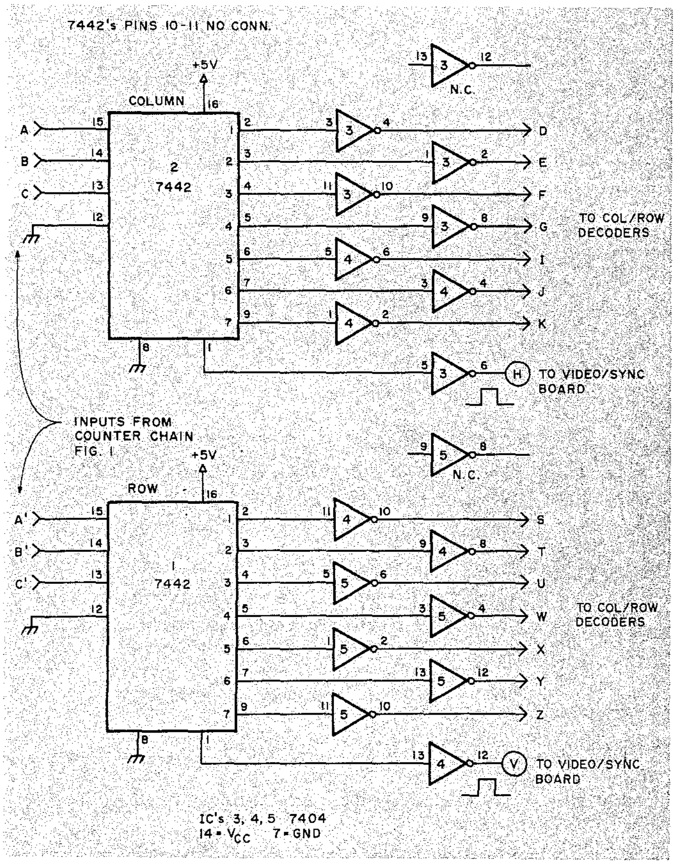

Fig. 7. Schematic of decoder board A.

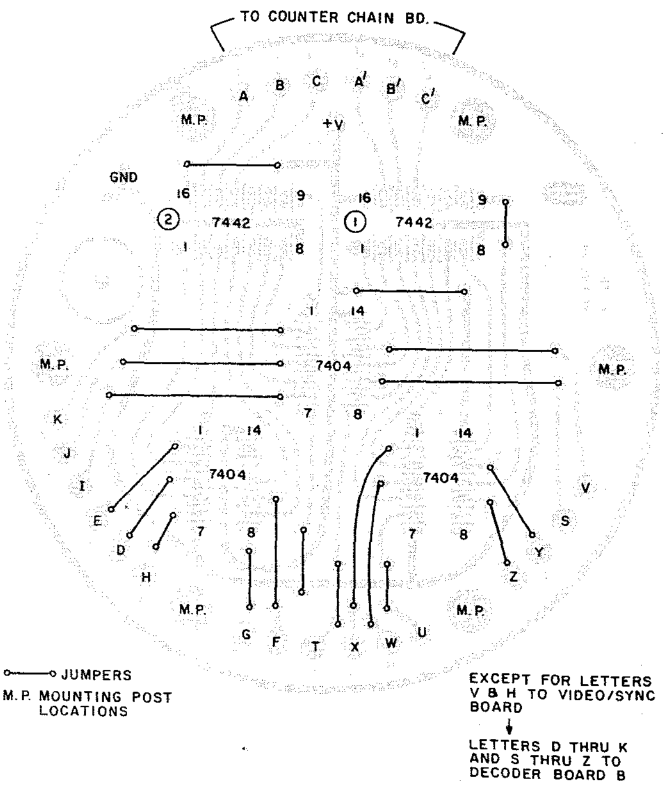

Fig. 9. Component side of decoder board A. Letters V and H are leads to video/sync board. Letters D to K and S to Z are leads to decoder board B (except V and H). Solid lines connecting dots are jumpers on component side.

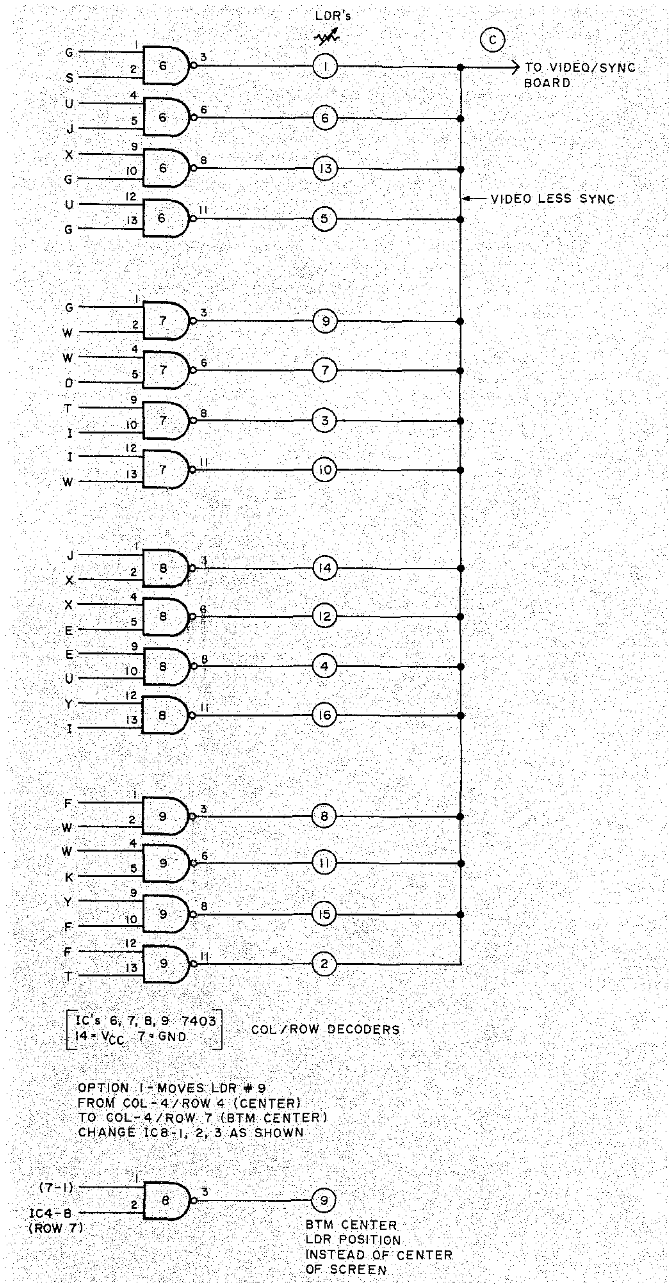

Fig. 10. Schematic of decoder board B. Option 1 moves LDR #9 from column 4/row 4 (center) to column 4/row 7 (bottom center). Change IC8 pins 1, 2, and 3 as shown, and load LDR at bottom center.

light is falling on all the LDRs. This will be a final check that all is working, before the mechanical assembly.

The row decoder (IC2) does the same job as the column divider (IC1) but at a slower rate, to handle horizontal rows. Therefore, it advances one position after each 32 horizontal lines. This happens seven times, forming 7 horizontal rows of 32 lines each. If more LDRs and decoding were used, the camera has a possible 7 × 7 or 49-position resolution. The complexity is not worth it, and the camera functions just fine using only 16 of these 49 possible locations. This is accomplished by allowing the focused moon image to be larger than one square of resolution and using multiple lit boxes to show where the image is relative to center screen (on target). A perfectly aimed antenna will produce a white + sign at the center of the monitor screen.

IC3, IC4, and IC5 are merely inverters to get the low 1-of-8 outputs of the 7442s back to highs that can be gated together in further TTL logic. Figs. 8 and 9 show the foil and component sides of decoder board A.

The last of the decoding occurs in Fig. 10, decoder board B, where 7403 gates are used to detect which of the 49 squares the monitor is scanning over and enable the proper LDR for that segment. Figs. 11 and 12 show the foil and component sides of decoder board B.

For the positions that have no LDRs, as you will see more clearly next on the video/sync board, there will be no LDR enabled and the video (VID) line will be at or very near +V. This +V on the VID line will represent a black screen on the monitor in the final video composite. For those squares that have an LDR sensor, each has a corresponding 7403 gate section. When the gate is enabled, the open collector output tries to pull +V down to ground through a load resistor. All the LDRs are in parallel by the video line, but only one at a time can be considered in the circuit—the one enabled by the scanning chain.

Going briefly to point C on Fig. 13, the video/sync board, you will see a 10k resistor to +V in the base circuit of the first video stage. The circuit is really a voltage divider consisting of that 10k at all times, in series with either (1) an LDR that is in series with the output transistor of its 7403 gate to ground, or (2) the 10k alone with no enabled LDR for those positions not having LDRs.

Remember, I said +V on the VID line meant a black screen. Automatically, you have 33 positions representing no LDRs and a black screen. In the 16 positions having LDRs, the LDR represents the lower resistor in a voltage divider and as such will cause the voltage at point C to be very close to +V (LDR off—no light), or very close to ground (LDR on—light shining on it). My LDRs swing from several megohms (dark) to about 400 Ohms (light). That means the voltage divider changes from (1) +V through 10k through megohms to ground, causing the junction of the 10k and LDR to be very close to +V, to (2) a series of +V through 10k through 400 Ohms, causing the junction of the 10k and LDR to be very close to ground. This junction voltage controls the base of the first video stage.

Following through the video for an example of one LDR with light on it, the VID line and point C will be low or near ground. The first video stage is just an emitter follower, so no inversion occurs and the base of the second video also will be low and the transistor at or near cutoff. When it is cutoff, the collector rises to at or near +V, and this represents white on the screen.

The last stage is also just an emitter follower to allow enough current to drive a 75-Ohm cable and the 75-Ohm load presented by either the game modulator or the video monitor input. If the monitor has a gain or video drive control, jumper A to C in the last video emitter circuit and omit the onboard gain pot, RL. If the monitor has no control or the game modulator no input gain adjust, use RL and jumper B to C to allow some means of adjusting overall composite video level.

The base of the final video stage has control from two more points that should be covered here. The two transistors with H and V for inputs are the sync mixer and make up the final composite video. Each time the H line goes high (every horizontal line, position 0) or the V line goes high (every vertical scan or field, position 0), the base of the final video is dropped to approximately 0.2 volts, or close enough to be called ground. This is sync-voltage output in my camera.

If the video example were reversed, using a dark or absent LDR position, the second video stage can turn on only to the point where its collector is at 1.4 volts. This is caused by the two diodes in its emitter for 0.6 volts apiece and the 0.2 volts from emitter to collector on the second stage. This 1.4 volts becomes our black level, and allows for the normal video composite of sync being blacker than black. If you consider my composite video as 0.2-volts sync, 1.4 volts-black, and 5.0-volts white, then divide it down with the level control, you will end up with video composite of very close to the standard of 1.0-volt video, 0.4-volts sync. It at least seems to be close enough for a perfect picture with stable sync, and I felt that trying to get any closer was not worth the time or extra components. Foil and component layouts for the video/sync board are shown in Figs. 14 and 15.

That about completes the electronics package, and if you have a power problem, the 74Cxx equivalents can be used for all the TTL devices except the final 7403 decoders. The 555 is running well below its maximum +18 volts, but seems content and quite stable on +5 volts.

Mechanical Assembly

The area of mechanical assembly will vary, as with most ham projects, along with its uses. For that reason, I'll outline how I did mine and you can carry on or modify from there. As illustrated in Fig. 16, the housing on my camera is PVC plastic pipe! That's why all the boards are round and separated by three spacers between each board. You can, thereby, build up a board-over-board sandwich by skipping every other hole of the six given per board to set the spacers on.

Looking straight into the LDR board, it is spaced from the board below it by 3 spacers in a triangle. The next board below, by 3 in an inverted triangle, and so on. I used 4-inch i.d. black pipe, and would suggest that whatever you use be black inside to avoid light reflections and stray light. You can buy end caps for the pipe, and I used one as is on the rear of the camera. It was stuck on with rubber cement for easy removal. One hole in this cover allowed the RG-59 feedline to exit through, and a second would have to be provided if the on-board level control is used—I did not use it.

The front cover I made from another end cap, but I sawed off the entire lip from the horizontal center line down. This allowed me to add small aluminum brackets to one side. To the

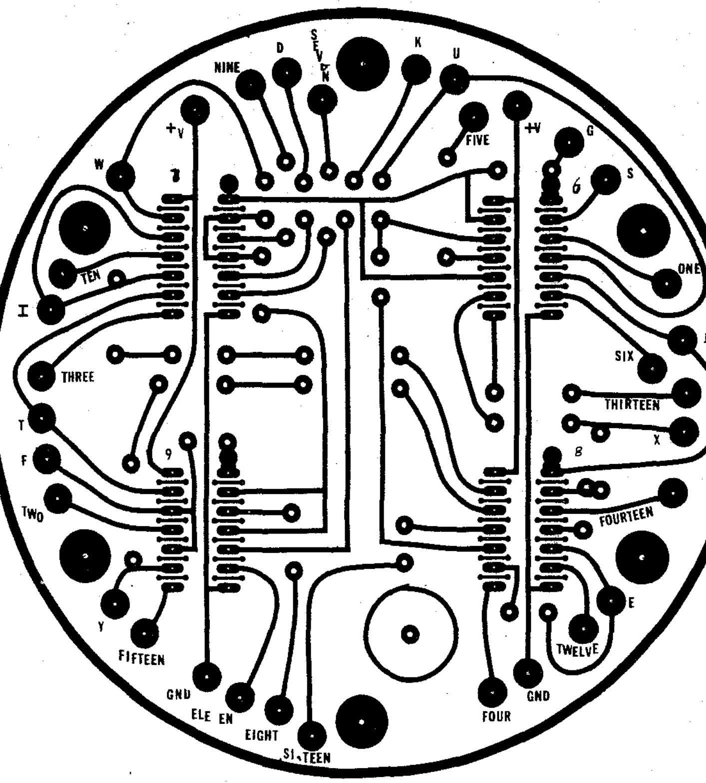

Fig. 11. Foil side of decoder board B.

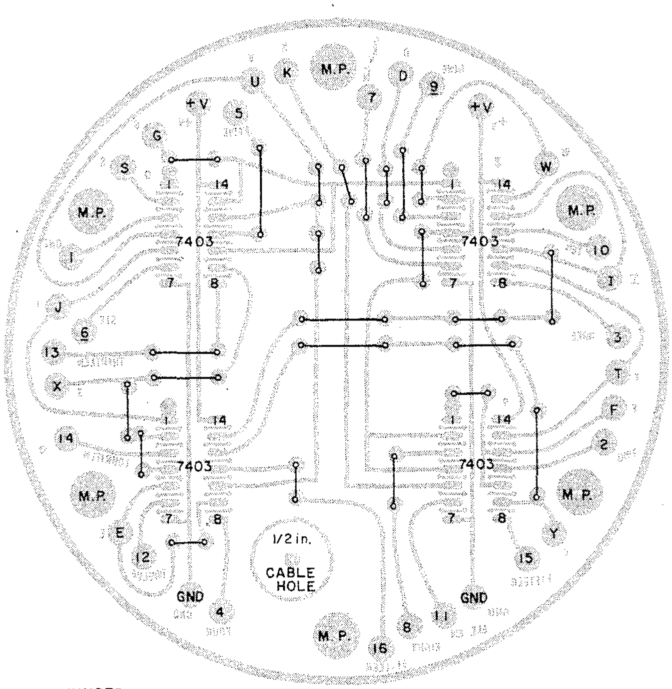

Fig. 12. Component side of decoder board B. Numbers and letters indicate proper placement of input/output leads to other boards. Solid lines connecting dots are jumper leads on component side.

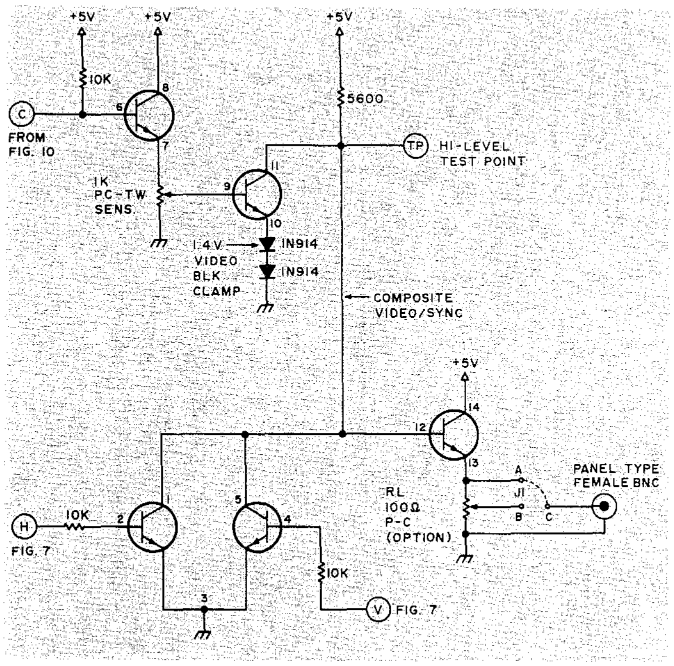

Fig. 13. Schematic of video/sync board. All transistor devices shown are small-signal NPN devices in an RCA IC, CA3046. Numbers shown around the e-b-c of devices indicate pin numbers of that IC for reference and troubleshooting. Note: If cable is terminated in 75 Ohms at the monitor or a drive-level pot (usually 50 to 100 Ohms in monitors), use J1 from A to C and omit pot RL. If no drive level is used on your monitor, jumper B to C and use RL as your drive control to prevent overload.

bracket is attached a rod that runs down the side toward the rear to a small, sealed, metal box that holds a 4-rpm dc motor I had lying around. It is much like the ones the advertising signs use, and I think it was for 6-V dc battery operation. Plus 5 volts runs it just fine, if a bit slow. This allows me to remotely rotate a "lens cover" of sorts on and off the end of the pipe to keep rain, snow, dirt, etc., out of the lens area.

On the topic of lenses, or optics, I am still trying for a better setup, but one of my prime criteria was that it be cheap. After all, I'm trying to avoid using an SSTV or FSTV monitor camera because of cost, so why use a camera lens that costs more than the system electronics? So far, the best combination I have found is with dime-store magnifying glasses with their handles removed.

I fixed-mounted one that was right at 4 inches o.d. at the center of a 6-foot piece of PCV pipe, and that allows me to slide the electronics in and out towards it from the rear. I also have a 3.5-inch lens mounted in a 4-inch collar that I can slide in and out from the front of the pipe to form a compound lens system. That is the area of experimentation at the moment, and I don't mind admitting my physics classes were too long ago. Optics was never really my bag, nor was photography, so all help offered will be gratefully accepted.

The limitation of this system would seem to be use only during full moonlight, but that depends on the response of the photo device you use and the lens system you end up with. As it stands now, I can track in some very hazy conditions, and even clouds don't confuse things too much. Next to try is a full-blown infrared system, I think!

For all the OSCAR fans who read on when the name was mentioned in paragraph one, I have not gone bananas enough to try visually tracking an OSCAR satellite with the LDR system. However, the same electronics system is being tried, mounted in the same waterproof-type housing with two full caps. The difference is that the 7403 outputs will be used to activate PIN diodes (or similar switching devices) on the downlink antenna system. I am trying to build onto the outdoor, steerable OSCAR antennas something like my Twinlead Terror antenna system (*73 Magazine,* November, 1977, p. 54), and then do the video add-on at the monitor end using the sync/white commands coming down the 75-Ohm cable. The video then would be derived from some form of the receiver agc. I mentioned this earlier, in the Twinlead Terror article (which got titled, "Cheap Ears for OSCAR").

You can do some positively wild things with scanned and electronically-steered antennas when you have only receiver power levels to worry about. It becomes even easier when you have a full-duplex, two-band arrangement like the OSCAR uplink/downlink. The receive antennas scan at a high enough rate to be above audio, so you can easily filter out the switch-rate whine. All you hear is the additive result, but each antenna's agc product is

Signal	Location	Measured Frequency	
1. F_{tp}	555 IC pin 3	122.880 kHz	(for H = 15,360 Hz, V = 60 Hz)
2. A	Column IC pin 12	61.440 kHz	
3. B	Column IC pin 9	30.720 kHz	
4. C	Column IC pin 8	15.360 kHz	
5. D	÷ by IC pin 11	960 Hz	
6. Q	÷ by IC pin 12	480 Hz	
7. A'	Row IC pin 12	240 Hz	
8. B'	Row IC pin 9	120 Hz	
9. C'	Row IC pin 8	60 Hz	

This has the horizontal sync running about 400 Hz low, but allows the vertical sync to be correct to avoid vertical "flutter." This is a compromise to reduce system electronics, but all sets tried pulled in easily to the lower horizontal rate. The following is a representation of the VID line with light shining on all LDRs. L is TTL low pulses. Scope Horz. rate = 1/60 sec per full horizontal scan or about 3 ms per cm on a 6-cm Horz. scale.

HHHLHHHSHHLHLHHSHLHLHLHSLHLLLHLSHLHLHLHSHHLHLHHSHHHOHHHS

H is TTL high, S is sync (app. 0.2 volts), O is option LDR 9

Table 1.

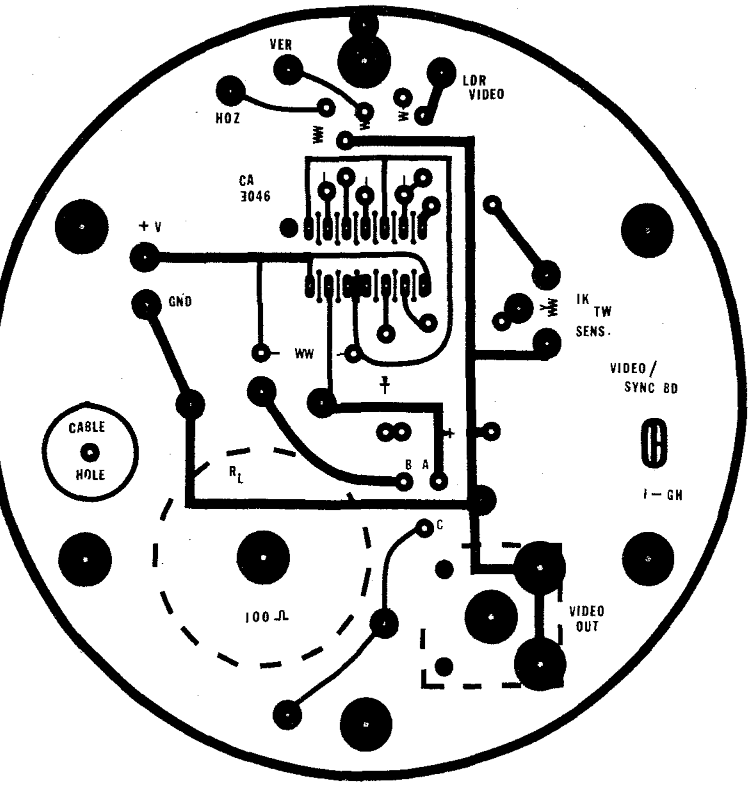

Fig. 14. Foil side of video/sync board.

sampled, and only the highest is used to light the white box on the monitor—sort of a sample, hold, choose-the-highest-figure, and use-for-display system.

I am still deciding whether to use steer antennas to produce center-box white scheme, or sample and display all levels as boxes in the same arrangement in which the antennas are mechanically set up. The latter has the advantage of being able to tell what polarity sense the signal really is, at the antennas, by observing what box(es) are lit the brightest, and to what polarity you have those antennas aligned. It does require small changes in the video stage of the camera, however, so you don't get just saturated white or black off positions intentionally chosen for the EME arrangement.

I have tried several sample-and-hold circuits and antenna positionings so far and have found none to be the perfect result I want. Many such circuits are already around as described in the articles over the past couple of years and 10-meter antennas are easy to build, so you may have your system running before I have mine complete. I am working hard on the EME version at the moment, but should get back on the OSCAR version soon.

The cost of the A-to-D converter IC is quite attractive now, and with my love for digital circuits I am going to try one more sample-and-hold circuit using that type of device. It is an analog in, 3 digits in BCD output device covered a bit further as an antenna readout device for use with CDE Ham 3 rotator controls in *Ham Radio,* January, 1979, p. 56. The device used there is an AD 2020 by Analog Devices, Norwood, Massachusetts.

If there are any questions, please include an SASE, and I'll sure try to help you. If you come up with other uses (surveillance, etc.), please write, as several people have already approached me with ideas beyond what I had in mind. I'll try to act as a go-between as best I can for any new ideas for my camera. Good lookin'.■

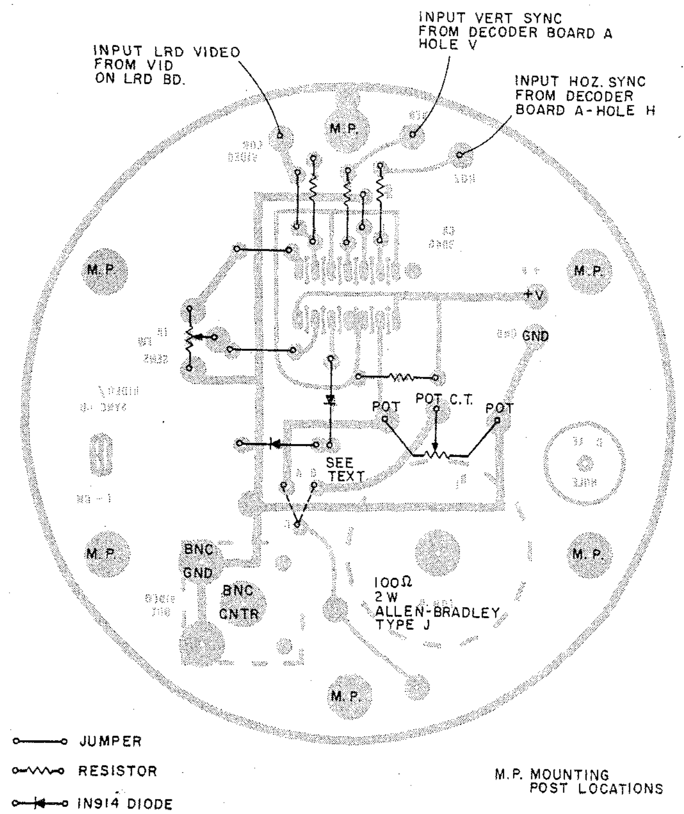

Fig. 15. Component side of video/sync board. Schematic type symbols are used to show loading placement of components. Solid lines connecting dots are jumpers on component side.

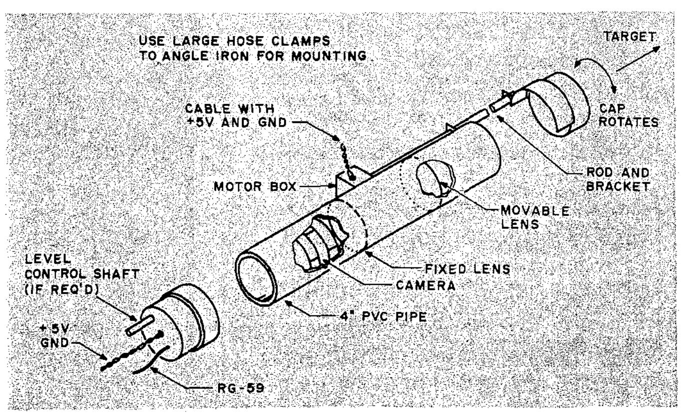

Fig. 16. Mechanical assembly of the camera.

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