This combination of a folded dipole, 3 directors and a reflector gives good results in marginal areas.

High-Gain Directional Array for Marginal TV Reception

The completed array mounted atop the roof. It will have maximum usefulness only for the specific channel for which it is designed.

By
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THE antenna to be described herein is highly satisfactory for marginal TV reception and has proved superior in performance to stacked arrays costing several times as much money. Its directional characteristics and high forward gain make it particularly desirable for eliminating ghosts and interference between two stations operating on the same channel. Construction of the array is not difficult, and if the indicated dimensions are carefully followed, the average builder should be able to assemble it with a minimum of effort.

Such a highly directional array with parasitic elements is good primarily to receive the frequency for which it is cut. It is possible, however, to secure satisfactory reception on adjacent channels if the signal strength is high enough. If the array is cut to favor a distant weak station, it will still be possible to pull in the strong locals, although if more than one channel is to be received, it would be more satisfactory to construct a separate array for each frequency.

These separate arrays may be mounted independently, or stacked one above the other; they should be separated by at least half a wavelength. For best results they should *not* be coupled to the same transmission line. Run separate 300-ohm lines, and use a switch at the TV receiver to change from one array to the other. If more than one station is to be received on a channel, some method of rotation will be necessary. Since the array is very light in weight, rotation presents no problem, and either a war-surplus motor or a regular stock antenna rotor will be satisfactory for the purpose. If a war-surplus motor is used, be sure it is not free to turn with the current off, as this would allow the array to rotate with the wind.

Fig. 1. Length and spacing of the various elements of the antenna.

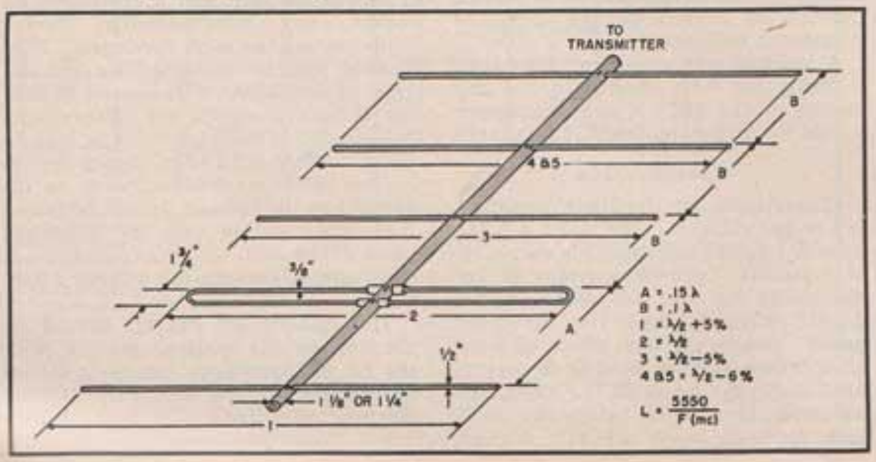

Fig. 1 shows the dimensions of the various elements, so that actual lengths may be determined by referring to Table 1. These dimensions are correct *only* if the constructor uses the same materials and the method of assembly shown in the photograph and sketches. Note that the folded dipole element is made very narrow and is mounted in a horizontal plane. It is *not* connected to the tube supporting the reflector and directors. The main support and mast should be grounded with #4 copper wire for protection against lightning surges.

Dimensions are given in Table 1 for each channel, also a separate set of dimensions for the middle of the low channels (2 to 6) and the middle of the high-frequency group (7 to 13). These two arrays may be combined and stacked on the same mast to cover all channels. They should be kept about 8½ feet apart, and it is best to run two separate lines to the receiver. Gain will not be uniform over the various channels, so it is usually best to cut the arrays to favor the stations most wanted. Positioning should be done experimentally, and if a motor is not used, it is a good plan to check with a map and compass since it is often difficult to determine the point of maximum signal by observation.

Construction Details

Use 1¼" round or square aluminum tubing for the center support. The length of this support is given in column "C" of the Table. Mark off the tubing to space the various elements and drill 17/32" holes to receive the directors, dipole, and reflector. A simple jig should be made to keep these holes in line. This jig consists of a board to which the tubing can be attached with a couple of lag screws. Drill one hole and fasten the tubing to the board at one end. Drill a second hole at the other end of the tubing and fasten to the board. The balance of the holes may now be drilled by hand or in a drill press, and it will be easy to keep them in line so all the elements of the array will be in the same plane. A little care at this point will avoid spoiling the whole job.

Using a small drill, make a hole for a self-tapping screw above each director and the reflector and dipole. Use screws long enough to penetrate the elements. Tighten these screws when the array is finally assembled, and all the elements will be firmly anchored in place. The screws fastening the dipole insulators in place must be tightened with extreme care to avoid cracking the polystyrene. To prevent collection of moisture, it is a good idea to close the open ends of all the pieces of tubing with bottle corks which can then be painted with a couple of coats of coil dope. It is also a good idea to paint each joint of the array with polystyrene dope to prevent the entrance of moisture.

Reflectors and directors are made from ½" OD aluminum tubing and require no processing except to cut them to length and to dress off any burrs at the ends with a file. Solid ends may be made from dural rod and fitted into the aluminum tubing if the constructor cares to go to the extra trouble. This type of construction will produce a better looking job, and it will also make the material cut to better advantage on the lower channels, since these solid rods can also be used to extend the length of reflector and director elements.

The dipole element is formed from ⅜" OD hard brass tubing with .025 wall thickness. This element should be plated with chrome on a silver base. Plating is important to add to the gain and prevent corrosion of the metal, and a chrome overlay will prevent the silver from tarnishing. Details of the construction of the folded dipole are given in Fig. 2. Pieces of ½" OD polystyrene tubing are used to insulate the dipole from its support. This method of mounting is simple.

TV Channel No.	Range in Mc.	Video Freq. Mc.	Sound Freq. Mc.	Spacing A	Spacing B	Reflector 1	Dipole 2	Directors 3	Directors 4 & 5	Support C
2	54-60	55.25	59.75	30⅜	20⅛	103	98	93	92⅛	93¾
3	60-66	61.25	65.75	27 7/16	18 5/16	92½	88	83½	82¾	85⅜
4	66-72	67.25	71.75	25	16¾	84	80	76	75¼	76¼
Lower Band	54-88			25½	17	84	80	76	75	79½
5	76-82	77.25	81.75	21⅞	14⅝	73½	70	66½	65¾	68¾
6	82-88	83.25	87.75	20⅜	13⅝	68¼	65	61¾	61	64¼
7	174-180	175.25	179.75	9¾	6½	33	31½	30	29⅝	32¼
8	180-186	181.25	185.75	9½	6 5/16	32	30½	29	28 11/16	31 7/16
9	186-192	187.25	191.75	9⅛	6	31	29½	28	27¾	30⅛
10	192-198	193.25	197.75	8⅞	5 15/16	30½	29	27½	27¼	29 11/16
Upper Band	174-216			8 15/16	6	30	28½	27	26¾	30
11	198-204	199.25	203.75	8 9/16	5¾	28⅞	27½	26⅛	25⅞	28 13/16
12	204-210	205.25	209.75	8 5/16	5 9/16	28⅓	27	25⅔	25½	28
13	210-216	211.25	215.75	8⅛	5 7/16	27¼	26	24¾	24½	27½

NOTE: All dimensions are in inches or fractions of an inch, and all measurements are to be made from the center of one element to the center of the adjacent element as shown in the drawings.
MATERIAL: Dipole—⅜" O. D. x .025 wall hard brass tubing. Reflector and directors: ½" O.D. aluminum or dural tubing. Center support: 1¼" O. D. aluminum tubing, square or round. Insulation: ½" O. D. x ⅛" wall polystyrene tubing. Lead-in: Standard 300-ohm twin line.

Table 1. Antenna element length.

Since it is difficult to bend the brass tubing, the dipole ends are made from 5/16" solid brass rod, which is easily bent. This rod is sold by welding shops for brazing. Bend two "U" shaped pieces on a ⅞" radius and allow a couple of inches to slide inside the brass tubing. After the array is completely assembled, adjust these ends to give the exact dipole length wanted and then solder them in place. This is the final step in assembling the array. The details of construction of the two polystyrene insulators may be seen clearly from the sketch. Take care to prevent cracking this material while assembling the array. Note that clearance holes drilled in the polystyrene tubing allow the 6-32 screws used to connect the ends of the dipole to the 300-ohm line to come down flush against the brass rod. Insert a short length of solid rod at this point and drill a hole for the 6-32 screws. The solid rod will prevent the thin brass tubing from collapsing when the screw is drawn up tight. Either thread the hole through the dipole element for the screw, or use a couple of nuts on the other side.

The vertical mast may be made from a 10' length of 1¼" thinwall conduit. Weld a small plate to the top with holes drilled for two "U" bolts. Make two "U" bolts from threaded brass rod, and use these to fasten the array to the upright support. Details of this assembly are shown in Fig. 3A. Balance the array by holding it out in one hand and attach the vertical mast at the balance point. Attach stand-off insulators for the 300-ohm line at intervals of about 2½' along the vertical mast. These may be welded in place. They are absolutely necessary to prevent the transmission line from contacting the metal mast and also to prevent it from flopping around in the wind. *Do not* tape the line to the metal mast. In bringing the line down to the set, avoid long runs, keep it away from metal objects, use enough stand-off insulators to keep it from flopping around but not more than is necessary for support, and twist it about once for each foot of run. Keep it away from power and telephone lines or other possible sources of interference, such as neon signs.

To stack two or more arrays cut for the same frequency, space them about 90% of a half-wavelength apart (ap-

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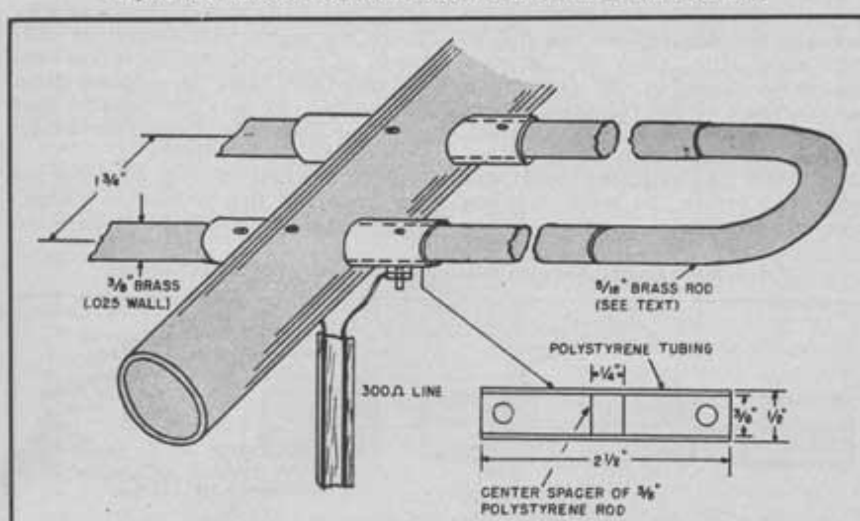
Fig. 2. Construction details of the folded dipole element and assembly.



proximately the same length as the folded dipole element) and cut two pieces of 300-ohm line half this length for the matching stubs. Connect one end to the dipole element and the other end to the 300-ohm lead-in as shown in Fig. 3B. Support the lines on an insulator at the splice to the mid-point of the supporting mast; be sure to maintain the proper phase relationship between elements and use additional stand-off insulators to keep all the lines from swinging in the wind. Separate the lead-in from the matching stubs as it comes down the mast.

Another simple and satisfactory way of coupling the elements of a stacked array is shown in Fig. 4B. Here the 300-ohm line is connected to the upper dipole, brought down the mast and given a half-turn before being connected to the lower dipole. Support all lines away from the grounded support on stand-off insulators. It is usually impractical and undesirable to stack more than two arrays for the same frequency. About 40% gain over a single array may be secured under ideal conditions, but mismatching often defeats most of this gain and sometimes results in an actual reduction in signal strength. Most signals too weak to come in on a single array are below the noise level. Stacking will often help by increasing the signal-to-noise ratio and by building up the forward gain, which may help to eliminate "snow" and lack of contrast in the picture.

Matching the Antenna

Since the effective impedance of a dipole is reduced by parasitic elements, some form of matching transformer is necessary to insure maximum energy transfer from the antenna to the line. A quarter-wave matching stub, made from a length of 300-ohm line, may be used at the dipole as shown in Fig. 4A. The point where the feeder line connects to the stub must be found experimentally by moving the line along the stub. (Strip the insulation along the stub and attach a couple of alligator clips to the line to make temporary contact until the best point is found; then take another piece of line and make a new stub for a permanent installation.) Match the antenna with set and booster (if used) tuned to a test pattern from the weakest station you plan to receive. If the antenna and line are matched, no matching will be necessary at the receiver if the line and receiver input are the same impedance.

An easy way to match the TV receiver and line is shown in Fig. 4C. This stub consists of a piece of 300-ohm line, with the end shorted, connected across the TV receiver or booster input terminals. Start with a piece of line a few inches over a quarter-wavelength long and cut off about an inch at a time until the test pattern shows maximum clarity. Solder the ends together for a permanent installation and cover with tape so that contact with other wires or ground will be avoided when the stub is allowed to drop back of the receiver.

An alternate matching method involves the use of a small ceramic trimmer connected across the antenna input terminals of the TV set or booster (2 to 36 μμfd. ceramic trimmer is suitable). This trimmer may be adjusted to favor either the video or audio as may be needed, and it can be readjusted when tuning other channels. It will be subject to drift and may require readjusting from time to time. An air padder may be used in place of the trimmer if desired.

A matching stub tuned with a metal slug is shown in Fig. 4D. Bend a small piece of sheet aluminum about ¼" wide, cut from an old coil shield, into a small loop which will just slip over the 300-ohm line and slide up and down freely. Tune by moving the slug along the line. It may be fastened in place with a small piece of tape when the best position is found. A matching stub is more stable in operation than the trimmer discussed in the preceding paragraph, but it is not so easy to adjust.

Proper matching is very important if maximum gain from the antenna is to be transferred to the set. Mismatch between set and antenna will often defeat all the extra gain that is to be had from an elaborate array. Practical experience with television installations in marginal areas indicates that proper matching will do more to improve reception than any other one thing. It is more important than the type or height of the antenna, and will often permit reception without a booster in areas where a booster would normally be used with the average antenna installation not properly matched to the TV receiver.

It will be found that an array cut for a lower frequency will be more effective in picking up the higher frequencies, within certain limits. For example, suppose we wish to pick up channels 4 and 6 on a single array. If channel 4 is weak, we should choose an array cut for that channel rather than one cut for channel 6. The higher frequency, channel 6, may be picked up on our channel 4 array under conditions where it would be impossible to get the channel 4 station on an array cut for channel 6.

An array cut for channel 5 might seem to be the one to use in picking up channels 4 and 6. This reasoning is not entirely correct, since we might as well get the maximum possible gain from one channel with fair results from the other channel, as to have only fair results from both channels, as might be the case with an antenna cut for an intermediate channel. These conclusions apply to marginal reception where both stations are relatively weak. If one station is stronger, it is usually a good practice to cut the array to favor the weak station, because

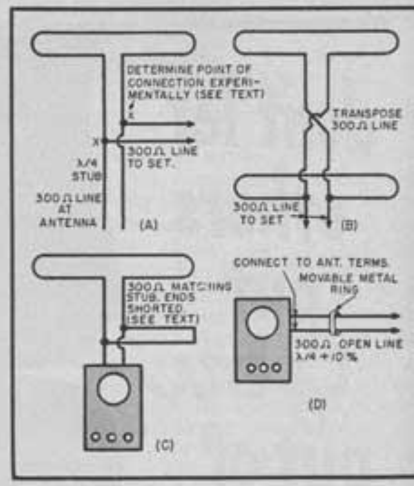
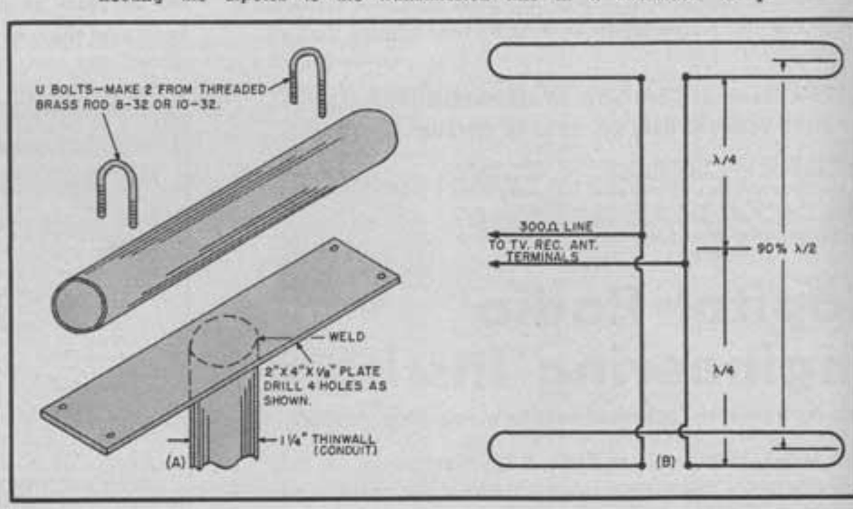


Fig. 4. (A) Scheme for matching 300 ohm line to the array. (B) Simple method of coupling the two elements of a stacked array. (C) A means of matching transmission line to the receiver. (D) Matching stub tuned with a metal slug.

Fig. 3. (A) Method of mounting the array on the mast. (B) Method of connecting the dipoles to the transmission line in a two-stack array.



the stronger one will come in without trouble anyway.

Some constructors may want to know what to expect in the way of reception from a directional array of the type described. It is, of course, impossible to set any hard and fast rules as to what will occur in any given location. The noise level and signal strength will vary greatly for different installations, even though they may be the same airline distance from the transmitter. Suburban locations are usually best because of the lower random noise level. If a fairly good location is available, the constructor should not hesitate to try for reception from any TV station within a 200-mile radius. Reception at maximum distances will be freakish and variable, but signals will come in under favorable weather conditions, and for distances up to 100 miles, reception can be fairly consistent. It is certainly good enough to justify the purchase of a TV receiver.

One or two boosters must be used to pull in the weakest signals. If two are used, tune one of them to the audio and the other to the video signal. Try connecting them in series and also in parallel. Two boosters of different manufacture will often work better than two of the same make when connected together, because the tendency to oscillate is usually less. Shortening or lengthening the lines between the boosters, or between the TV set and a booster, may also help cure oscillation troubles.

Stations less than 100 miles away will come in without boosters whenever weather conditions are favorable. Remember that a change in antenna location may boost signal strength by as much as 100%, so do not hesitate to move the array around on the roof to find the best spot. Height is not too important; usually ten feet above immediately surrounding objects is enough to get a good signal. —30—