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All Band Conical Antenna

Would you like to get away from your "antenna farm" with a separate antenna for each band, and operate on all frequencies from 80 meters through 10 meters with one antenna that will load flat with a 1:1 SWR all the way across each band?

The accompanying diagrams depict such an antenna. Dubbed the "All-Band Conical," and derived from the driven elements of a broad-banded television conical antenna, this antenna will allow operation on all amateur bands from 80 through 10 meters with maximum transmitter efficiency and vastly improved receiver reception.

The antenna system consists of two horizontal vees, back to back, center-fed with 450-ohm open-wire feed line, tied to an antenna coupler of the Johnson Matchbox type. Vertical arrangement may be either of the flat-top type, inverted-vee design, or just about any other configuration to fit your individual requirements, so long as it remains balanced on each side. The horizontal vees, with a 20° to 30° angle between each leg, cause the antenna to have very broad tuning characteristics, thus permitting large frequency excursions up or down the band from the resonant tuning point with resultant low increases in SWR.

All-band operation is accomplished by use of a Johnson Matchbox or similar parallel-feed antenna coupler. This provides a method of tuning the feed line to whichever band is desired and converting your unbalanced transmitter output to the balanced input of the conical feed system.

Maximum transmitter efficiency results with such a system because the matching coupler will present a near perfect resistive load to the transmitter on all bands. Problems of transmitter heating due to absorption of reflected power are eliminated; if you are troubled with your transmitter making like a "hotbox" with high SWR, this is the way to cool it off!

This antenna has been loaded from the low end of 80 meters through the high end of 10 meters with exceptionally good results throughout. The authors, operating a Viking II on AM and a Tri-Band Swan (home-brew conversion; both sidebands, too!) can load up on any band with a 1:1 SWR and can then move as much as 50 kc in frequency without affecting the SWR and transmitter loading enough to necessitate a change in any adjustments.

When transmitting on a coax-fed dipole or inverted vee cut for the center frequency of any single band, it is noted that movement up or down frequency from the antenna's resonant point introduces either inductive or capacitative reactance, with corresponding increase or decrease in plate current loading, and a rise in SWR. If a large frequency move is made, the final must be re-dipped, and sometimes more or less capacitance must be introduced or removed in the final tank loading circuit in order to maintain the required power level.

Not so, however, with the conical antenna; after loading the transmitter on any band and adjustment of the antenna coupler for a 1:1 SWR, movement to any other frequency within the band necessitates only minor antenna tuner adjustments to return to a 1:1 SWR at the new frequency. When this adjustment has been made, the transmitter again sees the same resistive load as previously, and transmitter loading will remain at the same point as before moving in frequency; only slight final tuning or re-dipping is required. This is indeed a bonus factor for those amateurs operating one of the fixed impedance output transmitters.

The development of the conical antenna resulted from the search for a broad-band radiator which would present a minimum physical mismatch to the feed line. The conical antenna arrangement approaches the ideal configuration to reduce this physical mismatch. The transmission line and antenna surfaces are smoothly tapered so the transmitted wave energy actually sees a metallic funnel. As the energy travels up the feed line, it will be smoothly squeezed out into the antenna while encountering a minimum change in direction of flow. Large-diameter antennas are very desirable in amateur operations, because they present very broad-banded characteristics, but a large-diameter transmission line (to avoid the undesirable physical mismatch) is not very practical. Thus a really thick antenna may prove to be less desirable than moderately thick ones unless some method of special shaping is employed to smoothly increase the cross-section of the practical transmission line to match that of the large-diameter antenna. The conical antenna herein described provides a method of making such a transition, and greatly reduces stray capacitance from such a mismatch at the antenna feed-point.

In addition, the progressive increase in cross-section from the center feed-point to the outer ends of the antenna tends to keep the surge impedance constant at each successive section of the antenna. A constant cross-section antenna such as the center-fed dipole or the inverted Vee exhibits successively higher surge impedance from the center feed-point to a point near the ends, where the surge impedance suddenly falls to a very low value.

Variations in the all band conical antenna's design are limited only by the number of individual ideas. The angles associated with the conical and the number of elements employed, from two to a solid conductor, or cone, have an infinite number of combinations, each with a small change in operating characteristics. The antennas of this design constructed thus far locally have consisted of only two legs or elements on each side of center. This is only the outline of a true conical, but the addition of two *more* elements or legs on each side would only reduce the Z/R ratio by less than 1/3 of the ratio of the two-element conical. The two-element conical reduces the Z/R ratio by more than ½ of the ratio of a single-wire doublet. The optimum ratio of Z/R is, of course, one to one. If the Z/R ratio of various antennas is examined, its importance will be realized.

Most single-wire inverted Vees have an angle of inclination from the horizontal ranging from 20° to about 45°. The Z/R ratio will be from 14:1 to 19:1, depending on the size of the wire conductor. The two-element double-vee conical can be constructed with any cone angle from 1° to 90°; the normal angle will be from 10° to 60°, with the optimum cone angle being around 30°. The Z/R ratio at this angle will be about 8½:1. With four elements

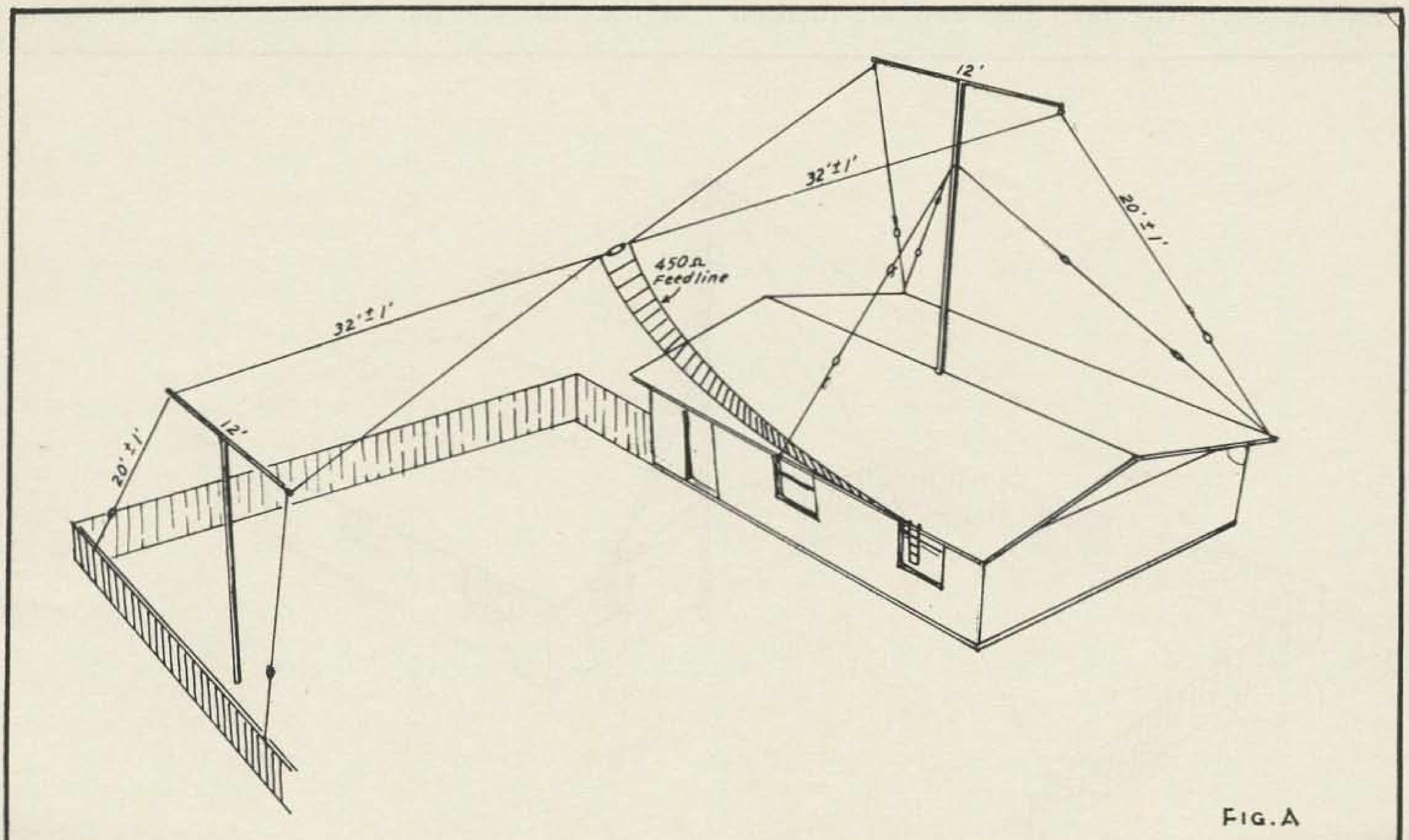

Fig. A—The installation at W5VOH. The spreaders are made of one inch conduit with a one inch dowel driven inside the conduit and protruding a foot on each end. A pulley on the mast makes it possible to raise and lower the spreaders. Both masts are of the TV telescoping variety.

forming each cone on each side of the center feed-point and the same optimum cone angle of 30°, the Z/R ratio is only reduced to about 6½:1. It is important to note that when Z/R is at a minimum, the ratio of R_{max} to R_{min} is also at a minimum.

Another factor to note is the load resistance, which varies with the cone angle. As the cone angle is increased, the impedance of the antenna decreases. Again the optimum cone angle is about 30°; at this point the center feed-point impedance is about 350 to 450 ohms. This impedance is also related to height above electrical ground; you should strive to elevate the center feed-point a quarter-wave or more above electrical ground at the lowest operating frequency.

Still another aspect of the conical which will be appreciated by those who are limited in space in which to erect an amateur antenna is the fact that as the cone angle is increased, the electrical antenna length is increased. At the recommended cone angle of 30°, the electrical length will be approximately 75% of the calculated length required for a single wire. Ninety feet will resonate at 3900 kcs. However, it is recommended that an overall length of 105 feet be utilized if at all practicable from an erection standpoint.

Additional efficiency is obtained by use of 450-ohm open-wire feed line and the method of feeding the antenna. RG-58/V coax, in popular usage for center-feeding inverted vees and half-wave dipoles, has an attenuation factor of approximately 2 db per 100 feet at 30 mcs, and the attenuation factor for RG-8/V is around 1 db per 100 feet. However, the attenuation factor of 450-ohm open-wire line is only 0.15 db per 100 feet at the amateur frequency mentioned. When it is considered that a doubling of transmitter power will result in only a 3 db signal increase, it can readily be seen that use of open-wire feed line as compared to use of coax results in quite a gain.

Added efficiency will also be noted at the receiver when this antenna is used as a receiving antenna. Consider a center-fed half-wave dipole, fed with coax transmission line, and cut for the center of the 40 meter phone band. The center conductor of the coax is connected to only one-half of the antenna, with the other half acting as a grounded counterpoise, so any signal to the receiver is obtained by the E.M.F. generated in 32′ 3″ of antenna. (The coax won't pick up any signal, either; it's shielded.) The conical antenna will provide around 300 to 400 feet of receiver antenna wire for generation of an E.M.F. at the receiver's terminals, depending on the length of the open-wire feed line (it is a part of the antenna and picks up signals also). Thus there is more wire available in the antenna for receiving and the signal

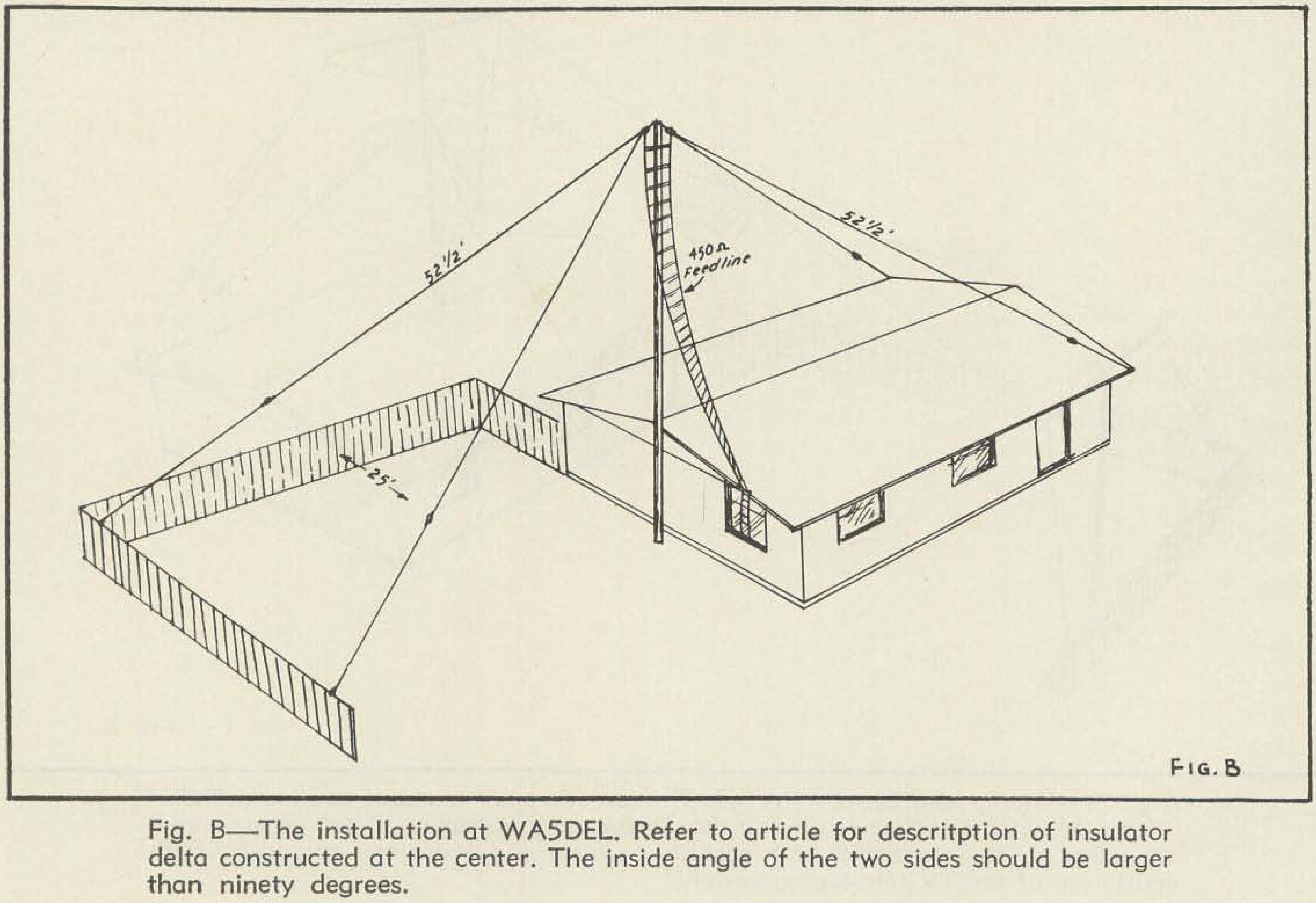

Fig. B—The installation at WA5DEL. Refer to article for descritption of insulator delta constructed at the center. The inside angle of the two sides should be larger than ninety degrees.

heard will be stronger.

Still a further advantage to this antenna will be realized by use of the antenna coupler. Since the antenna coupler's use results in the addition of another tuned circuit, further and better elimination and suppression of harmonics is obtained. And, if this is not enough, the system lends itself well to insertion of a low-pass filter in the transmission line between the transmitter and the antenna coupler for further reduction of harmonics above 30 mc if desired (TVI you know).

The directivity pattern, if any, of this antenna has not been determined by the authors. No doubt, it does possess major and minor lobes which probably shift with band changes, but it is thought that very little difference in signal strength exists between the major and minor lobes. The authors have worked with full-circle coverage on all bands with very little attenuation in signal strength reports from any direction. It should not be any more directive than the ordinary garden variety of center-fed dipole or inverted Vee, and, when the band is in, you can talk with it wherever the signals may be coming from.

An antenna length of 105 feet is recommended, with each leg of each horizontal vee being 52½ feet in length. No. 12 or no. 14 wire would probably work very satisfactorily, but the authors recommend use of no. 10 soft-drawn copper wire for the antenna, because of both the larger cross-sectional area and the added structural strength obtained. Don't worry about soft-drawn copper's stretch in hot weather; the antenna coupler will take care of changes in length due to temperature changes. Thus still another advantage is realized from the conical antenna system because you get away from the changes in antenna resonance which occur on a single-band coax-fed dipole when it is lengthened due to temperature changes or physical sag.

The 450-ohm open-wire feed line used by the authors is formed from no. 18 wire, with 1" polystyrene spacers every six inches or so, and is the commercial TV variety which is readily available for approximately 2c per foot from most radio supply houses (Lafayette, Burstein-Applebee, etc.). This size feed line should safely handle powers up to 400 watts or so on AM and a KW on side band. Remember that $P = I^2R$. Assuming a power of 1000 watts on the 450 ohm transmission time we have $I^2 = 1000/450 = 2.222$ or $I = 1.5$ amps. In an open air installation, such as a feed line, the no. 18 conductor will handle more than

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twice this current with ease. If you are going to run a full gallon on AM you may wish to construct your own feed line from no. 12 or no. 14 wire. In this case, spacing between each side of the feed line is dependent upon the diameter of the wire used, and can be calculated for an impedance of 450 ohms by the formula for the impedance of air-insulated parallel-conductor transmission line, which is:

$$Z_0 = 276 \log \frac{b}{a}$$

when "b" is the center-to-center distance between conductors and "a" is the radius of the conductor. If you do construct your own, we suggest that you purchase ¼" diameter polystyrene rods, cut them up into lengths required for the spacers, and drill the wire holes just large enough to pass the wire through. A hot soldering iron judiciously applied will then seal each spacer hole around the wire and you've got your feed line made with a minimum of effort.

The feed line length is apparently not critical; one of the authors uses a length of 40 feet, the other uses 95 feet, while still a third local amateur installation uses 60 feet, and results at all three stations have been very good. If, after erection, trouble is experienced in loading on any band, try experimentally adding ⅛ to ¼ wave length or so at a time to the feed line until you arrive at a length where good loading characteristics are obtained. If you have trouble at all in loading, it will probably be on the higher frequencies, and if you can arrive at a feed line length which works satisfactorily on 10 and 15 meters, it will work well on the lower bands.

A word of caution: the open-wire feed line is hot with rf when transmitting, and must be insulated from contact with any conducting surface. Provision must be made for use of feed-through and stand-off insulators for passing the feed line through windows, etc., and at roof eaves. The authors utilize old-fashioned porcelain knob-and-tube insulators, such as were in prevalent use years ago by electricians for open-wire house wiring before the advent of romex house wiring. In case you have trouble locating this item at the radio supply house, try Sears Roebuck; they were obtained for 5c each here in Texas.

A method of getting through a window of the shack to the outside without drilling holes in the window itself requires a piece of masonite board cut to your window width and about 6" high; raise the bottom window sash and use the masonite as a spacer, and the top of the masonite will fit into the weather-stripping groove on the under side of the window sash, affording a weather-tight closure. The feed line is passed through feed-through insulators in the masonite and in the outer window screen wood frame.

The authors found that the porcelain knob insulators mentioned above had a high-resistance leakage to ground when wet from rain. Resistance to ground, reading infinity when dry, was found to be 700 K ohms when wet, but this defect was easily remedied by wrapping the open-wire feeders at the contact points with the insulators with plastic electrical tape and no further trouble was experienced due to leakage to ground.

A support for the antenna center feed point, and a convenient method of hanging the antenna to your mast, can be devised by forming a delta from three strain insulators about three inches in length, readily obtainable from your radio parts house. Attach each vee to one of the two bottom points and hang the whole antenna to your mast or pulley by the top point.

If difficulty is experienced in obtaining a 1:1 SWR after installation, examine the antenna to determine if a metal wire guy line or any other metal conductor might be within the field of one of the horizontal vees, thus unbalancing it with respect to the other vee. The conical is a *balanced* antenna, and metal within the field of one of the sides will cause unbalance and consequently you cannot get the SWR down to 1:1. This trouble in the installation of one of the authors' antennas, was caused by a top tower metal guy line within the field of one vee; it was remedied by replacement of the metal wire guy line with a nylon rope guy line. Another possibility that may result in an unbalance can be caused by bringing off the feed line too close to one side of the antenna. The feed line should be brought off from the plane of the antenna as close to 90° as is practicable. The angle does not have to be at exactly right angles, but an angle smaller than 60° may cause an unbalance due to coupling.

The conical antenna is a simple antenna to construct and erect. The accompanying diagrams depict the arrangements used by the authors, and you may improvise any arrangement required to suit your space requirements, so long as you keep it balanced. If you will utilize a little care in making good electrical connections and in insulating the feed line, it will put a signal on the airways that you can be proud of. One word of caution is in order: Since the conical presents such a good load and pulls all the rf available from the transmitter, the authors have found it necessary to bolt their transmitters to the operating table to prevent them from being pulled up the feed line and lost in outer space.

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Single Diode Frequency Double

Rufus Turner K6A1

The output ripple of a full-wave rectifier is an easily obtained double-frequency voltage for synchronization, timing, tone generation, frequency doubling without amplifiers, etc. Four diodes (or two diodes plus two resistors) generally are used in a bridge circuit, since this is more economical and less frequency dependent than the transformer-coupled full-wave rectifier. Further economy is provided by the circuit shown in Fig. 1; this is the less well known single-diode rectifier bridge.

To balance the circuit initially, apply the input ac voltage, connect an oscilloscope to the output terminals, and adjust R_1 for equal height of the output-signal humps. No readjustment is needed unless the diode is replaced.

This circuit has the advantage that it will work with any kind of diode and is not frequency selective (the frequency range of the diode itself determines the circuit range). Operation thus is provided from the lowest audio to ultra-high frequencies. Nor does it discriminate against most waveforms. Its disadvantages are the few common to such bridge rectifiers: lack of a common (ground) connection between input and output, and signal attenuation due to voltage divider action of the bridge.

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