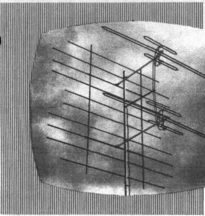


The 2-Bay Champion antenna, recommended for superior reception in all secondary and fringe areas. 4-Bay stacking extends reception to super-fringe areas.

Development of a New Type of All-Channel VHF Antenna

By

HAROLD HARRIS
V. P. in charge of Sales and Engineering

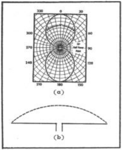
Channel Master Corporation

An outstanding new high gain antenna, introducing the last word in broad-band dipole systems, is now available to solve all your multi-channel reception problems.

The lifting of the TV freeze means the gradual disappearance of the single channel VHF area, and with it, the use of the single channel Yagi. As this evolution proceeds, many of the needs for multi-channel reception can be met by the broad band Yagi. However, because this antenna is limited to either the low band or high band of VHF, there has been a steady trend toward 12 channel VHF antennas. This article will describe the development of a new type of all channel VHF antenna which has the highest gain ever achieved in commercial application.

Work was begun on this antenna more than a year ago at the Channel Master laboratory. Harry Greenberg, Chief Engineer, assigned the project to Dr. Yuen T. Lo, one of the few men in the country to write a Doctorate thesis on the subject of antennas. Dr. Lo undertook a complete review of dipole systems, and specifically those systems which have been evolved for 12 channel operation in VHF, in order to choose a point of departure.

Fig. 1 — (a) Horizontal polar diagram of half wave dipole. (b) Current distribution of half wave dipole.

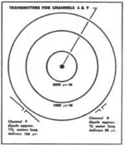


THE PROBLEM — AND THE IDEAL SOLUTION

The horizontal polar diagram of a half-wave dipole is shown in Fig. 1a., and its current distribution is shown in Fig. 1b. Since the size of the dipole varies inversely with frequency, Fig. 2 shows the relative size and interception area of a half-wave dipole tuned to the middle of the low band compared to one tuned to the middle of the high band. The ratio is approximately 3:1.

Since the voltage that a dipole picks up is proportional to its length, a high band dipole will pick up only one third the energy of a low band dipole. If we attempt to use the low band dipole for high band reception, the current distribution is shown in Fig. 3a. The dipole is then said to be working on its third harmonic. This current distribution results in the horizontal polar pattern shown in Fig. 3b. The low band dipole can be considered to be three half-wave high band dipoles tied together. The lobe-splitting is due to the fact that the two outside dipoles are in-phase and the center dipole is 180° out-of-phase. Therefore, cancellation occurs.

Fig. 2 — Comparison of size and interception area of channel 4 and channel 9 half wave dipoles.



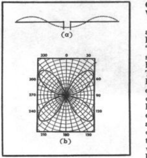
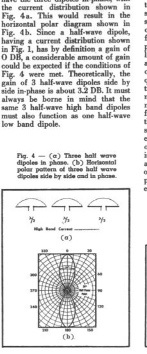


Fig. 3 — (a) Third harmonic current distribution of half wave dipole. (b) Horizontal polar-pattern of dipole operating on third harmonic.

The desirable goal would be to have the three dipoles in-phase, with the current distribution shown in Fig. 4a. This would result in the horizontal polar diagram shown in Fig. 4b. Since a half-wave dipole, having a current distribution shown in Fig. 1, has by definition a gain of 0 DB, a considerable amount of gain could be expected if the conditions of Fig. 4 were met. Theoretically, the gain of 3 half-wave dipoles side by side in-phase is about 3.2 DB. It must always be borne in mind that the same 3 half-wave high band dipoles must also function as one half-wave low band dipole.

Fig. 4 — (a) Three half wave dipoles in phase. (b) Horizontal polar pattern of three half wave dipoles side by side and in phase.

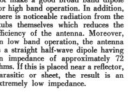


OTHER TYPES OF BROAD BAND VHF DIPOLES

(a) One of the early attempts to achieve an all VHF dipole was the RCA system adopting a so-called "bat wing" as shown in Fig. 5. This shows the current distribution on both the high band and low band. This method actually provides both high and low band operation. The dipole structure acts as a half-wave dipole on the low band but on the high band, the "bat wings" form electrical discontinuities in the dipole and effectively isolate the outer third of the dipole on each side. This means that from apex to apex of the "bat wings" on the dipole, we have one half-wave on the high band and, therefore, this dipole acts as an ordinary half-wave dipole. However, its full length is not utilized on the high band; consequently no significant gain is achieved in the high band dipole alone.

(b) One of the oldest methods of achieving resonant operation is the use of the colinear dipole with quarter-wave phase-reversing stubs, as shown in Fig. 6. This quarter-wave stub effectively transforms the phase on the high band 180° and, therefore, all 3 dipoles are in the same phase. However, there are two severe limitations in any broad band VHF antenna built around this dipole. First of all, the quarter-wave stub is a frequency-sensitive device which is optimum at only one frequency. This means that the colinear dipole does not make a good broad band dipole for high band operation. In addition, there is noticeable radiation from the stubs themselves which reduces the efficiency of the antenna. Moreover, on low band operation, the antenna is a straight half-wave dipole having an impedance of approximately 72 ohms. If this is placed near a reflector, parasitic or sheet, the result is an extremely low impedance.

Fig. 5 — Half wave low band dipole with RCA "bat wings" attached.



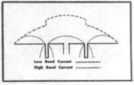


Fig. 6 — Half wave low band dipole with phase-reversing stubs for colinear operation on high band.

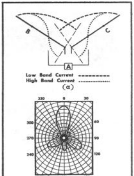


Fig. 7 — (a) High and low band current distribution of a conical dipole vee'd forward. (b) High band horizontal polar pattern of conical antenna.

(c) Probably the most familiar types of broad band antennas are the conical or fan types. The total length of the elements equal one half-wave on the low band and 3 half-waves on the high band. (See Fig. 7a). The current distribution on the high band is the same as an ordinary low band dipole, with the outer two sections being out-of-phase with the center section. The normal split-lobe pattern is overcome by tilting the dipole forward from the apex. In this case, points B and C, which are the electrical centers of the outer dipole, are moved forward in space in respect to point A, (the electrical center of dipole A). Therefore, a considerable addition in currents occurs. In this manner, a significant amount of the cancellation from Dipole A is overcome. However, this pattern still produces side lobes on the high band. (Fig. 7b).

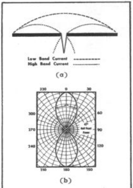
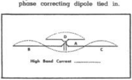


Fig. 8 — (a) Current distribution of dipole functioning as two half waves on the high band. This dipole is less than a half wave on the low band. (b) High band polar pattern of two half wave dipoles, side by side in phase.

Another criticism of this type in general is the fact that tilting the dipole forward reduces its area of interception which, in turn, means reduced gain. Moreover, since the fingers in the dipole simulate the sides of a conical section, they have a considerable vertical component which means some loss of efficiency plus additional sensitivity to vertical components in noise sources.

(d) Another type of dipole which has come into use recently is shown in Fig. 8a. Fig. 8b shows the horizontal polar diagram of this antenna. The tip to tip distance of this dipole is only 2 half-waves at the high band. A high band quarter-wave stub is hung from the feed points. On the low band, the total length of the dipole, including the length of the quarter-wave high band stub, is one half-wave. However, this quarter-wave stub does not contribute to the area of interception or space aperture, and the low band pickup of this dipole is approximately 1/3 less than an ordinary half-wave dipole. On the high band, the antenna acts as a voltage-fed, full-wave dipole; and since only *two* half-wave dipoles are operating here, approximately 33 1/3% of the potential pickup is again lost. Fair broad band operation in this antenna can be achieved by using large diameter conductors.

Fig. 9 — Straight dipole operating on third harmonic with one phase correcting dipole tied in.

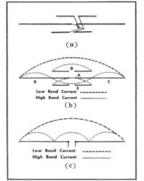


STEP-BY-STEP DEVELOPMENT OF A NEW ANTENNA

After reviewing the above material, Dr. Lo realized that the problem of getting the low band dipole to act normally on its own band, and as *three* effective dipoles in-phase on the high band, had not yet been solved by any of the existing types of antennas. In his early experiments, he hit upon the idea of reversing the phase of the center dipole during high band operation. This fruitful avenue of approach is shown in its earliest form in Fig. 9. This configuration effectively produced another high band half-wave dipole immediately adjacent to the out-of-phase section in the low band dipole, when operating on the third harmonic. Fig. 9 also shows the current distribution on the high band.

It will be seen that since Dipoles A and D occupy approximately the same point in space, they cancel one another, so that high band operation is achieved through the use of Dipoles B and C. However, this approach produced only *two* half-wave dipoles on the high band. Low band operation remained unimpaired. The next step, then, was to tie another high band half-wave dipole to these same feed points. (Fig. 10a). Fig. 10b shows an exploded view of this system and the resulting current distribution. As in the previous case, Dipoles A and D can be considered to cancel each other out; but now Dipole E fills the gap since this new dipole is in the same phase relationship as Dipoles B and C.

Fig. 10—(a) Low band half wave dipole with two high band phase correcting dipoles tied in. (b) Current distribution on both high and low band operation of type assembly illustrated in Figure 10 a. (c) Current distribution resulting from addition of all currents in Figure 10 b.



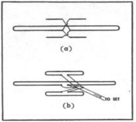
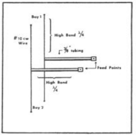


Fig. 11 — (a) Dipole circuit equivalent to Figure 10 a, using folded dipole for low band screen. (b) Completed dipole assembly using folded dipoles throughout.

Adding all the currents together, Dipoles A and D cancel each other out, and Dipoles B, C, and E are in-phase. The resultant current distribution is shown in Fig. 10c. This system did achieve in-phase operation of the three sections on the high band. and also functioned as a

Fig. 12 — Transformer arrangement for increasing the impedance of high band frequencies more than impedance of low band frequencies.



half-wave dipole on the low band. However, due to low impedance characteristics, it had limited band width.

OVERCOMING IMPEDANCE PROBLEMS

Throughout all of the above experiments, concerned solely with the development of a high and low band dipole, it was borne in mind that some reflector system would be required and that this would reduce the impedance of the antenna even further. Higher impedance was necessary and was obtained in the configuration shown in Fig. 11a, in which a folded dipole was used for the low band dipole, and straight conductors were used in the phase reversing dipoles. This design still lacked the high band characteristics necessary for flat response on channels 7 through 13. And so, in the final arrangement, (Fig. 11b), folded dipoles are used throughout the entire structure.

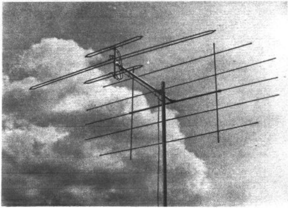
The impedance of each of the two small phase-reversing dipoles was well below 300 ohms, due to mutual impedance and coupling. Special one quarter-wave transformer lines had to be designed to transform these low impedances to sufficiently high values so that the total impedance of the three dipoles in parallel stayed in the vicinity of 300 ohms. In this final version, the high band impedance is slightly lower than 300 ohms, and the low band impedance is slightly higher.

ADDING A REFLECTOR SYSTEM

With the development of a dipole system which fulfilled the requirement of half-wave operation on the low band, and three half-wave in-phase operation on the high band, it was necessary to add a reflector system. A straight bar parasitic reflector was ruled out for the following reasons:

The maximum potential gain of a straight bar reflector is somewhat over 3 DB and can be achieved only at one frequency. A straight bar parasitic reflector could not function effectively on both the high and low band. However, a screen type reflector has an optimum gain of approximately 7 DB and is non-resonant. This means that the reflector itself is not frequency sensitive.

Our engineers designed a screen reflector big enough to give efficient reflection at the low band which, in turn, meant that its size was more than adequate for the high band. The dipole was spaced a quarter-wave from this reflector at low band operation and three quarter-waves on the



The single-bay Champion. Ideal all-VHF installation for local and suburban areas.

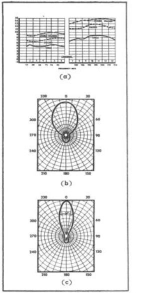
high band. An interesting mechanical arrangement was developed for this screen reflector so that the entire reflector could be preassembled and folded in manufacture, and opened up in a few seconds for installation.

STACKING THE ANTENNA

The widest application of this particular antenna system is in a two bay array. A stacking harness introduced other problems. Since the transformation of impedances tends to multiply differences, considerations had to be made for the fact that this antenna had slightly different impedances on the high and low bands. In order to insure optimum performance on both bands, the high band impedance was transformed in two stages, while the low band impedance was transformed in one. This is illustrated in Fig. 12, showing how the stacking harness provides an excellent match in the stacked antenna for both the high band and low band.

Gain figures and typical horizontal polar patterns for this antenna in single, two bay, and four bay versions are shown in Fig. 13a, b, and c. The truly remarkable high band efficiency of the antenna stands out particularly in the two bay version which has gains in excess of 10 DB across the entire high band. In conclusion, it is interesting to note that in following the logic of the development of the dipole system explained above, Dr. Lo evolved a broad band system entirely new to the antenna art.

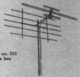
Fig. 13 — (a) Gain curves for single, two bay, and four bay antennas. (b) Horizontal polar pattern of completed antenna on channel 4. (c) Horizontal polar pattern of completed antenna on channel 10.



CHANNEL MASTER'S

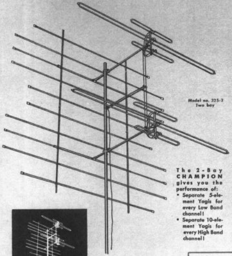
CHAMPION

out-performs every all-channel VHF antenna ever made!



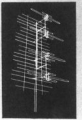
Model no. 325
One bay

2-Bay array gives:
- **11-13 DB on the High Band.**
- **6½-7½ DB on the Low Band.**



Model no. 325-2
Two bay

The 2-Bay CHAMPION gives you the performance of:
- Separate 5-element Yagis for every Low Band channel!
- Separate 10-element Yagis for every High Band channel!



Model no. 325-4
Four bay

The CHAMPION is versatile!
Ideal for any area:
1-Bay — Local areas
2-Bay — Secondary and fringe areas
4-bay — Super-fringe areas

Here is a totally NEW kind of TV antenna, completely different — in principal and performance — from any VHF antenna you've ever seen!

Channel Master's CHAMPION is the first antenna to employ a unique new broad band dipole system, in which the Low Band dipole provides exceptional Low Band gain, and also functions as *three* half-wave dipoles tied together *in phase* on the High Band. The result is an antenna that provides spectacular gain on every VHF channel, particularly on the High Band.

The CHAMPION is the most sensitive all-channel VHF antenna ever designed! It is an original development of the Channel Master Laboratories — further proof that Channel Master engineering *pays off* for you!

PREPARE NOW

Be ready for tomorrow's VHF channels in your area. The VHF area of the future, in almost every locality, will be a *multi-channel* area. Prepare now for outstanding reception on *all* VHF channels— present and future — with Channel Master's super-sensitive CHAMPION.

DR. YUEN T. LO

designer of the CHAMPION

Dr. Lo, the Channel Master scientist who headed the Development Project which produced the CHAMPION, is one of the few men in the country to have written a Doctorate thesis on the subject of antennas. In designing the CHAMPION, Dr. Lo actually created a completely new type of broad band dipole system — and made a major contribution to the field of antenna engineering.