The Helical Hi-Pot

AN EFFECTIVE "COMPRESSED" ANTENNA FOR THE LOW FREQUENCY BANDS

TAFT NICHOLSON, WØCKR*

THE HELICAL HI-POT ANTENNA, as the name implies, is a high potential antenna arranged in the form of a helix (*Fig. 1*). It can be adjusted to have the same voltage distribution as a sine wave, although its physical length is only a small fraction of a wavelength. For example, one of these antennas will be described which has a quarter-wave voltage distribution on the 75-meter band but is only 9 feet long (*Fig. 2*). As a one-terminal antenna it must, of course, be operated against a good ground, counterpoise, or another similar antenna. Two of the quarter-wave Helical Hi-Pots, horizontal, and fed with a piece of resonant RG-8/U, appeared to be less than 2 S units below a reference horizontal antenna. In fact, in 24 contacts there was only an average difference of 3 db. The reference antenna is a special antenna with a slight vertical gain (desirable on 75 meters) and is stretched out over a plot 90 × 40 feet and is well removed from the house. The over-all length of the Hi-Pot is 15 feet and it is 6 feet above the roof of the house. A method of reducing loss in the Hi-Pot will be suggested for further development. The Hi-Pot should not be expected to out-perform a normal half-wave antenna, but may approach this condition if the losses can be further reduced. For the amateur with limited antenna space it should prove useful in increasing the effective length of short antennas. It may be used as a counterpoise to work against a normal quarter-wave antenna, thereby reducing the space requirements by 50%. In this application it will work better than the average run of amateur ground systems. In many Marconi antenna systems most of the power is lost in the ground connection unless the ground system is large in size and in earth of good conductivity.

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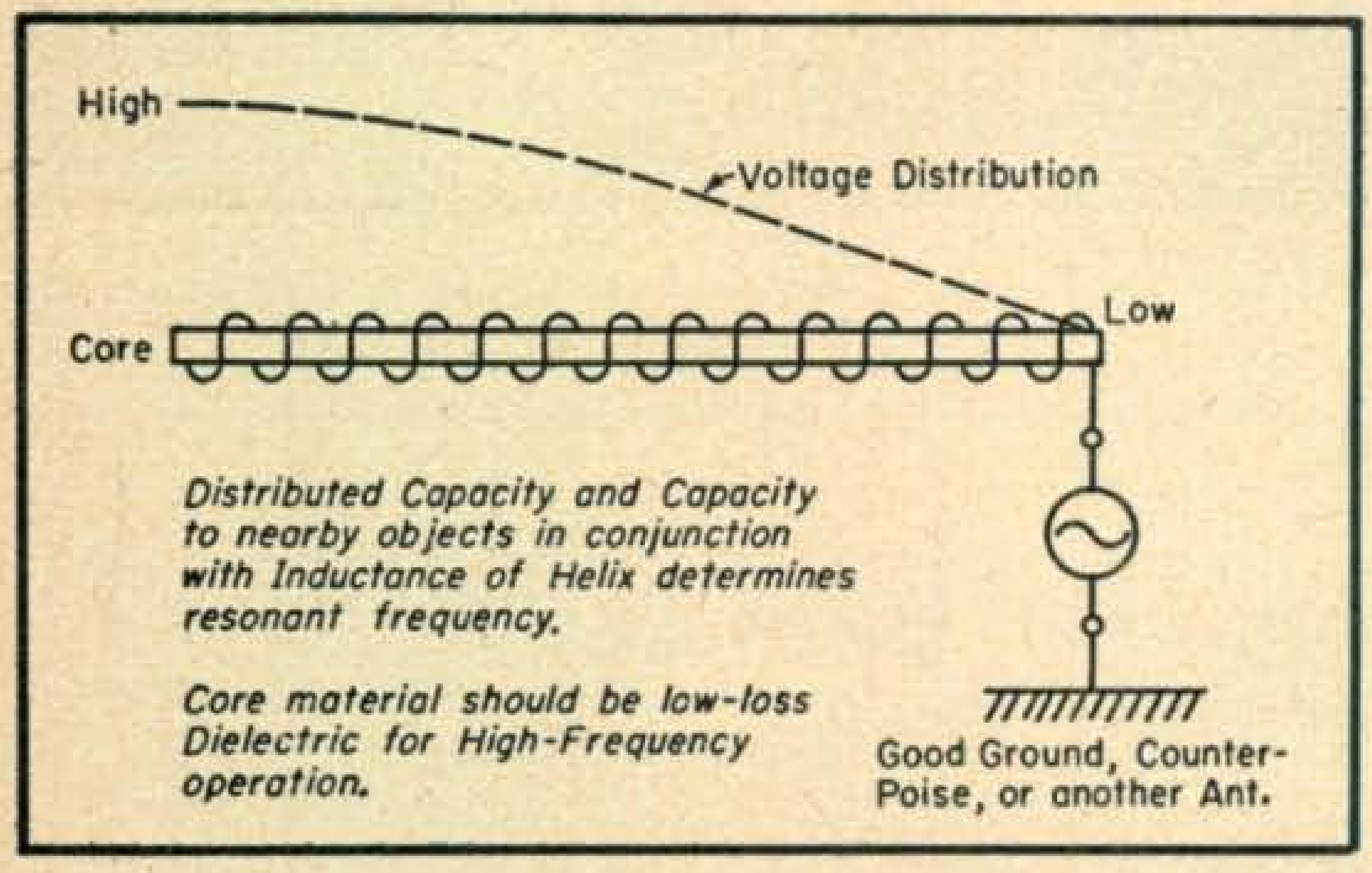

Fig. 1. The voltage distribution of the Helical Hi-Pot is similar to that of any quarter-wave radiator.

The Helical Hi-Pot is attractive as a mobile antenna and will work better than a solid whip of the same length.

Theory

Most radio men are familiar with the pattern of a half-wave dipole in free space (*Fig. 3*). This pattern may be found in the average text or antenna handbook. As the wire is shortened, the configuration of the pattern changes but very little and, for practical purposes, may be assumed to have the same pattern. It also follows that a short wire would be just as good a radiator, provided power can be put into it. This is the difficulty; as the length is shortened, the radiation resistance becomes very low so that eventually all the power is dissipated in the coupling circuits. Quite a bit can be done with low-loss coupling circuits, and the reader is referred to the design work that has been done on aircraft transmitters and their associated antenna circuits. There is a practical limit to this approach, however, and other means have been resorted to.

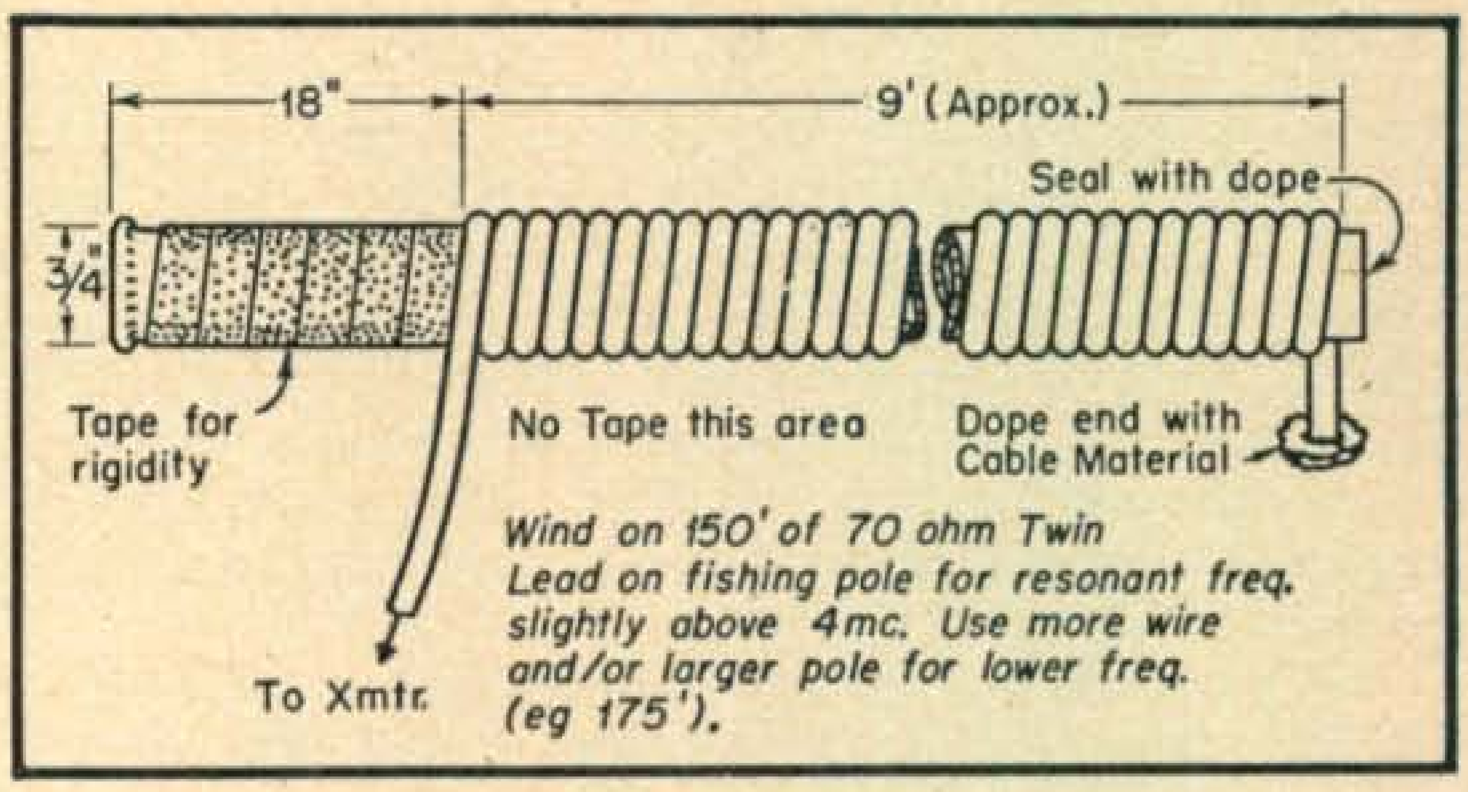

Fig. 2. Details of a nine-foot antenna for use on the 3.5-mc band.

The effective length or the radiation resistance of a short wire can be increased by a capacity end or top. The old "Tee" antenna is an example. In this case the flat top prevented the current from becoming zero at the top of the vertical down lead. Without the capacity top, the effective length of the vertical section is approximately 50% of the physical length (average of early part of a sine wave). With the capacity top, the effective length will approach 100% of the physical length, although never attaining this value due to radiation losses and electrical losses in the flat top. A quarter-wave vertical without flat top has an effective length of 63% of the physical length,

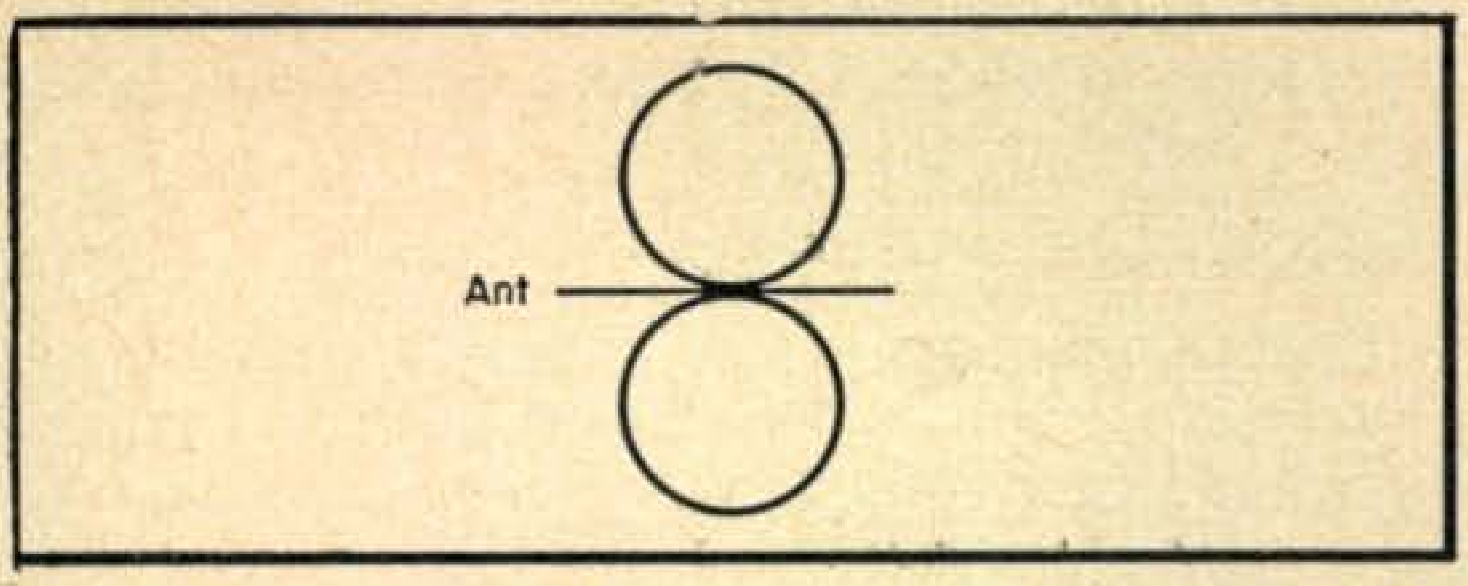

Fig. 3. The theoretical pattern of a half-wave radiator in free space.

but has a radiation resistance which can be handled easily.

Another example of the capacity top antenna is the top-loaded antenna which is used extensively by the standard broadcast stations. A smaller capacity top is used, but the same loading effect is obtained by using an inductance just under the capacity top—the inductance increases the effective capacity of the device, etc. In some respects this is a better antenna, inasmuch as the loading device does not distort the pattern of the vertical section, as does the flat top of the "Tee" antenna.

The half-wave dipole sets up a composite electric field by two means, namely, electrostatic and electromagnetic. The voltage is zero in the center and maximum at the ends, and therefore a voltage gradient of a given number of volts per meter exists along the antenna. This voltage gradient has the same dimensions as electrostatic field strength and contributes to the radiated field. The current in the half-wave dipole sets up a magnetic field which contributes to the radiated field. From transformer theory magnetic field

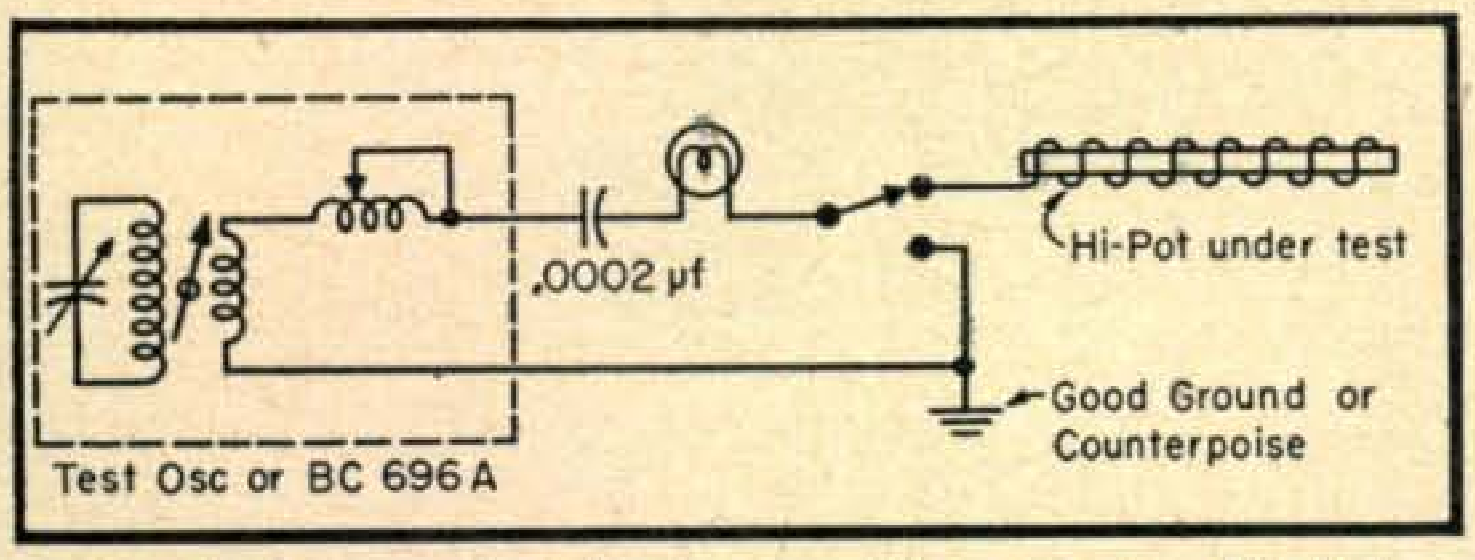

Fig. 5. Connecting the test oscillator to the Hi-Pot.

may be measured in ampere turns with certain assumptions. If the turns are less than one, as in the case of the antenna, the magnetic field is proportional to the length times the current flowing. If the current is not constant along the length, the field is proportional to the current times the effective length as discussed above. It will be recalled that the term "meter amperes" has been used as an expression of magnetic field strength. Thus, the half-wave dipole sets up a field in space about it by electrostatic and magnetic means.

Capacity-loaded short antennas make use of the magnetic field as the principal vehicle for radiation. The current is heavy and the voltage gradient is small. This may seem confusing at first, since all these antennas are "hot" with voltage. The voltage gradient is small because the voltage does not vary appreciably over the entire length. The short shunt-fed antenna, which has been recently described for mobile use, falls into the magnetic category but is not particularly "hot" with voltage. The author has been using a large shunt-fed horizontal antenna for the past three years, and the performance has been excellent on the lower frequency bands.

The Helical Hi-Pot falls into the electrostatic category. The voltage gradient may be controlled and can be made to have a sine wave distribution if desired. The "volts per meter" along the antenna is much greater than that of a half-wave dipole, and this fact compensates to some extent for its extremely short length. Although the current is heavy in the helix near the generator, this current is at right angles to the length and is confined; therefore, very little magnetic field exists in close proximity to the antenna. One of these Helical Hi-Pots wound out of #18 wire without end protection caught on fire with less than 200 watts input to the 75-meter phone transmitter at WØCKR. This will give some idea of the voltage built up along the antenna. When the Helical Hi-Pot is used to load a short wire, both induction fields are made use of. The magnetic field results from the heavy current flowing in the short wire feeding the helix and the electrostatic field from the helix itself. This combination was used successfully in 1939 by the author (W5ANB), and one is in use at the present time at WØCKR. One nearby local reports this antenna 30 db stronger than the regular horizontal antenna at this station. This ground wave is only good for a few miles at 4 mc, however.

The two Helical Hi-Pots recently constructed at this station were 9 and 6 feet in length. It would be possible to reduce this length by using smaller wire and on a larger diameter form and yet obtain an antenna with zero voltage at the generator and a very high voltage at the far end. The largest available length for the helical form should be used, however, in order to reduce losses to a minimum. In addition, the resistance of the antenna decreases as the length is reduced; therefore the coupling losses go up.

Harmonic operation of the Helical Hi-Pot has not been thoroughly investigated. The 9-foot antenna referred to above was excited at 28.5 mc and found to have 2½ standing waves of voltage. It remains to be seen whether a useful antenna can be developed using the device as a multi-lobe element.

If the losses can be overcome, the device could be used in a vest pocket rotary beam.

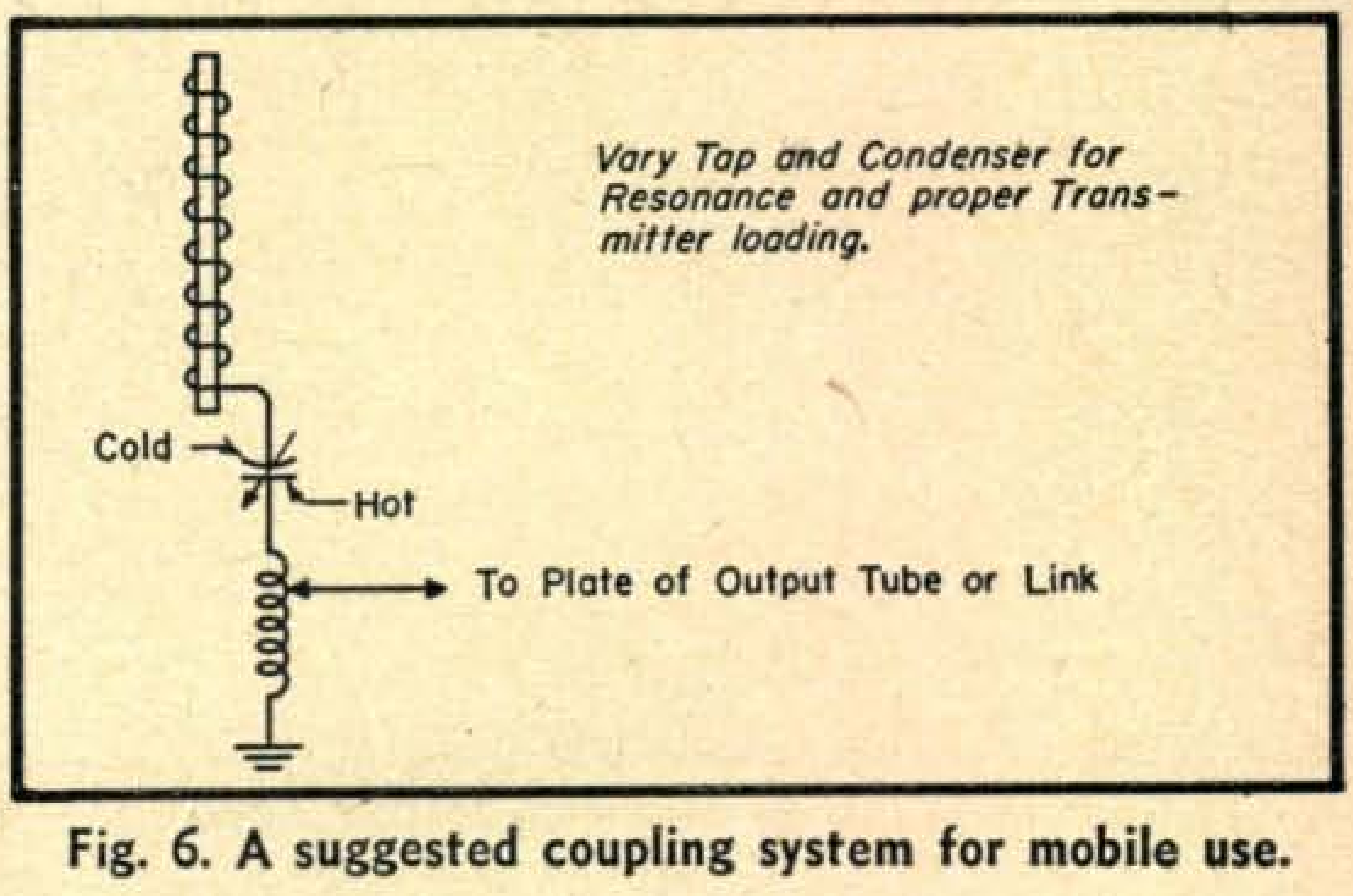

Fig. 6. A suggested coupling system for mobile use.

Construction

One of the Helical Hi-Pots will be described. The 9-foot antenna referred to above was made by winding 150 feet of 70-ohm twin lead on a bamboo fishing pole. See *Fig. 2*. This particular pole was slightly over ¾ inch in diameter at the base end and 16 feet long. The first 18 inches of the pole should be reserved for mounting arrangements and the winding started 18 inches from the base. The 150 feet of twin lead will cover about 9 feet of the pole. The one constructed resonated at approximately 4100 kc and was considered satisfactory since it was to be used eventually with a 25-foot lead-in for the 80-meter band. A lower resonant frequency may be obtained by winding on more wire and/or using a pole of larger diameter. A slightly larger fishing pole is suggested with 175 feet of 70-ohm twin lead. Both conductors should be placed in parallel connection at the starting end. The far end of the helix or coil should be turned back for about an inch and the bare wire end covered with twin lead dielectric or similar material to reduce the tendency for corona. The above antenna as described has not broken down with 200 watts of modulated power. The 6-foot antenna was wound with #18 enamel wire and did ignite with this power. With 10 inches of burned fishing pole at the end of the coil, the r.f. resistance of the element increased several times its former value. The burned portion was cut off and the resistance returned to a low value!

Adjustment

The resonant frequency of the element may be determined with a variable frequency oscillator or transmitter. A BC-696A was used at this station with a fixed 0.0002 μf condenser in series with its output. See *Fig. 5* for the test set up. Proceed as follows: With a good ground on the oscillator chassis, and with minimum output coupling, adjust the output tuning for maximum current with the flashlight bulb only in the circuit. The chassis connection of the flashlight bulb is then lifted and connected to the Helical Hi-Pot. Increase output coupling for medium brilliancy. If the current does not come up, the oscillator should be tuned throughout its entire range until the element does take current. When this frequency area is found, the above procedure should be repeated 2 or 3 times in order to cancel out the reactance of the tuned coupling circuit. When all adjustments are correct, and the oscillator frequency is the resonant frequency of the element, the setting of the loading coil for resonance will be the same for either the flashlight bulb alone or with the antenna in the circuit. If this frequency is below the

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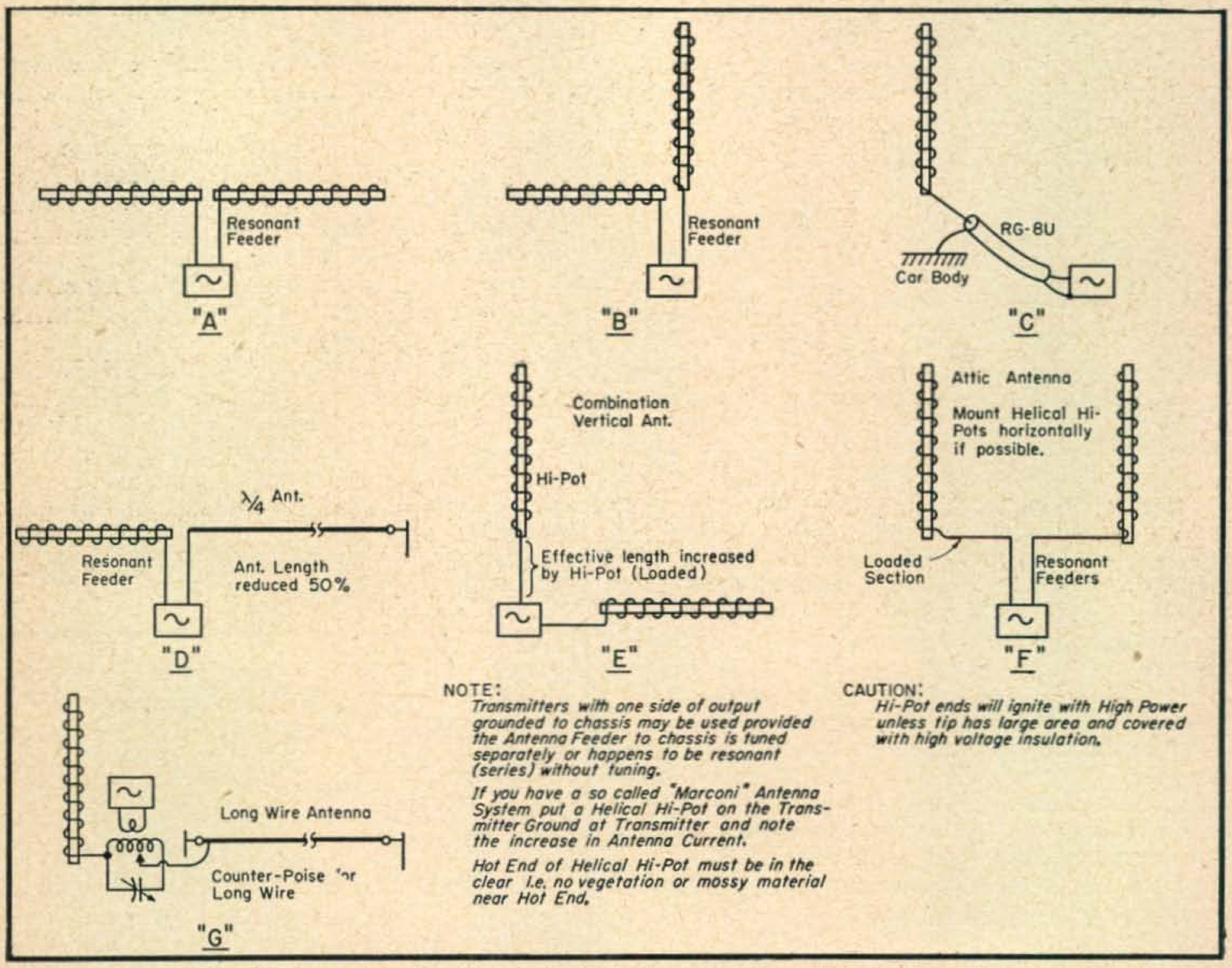

Fig. 4. These are only a few of the possible applications of the Helical Hi-Pot.

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supply will eliminate the latter, and a little judicious juggling of bypass condensers at the BC-459 power plug will cool off the lead that is radiating.

If this article makes it appear that eliminating television interference from the BC-459 is an almost hopeless task, this is not so. In the majority of cases, stabilizing the 1625s and eliminating key clicks is all that is necessary. To be complete, however, it was necessary to discuss the more difficult cases. Besides, the changes suggested will improve the unit as an amateur transmitter, even where television interference is not a problem.

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operating frequency, a series condenser may be used for tuning. If the frequency is high, use a series loading coil, etc. The antenna element should be mounted in the clear, especially the far end. Stray capacity at the far end will lower the resonant frequency of the element. A small whip or metallic object may be placed at the far end to lower the resonant frequency if this is desired.

Further Developments

Losses in the Helical Hi-Pot may be reduced by using larger wire and winding it on a low loss core such as the "poly" materials. For a given length of pole and frequency, there should be an optimum diameter, and this diameter would be somewhat dependent upon the dielectric losses of the pole. It should be possible for a wire manufacturer to produce the Helical Hi-Pot by the foot in any desired length. There may be a market for helically-loaded cable of this sort for low frequency radio work. It may also be possible to use magnetic core material with an insulating binder for low frequency work.

The voltage gradient of the device may be adjusted by changing the turns per inch along the length, however, this complication may not be warranted.

If the Helical Hi-Pot is operated against a good ground, car body, or similar element, lower losses will be obtained if the antenna system is tuned separately and direct coupling used to the transmitter. *Fig. 6* is an example of this type of coupling.

Results

The most practical uses of the Helical Hi-Pots are to increase the effective length of a short wire or its use as a counterpoise or low impedance reference point to reduce antenna length 50%.

Since its impedance is low, it serves either of these purposes well. Refer to *Fig. 4* for suggested arrangements.

It has been noted recently that long distance daytime contracts on 75 meter phone are worked better with vertical polarization. This has not been found true for stations within 150 miles or any stations at night. The 9-foot Hi-Pot referred to above has been mounted vertically with a leadin having a 15-foot vertical drop. This antenna is usually worked against a 66-foot horizontal antenna to give a Bi-polarized effect. Some daytime signals which are unreadable in the noise with the regular all-horizontal antenna are readable with the vertical antenna, in spite of the fact that power line noises have a higher level in the vertical antenna. The same stations are stronger at night using the horizontal antenna. Most local contacts are better with the vertical antenna.

The work of Mr. Wade Spears, W5GCB, on this type of antenna is acknowledged. Mr. Spears and the author conceived the idea for the antenna in 1939. One was designed and used at W5ANB. Mr. Spears applied the design to an automobile whip for police operation in the 1700 kc band. The design was used extensively in the Oklahoma Highway patrol radio service and has since, I believe, been used in other states. At that time, Mr. Spears reported outstanding improvements over the conventional whip.

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