USING A T NETWORK

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The Pi-network is familiar to all as a circuit used in most transmitter output stages and unbalanced type antenna tuners. A 'T' network tuner, which employs the same elements as a pi-network but in a different circuit arrangement, has definite advantages over the pi-network when a match to very short antennas is required.

THEORETICALLY, whenever two impedances are matched by a 3 element reactive network of either the pi or T configuration, (fig. 1) the losses should be the same whichever network form is used. Intuitively, this is understandable since complementary current and voltage relationships must exist regardless of the network used if the terminal impedances are to be properly matched.

In practice, however, various other factors enter the situation which may upset this idea of equality. For one thing, the dissipative losses in various reactive elements is different, generally lower in variable capacitors, for instance, than in large inductances. The physical size, cost, *etc.*, of the practical elements needed to match a given set of impedances may also make one form of circuit more desirable than another.

The pi-network has received deserved acceptance as a versatile and generally easily adjustable form of matching network. Details of its construction is well documented in many articles and handbooks and will not be repeated here. One sees for less usage, however, of the T form of matching circuit and yet for the proper application, it can be more useful than the pi-network. The purpose of this article is not to present any detailed theoretical discussion of the T network, but to generally explore the conditions under which it is useful and to give some values for practical circuits.

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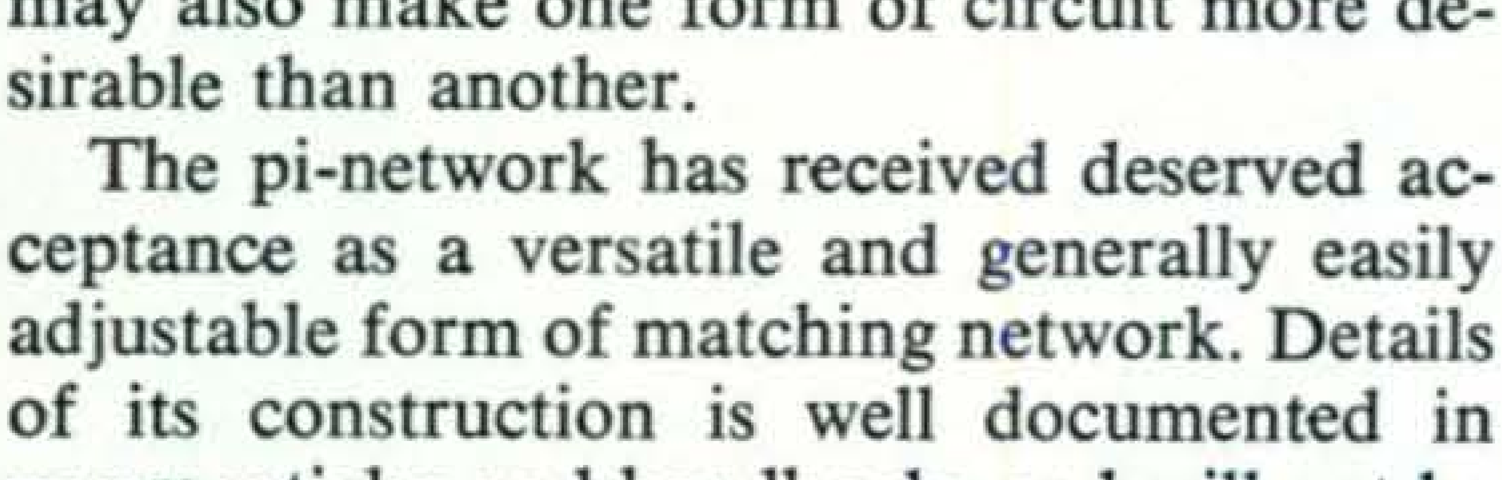

Fig. 1—Theoretically the losses using a 3 element reactive network will be the same for a given impedance match for either a pi or T network.

Basic T Network

The T network can be visualized as a combination of L networks, the same as the pi-network, Figure 2(A) shows the usual L network and the pi-network. The pi-network can be formed by connecting another L network, reversed and following the first L network. The T network can be formed by connecting another L network, reversed, but preceding the first L network.

For a given impedance transformation, the values of the two reactances (in ohms) which form the basic L network are equal. Therefore, while practical construction restraints usually preclude its use, there is no reason why the basic L network cannot be constructed as shown in fig. 2(B) with the reactive elements interchanged. Both pi and T network forms using this version of the basic L can also be formed as shown.

A total, therefore, of four networks (2 pi and 2 T types) can be formed, all of which can perform the same impedence matching function and all of which can be made to have the same bandwidth and harmonic reduction features.

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Aside from the physical component values which result, the one pi and one T form which use two inductors are undesirable because of the losses that would take place, the cost of the inductors and the difficulty of bandswitching two inductors. The two forms which are left are the conventional pi-network and the less well known T network with capacitive legs.

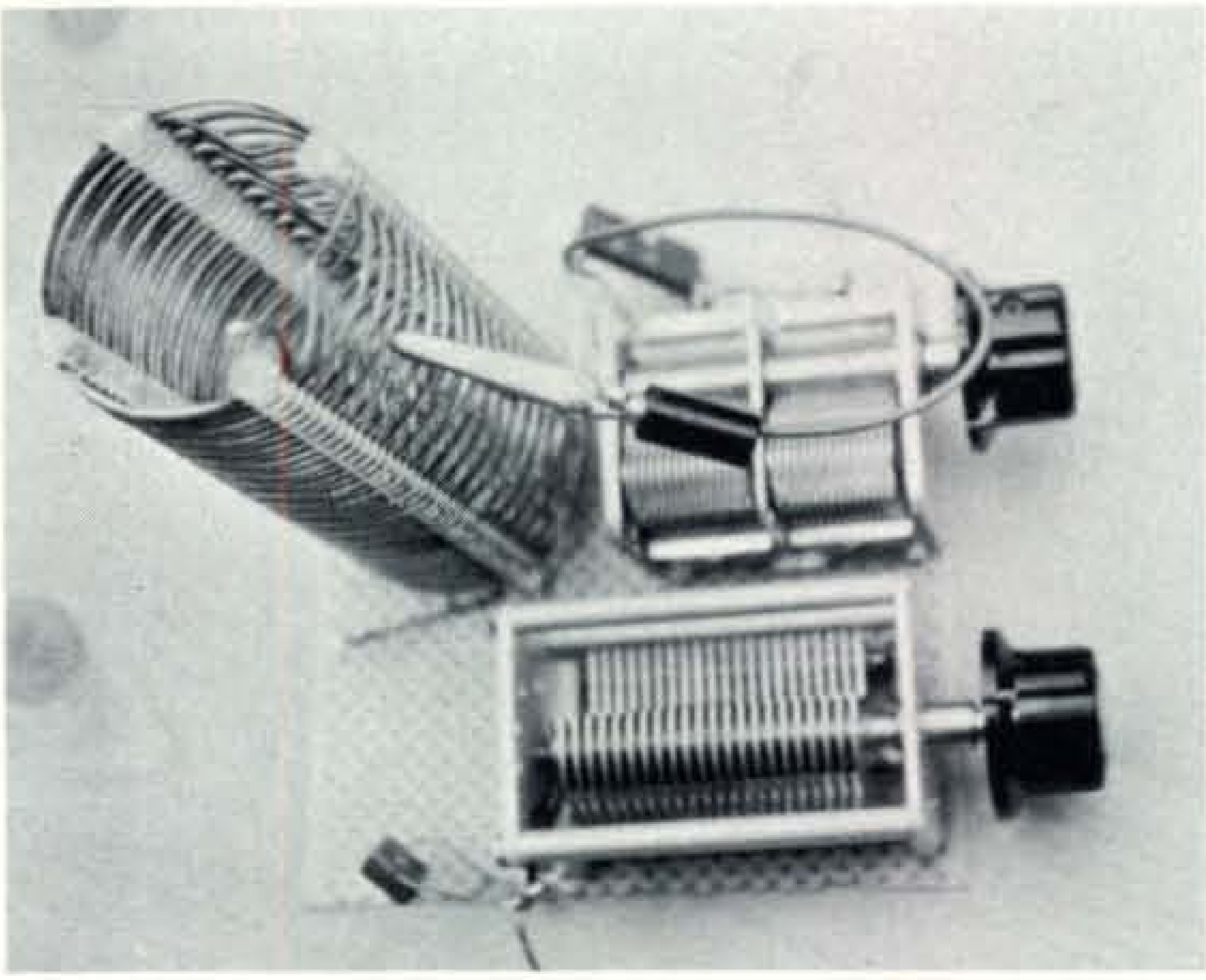
The T network for a practical matching problem, such as that for which a pi-network might be used, has the advantage that one trades some capacitance for inductance and the coil size required will be somewhat lower than for the pi-network. This factor combined with the one that less current flows through the inductive branch means that overall losses, assuming the use of good quality air variable or vacuum variable capacitors, should be somewhat lower with the T network. The difference in efficiency between the pi and T network forms becomes most noticeable when a large impedance transformation must be made (such as from a very short antenna used on a low frequency band) and when high power is used. Less loss will occur in the T matching network and, if bandswitching is employed, component requirements are less stringent. Usually one large range air or vacuum variable capacitor in each leg will suffice to cover the bandswitched network operating from 80-10 meters. Only the inductor element has to be switched and this can be done by a relatively simple and inexpensive switch since one end is grounded. The insulation requirements are reduced, especially when matching a very reactive load. In a pi-network this would require the inductor bandswitch to be well insulated from ground.

Test Circuit

Figure 3 shows the component values for an experimental T coupler built by the author and the photographs show the simple grouping of the components. No chassis construction was used since the circuit was experimental in nature and designed only to prove the coupler before later constructing a more elaborate model.

The values given for the components are such that a 50 ohm coaxial line can be matched to a highly reactive load (a 12 to 16 foot whip) over the 80-10 meter range.

The network is adjusted similarly to a pi-network with a value of inductance being chosen and then the variable capacitors used for tuning and loading functions. A field strength meter should be used to determine which set of element settings gives the best efficiency although, invariably, it will be found to be the one using the least inductance with capacitor values such that the transmitter can still be properly loaded (1:1 s.w.r. on the coaxial line between the transmitter and T network).



Simple T network configuration used to check comparative performance of pi and T network using various length antennae.

Loading on all bands was easily achieved and with far less problems than ever would have been possible using a pi-network with such a short antenna. An exact comparison of the network performance versus a conventional pi-network was not possible because of

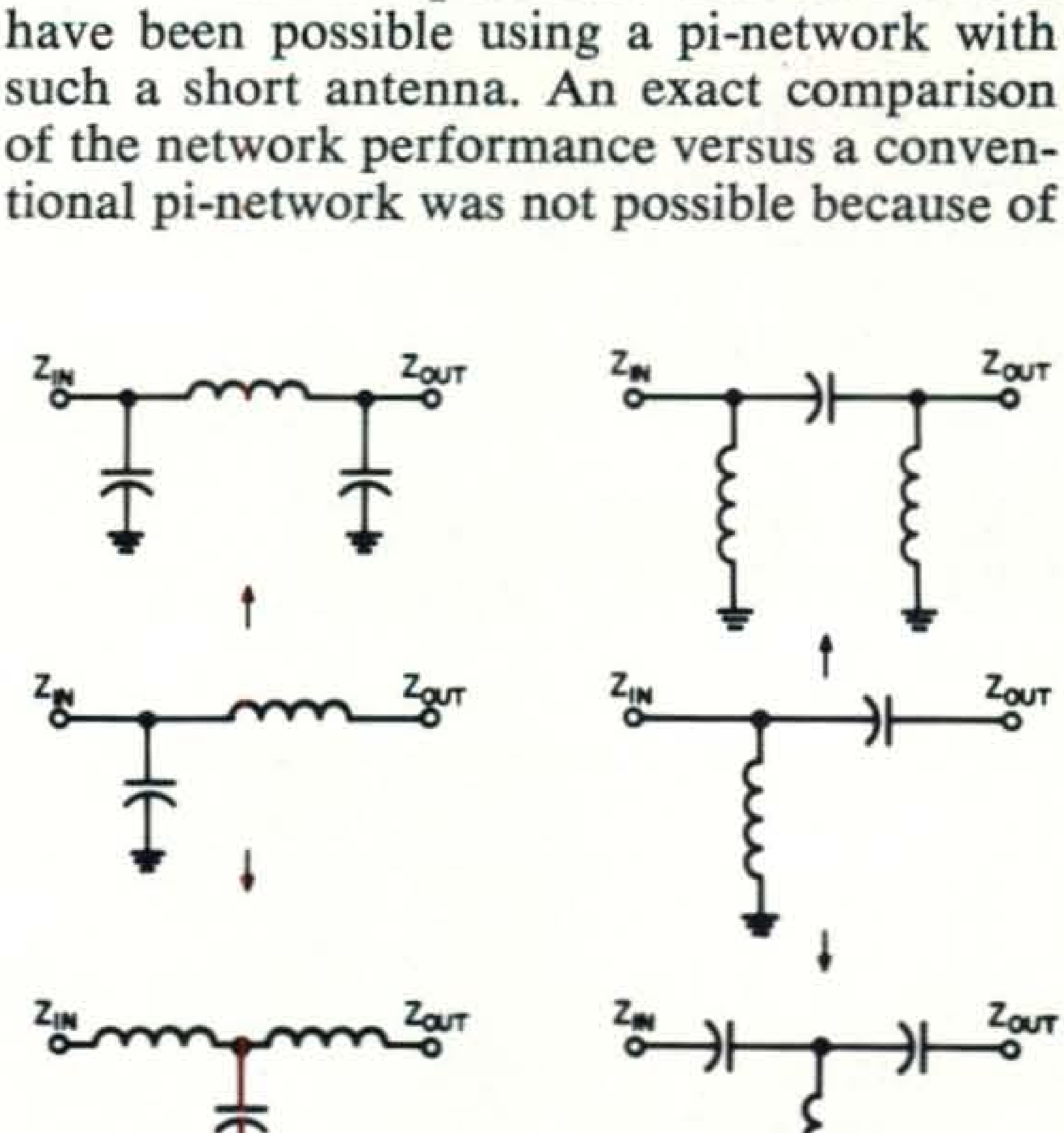


Fig. 2—The reactive values of the arms of the L network are equal in (A) and (B) for a given impedance match. One form of pi and T network can be constructed from each basic L section.

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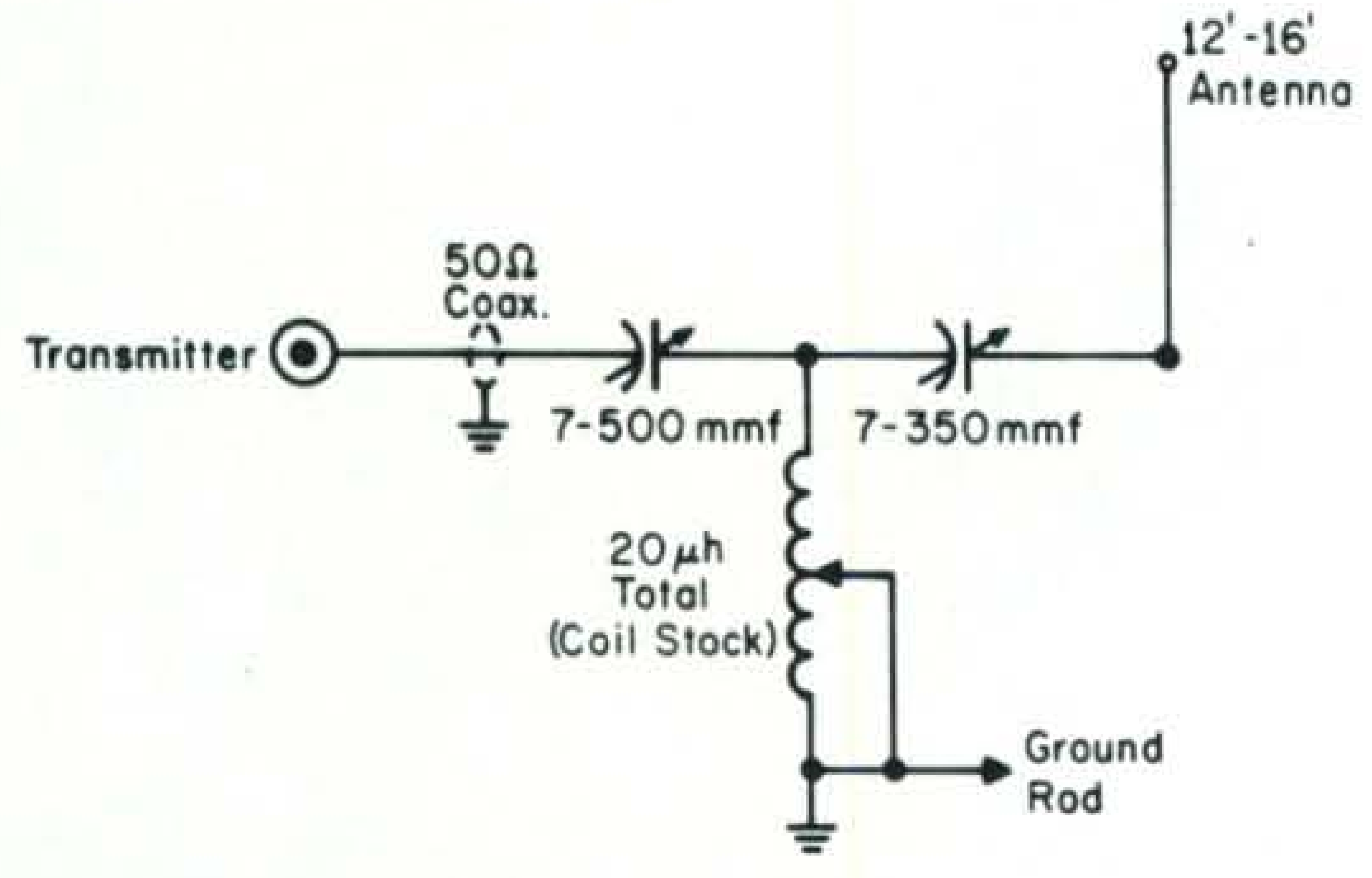

Fig. 3—T network constructed to operate into short antenna on 80-10 meters.

the time required to change and adjust the networks. The general impression, however, was that the T network was definitely superior on the lower frequency bands, 80 and 40, and this coupled with the ease of loading on these bands made us regard the experiment as a success.

Summary

On the higher frequency bands and when using an antenna of reasonably long length (¼λor more) there would seem to be little advantage to the T network over the pi-network. However, on the lower frequency band and when using a very short antenna, the T network appears to be of definite advantage.

This form of antenna coupler has already been used by commercial equipment manufacturers where, for instance, a high-powered mobile transmitter must be matched to a short whip which could not be inductively loaded because of the possibility of damage to the loaded whip due to physical factors. The approach may be very useful for amateur mobile operation on the lower frequency bands by having a well constructed T network in the trunk of a car and eliminating the inductive loading of the whip antenna. The increased efficiency of the T network may well compensate for the improvement in efficiency achieved by center-loading versus base-loading of the whip and so one could have still efficient mobile installation (as far as mobile installation efficiencies go, anyway) without a costly and conspicuous antenna structure. Otherwise, the T network should also be useful in a fixed or portable situations for anyone constrained by a short antenna on the lower frequency bands.

As with any antenna coupler, the practical efficiency depends upon the quality of the components used. Fortunately, with the T network this is not difficult to achieve since the component values are such that readily available parts can be used. If possible, fixed capacitors should not be shunted across the variable capacitors to increase the total capacity, since unless expensive transmitting mica types are used, they will degrade performance. For low power installations (up to a few hundred watts) the inductor wire size can be #12 or #14. For higher-power installations, the inductor should be made of 3/16 to ¼ inch tubing. In the latter case, for a given installation, the inductor value required can be determined using very low power and a small wire-size inductor and then the larger inductor constructed according to the values found. ■

BY THE WAY...

VQ8RCS On Top Of The World

This is a view of the world's most northerly amateur radio station, VQ8RCS, 437 miles from the North Pole. The operators of the station (Canadian Forces Alert, Alert, Northwest Territories, Via Ottawa, Ontario, Canada.) and other operators throughout Canada are constantly making phone patches for the men stationed at Alert to keep them in touch with their families. Conditions permitting, VQ8RCS is on the air daily, on 14.165 mc ready to contact amateurs in all parts of the world. If you hear them on, give them a call.

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