A New Look At Helically Loaded Antennas

BY JOHN SCHULTZ, K3EZ

The advent of PVC (and similar plastic materials) for piping has certainly made simple plumbing jobs easy for the handyman. It has also lead to the birth of a few new ideas for antennas for radio amateurs since the plastic tubing is available in lengths up to 20 feet, in diameters up to several inches and with a variety of accessory T-joints, bends and angles such that almost any antenna form can be constructed. No threading is involved; the parts are bonded together with a special cement. Adapters with threading are available, however, if one wanted to go, for instance, from a PVC boom on a beam to a steel pipe as a mast. The PVC tubing is tough and can be used outdoors under almost any condition.

The PVC tubing can only serve as a form for an antenna, however. One would not want to build a full-size antenna out of PVC since aluminum could then be used as well. So, the PVC material is ideal if one wants to build some form of shortened antenna—be it a dipole (one-element beam), a multi-element beam or a vertical. Articles have appeared before using this idea but the shortened antenna form was achieved either by lumped constant loading (a big inductor) with its consequent losses or by more efficient helical loading. But, the latter required the tedious winding and glueing of wire around the PVC tubing. Fortunately, the advent of stainless steel tape has changed this. This tape can be wound easily around the PVC tubing to form a constant helical loading of an element. Furthermore, it is weatherproof, can be soldered to attach transmission lines and has low loss at h.f. because of its large surface area.

The marriage of PVC tubing and stainless steel tape can produce a variety of efficient, low-cost shortened antenna forms ranging from helical loaded mobile antennas which are more efficient and have greater bandwidth than the usual base or center loaded type; to disguise balcony antennas, to portable antennas, to shortened multi-element beams, etc. The purpose of this article is not to present any specific antenna type, however, but to give the amateur a design guide and method for approaching the construction of such an antenna. One could, of course, rush out to buy PVC tubing, stainless steel tape and start winding the tape around the tubing. Eventually with the use of a grid-dip meter and s.w.r. meter a workable antenna will be developed. But, it would be easier to do a few simple calculations first and consult the graph presented in this article to get the antenna dimensions in the right ballpark at least.

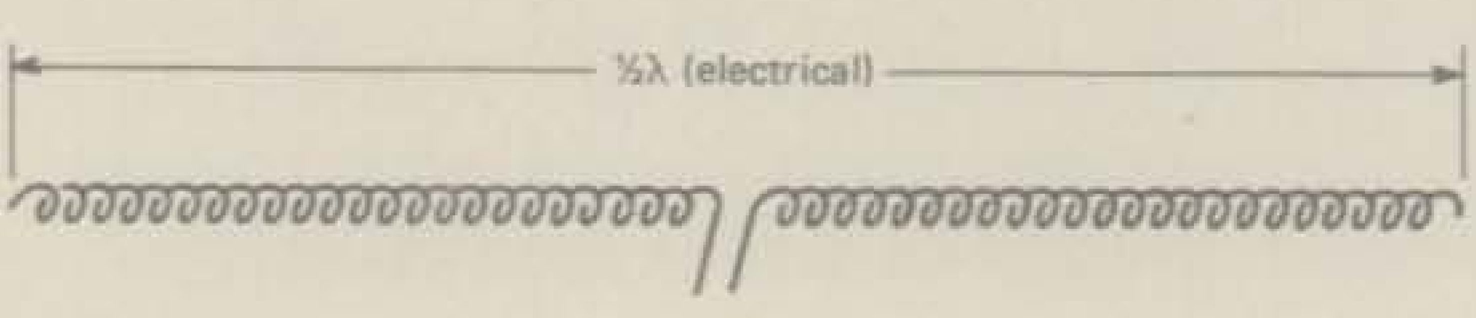

Fig. 1—A helically wound half-wave dipole with a constant diameter and pitch of the windings.

The helical form of loading is simply constant inductive loading along the length of the antenna as shown in fig. 1 for a simple half-wave dipole. The essential characteristics of the dipole are maintained (that is, maximum radiation broadside to the axis of the antenna) as long as the diameter of the loaded element is small as compared to the operating wavelength. This will certainly always be the case on the h.f. bands using PVC tubing. If the diameter starts to become significant in terms of wavelength (perhaps 10% or more) then the basic dipole characteristic will change as significant radiation starts to take place from the ends of the antenna.

Unfortunately, one cannot measure out a half-wave-length of tape for a given band as based on the usual half wave-length formulas, wrap it around the tubing and have an antenna that resonates properly. The spacing (pitch) of the windings, size of the tape width and diameter ratio of the tubing with regards to wave-length all play a role in making the antenna resonate properly. These terms are illustrated in fig. 2. The only exception to this might be if one simply wanted to construct a helically loaded vertical in a space-available situation and then use it with a transmatch at its base to get power into it on any given band. Especially on the lower frequency bands where the loaded antenna does not exceed a ¼ , this will still get more power radiated than loading into a metal rod of the same length as the tubing.

Fig. 3 presents an emperical graph which can be used to determine the spacing of the windings needed on tubing and possible tubing diameters to use. By another simple formula (given later) one can determine the total length of stainless steel tape needed to be wound on the tubing. The graph does not yield exact, unique solutions for any antenna but rather indicates possible combinations of winding pitches and tube diameters that will work. The graph is good for the cases where one might employ 1″ wide steel tape wound on a 4″ diameter PVC tube to ½″ wide tape on a 1″ diameter PVC tube. Naturally, to reduce ohmic losses it is desirable to use a large width tape but the tape width has to be governed by the pitch and this in turn is governed by how much one wants to reduce an antenna in size from its full length.

Some examples will make this clearer. The graph is based on the size reduction desired for an antenna. A ¼ whip for 20 meters in full size would be about 16½ feet long. Say we want to reduce this to about 8 feet or about 50% of its full size by helically loading an 8 foot length of PVC tubing. Entering the graph at 50% we encounter three possible D/L ratios (diameter of tubing to length of tubing) of .01, .02 and .04. Since we know L (8 feet or 96″), the corresponding diameters would be .96″, 1.92″ and 3.84″. For a mobile application, the .96″ diameter possibility using 1″ diameter PVC looks interesting. The .01 D/L line at 50% produces a P/D ratio (pitch to diameter ratio) of about .75″. So, the taped turns have to have a center-to-center spacing of .75″ which means the tape can only be about ½″ wide to provide a ¼″ gap between windings.

For a fixed station installation one might go all the way up to the available 4″ plastic tubing for the 3.84″ result on the D/L ratio of .04. From the graph again, at 50% size reduction and for a D/L ratio of .04, the P/D result is about 1.5. For a diameter (D) of 4″, the pitch is 6 inches. This is long enough to easily use 1″ wide tape and to have the spacing great enough so the turns are sufficiently separated even at voltage maximum points on the antenna with high power.

Obviously, all sorts of combinations are possible but size reductions greater than 30-40% usually yield unrealistic results. One could build a 40 meter rotatable dipole only 20 foot long but the tape width would have to be reduced to the point where losses increase significantly, bandwidth would be restricted to a small portion (perhaps 50 kHz) of the band, and the antenna would only be good for low power because of the very close spacing of the turns. But, reasonably size-reduced beams, quads and verticals can all be produced with the helically wound tape method while preserving better efficiency and bandwidth than with lumped constant loading. One can go back and forth with the graph. That is, start with a desired reduction for an antenna, start with a length of space available for tubing, start with a tubing size or even start with a given pitch and then determine how the other factors come out. Don't forget also that various sizes of PVC tubing can be nested together. So, one can produce a tapered helically loaded element by calculating the pitch, etc. for each length of different diameter tubing. This has the nice advantage that the pitch of the larger size tubing can be made so wider tape can be used at the center of a dipole or base of a ¼ vertical, where the current is highest, to reduce ohmic power loss. The graph was based on test results using a constant diameter but there is no reason to believe that it would not be reasonably accurate for the tapered diameter situation also.

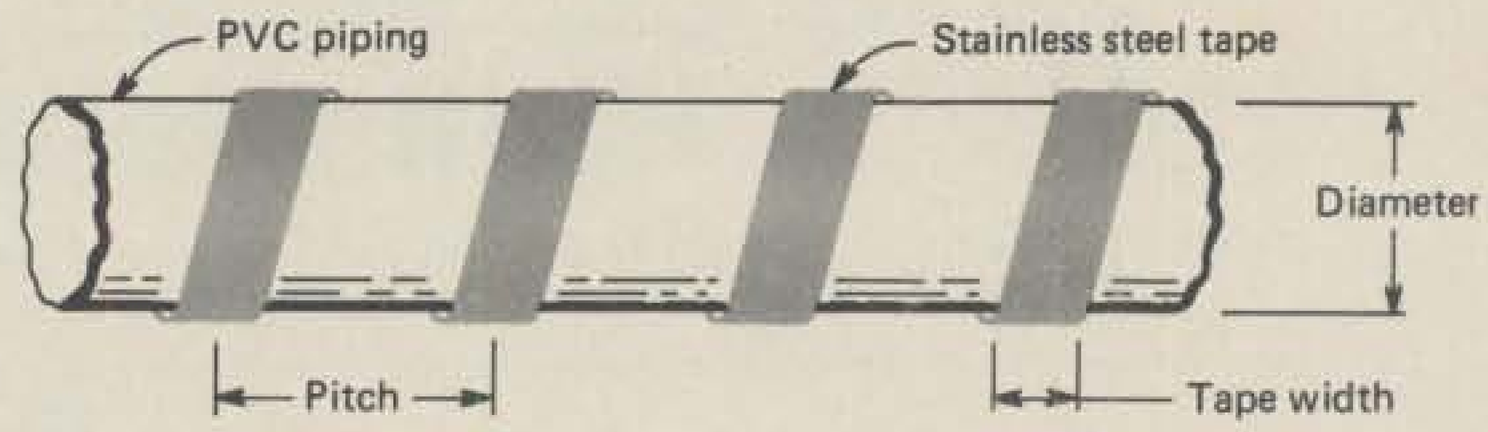

Fig. 2—Stainless-steel tape used over plastic PVC tubing to provide helical loading.

The length of tape needed can be calculated from the formula $\frac{L}{P} \times \sqrt{P^2 + (\pi D)^2}$. This is the number of turns ($\frac{L}{P}$) times the stretched out length of one turn. Steel tape isn't as cheap as Scotch

(continued on page 73)

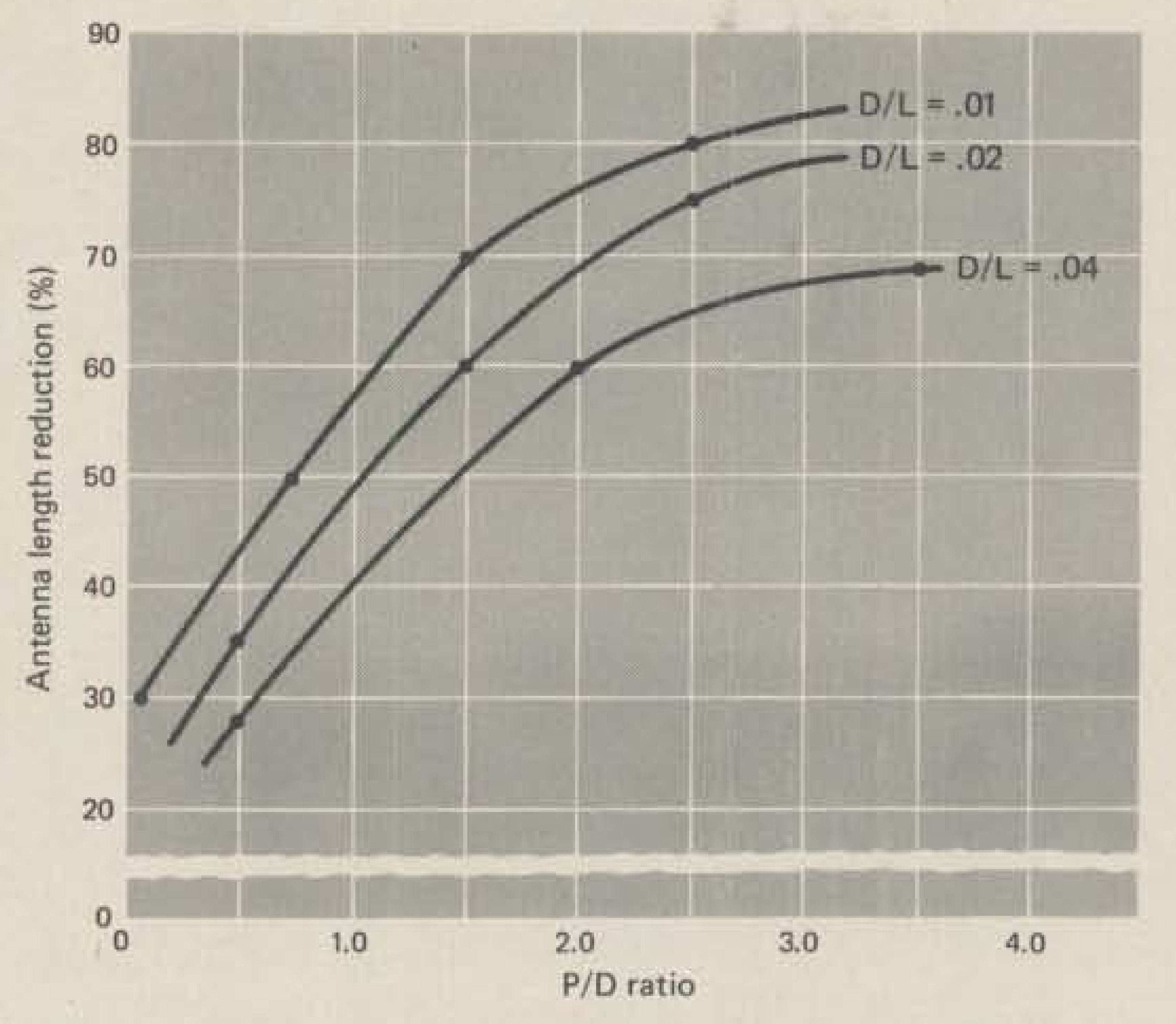

Fig. 3—A graph to determine helically loaded antenna dimensions. Refer to the text for examples of usage.

Waldmeier, M., 1961, *The Sunspot-Activity in the Years 1610-1960*, Schulthess and Company, Zurich, Switzerland.
Waldmeier, M., (Monthly), *Monthly Sunspot Bulletin, Swiss Federal Observatory*, Zurich, Switzerland.
Wolf, R., 1852, *C.R.H. Acad. Sci.*, Vol. 35.
Wolf, R., 1868, *Astron. Mitt.*, Zurich, Vol. 24. ■

Deception Island *(from page 19)*

countered. I later learned that another volcanic eruption had occurred just a few months after we departed from Deception Island.

It is hard to predict when LU1ZC will be activated again, but if the scientists that have studied the volcanic activity of the island are correct in their predictions, the volcanoes that once silenced the radio amateur stations in the island will remain very active for a long time. ■

Helically Loaded Antennas *(from page 21)*

tape yet so it pays to do a bit of hunting around for a good price if a considerable quantity is desired (20 feet, one inch wide should run about $2 at most auto/hardware outlets).

The final turning of an antenna will have to be done using a grid-dip meter and a s.w.r. bridge by pruning turns at the ends of the elemen(s). Turns can be removed or a few turns wound more closely (and with smaller width tape) at the end to vary resonance. The grid-dip meter is used to check approximate resonance and then a s.w.r. meter used for final tuning within a band.

Although stainless steel tape is weatherproof by itself, further protection can be afforded by spraying the finished element with a clear plastic coating such as Krylon. Although no test data is available, it would seem that painting an antenna element with an acrylic resin base paint will not effect its electrical performance if one wants to hide the presence of the shiny stainless steel tape.

This article has not presented the reader with specific numbers on antenna construction, except for the design example. It may take a little time to figure out dimensions for a given antenna need but think of the simplicity of construction—steel tape wound on PVC tubing—as compared to constructing, waterproofing and tuning other loading devices.

Bandspread for SP-500-JX *(from page 24)*

across the dial-plate, to under the main tuning knob, which is supplied with the vernier; the width is not important. A line is drawn down the middle of the dial-pointer, and then half the plastic is cut away. This will leave only the permanent-ink line and half the plastic piece. This aids in calibration-marking later. The pointer is then mounted on the template with a self-tapping screw.

Finally the dial plate is cut from stiff, thin aluminum stock and a ½-inch hole punched in the center