A Kite-Supported 160- (or 80-) Meter Antenna

"The Parafoil® is a ram-air wing type aerial device that has no rigid parts. If it is shaped like a wing, and looks like a wing, then it must be a wing. A Parafoil rises against NOT WITH the wind." — Domina Jalbert, a pioneer of tethered flight.

By John S. Belrose,* VE2CV

Kite flying is a sport that from early times has been a national pastime of Asian peoples. Kites have also been put to practical use. In 1751, Benjamin Franklin hung a metal key from a kite line and, by attracting electricity during a storm, demonstrated the electrical nature of lightning. In 1901, Guglielmo Marconi[1] flew a kite-supported antenna from Signal Hill, St. John's, Newfoundland and succeeded in receiving radio transmissions from the Poldhu Wireless Station in Cornwall, England. Kites were long used for weather observation, with instruments being carried aloft to record data.

There are about five basic types of kites: the 3-sticker (hexagonal), the Malay (modified diamond), the box kite, the tetrahedral and the parafoil, an aerofoil kite. The shape of the kite can be designed so that the kite will be self-correcting by incorporating a diehedral (two-sided) angle in the surface, or by bowing the main cross-stick to a depth of about 10% of its length. This latter type is the kind of tailless kite that Marconi flew. If not self-correcting, the kite will require a tail for stabilization.

The box kite,[2] the invention of an Australian named Lawrence Hargrave in the 1890s, is identified by its rectangular shape. The frame is twice as long as its width, the ends are left open, and one-third of its length is covered around each end. The bridle consists of two lines, one to each end of one of the vertical sticks, meeting a little above the lower edge of the top panel. The kite flies on one edge and needs no tail.

The tetrahedral kite[3] was invented by Alexander Graham Bell in about 1903. This structure, of triangular construction in every direction (longitudinal as well as transverse), was developed in his Nova Scotia laboratory. It is formed by six equal rods, and has great strength and lightness. Two of the sides of the tetrahedron are covered, and this constitutes the "sail" of the kite. A toy Tetrakite® manufactured by Synestructics, Inc.[4] has four such cells, hence four sails. Their Super Tetrakite has 16 sails.

Marconi launches a kite-supported antenna from Signal Hill, St. John's, Newfoundland, and succeeds in receiving radio transmissions from Poldhu, Cornwall, England (1901).

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[1]Notes appear on page 42.

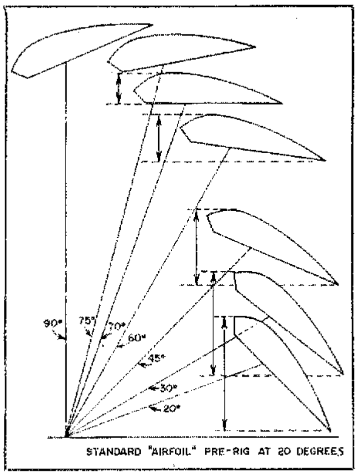

Fig. 1 — Sketch illustrating how stable flight is achieved with a Jalbert Parafoil. If the kite overflies, it stalls; if it underflies, it gains lift. It is a self-correcting device.

The tetrahedron shape is such that in every direction the cross-section is the same, which is the reason that the kite is so steady in flight. The kite flies on one edge of the sail(s) and needs no tail.

For the application considered here, viz. a kite-supported antenna for portable use, the Jalbert Parafoil kite[5,6] is perhaps the best of the various types of kites. The Parafoil is a ram-air wing type aerial device that has no rigid parts. It requires no sticks to carry and assemble. It combines in a marked degree the qualities of strength, lightness, lift and steadiness of flight. The Jalbert aerofoil kite achieves its lift and stability through its excellent aerodynamics, because its shape is that of an aerofoil. The bridal, which resembles the shrouds of a parachute, is prerigged at 20° so the kite flies stably when its kite line makes an angle 70° from the horizontal. If the kite overflies, it stalls; if it underflies, it gains lift. Hence it is always trying to fly at the design angle (Fig. 1).

The leading edge of the kite is open to wind, and it is launched by holding this edge into the wind. The kite fills with air, and becomes "rigid" because of the ram-jet action of the wind. A small amount of the air that enters the kite is bled out at the rear edge of the kite, and these jets blow onto the webbed "tail" flap, providing additional stability. The fins also act like stabilizers, similar to the rudder of an airplane.

Kites as antenna supports can be very successfully employed in the Arctic, on the land above the tree line, at the ocean beach, or anywhere that the wind can be depended upon. The kite flies best in a steady wind between 15 and 30 km/h (9 and 18 mi/h). In the higher winds, a tail is recommended to increase the stability of

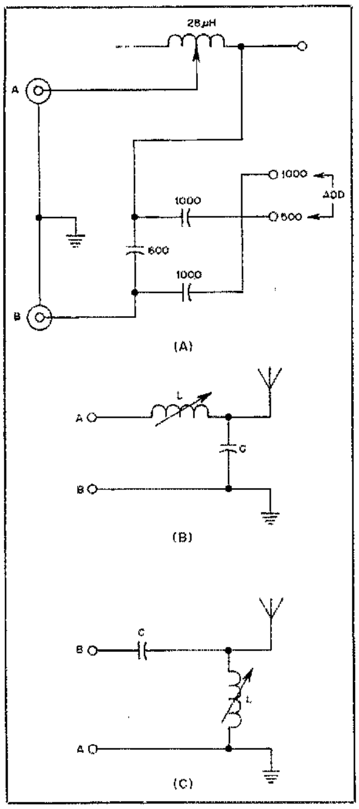

Fig. 2 — L-section matching network. Capacitances are in picofarads. The circuit at A is the schematic diagram of the antenna coupler used by the author. At B it has been configured to match a 1/2-λ antenna to 50 Ω. At C, the circuit will match a 5/8-λ antenna to 50 Ω.

the Parafoil. The best tails are made of plastic strips, 50 mm wide and 3 to 4 m long (2 inches wide and 10 to 12 feet long). Use 5 to 6 multicolored strips to form a tail. A swivel snap attached to one end of each strip should be put on the loop at the center of the trailing edge of the parafoil. The swivel snaps keep the strips from becoming tangled. At all times a winch should be used to facilitate bringing the kite down. Also, never fly a kite carrying a wire antenna near power lines, or during an electrical thunderstorm. And don't fly the kite too high where aircraft are flying.

The Antenna

Two types of antennas have been employed: a simple wire antenna which was end-fed by an L-section matching unit, and a J antenna. The J is an end-fed half-wave radiator, fed and matched by means of a tapped quarter-wavelength shorted transmission line, and constructed from 300-ohm twin-lead.[7]

If the kite-supported antenna is operated from an ocean beach, a 5/8-wavelength wire antenna could be employed and the ocean used as a ground plane. In this situation, the antenna will exhibit some directivity with maximum gain in the direction of the open sea. If an ocean is not available for a "ground plane," a half-wave radiator should be employed, since this antenna works well with no physical connection to the ground.

My wire antennas used braided, bronze fishing line (diameter of the wire is about 0.18 mm or 0.032 inch) and a test strength of 27 kg (60 lbs). Do not kink or solder to this wire; otherwise, it will break at these points. Braided monel and solid monel fishing lines are also available,[8] and in fact either of these lines might have better mechanical properties.

Since the length-to-radius ratio (h/a) is large, an end-fed half-wave radiator for 75 meters has a very high impedance (4000 ohms); the resistance and reactance values for a 5/8-λ antenna are estimated to be 135 − j912 ohms; that is, R_a = 135 ohms and X_a (capacitive) = 912 ohms.[9]

Matching End-Fed Wire Antennas

An L-network impedance-matching device is the simplest type that can provide a perfect match between the transmitter and the antenna. The one I used was the "Wide Range Wire Tuner" manufactured by the Unique Products Company, West Covina, California. This device allows for two configurations for the L-match network, and both are needed for 1/2- and 5/8-λ antennas (Fig. 2).

If the antenna is a resonant 1/2-λ radiator, the values for the inductance and capacitance can be readily calculated using

$$2\pi fL = j\sqrt{R1(R2 - R1)}$$
$$= j\sqrt{50(4000 - 50)}$$
$$= j444 \text{ ohms } (18.6\ \mu H)$$
$$\frac{1}{2\pi fC} = -j\,R2\sqrt{\frac{R1}{R2 - R1}}$$
$$= -j450 \text{ ohms } (93\ pF)$$

where

R1 = desired transmitter impedance = 50 ohms

R2 = antenna impedance (estimated to be 4000 ohms)

The parenthetical values are inductance and capacitance for an operating frequency of 3.8 MHz.

When the antenna impedance is reactive, the L-network parameters can only be calculated by iteration; several settings provide zero reactance, but only one of these settings provides a match to 50 ohms. Also, the "tuning" will be more critical than for resistance matching. An initial dial setting calibration, in our case using a vector impedance meter and "equivalent" lumped-circuit antenna parameters, facilitated tuning in the field.

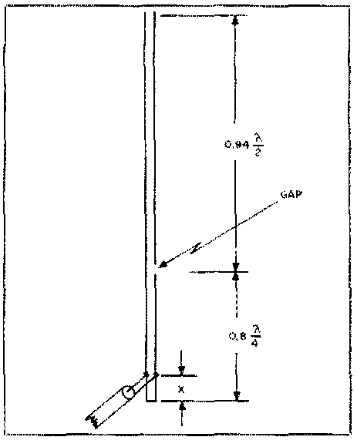

Fig. 3 — Schematic diagram of a J antenna which can be constructed from 300-Ω twin-lead. See text regarding dimension X.

These results are given in Table 1.

J Antenna for 75 Meters

A J antenna constructed from 300-ohm transmission line is sketched in Fig. 3. The lengths of the 1/4-λ matching stub and the 1/2-λ radiator are calculated from the conventional wavelength formula

$$\lambda = \frac{300}{f\ \text{MHz}}\ \text{meters}$$

Appropriate factors must be used, which for a 300-ohm twin-lead stub is 0.8 times a free-space quarter-wave (velocity factor for polyethylene is 0.8). For the radiator, the antenna length is about 0.94 times a free-space half-wave. The correct tap point, which must be determined by experiment, is about 0.0134 λ (distance X measured from the shorted end). Thus, for 75 meters (3.8 MHz), the length of the 1/4-λ section is 15.8 meters (51.8 ft) and the length of the 1/2-λ radiator is 37.1 meters (121.7 ft) for an overall length of 52.9 meters (173.5 ft). The tap point is about 1.03 meters (40-1/2 inches) from the shorted end. While any kind of 300-ohm twin-lead will work, that made by Belden (type 8230) was used, since, according to the manufacturer, it is stronger and has more flex-life than equivalent twin-lead. Hence, it should have superior resistance to the pulling, whipping and twisting that it is subjected to as a kite-supported antenna.

I have used kite-supported antennas on trips to Koartak, in an Inuit community on the northwest tip of Ungava Bay in Arctic Quebec. The braided bronze fishing-line antenna was wound on a fishing reel. Sixty to ninety meters (295 ft) of kite line was used above the wire antenna, so the kite flew in stable air.

Lighter-than-air balloons and Kytoons[10] (combining the advantages of a balloon and a kite) can also be used to

A Parafoil upside down on ground. The bridal resembles the shrouds of a parachute.

Table 1

L-Network Match for Various Antennas

Antenna Type	Estimated Impedance $R_a \pm jX_a$ (ohms)	L-Section L (μH)	C (pF)
Half-wave	4000	20.2	115.4
5/8-λ wire	130-j974 (43 pF)	15	105
5/8-λ whip	100-j600 (70 pF)	10.9	136

hoist antennas aloft (see November 1975 *QST*, page 57). Regular meteorological-type balloons are close to useless as antenna supports unless there is no wind, because they tend to "heel over." There are two solutions. Either use a balloon with a very strong lift or use a Kytoon that is designed to fly in the wind. The ILC Dover Company[11] markets an inexpensive 1 cubic meter balloon with a lifting capacity of about 500 grams (1.1 pounds). Both ILC Dover and Jalbert Aerological Laboratories market Kytoons.

Concluding Remarks

Jalbert Parafoil kites are available in three sizes.[12] The kite most suitable for use in the present application is the model J-15. The model J-35 is a much larger kite which *must not* be flown without a winch. This larger kite is suitable for carrying a lightweight battery-operated repeater, or for supporting a vertical antenna for the higher hf or vhf bands where height is desired, and where the kite must support the coaxial feed cable.

In considering the application of a kite-supported repeater, it should be noted that the record height reached by a kite, according to the Encyclopaedia Britannica, was 7265 meters (23,835 ft). This height was reached on May 5, 1910, at Mount Weather, Virginia, using a train of 10 kites on piano wire from a ground winch. A more modest height would be

The author holds the kite line immediately after launching. As can be seen from the faces of the children, kites are fun whether you have an interest in antennas or not.

quite satisfactory for a vhf repeater for emergency or experimental use.

Nylon flying line for the above-mentioned kites is available from the manufacturer in 914 m (3000 foot) lengths having 90 and 159 kg (200 and 350 lb) test.

All of us have dreamed of a skyhook for supporting a vertical antenna. If this article encourages you to fly kites in connection with your hobby of Amateur Radio, good luck, have fun, and may favorable winds be at your back when flying your Parafoil. QST

Notes

[1] McNicol, *Radio's Conquest of Space*, Arno Press, New York, 1974, pp. 132-143.
[2] *Encyclopaedia Britannica*, William Benton, publisher, 1964, pp. 421-422.
[3] Bell, "The Tetrahedral Principle in Kite Structure," *The National Geographic Magazine*, Vol. XIV, June 1903.
[4] Synestructics, Inc., 9559 Irondale Ave., Chatsworth, CA 91311.
[5] Jalbert Aerology Laboratories, Inc., 170 NW 20th St., Boca Raton, FL 33432.
[6] Jalbert, "The Jalbert Airfoil," *Annals of the New York Academy of Sciences*, 1969, pp. 163-271.
[7] Belrose, "The Vertical-J for 2-Meters — A Roll-up and Put in Your Pocket Type," *TCA* (The Canadian Amateur), Aug./Sept. 1979.
[8] In Canada, such fishing line is manufactured by the Schindler Co. of Canada, No. 1 Audley St., Toronto, ON M8Y 2X3.
[9] Jordan, *Electromagnetic Waves and Radiating Systems*, Prentice-Hall, New York, 1950, pp. 482-483 and 508.
[10] Ferrier and Baird, "A New Kind of Skyhook," *QST*, October 1946, p. 24.
[11] For more information contact Frank Mathews, ILC Dover, P. O. Box 266 Frederica, DE 19946, tel. 302-335-3911.
[12] See note 5.

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Bonadio, "The Balloon Antenna Rides Again," *QST*, March 1947, p. 60.
Griffin, "Tri-County Takes a Holiday or Benjamin Franklin in Reverse," *QST*, June 1939, p. 30.
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