TRANSLATED AND EDITED BY ERWIN DAVID, G4LQI

A full-size **7MHz HB9CV** beam is not beyond the ability of the serious home constructor provided adequate mechanical precautions are observed. **Daniel Caudroy, F6BXC** described how he did it in *Radio-REF* 10/93.

THE ELECTRICAL PROPERTIES of the HB9CV can be found in earlier amateur publications [1]. These also contain mechanical designs for VHF and UHF and, less frequently, for the higher HF bands [2]. The HB9CV is just as useful for 7MHz DX. Home construction was a challenge, which I met as described. [The mechanical design of this antenna is applicable to other full-size two-element close-spaced 7MHz arrays. Available space does not permit reproduction of detail drawings and photographs - *G4LQI*].

SIZE AND WEIGHT

THE ANTENNA FITS in a rectangle of 21.5 x 5.5m. See **Fig 1**. An uncluttered assembly area of that size is required, preferably near the tower. Once aloft, the antenna has a turning radius of 11.5m; make sure it does not infringe on your neighbour's property. [In the UK, the advice of the local planning authority should be sought to avoid a planning application being rejected out of hand - *G4LQI*]

The antenna elements are made of dural tubing; the boom is a galvanized steel tube of 50 x 47mm (OD x ID), as used for central heating installations; if the boom were to be made of aluminium alloy as well, a larger diameter would be required. The assembled weight of the antenna is near 60kg. The maximum wind area is approx 2m².

For a rotary array of this size, commercial hardware sold for beams for 14MHz and above is definitely inadequate. The weights and dimensions given will serve as advance notice of the magnitude of the project. If the following guidelines are adhered to, however, you will not have to worry during every gale. My beam has been up for two and a half years now and has survived winds up to 120km/h.

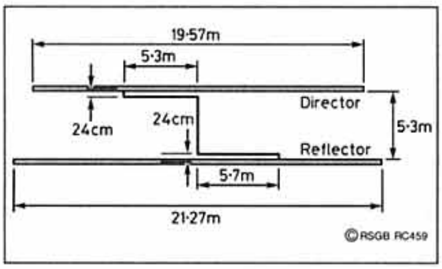

Fig 1: General layout and nominal dimensions of the 7MHz HB9CV. F6BXC got best results with elements of equal length and phasing lines as shown.

THE TOWER

FOR THE DESIRED LOW-ANGLE radiation, the antenna height should be at least a half wave-length, ie 21m. My tower is 16.5m high.

A self-supporting lattice tower should have a bottom section of 70 or 80cm across and be set on a concrete base of 2m³ [3].

For a guyed lattice tower, **Fig 2**, a cross section of 35 - 40cm is suitable; it should be solidly anchored to a concrete base 80cm square and 50cm deep. Its guys must take not only the wind load on the tower and antenna, but also the torque exerted by the antenna on the tower through the rotator. I use 8mm steel guys, electrically broken up by egg insulators; the guy anchors are appropriately massive [3]. I must warn against the use of nylon rope for guying. Fibreglass is OK if not stressed beyond 20% of its rated breaking strength.

To reduce the effect of the torque, an anti-twist crossbar is used. It is a 6m long tube, of the same material as the boom of the antenna, which is rigidly bolted to the base plate of the rotator. Guyed to two anchors, **Fig 3**, this crossbar has the effect of increasing the tower cross section at the level of maximum torque. Other, smaller antennas may be mounted on the cross bar.

ROTATOR AND STUBMAST

BECAUSE COMMERCIAL AMATEUR rotators are inadequate, a second-hand industrial motor with a built-on reduction gear was used. 1/3 - 1/2 RPM is about right. If too fast, an additional reduction gear may be used. The output shaft, which is directly coupled to the stub mast, should be at least 30mm dia.

The control box should provide a delay to prevent the motor from reversing direction before the antenna has stopped completely. When the antenna is not used, a servo, coupled to a wind vane, parks the antenna in the position presenting the minimum area to winds over 40km/h.

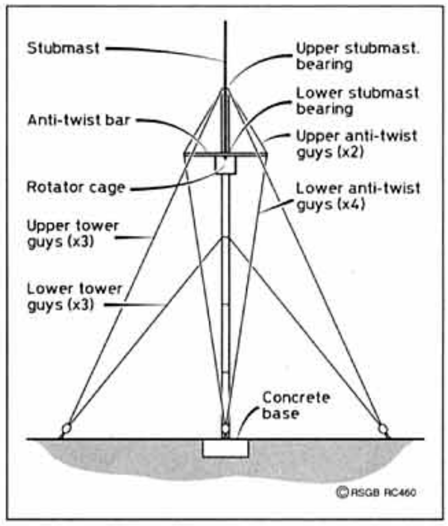

Fig 2: Diagram of the guyed tower, rotator, stub mast, and anti-twist crossbar.

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lamp driver connection, the connection to a 16-key keypad, a serial shift register to provide eight inputs, but using only three pins on the MPU, and an input from a switched 12V source.

Label	Instruction		Notes
normal	GOTO	normal	;this simulates normal operation ;instructions that are obeyed ;repeatedly.
interrupt	BTFSS	portB,rb4	;is the rb4/SWA pin high or low
	BSF	portA,ra1	;it is low, turn the LED 1 on
	BTFSS	portB,rb5	;is the rb5/SWB pin high or low
	BSF	portA,ra2	;it is low, turn the LED 2 on
	BTFSC	portB,rb6	;is the rb6/SWC pin high or low
	RETFIE		;its high so end the interrupt
	BCF	portA,ra1	;its low so turn LED 1 & 2 off
	BCF	portA,ra2	
	RETFIE		;end the interrupt

Table 3: Program using interrupt instructions.

There have been many cases of badly designed microprocessors radiating noise over bands and disrupting communications. It is worth noting that single chip microcontrollers have all their high frequency switching elements internal. There are no bus and control lines to other chips to radiate noise, therefore they are inherently quiet. The cost of the Pic start-16B is £170 including VAT from Maplins.

COMPONENTS AVAILABLE

IT IS IMPOSSIBLE in a few pages to provide an 'introduction to programming' course, however, I hope that this article has whetted your appetite to experiment. All parts described in this article may be obtained from any Maplin store. The mail order address is Maplins, PO Box 3, Rayleigh, Essex SS6 8LR or telephone 01702 554161. If you wish to try your hand at programming PIC microcontrollers an 'Aid To Easier Programming' disk is available from the author (see below) that includes many maths routines that have been tried and tested. It is much easier to use routines that have been written and debugged than to re-invent the wheel. The disk also includes several useful programming suggestions and has a simple layout format to help your first attempts at programming to be successful.

NOTES

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SOFTWARE AVAILABILITY

FOR THE *Aid To Easier Programming* disk send a cheque for £5 to A A Mockford, 47 Kendalls Close, High Wycombe, Bucks HP13 7NN. ♦

The rotator is installed in a cage between the top section of the tower and the next lower section. The motor/gearbox should not be required to take any force other than the turning moment of the antenna. To that end, the stub mast rotates in two bearings, one at the top of the mast, the other 3m down, where the bottom of the top mast section is joined to the rotator cage.

Because the rotation speed is low, the stubmast does not require ball bearings. Sleeves of steel tubing, 100mm long and with an ID a few millimetres larger than the OD of the stub mast, are welded through the centre of steel plates the size of the cross section of the tower. The steel-on-steel friction in these bearings, with or without grease, is negligible as compared with the torque required to turn the antenna.

The stub mast is a 6m length of 76mm OD galvanized steel pipe. The upper stubmast bearing carries the weight of the antenna and stubmast. Almost half of the latter rises above the tower and doubles as a gin pole to hoist the antenna to its position just above the upper stubmast bearing.

ANTENNA CONSTRUCTION

THE ELEMENTS ARE OF TELESCOPIC construction, each comprising two lengths of dural tubing of 50, 35 and 25mm OD. Two 6m lengths of 50mm OD are butt-joined together by inserting a 1m long 45mm OD steel tube, tightly shimmed at both ends and in its centre under the seam between the two dural tubes. The centre section of this assembly fits into a 1m length of thick-wall U-profile aluminium to which it is attached by M8 stainless steel U-bolts.

2.5m long sections of 35mm tubing are spliced into the ends of the 50mm tubes. The overlap is 20cm and the space between is carefully filled with intermediate diameter tubing. This may even be PVC, as electrical continuity is assured by aluminium straps under the heads of M6 SS bolts through each splice and through the thinner tubing just outside the splice.

End sections of 25mm tubing are similarly spliced into the ends of the 35mm tubes and cut to obtain the desired director or reflector length, though it may be useful to drill several sets of bolt holes (no pun intended) in the thinner tubing to permit later adjustment of the element length. Cap the ends of the elements to prevent them howling in the wind.

Strong as each element is, you can lift its centre way above your head and the ends still will not clear the ground. They would make a sad sight if allowed to droop that much. To alleviate this, a vertical 25mm OD dural tube is fixed 1m above each boom-to-element joint. This serves as an attachment point for guy wires supporting the element at each of its four telescoping splices. These guys are made of 2mm galvanized steel wash line, broken up near each end and near the support pole by egg insulators. The guys are tensioned to give the elements the slight gull-wing shape shown in **Fig 4**.

Fixing the elements to the boom is a critical operation. Rectangular steel flanges are welded to the ends of the boom; the U-profiles holding the element centres are bolted to their respective flanges. The flange faces must be

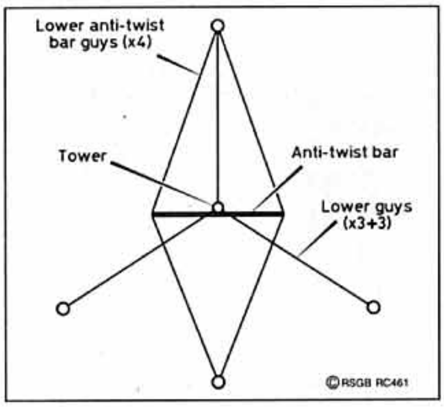

Fig 3: Guying the anti-twist bar.

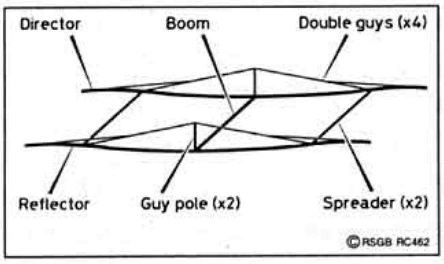

Fig 4: Guys keep the elements from drooping.

in parallel planes and the horizontal centre lines of the bolt holes must be parallel to ensure that that the elements are parallel. I did the welding on the flat concrete floor of my garage. Steel sockets for the guy poles are welded to the flange faces above where the U-profiles are to go. Drain holes are required at the bottom of the sockets. I insulated the guy poles from their sockets with PVC tubing and nylon washers at the bottom to avoid them affecting the resonance frequency.

Spreaders are installed between the director and the reflector near the ends of the 50mm sections. When the elements sway in the wind, the correct spacing between them is maintained. Each spreader consists of a 30mm OD dural tube which is cut and spliced with a fibreglass insulating section near each end. The total length is 5.5m, permitting attachment to the elements by commercial cross brackets (saddle and U-bolts).

PHASING LINES

THE PHASING LINES ARE MADE OF 5mm aluminium wire. They are spaced along the elements by 213mm long stand-off insulators, four to each element. The phasing line section between the elements runs 23mm above the top of the boom. Though the aluminium wire is light, the insulators should be robust as they are not only buffeted by wind and weather but also are vulnerable during the hoisting of the antenna.

ANTENNA TUNING

IT WAS FOUND THAT adjustments made at 3 or 4m above ground were still correct when the antenna was raised to its operating height. To make these adjustments, the boom was cradled in a U-channel clamped to a horizontal tower member. This same fixture was used to rest the antenna on its way up.

After completing the adjustments, all exposed steel should be painted, all electrical joints tightened and weather-proofed [4] with silicone paste and telescopic joints sealed to prevent water getting in.

RAISING THE BEAM

THE ANTENNA CAN be raised to the top of the tower single handed. I managed to do it, although it took two weeks, one or two hours each day after work. With an unguyed tower, it would take less time. Help was required to carry the beam from the assembly area, however. To get the centre of the boom to the foot of the tower, one of the spreaders was temporarily removed.

A rope was attached to the boom at the centre of gravity, pulled through a pulley block [5] at the top of the stub mast and down again to a winch temporarily but solidly bolted to the tower approximately one metre above ground [it might be safer to run the rope through a second block at the base of the tower and install the winch far enough away so no-one is hit by anything falling down instead of going up [6]; even so, this is a hard-hat job! - *G4LQI*].

Winch slowly, always keeping the beam from dangling out of control; its size permits resting it on one guy or another, which tends to steady it. When the boom or a spreader is about to hit a tower guy, stop and secure the boom in the cradle. Install a temporary guy to pass just below the interfering beam member, detach the permanent guy, winch the beam a little higher, cradle it again and replace the permanent guy. And so on.

BOOM TO MAST FIXTURE

TWO STEEL PLATES, 120 x 300 x 8mm are welded into a cross. The boom is attached to it with two 10mm U-bolts, the stubmast with four 12mm U-bolts.

I like the antenna to be insulated from its support. To that end, a 15mm thick plate of nylon separates the cross from the stubmast; nylon bushings and washers insulate the 12mm U-bolts from the cross. [To be prudent, a dozen or so ferrite rings should be slipped over the coax near its antenna connector - *G4LQI*]

REFERENCES

[1] Rudolf A Baumgartner, HB9CV, 17pp in *Radio-REF* 3/81 (in French).
A 2m example is shown in the RSGB. *RadCom Handbook*, 6th ed. p 13-29.
A 3.5MHz wire version is shown in [2] below.

[2] *Antennas and Techniques for Low-Band DXing*, 1994 edition, by John Devoldere, ON4UN, discusses strength-of-materials, calculations to withstand wind and ice loading; with PC programs. Sold by RSGB (see page 90).

[3] 'Wind Loading', D.J.Reynolds, G3ZPF, *RadCom* 4&5/88

[4] 'Waterproofing', J Nelson, GW4FRX, *RadCom* 1/89

[5] 'Keeping the Tower in Trim', R W Addie, G8LT, *RadCom* 5/88

[6] 'Planning your Antenna for Safety', E David, G4LQI, RSGB *HF Antenna Collection*. This book also contains the articles in [3], [4] and [5] above. ♦