NDD

RADIO EXPERIMENTER'S HANDBOOK

VOLUME 2

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PROJECT TO BUILD

Listening Post 2

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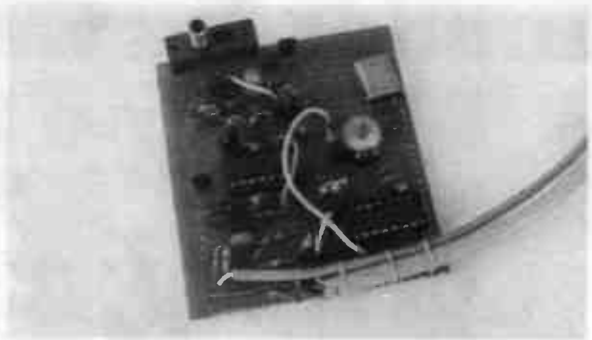

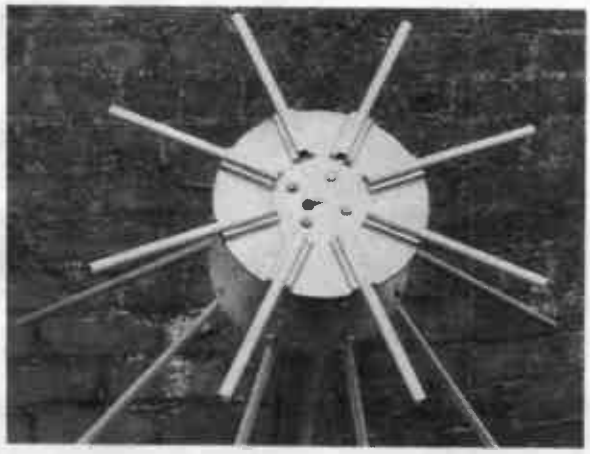

Listening Post Mark II compiled by Tom Moffat. All other material compiled by Roger Harrison of The Apogee Group. All diagrams copyright The Apogee Group.

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Improved low cost decoder for weatherfax, RTTY and Morse:

LISTENING POST II

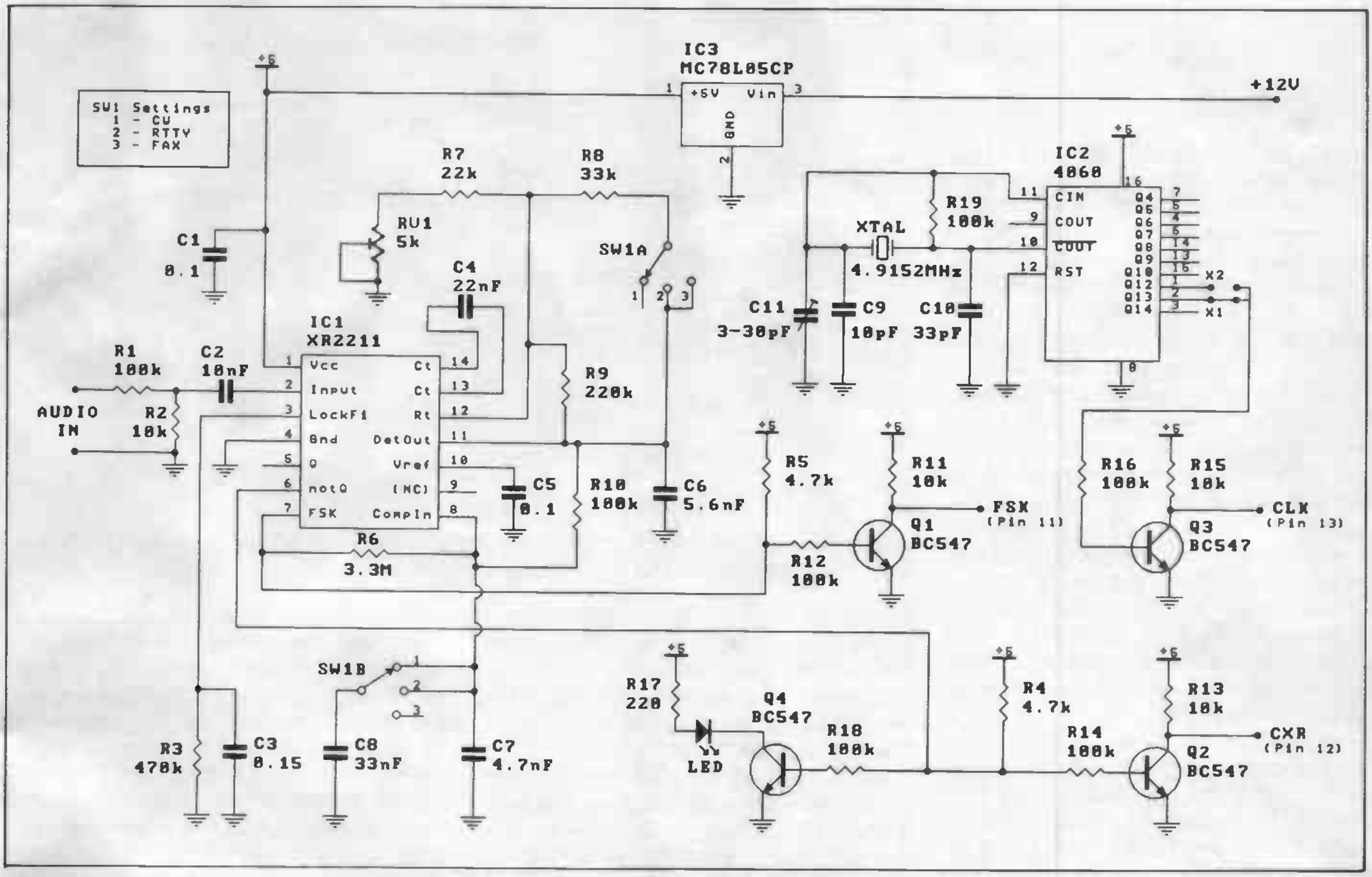
What's the weather pattern over the North Atlantic? Will it blow in Antarctica? Will there be drought in India? Will we be able to see the lunar eclipse over Australia? Is the climate really changing? It's the talk of the day — things like the greenhouse effect and global warming. You can have your own private eye on the world's weather, and lots of other things, if you have an IBM-PC or clone, a shortwave radio, and the new Listening Post II decoder project. By TOM MOFFAT, VK7TM.

SNOOPING around on the shortwave bands has always been jolly good fun, listening to broadcasts from the other side of the world, or to ships or aircraft. But among the normal broadcast stations you can't help but notice funny bleats and whistles and 'scrunch-scrunch-scrunch' noises. These transmitters are using digital or other non-verbal communications modes.

Much of the traffic is radioteletype or 'RTTY', sending printed messages such as weather information or news-wire services or even secret diplomatic messages. Some is facsimile – complete pictures, mostly weather maps, going out from powerful shore-based transmitters to ships at sea. And then there's good old Morse code, said by some people to by obsolete and therefore useless. But there are still hundreds of stations, mostly marine coastal stations, communicating by Morse code every day.

Listening Post II takes the audio output from your receiver and turns it into fax pictures on your computer's screen. Or it can receive radioteletype messages, or Morse code messages, and type them onto your screen as they come in. You can save your fax pictures or Morse or teletype messages on disk and recover them later for detailed study. Or you can print them out – even paper your walls with weather maps, just like they do at the Weather Bureau!

Listening Post II comes to you as an easy-to-build kit of parts, along with a disk containing a suite of programs for the IBM-PC. If there's enough interest,



The schematic for the new decoder, which retains the simple mode switching system of the original unit for ease of operation. A new crystal-controlled clock circuit ensures really stable fax decoding.

software for other computers may come later. All you need to make it go is a shortwave receiver, a PC, and possibly a printer.

This project has been evolving through various kit designs, through a fully commercial weather-fax machine, and back to a kit again. Listening Post II is a distillation of the best features of all those earlier devices, with some new additions to make it the best performer ever. Perhaps some history would be in order before we go much further:

Previous designs

My own involvement in RTTY reception began with an article in *ETI* in August 1979. This described the ETI-730 project, a precision RTTY decoder that used analog filters and comparators to provide top-quality RTTY reception on the shortwave bands. That project was quite complex and fiddly to operate, but when the going got heavy it provided absolutely first-rate performance, hooked up to an old mechanical teletype machine. I still frequently use the ETI-730 with a Siemens teleprinter, and it's as good as ever.

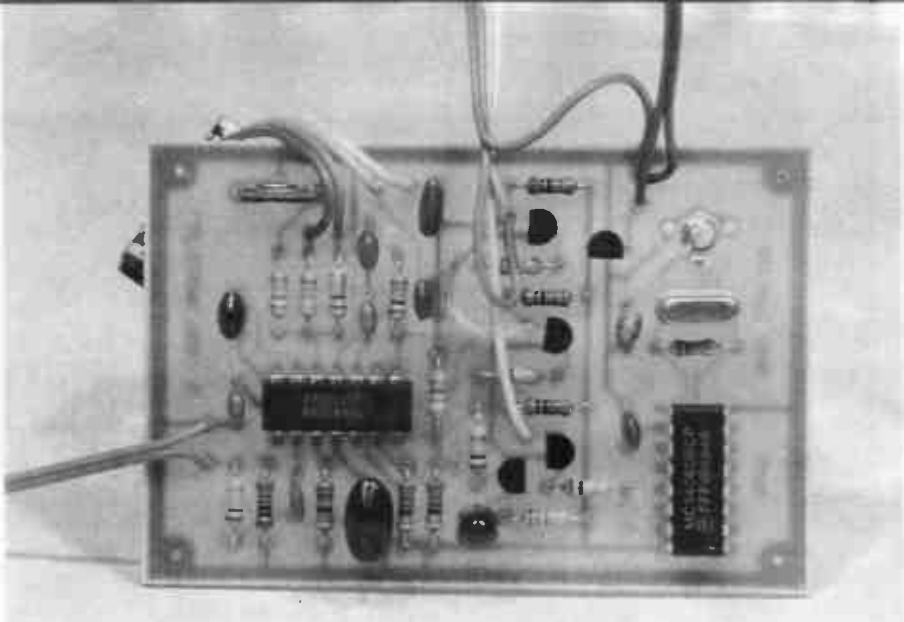
In January 1981 came the first computer version of the project, which fed the output of the ETI-730 decoder into an *Electronics Australia* DREAM computer. This system displayed teletype on the computer's screen, but only as one line of 16 characters that marched past in 'moving marquee' style. I patterned the display after the old ticker-tape machines that displayed share-market quotes back in the thirties. This format became so useful as a diagnostic tool that I included it as a 'tape mode' option in every subsequent decoder project, including this latest Listening Post II.

Next came the ETI-733, a dead-simple RTTY decoder project that replaced all the earlier analog filter circuitry with a 4046 phase-locked loop integrated circuit. The output of the 733 was processed by a Microbee computer, which had a proper 64 character x 16 line screen, so it produced a decent page-formatted display, just like a real teletype machine. Since the design was so basic, the 733 didn't perform as well as the 730 in the presence of noise and interference, but it was still an outstanding success that sold heaps of kits through retailers all over Australia.

The first weather fax project was an *ETI* one called the 'Picture Plucker' which used the same 4046 phase locked loop as the RTTY decoder. It worked for fax only, processing the pictures within a Microbee computer for printing onto a C-Itoh graphics printer. Since the Microbee's graphics capabilities were limited, there was no way to produce a fax picture directly onto the computer's screen. This was really a primitive system, but as I said in that article, "As far as I know this is the first time the world of fax has been opened to the electronics enthusiast. The secret, of course, is the computer."

That Picture Plucker turned out to be a big success, so much so that I tried to flog a similar idea to the prestigious American computer magazine *BYTE*. They said thanks but no thanks – there wouldn't be any interest in it. And then they proceeded to come up with their own version for the Apple computer, a few months later. But we were there first, folks!

The next big jump forward came with my original Listening Post, which was the very first project in the *Australian Electronics Monthly* magazine, now defunct. The Listening Post traded the somewhat cranky 4046 IC for the newer XR-2211 chip which contained a phase locked loop, a comparator, and a carrier detect circuit all in one



A top view of the wired-up decoder board, showing where everything goes and the orientations. Use it as an assembly guide.

package. The XR-2211, although a bit pricey, proved very easy to design with. And the off-air results proved, oh, a hundred times better than the 4046. In short, it was fantastic.

The original Listening Post was mated with a Microbee to provide fax, RTTY, and Morse code reception. The XR-2211's FSK (frequency shift keyed) output provided the data for fax and RTTY, and the carrier detect output was used to provide Morse code. The fax and RTTY software were very similar to the techniques used with the earlier *ETI* projects; RTTY displayed on the screen in either page or tape mode, but fax could only display on the printer, not the screen. As for Morse code software, that was a write-from-scratch job, and it proved a real battle to get something that would work with off-air Morse of varying speeds.

Enter, at this stage, the Navimate: a commercial weather-fax receiver for yachts and fishing boats. On the strength of the Listening Post's success, I was hired by a Hobart company to produce a similar thing that could be sold as a complete package and operated by non-technical people. What we ended up with was a plastic case with connections for a 12 volt battery, an audio input from a marine radio, three buttons and five LEDs, and nothing else. The case contained a little thermal graphics printer, a custom-designed Z-80 computer, and an XR-2211 decoder circuit virtually identical with the one in the Listening Post.

Navimate's rather complex software used interrupts to allow the computer to simultaneously suck the signals in through the audio cable and paint the pictures out to the printer. Once you started it the device worked just like a traditional mechanical weather fax, churning out a continuous string of pictures, automatically, onto a paper roll. It also had the teletype function, printing as it received, although I deleted the Morse code part because I wasn't really happy with its performance. Didn't want people to knock the Navimate because of poor Morse code reception; they couldn't do that if it didn't have Morse code at all! (The Morse has since been fixed, though.)

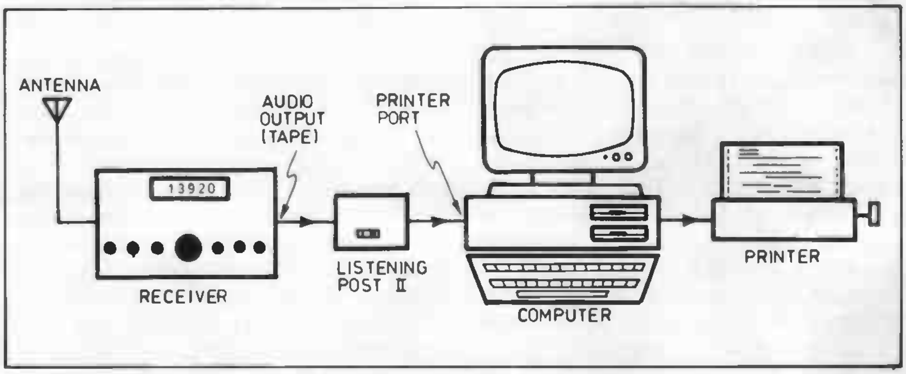
The Navimate's picture was on 8″ wide paper, but most professional mariners were used to fax pictures twice that big. So I rewrote the software and came up with a version that would work on a big Hewlett Packard ink-jet printer 15″ wide. This provided many more dots of picture resolution, both horizontally and vertically, and the resulting pictures were every bit as clear as those produced by the best mechanical fax machines.

What this means is that the decoder circuit used in the Listening Post II project is limited in picture quality only by the resolution of the computer screen or printer it's displayed on. The present software is for the popular CGA standard PC screen, but the door is open to provide versions for the more up-market EGA and VGA standards, with a corresponding increase in picture quality. I will be producing these versions if there's enough demand.

How weather-fax works

When the first computer-fax project came out in *ETI*, the whole idea of fax was quite a mystery. But nowadays fax is as common in offices as the push-button phone and the photocopier. Weather-fax operation is much like office fax, only much slower, perhaps one-fiftieth the speed. Both systems rely on scanning a document line by line, as in television, and reproducing it line by line on the receiving end. Television, with its wide bandwidth of 6MHz or so, is restricted to the line-of-sight coverage of VHF. But since narrow band fax can be transmitted on HF, the range is world-wide, and it makes for some interesting viewing.

The traditional method of weather-fax transmission is shown in a much simplified form in Fig.1. The system consists of two metal drums, one at the transmitter and the other at the receiving end. The two drums are rotating at the same speed. Near the top of the transmitting drum is a lamp illuminating the whole surface. Above the drum is a 'telescope', a system of lenses, feeding into a light dependent resistor. The light falling on the LDR is only that from the image of the tiniest pinprick portion of the drum, directly at the focal point of the telescope. (The thing should really be called a microscope, but telescope is the proper term in a fax machine.) The telescope



The Listening Post II decoder takes the FSK audio from your receiver, and produces digital signals for processing by your PC.

SOME OF THE WORLD'S RADIO-FAX STATIONS

JMH	Tokyo #1	3655.2	7305	9970	13597	18220	22770
JMJ	Tokyo #2	3365	5405	9438	14692.5	18130	
JJC	Kyodo Press	4316	8467.5	12745.5	16971	17069.6	22542
JFA	Chuo-Gyogyo	4274	6414.5	8658	12655.5	16907.5	22445.5
JKB	Jiji Press	3820.5	7368	9410.5			
JKC	Jiji Press	5457	9855	12322			
JKD	JiJi Press	3712.5	6893	9885			
JKE	Jiji Press	3600	5851	8088			
JKF	JiJi Press	3824.5	7372	9414.5			
NPN	Guam	3377.5	4975	7894	10255	10966	12777
		15564	15990	19860	22865	22910	
NPC	Philippines	3377.5	10966	22865			
	Khabarovsk	4516.7	7475	9230	14737	19275	(strange IOC)
BAF	Beijing	5525	8120	10115	14356	18235	
HSW	Bangkok	6765	7395	17522			
9VF	JJC via Singapore	22775					
AXI	Darwin	5755	7535	10555	15615	18060	
AXM	Canberra	5100	11030	13920	19690		
ATA	New Delhi	4995.5	7409	14722	14842	18227	
5YE	Nairobi	9044.9	10115	17366.9	22867		
ZRO	Pretoria	4014	7508	13773	18238		
HXP	Reunion	8176	16335				
IMB	Rome	4777.5	8146.6	13600			
YZZ	Belgrade	3520	5800				
DCF	Germany	134.2	(appears to be VHF aviation frequency)				
OLT	Czechoslovakia	111.8	(appears to be VHF aviation frequency)				
LZJ	Sofia	5093					
YMA	Ankara	3377	6792				
SUU	Cairo	4526	10123				
ZKLF	Auckland	5805	9459	13550	16220		
FFP	Martinique	5013	14521.5				
NAM	Norfolk USA	3357	4975	8080	10865	16410	20015
WLO	Mobile USA	6852	9157.5	11145			
WFA	Brentwood USA	9290	9389.5	11035	17436.5		
NIK	Boston USA	3242.4	7530	8502	12750		
CFH	Halifax Canada	4271	6330	10536	13510	122.5	(VHF?)
VFF	Frobisher Canada	3253	7710				
VFR	Resolute Canada	3253	7710				
NPM	Honolulu	2122	4855	7995	8494	9112	9396
		14826	21837				
NMC	San Francisco	4344.1	8680.1	12728.1	17149.3		
WWD	La Jolla USA	8644.1	17408.6				
NOJ	Kodiak Alaska	4298	8459				
CKN	Esquimalt Canada	4268	6946	12125			

Note: All of the above frequencies are in KHz. For use with Listening Post II, subtract 1.6kHz from the assigned frequency and use upper sideband (USB). The highest usable frequency for a given station will generally give the best picture quality. The strongest signal may not be the best.

is connected to a leadscrew arrangement that moves it slowly along the length of the drum.

We will assume for this illustration that the transmitter and receiver are directly connected by a pair of wires, instead of a radio link. The receiver has a similar telescope over its drum, although there is a lamp in place of the LDR. The receiver lamp is connected through the pair of wires to the transmitter LDR, via a battery to power the lamp.

To the transmitter drum we will attach a piece of paper with some wavy lines drawn on it. We will hold it in place with a piece of black electrician's tape. To the receiver drum we will attach a sheet of photographic printing paper (having first turned out the room lights).

Now we will start the drums rotating in unison. As the telescope at the sending end 'sees' the white paper, the LDR will pass maximum current from the battery via the pair of wires to the lamp at the receiving end. The lamp, through its lenses, will expose at any instant a tiny portion of the photographic paper. When the first of the wavy lines appears under the sending telescope, its black colour will cause less light to fall on the LDR, less current will pass, less light will fall on the photographic paper, and the black image will be reproduced.

As the process continues, lines of whiteness or blackness will begin to build up on the paper on the receiving drum, a new line for each rotation of the drum. If the drum turns 1000 times, there will be 1000 lines – quite a high resolution picture, better than television's 625 lines. (Purists will note that since photographic paper is negative-working, the resulting picture will have its blacks and whites reversed. But it illustrates how the system works.) Also note that the image of the black electrical tape will be reproduced. This is important, as we'll see later.

Now that we're instant experts on the basic fax system, we can see the problems it generates. If the drums aren't running at exactly the same speed, the picture will slant one way or the other, like on a TV set with a misadjusted horizontal hold control. If the drums don't start rotating from exactly the same angular position, what's on the left of the picture on the transmitter may be in the middle of the picture on the receiver. If the transmitter sends 1000 lines and your receiver needs 1500 lines to cover the paper, your image will be squashed into the upper ⅔ and the lower ⅓ will remain unexposed.

Let's tackle the problems one by one, beginning with the matter of getting the transmitter and receiver to start together. Most weather-fax systems transmit what are called 'phasing pulses' – bursts of white against a black background – before the actual picture begins. One pulse is sent for each line, and the END of the pulse, the white to black transition, says, 'the next line starts here!'. At the receiving end the machine adjusts its motor speed faster or slower until the edge of its paper coincides with the finish of each phasing pulse. Normally about 30 seconds of phasing pulses are provided, and if the receiver doesn't 'lock up' in that time, the picture is going to be a mess.

Now to the problem of keeping both drums going at the same speed, once phasing has been achieved. There are several ways of going about this, and they're all currently in use. The simplest method of 'sync' is to use synchronous motors at each end. This method is common in simpler fax systems, which are communicating via wire instead of radio. It assumes that both transmitter and receiver are running from the same power grid, so their mains supplies are in sync.

A more elegant way of going about it involves driving both the transmit and receive motors from power supplies derived from crystal oscillators. If the oscillators are stable within 0.001%, good fax pictures will result, and there's no dependence on mains frequencies. So reception is possible aboard a ship,

Wide view: Hobart Weather Bureau, computer screens everywhere.

for instance. This is the most common sync method.

A third and slightly older system involves the transmission of sync pulses at the start of each line, just like in television. The receiving motor is set to run slightly fast, and when it reaches the end of a scan line it slows or stops until told to 'go ahead' by a sync pulse. Sync pulses show up as a black line down one side of the picture. Sometimes the sync pulses are unintentional, caused by the black tape or even ink stains at the edge of the transmitted picture.

Listening Post II can make use of any substantial black area to lock the receiving picture onto the sending picture. Many Japanese weather-fax stations use the sync-pulse system; Australian stations rely on the crystal-control method.

The faithful reproduction of shape is determined by the system's 'index of cooperation' or IOC. This the product of the length of a line measured in some unit, and the number of scanning lines per the same unit. Assume that our transmitter drum can take a picture 34.8cm wide. Assume that it sends 15 scan lines for each vertical centimetre of picture. The system's 'index of cooperation' is 15 × 38.4 = 576. Now assume that our receiving system is only 18cm wide (about the size of the image on a computer monitor). If we still went for 15 lines per cm, the resulting picture would be very tall and narrow.

To stay with the transmitter's index of cooperation of 576, our line density must be 576/18 or 32 lines per cm. If this is so, a circle from the transmitter will look like a circle on the receiver. For various reasons the Listening Post II's IOC isn't exactly 576, and the resulting circles are slightly 'tall' on a CRT screen. But they're a touch 'short' on a laptop computer's LCD screen and 'just about right' on an Epson printer, so they all even out.

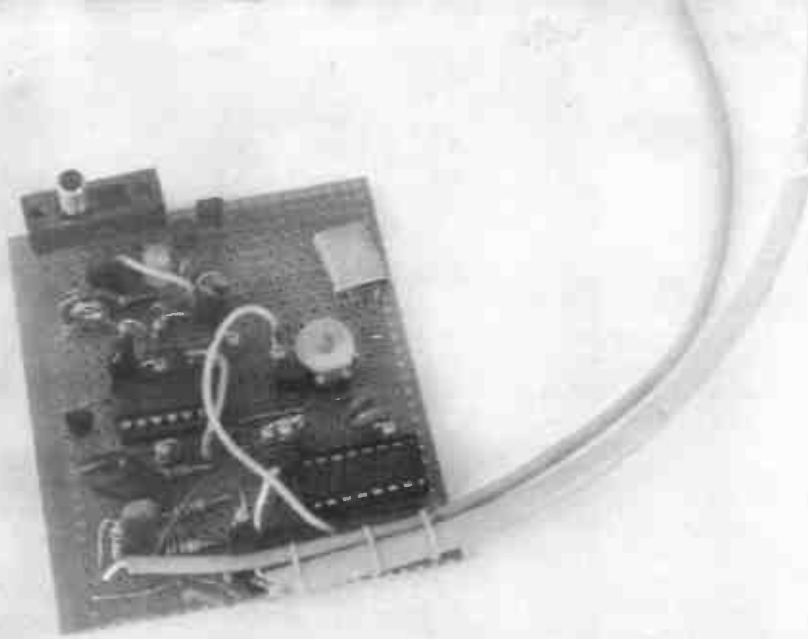
There are many radio fax standards in use around the world. Scan speeds can range from 60 lines per minute (lpm), or one a second, to 360lpm. Scan densities can be just about anything. Radio fax can be sent as AM, where the strength of the carrier varies with the picture, or as FM, where the frequency varies. A picture may run for 7, 10 or 20 minutes. Pictures may be black and white only (binary) or they may contain many shades of gray (analog).

On the shortwave bands, almost every station uses an index of cooperation of 576. About 80% scan at 120lpm; around 18% use 60lpm, and the remaining 2% use some weirdo system. All seem to use FM, with white being the higher frequency, and most seem to shift their carriers about 800Hz between white and black. So the Listening Post II is set up for the most likely signals: an IOC of 576 (or thereabouts), a choice of 60 or 120lpm, FM with shift in the 800Hz region, and a picture height of 1000 lines.

A new and very important feature in the Listening Post II is that it is now crystal controlled, just like the very best mechanical machines. This provides a major boost in picture quality over previous computer-fax projects.

There's some trickery in the software, that first tries to synchronize the system on phasing pulses at the start of the picture. If the phasing pulses are missed, possibly by starting reception after the picture has started, the software will then look for sync pulses on each line. If there are no sync pulses, it will then look for some black 'grot' to lock up to (see the edges of Fax Picture 8). Using one or another of these methods, Listening Post II will lock onto a picture

A wall of weather maps at the Hobart Weather Bureau.



The Listening Post II prototype on Veroboard. This was used to collect all the pictures in this article.

nearly every time.

Like so many things nowadays, traditional fax technology is becoming dated. Even the Weather Bureau, the supplier of so many of these pictures, is abandoning the old mechanical fax systems in favor of computer systems. High resolution satellite pictures are now coming in every hour and they're being sent around Australia, not on a fax system, but on a network of IBM-PC's.

The wall of fax pictures in the photos, and the mechanical fax they've been received on, will all be gone from Hobart at least by the time you read this. The old telex machines are gone too, replaced by the ubiquitous computer keyboard, screen, and a printer. The Weather Bureau is of course still deeply committed to serving ships at sea and other outlying users by weather fax. They're still using the old round-and-round machines for transmitting charts, but who knows what they will be replaced with in 10 years.

How it works

Like the original Listening Post, the hardware of Listening Post II is based on the Exar XR-2211 integrated circuit. This is a very modern phase locked loop that happens to be expressly designed for the job we're using it for (for once).

Put simply, a phase locked loop 'locks on' to an incoming tone and follows it up and down in frequency, providing that the tone remains in the specified passband. As mentioned above, this IC and its surrounding circuitry have been used in several different projects with absolute success, so it's left unchanged for Listening Post II. If it ain't broke, don't fix it!

A mechanical weather-fax machine at the Hobart Weather Bureau.

In general you specify two parameters in a phase locked loop circuit. With Listening Post II, each parameter can be switched between two values. The passband can be wide or narrow. 'Wide' allows signals to move in frequency over a range of up to around 600Hz each side of the centre. This is in line with facsimile and wide-shift teletype. 'Narrow' caters for signals that move in frequency about 100Hz each side of centre, such as narrow-shift teletype, or signals that don't move at all, such as Morse Code (which only switches on and off).

The speed of detection also has two values. 'Fast' is for facsimile data which can have video components up to 1000Hz or so. It's also useful for the highest teletype speeds. 'Slow' is for teletype at the slower speeds, and for Morse code.

It has proved convenient to use one two-section, three-way switch to make these selections. The switch is labeled with each position's most likely use, although there's nothing to prevent you using whichever works best in the circumstances. 'FAX' is wide passband, fast speed. 'RTTY' is wide passband, slow speed. And 'CW' is narrow passband, slow speed. You might also find narrow-shift RTTY signals are better received on the 'CW' position.

You will notice there is a trimpot associated with the XR-2211. This is for setting the centre frequency, the overall part of the audio spectrum in which the circuit operates. You can adjust this for your own receiver. If its filter seems to favour the higher audio frequencies, you can set the trimpot a bit higher. If your filter favours lower frequencies, set it a bit lower.

I've found in practice that most receivers work fine with the trimpot set about mid-range, and the Navimate version of Listening Post replaced the pot with a fixed resistor. I'm seriously thinking of deleting the trimpot from this design too, so if your Listening Post II kit comes with the trimpot missing, that's what has happened. One less thing to go wrong!

Completely separate from the actual decoder part of the Listening Post II is a one-chip crystal oscillator. This serves as the heartbeat of the whole system, and is what makes Listening Post II stand out from all the previous designs. The 4046 IC contains a CMOS oscillator circuit which feeds into a multi-stage binary divider. In this version, the crystal running at 4.9152MHz is divided by 8192 to produce a very accurate 600Hz square-wave output.

During fax reception the computer's software looks for each transition of the square wave, to tell it precisely where to place each of the 600 pixels (picture elements) on the scan line. If the incoming fax picture contains a vertical line, each dot on a horizontal scan line will be placed exactly below the one above it, resulting in the finest possible resolution. Earlier designs relied on the computer's internal clock to place the pixels, with resulting inaccuracies and fuzzy lines.

Listening Post II has three outputs, which are connected to status input bits of the IBM-PC's parallel printer port. The signals are at TTL level, so they should be useful with other computers as well.

The signal connected to Bit 7 of the status port carries the FSK data for fax or RTTY. Bit 5 is the carrier detect output, used to tell the FAX and RTTY software when a valid signal is present. This input is also used for Morse code. A LED is also connected to the carrier detect output; it comes on when a valid RTTY or fax signal is present and flickers with Morse code signals. Bit 4 is the crystal clock input. On the circuit board allowance has been made to feed the computer with 1200Hz instead of the 600Hz signal, for potential use with a higher resolution graphics system.

The LPII kit

You cannot buy the Listening Post II kit from the usual electronics retailers. It is only available through mail order from High Tech Tasmania, 39 Pillinger Drive, Fern Tree, Tasmania 7054. This is my own family business, which has been in existence now for close to 10 years.

Other projects I have designed have sometimes been disappointing when electronics retailers have offered them as kits. Some suppliers insist on supplying the lowest possible grade components, and sometimes even wrong components, such as ceramic capacitors where the design calls for greencaps. Although I try to make the designs as non-critical as possible, there is a limit to the 'crumminess' of the components they will tolerate, and I've had to deal with many complaints over the years that 'yer project don't work', when in fact the problem is with the components in the kit version.

So this time I'm doing the lot myself. The circuit boards are being made here in Hobart by Critech, a company that can make boards right up to military standard (they are also related to the Protel PCB design software people). I am personally checking the work at every stage. The parts are being bought through professional instead of hobbyist sources and are of the highest available quality. This means the kit will be a bit more expensive than otherwise, but you can be assured it will be 100% RIGHT!

This same technique was used a few years ago to market the *ETI* Chatterbox speech synthesizer kit. Critech made the boards, and we sourced the components through professional sources. It was a lovely kit, and out of something like 500 sold, not one backfired. The magazine acted as a clearing house for orders for the Chatterbox. This time High Tech Tasmania will be taking and filling orders directly; no magazine will be involved.

The Listening Post II kit costs $59.00 plus $7.00 for post and packing anywhere in Australia or New Zealand. What you get is a top quality solder plated circuit board, a bag of parts, and everything you need to connect the circuit to your PC-compatible computer (including the DB25 plug for a normal LPT port). Included also are simple instructions to help you assemble the circuit, and a quick-reference guide to the software.

You will also receive an MS-DOS floppy disk containing all the Listening Post II software, some sample fax pictures, and a couple of public domain utilities – one to compress your fax pictures for storage, and another to display text files generated by the RTTY or MORSE programs.

You will need to supply a few items yourself; possibly a case to house the circuit board, and a 12 volt DC plugpack power adapter (you may already have one of these, or you can pinch the voltage from your receiver or computer). You will also need to provide a means to connect the Listening Post II to your receiver's audio output. There are many ways to go about this, as we will soon see.

A sample fax picture of the kind produced by the author's Listening Post II software, on a laptop's LCD screen...

LPII software

The Listening Post II software consists of a suite of small programs for the IBM-PC, each written in pure assembly language (8088/8086 machine code). A lot of activity goes on in the computer to decode fax, Morse, or RTTY signals in real time as they are coming in, and machine code is the only practical way to do the job quickly enough. The software is fast and lean; no program is longer than 1000 bytes. Software to do the job in BASIC (if it could be done) would probably be twenty times as big.

The software has been written to make it work on as many MS-DOS computers as possible. It assumes the computer has two facilities: at least one parallel printer port, and a screen that can handle the CGA standard. It would

...and here's the same image reproduced on a CRT screen. The software can be set up to suit either, as you can see.

be a rare PC indeed that didn't have a printer connection, and the CGA (colour graphics adapter) is the most common and basic form of PC graphics.

The programs have been successfully tested on PC brands such as Unitron, Amstrad, Sawtron and a couple of home-made ones, as well as various models of Toshiba and Compaq laptops. Many of these computers are now supplied with up-market video systems such as the EGA and VGA standard, but all the new systems are downward compatible. The Listening Post II software commands these graphics systems to behave as if they were CGA while displaying fax pictures, and restores them back to normal afterward.

In fact a VGA screen running in CGA mode usually looks sharper than a proper CGA screen; possibly a result of the VGA monitor's smaller dot size. The Listening Post II display, of course, is in black and white, even on a colour monitor, because the fax pictures themselves contain no colour information. RTTY and Morse are displayed in normal 80x25 text mode, and no graphics are required.

Picture clarity would of course be improved if an EGA or VGA screen were used for its intended purpose: high resolution graphics. The Listening Post II hardware device is quite capable of this, and a 'twice the clock speed' output has been arranged on the circuit board to double the number of pixels produced per line of fax.

I have NOT produced any EGA or VGA software at this stage, simply because I do not have access to an EGA or VGA graphics system (the tests were done in computer shops). If there is enough interest I may have to take the plunge, get a VGA system, and write some EGA/VGA software. As for other computers like MacIntosh and Amiga, let's just wait and see how this version goes first.

The Listening Post II software is presented as several programs instead of one, for a very good reason: any of the functions can be called up by simply typing its name on the DOS command line. There are no big turgid menus to wade your way through; you simply type 'FAX' and you get fax. You type 'RTTY' and you get RTTY. So each function is in its own little program. Since they are so small they don't take up much room on the disk. You can get the whole works onto a 360K floppy and still have plenty of room to store fax pictures or Morse or RTTY messages.

The programs have been written so their operation is as similar as possible; for instance the function key 'F10' will stop any of the programs, and the FAX and SHOW programs share the same commands. Since the screen usually has a picture on it which we don't want to disturb, most keypresses are acknowledged with a distinctive beep. This generally means the program is waiting for another keypress. Here's a rundown of each of the programs, one by one:

FAX.COM: You wait until you hear phasing pulses – 'pip-pip-pip' – coming over the radio. You then type FAX and hit (ENTER) and the program does the rest. When the phasing pulses finish and the picture information starts, the computer will begin displaying the picture line by line as it comes in. The picture should be properly centred. If you missed the phasing pulses at the start, the program will still make an attempt to centre the picture, using sync pulses if these are being transmitted. Otherwise it will go for a large black-to-white transition, hoping this will be at the edge of the picture. It sounds a bit rough and ready, but it certainly works.

When the screen is full of fax picture, the computer will emit a short beep, and you can then do one of three things: If you press F1, the picture will be changed from positive to negative or vice versa. F2 will turn the picture upside-down or right-side-up (they are sometimes transmitted upside down, and this allows you to correct them). F10 clears the screen and asks you for a file name if you want to save the picture to disk. You then type a file name (the extension .FAX is forced), or just hit (ENTER) if you don't want to save the picture. The program then returns you to DOS.

In the event you don't want the picture after seeing the first part of it, you can hit F10 at any time to abandon reception. You will then be asked if you want to save the (partial) picture, as before. This feature lets you cruise around from station to station looking for something interesting, and then you can receive a whole picture if you like it.

The problem of positive and negative pictures has taken a lot of effort to solve. Most people feel the fax pictures look best as black images on a white background, just as if they were printed on paper. With a normal CRT computer monitor on which the images light up against a black background, it means we must use inverse video. FAX.COM takes care of this by lighting up each scan line completely and then writing dark pixels upon it.

Most laptop computers, on the other hand, have a light coloured background and dark images, just the opposite from CRT screens. The software required to make dark-on-bright, or bright-on-dark pictures, is very different. I found the easiest way to overcome this was to produce two separate programs, FAXLCD and FAXCRT. As part of the installation process, you tell the software which system you intend to use, and the appropriate file will be copied to FAX.COM, making the program which produces fax pictures.

The main fax program receives at 120 lines a minute, the most popular speed. The 60 line per minute standard is catered for by the program FAX60.COM. So if you hear a 60lpm transmission, you type FAX60 instead of FAX. Everything else operates as in FAX.COM, but you'll notice the picture is coming in slooowwwly. FAX60 also comes in CRT and LCD versions, called FAX60CRT and FAX60LCD. The installation program handles these as above to produce FAX60.COM

SHOW.COM: This is the program that lets you display the pictures you have saved on disk. You type SHOW, a filename (the .FAX extension is assumed), and hit (ENTER). The picture pops up on the screen, and you can then use F1 to make it negative, or F2 to flip it over. F10 returns you to DOS. SHOW.COM cannot write back to the disk; it has been purposely written so it cannot modify the fax pictures in any way. So it it safe to leave a copy of SHOW.COM on every disk containing your valuable collection of fax pictures.

INVERT.COM: This lets you permanently change a picture from CRT to LCD, or LCD to CRT format (positive/negative). It is useful if you want to want to swap pictures between a PC and a laptop. You type INVERT and a filename (.FAX is assumed) and the picture is changed and written back to disk. Nothing happens on the screen, but a short beep signifies success. Remember that any picture can be 'inverted' temporarily by the SHOW program, but it can't be saved that way.

PRINT.COM: This prints a fax picture onto a graphics printer. After ensuring the printer is ready, you type PRINT, a filename, and hit (ENTER). The .FAX extension is again assumed. The picture will appear on the screen, just like with SHOW.COM, and lines of picture will begin painting onto the printer. If you look closely you may see a little glitch working its way along the screen. This is the data being read for the printer. When the printout is finished, the printer will then label it with the picture filename, date, and time. Like SHOW.COM, PRINT.COM is incapable of modifying a fax picture, so you can safely leave it on a picture disk.

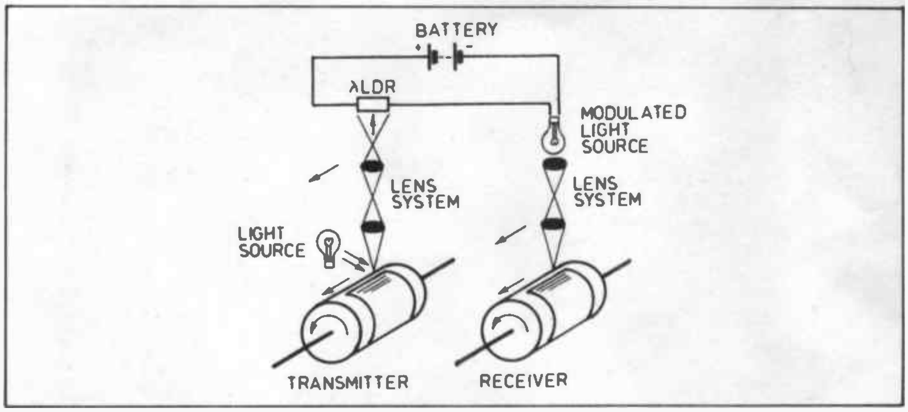


Figure 1: The basic principle used in facsimile or 'fax' image transmission. The image to be sent is scanned, a line at a time.

The printing program can work with two types of printers, Epson and its compatibles, and C-Itoh. There are major differences in the way these printers handle graphics, so two individual programs are provided: PRINTEPS and PRINTITO. The installation program copies one of these to PRINT.COM.

MORSE.COM: This is the Morse code decoder, and is fully automatic over the speed range of 10 to 40 words a minute or so. You type MORSE and (ENTER) and the program soon locks on to the sending speed and tracks it thereafter.

No computer Morse program is perfect; the trained ear always receives Morse code better, but this program has had some software filtering written into it to optimize reception as much as possible. It now performs many times better than the Morse routine with the original Listening Post. You can exit MORSE.COM by pressing the F10 key. You will be asked for a filename (the extension is forced to .MOR) for saving the received text, or you can hit (ENTER) on its own to leave the program without saving. The .MOR file is in standard ASCII format, so you can type it to the screen or manipulate it with a simple text editor.

RTTY.COM: This receives radioteletype in both the Baudot and ASCII codes at speeds ranging from 45 to 300 bauds. It can receive in both page and tape modes, and force figures/letters shifts. Every function key does something; these are detailed in the quick reference chart elsewhere. F10 exits as usual, and you can save the received text if desired. The file extension is forced to .TTY.

SETLPT.COM: This lets you select which line printer port (LPT#) you want to use for the Listening Post II device, and which LPT# for the printer. These can be the same if you have only one LPT# port, otherwise you can leave your printer connected to one and hook the Listening Post II to the other. The program installs all the Listening Post II programs in one go, so they all have to be on the same disk or in the same directory. SETLPT will complain about any missing files. This program is run automatically from the batch files described below:

MAKEEPS.BAT, MAKEITO.BAT: These select which type of printer will be used with the PRINT.COM program.

MAKECRT.BAT, MAKELCD.BAT: These files select the appropriate fax programs for use with either an LCD or a CRT screen and then generate FAX.COM and FAX60.COM. Next they call up the program SETLPT.COM so you can select the correct LPT numbers.

HELP.BAT: A handy utility which displays the quick-reference chart on the screen.

Installing the software

Do NOT attempt installation on the original disk! Copy the files to another 'working' disk, or to a special directory on your hard disk, and put the original disk away in a safe place. Remember that ALL the Listening Post II files must reside in the same directory for the installation program to work.

The installation job will be dead easy, but you must first make some choices before beginning. You must decide whether you want to use a CRT screen (normal desktop computer) or an LCD screen (laptop). But feel free to use these the wrong way around if you prefer negative pictures – it certainly won't hurt anything.

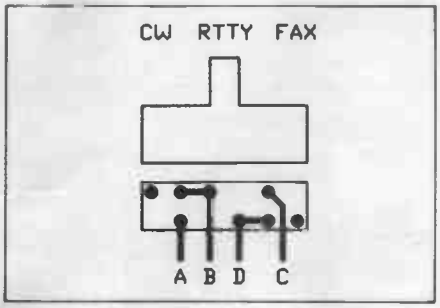


Figure 3: Wiring details for the mode control slider switch.

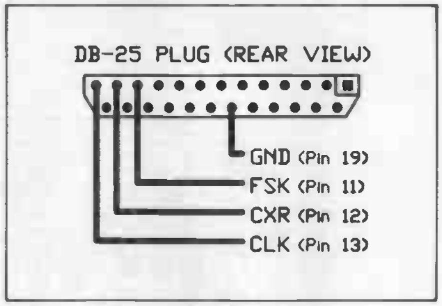


Figure 4: And the connections for the DB-25 computer plug.

Next you must decide which parallel printer port to use for the Listening Post II, and which to use for the printer. If you've got only one port the choice is easy; both devices will work through the same port, but you must swap plugs over when changing from one to the other.

Log the computer onto the copied disk, or onto the Listening Post II directory of your hard disk. The first thing to do is specify the printer type; choices are the popular Epson and its clones, or the C-itoh 8510 which also goes under the name of Toshiba and Prowriter. These are the only printer types at this stage, because they are the only ones I have access to. Type MAKEEPS for Epson, or MAKEITO for C-Itoh. These will generate the user program PRINT.COM.

Next the screen: if you are installing for a CRT screen, type MAKECRT (ENTER). Things will whir a bit, and you will then be asked which printer port for the Listening Post II device. Choices are 1, 2, 3, or 4, and the program will complain if it can't find the specified printer port in your computer.

If there's a discrepancy, test the port in question to make sure it actually works with a printer, completely separate from Listening Post II. You may need to fiddle with some DIP switches or jumpers in the computer to get the port going, if you haven't used it before.

Next you will be asked which printer port to use for the *printer* during Listening Post II operation; again specify 1, 2, 3, or 4. The installation program will emit a short beep as each program is read in from the disk. It will complain about any files it can't find. If one is missing, check that ALL files are present and start again.

For an LCD screen, proceed exactly as above, only type MAKELCD (ENTER) instead of MAKECRT. None of the Listening Post II master files (file type .MAS) is affected by the installation process. You can do it over and over again, trying different screen types and ports, with no danger of messing anything up. The installation process produces the programs you will actually use – FAX.COM, FAX60.COM, SHOW.COM, PRINT.COM, RTTY.COM, and MORSE.COM. These can be moved around and used anywhere in the computer.

Building the kit

Successfully building the Listening Post II requires only a moderate amount of electronics skill – if you've ever built any kit before you should be able to handle this one with no trouble. The circuit board has been carefully laid out so there are no tight spots; plenty of space has been left between components and everything should fall into place nicely.

The only problem may arise from the metal film resistors used in some parts of the circuit. Colour codes on these are sometimes difficult to interpret, but any perplexing ones will be explained in the notes that come with the kit.

The parts list gives the part type and value for each component number on the circuit board. Before beginning construction, check and identify each component from your little bag of goodies with what's on the list. We have taken every care to make sure each kit is complete, but still, mistakes can happen. Fig.2 is a component overlay for the circuit board, a 'road map' showing which parts go where, and how they are to be orientated.

Begin construction by installing the resistors. Try to make sure the colour codes read from left to right or bottom to top; this is good professional practice and makes for a nice looking board. Next come the transistors, making sure they are the right way around. Now to the capacitors, doing the smallest ones first. Leave the larger greencaps for last; otherwise they're easy to break off. I like to put a dab of Silastic under the bigger greencaps before soldering them it; it gives them much-needed extra support. The vinegar stink doesn't last for long.

Now install the IC's, making ABSOLUTELY CERTAIN they are the right way around; check their orientation carefully on the overlay. Pin 1 on the PCB overlay will be blackened in, and the notch on the end of the IC must coincide with the notch on the overlay. Make sure the flat part of the voltage regulator IC3 faces the same way as it does on the overlay. Last, fit the trimpot, the trimmer capacitor, and the crystal. A dab of Silastic under the crystal might be a good idea, but do NOT use Silastic on the trimpot RV1 or trimmer capacitor C11!

The LED and the switch may be installed on short leads close to the circuit board, or on longer leads if you are going to install your Listening Post II in a case. Note that the positive side of the LED (usually the longer wire) goes to the right of the word 'LED', closest to R17. Connect the switch to circuit board points A-B-C-D as per the diagram in Fig.3.

With the circuit board complete, you must now assemble the cable between the board and the computer plug. Wire it up following the diagram in Fig.4. Finally prepare whatever audio connection is needed for your receiver. If this has a 'recorder' or 'line' output, use it, since its operation will be independent of the volume control. Otherwise use the external speaker or headphone jack. Use shielded audio cable to connect the receiver with the Listening Post II.

Testing

When construction is finished, carefully check again to make sure the components are in the right places and the right way around. Look under the board to see if there are any solder bridges between tracks. Set the trimpot RV1 (if supplied) to the centre of its rotation. Finally connect the power from the plugpack or other supply, making sure plus and minus are the right way around.

Since the Listening Post II has an on-board voltage regulator, the input voltage can be anything between 8 and 18 volts or so. Many communications receivers have a connection on the back for supplying power to accessories, and this might be suitable; check your instruction manual.

When everything is ready, turn the power on and check for signs of distress such as hot IC's or transistors. No smoke? Good.

Now connect the audio line to your receiver, set the mode switch for single sideband, and tune around until you find any carrier, any whistle, anything to produce a steady tone. At some tone pitch, the LED should come on, indicating a carrier is present. If you can't get the LED to light up, you've got troubles. For a start, is the LED wired in the right way around?

If the LED is working, it's a pretty good guess that the whole phase locked loop system is OK.

We'll need the computer for the rest of the testing, so you'll have to install the software before going any further. See 'Installing the Software', above.

Right! Back to the circuit. Disconnect the audio source, extinguishing the LED, and connect the computer plug to whichever printer port you have chosen for the Listening Post II. Now type FAX (ENTER). If everything is all right you should get a message complaining that there is no carrier signal (because you just disconnected it). If the program complains that it can't find the Listening Post II device, this is because you've plugged it into the wrong printer port, or there's something wrong with the crystal oscillator on the circuit board, or the plug is wired wrong. Check your work again.

If your Listening Post II passes all these tests so far, there's a pretty good chance it's actually going to work! Let's give it a try.

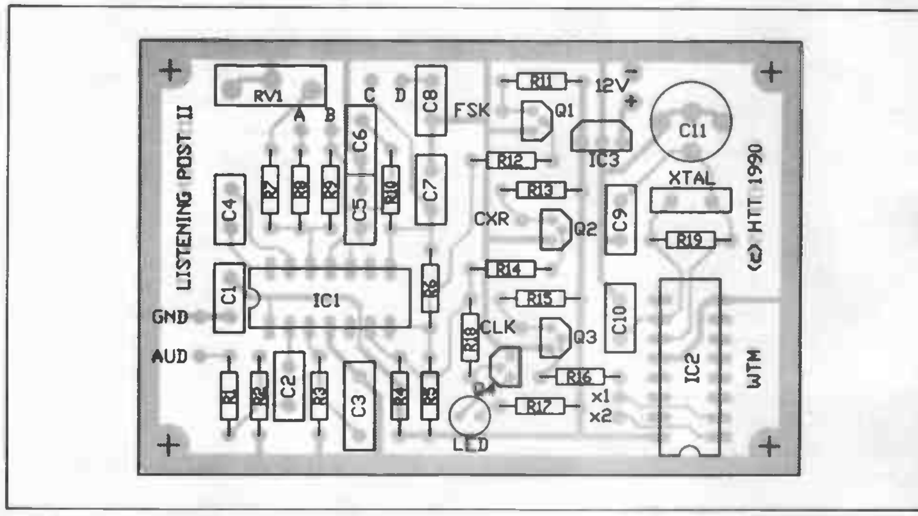


Figure 2: The PCB board wiring overlay, to provide further help in wiring up the decoder.

PARTS LIST

Resistors

All ¼W:
R1,10,12,14,16,18,19
100k
R2,11,13,15
10k
R3 470k
R4,5 4.7k
R6 3.3M
R7 22k
R8 33k
R9 220k
R17 220 ohms
RV1 5k trimpot

Capacitors

C1,5 0.1uF monolithic
C2 10nF ceramic
C3 0.15uF metallised polyester
C4 22nF metallised polyester
C6 5.6nF metallised polyester
C7 4.7nF metallised polyester
C8 33nF metallised polyester
C9 33pF ceramic
C10 47pF ceramic
C11 3-30pF trimmer

Semiconductors

Q1-4 BC547 transistor
IC1 XR-2211 PLL IC
IC2 4060 oscillator/divider
IC3 78L05 5V regulator
LED Any type of LED

Miscellaneous

4.9152MHz crystal, PC board 85 × 55mm, two pole three-position slider switch, DB-25 plug, ribbon cable, case to suit.

Adjustment & operation

Reconnect the audio from the receiver, set the switch to FAX, and tune in a weatherfax station. The Australian AXM transmitter on 11030kHz is a good place to start; it's audible in most parts of Australia. Select UPPER sideband, and then tune the receiver to 11028.4kHz – 1.6kHz below the station's assigned frequency. This shifts the signals into the audio range, where we can deal with them.

You may hear a steady tone if the station is resting, or data noises if it's sending a picture; the sound will appear to repeat itself at half-second intervals. Wait until the start of a picture: a steady tone, followed by a 'blurt' noise, followed by a string of pip-pip-pips. Type FAX (ENTER) and the screen should go totally blank. When the pips are finished (30 seconds or so) and the picture data starts, the computer should start drawing the picture on the screen slowly, line by line. If this happens it is now time to congratulate yourself for a job well done.

The picture will probably be slanted one way or the other. If so you must adjust the crystal trimmer capacitor, gently and slowly, until vertical lines are perfectly vertical. Once this is done you will probably never have to touch the trimmer capacitor again.

You can also experiment with the setting of the trimpot RV1, which affects the audio frequency required from the receiver to produce the right range of whites and blacks. This may improve reception with some receivers, but in practice it's very non-critical. As mentioned before the trimpot may be deleted from future kits.

You should now be able to receive any fax station you desire. Occasionally a station will require you to use lower sideband to get a positive picture, but these are very rare. If you decide a particular picture is not worth having, you can bail out of the program before the picture is finished with the F10 key. Once the program is stopped, either by F10 or when the screen is full, you can reverse the picture positive/negative with the F1 key, or flip it upside-down with F2. Pressing F10 a second time will exit the program, asking you if you want to save the received picture.

In general it is best to use the highest possible transmitter frequency for receiving fax pictures, even if it is not the strongest. The lower wavelengths, even though stronger, may have bounced off the ionosphere several times and the pictures may be fuzzy and indistinct. It's like trying to listen to a voice as it echoes across a hollow empty room.

The FAX60 program is available for 60 line-per-minute transmissions. You'll know you've found one, because everything seems to be running at half speed. Operation is identical to the main FAX program, but be patient; it will take nearly 17 minutes to fill the screen.

RTTY operation

RTTY (radioteletype) signals come in various high/low tone shifts, from 850Hz right down to 70Hz. They may also be upside-down or right-side-up, so if a signal is uncopiable in upper sideband, try lower. For the wider shifts use the RTTY switch position, but for 70Hz stations the CW position will prove best since it has a narrower audio bandpass.

The program starts in the Baudot code, page mode, on the 50 baud speed, but you can use the function keys to change these. See the complete list of RTTY functions in the quick-reference guide. As in FAX you are invited to save what you have received on disk as you exit.

Morse operation

There are no controls for Morse operation other than F10; operation is fully automatic and the program will lock onto and track any sending speed from 10 to 40 words per minute. Tuning however is very critical.

Select CW on the switch and then tune into some Morse code. Tune the pitch until the decoder LED is flickering on and off with the dots and dashes. You must then carefully adjust the signal level with the volume control or the RF gain control, so that the LED goes out COMPLETELY between the dots and dashes, but comes on completely with them on. As the audio is reduced you may have to retune the frequency slightly to 'peak' the LED response.

When the LED is behaving correctly, type MORSE (ENTER) and the code should produce text on the screen. Some of this may look like gibberish, but it may simply be lists of ships' radio call-sigHT. Sometimes there will be plain-language weather forecasts, and you may occasionally see private traffic between ships and their owners.

A good place to test the Morse code is on 12997kHz between 4PM and 5PM every day, Eastern Standard Time. This is a Morse code news transmission from the ANSA news agency in Italy. Copy is usually very good, and you'll notice the Morse program faithfully producing the accented A's and E's of the Italian language. The program contains most known international Morse code characters and symbols.

As with fax transmissions, copy will generally be cleaner on the higher frequencies.

If all else fails

Type HELP (ENTER) at the DOS prompt. The Listening Post II Quick-reference chart will be displayed on the screen.

Happy listening! ●

Samples of what you can get with Listening Post II:

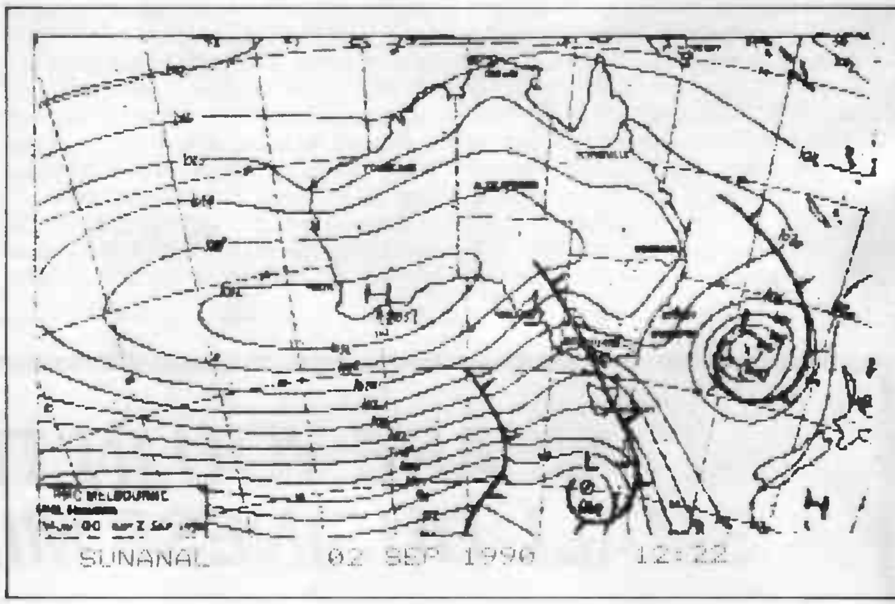
Here are some examples of the type of weather pictures you will receive while tuning around the shortwave bands with Listening Post II. The maps on these pages were collected using either an Icom R-71 or R-72 communications receiver in Hobart, or the receiver part of an Icom IC-735 amateur transceiver at Port Cygnet in the country south of Hobart.

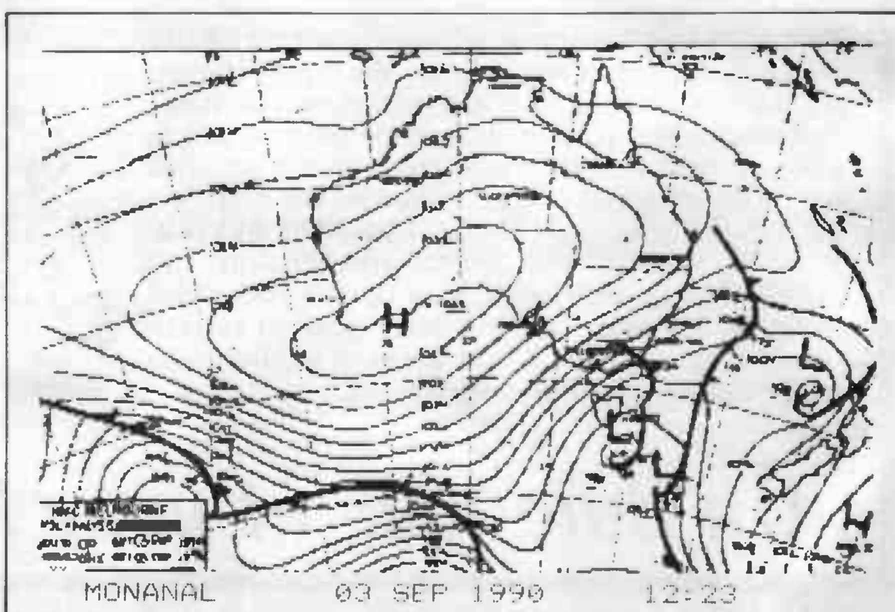
Picture 1 is a sequence of four surface analysis charts, received from the Australian weather-fax station AXM at the Port Cygnet location. They came through at lunchtime on consecutive days during the first week of Tasmania's September school holidays. The charts show how you can track the day-to-day movements of weather patterns, and they graphically illustrate the rotten weather that is traditional at holiday times!

On the chart for Sunday, September 2, there is a deep low between Australia and New Zealand. Another low is south of Tasmania, a cold front is crossing southern Australia, and another front is coming along behind it. Winds that day were unpleasantly strong and cold.

On Monday, the biggest low is closer to New Zealand but it's lost some of its strength. The low south of Tasmania has moved north, and to the southeast of it a third low has formed, complete with the beginnings of an occluded front (that's the notch, just below the letter L). The isobars, and hence the winds, have turned much more southerly. It snowed that day in the higher suburbs around Hobart.

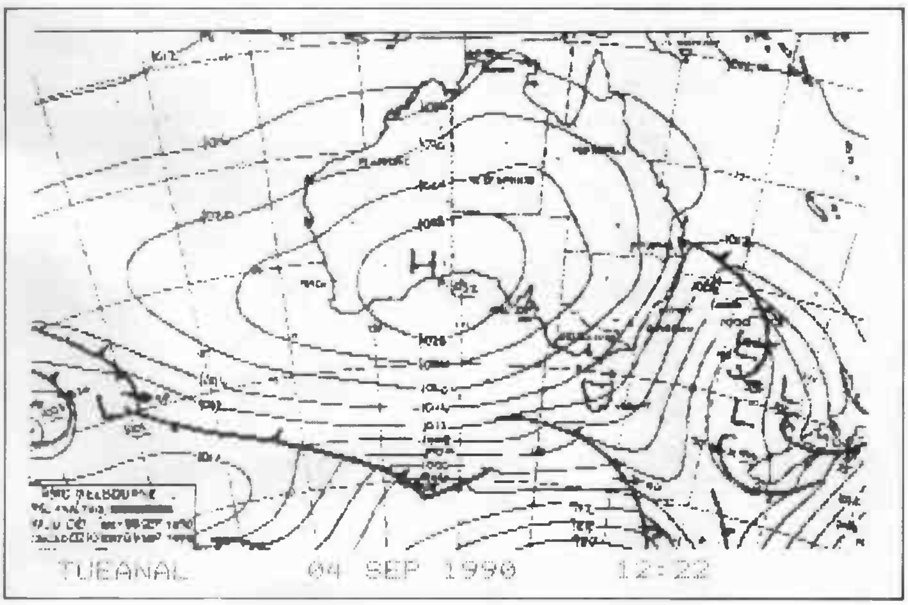
Tuesday's chart shows the three low pressure areas apparently circling

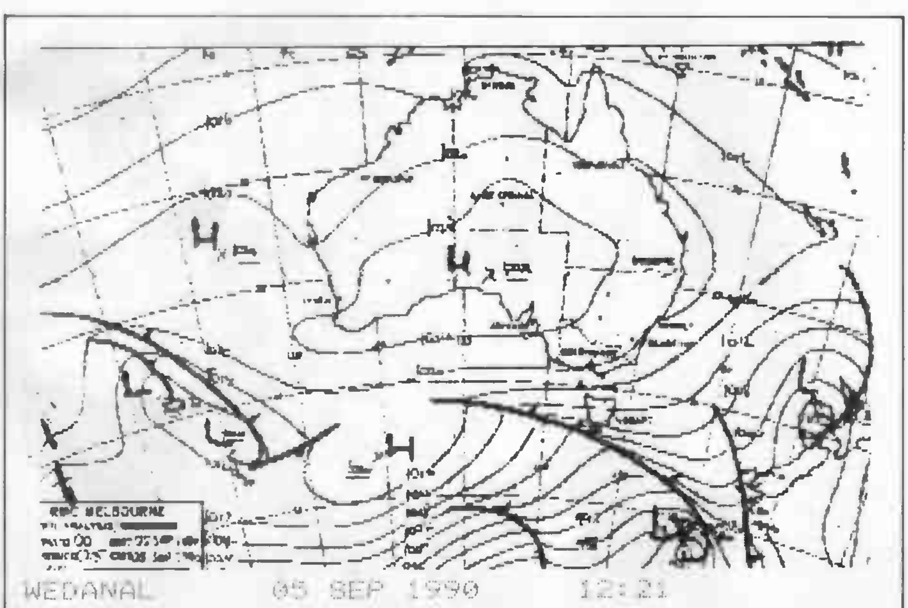




LISTENING POST II - QUICK REFERENCE

FUNCTION	FAX	FAX60	SHOW	PRINT	RTTY	MORSE
Invert pos/neg	F1	F1	F1			
Upside-down	F2	F2	F2			
45.45 Bauds 60 WPM					F1	
50 Bauds 66 WPM					F2	
57 Bauds 75 WPM					F3	
75 Bauds 100 WPM					F4	
110 Bauds					F5	
300 Bauds					F6	
Flip Figs/Ltrs Case					F7	
Flip Baudot/Ascii					F8	
Flip Page/Tape mode					F9	
Abandon fax picture	F10	F10				
Quit program	F10	F10	F10	F10	F10	F10
Save file?	YES	YES	NO	NO	YES	YES





around each other, over the Tasman Sea. The isobars over southern Australia are not so tightly packed and the winds have moderated. Another cold front is heading toward Tasmania, but it's being squashed a bit by the big high over the Great Australian Bight. Ceduna would have been the place to be, that day.

On Wednesday, the big high has split into three centres, one of them a small bubble-shaped area west of Tasmania. This little high became the major influence over Tasmania the next day, bringing the first decent weather of the holidays. So I didn't hang around to receive the lunchtime weather chart that day – we went sailing instead!

AXM transmits these analysis charts every six hours. Just before the lunchtime chart they send a nephanalysis – a stylized representation of cloud cover over the southern half of the earth ('neph' means cloud). These pictures are based on satellite photographs, and they are prepared by laying a transparent sheet on top of a large satellite photo and tracing the cloud shapes. The forecaster then adds symbols indicating the types of clouds, and abbreviations to show the amount of cloud cover; MOP means mostly open, MCO means mostly covered, C means covered, and so on.

About receivers . . .

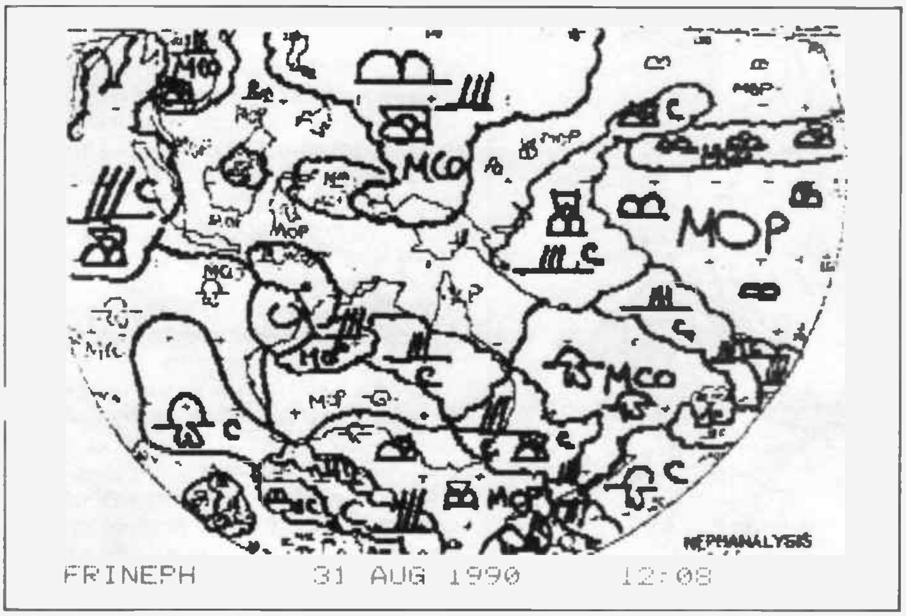
Any receiver for use with Listening Post II must be able to receive single sideband signals. Fax, RTTY, and Morse code are not single sideband of course, but they're handled through the receiver as if they were. Up to a certain point, the better the quality of the receiver, the better the results will be. After that it's the law of diminishing returns.

The cheapest receiver I've tried with Listening Post II was a little Sony 7600 pocket-sized shortwave radio. This was barely adequate, and only for the strongest signals. At the other end of the scale, Listening Post II has been tested with the Icom R-9000, the most sophisticated receiver on the market today. Of course the results were great, but Listening Post II works just as well on my Icom R71 for a fifth the price.

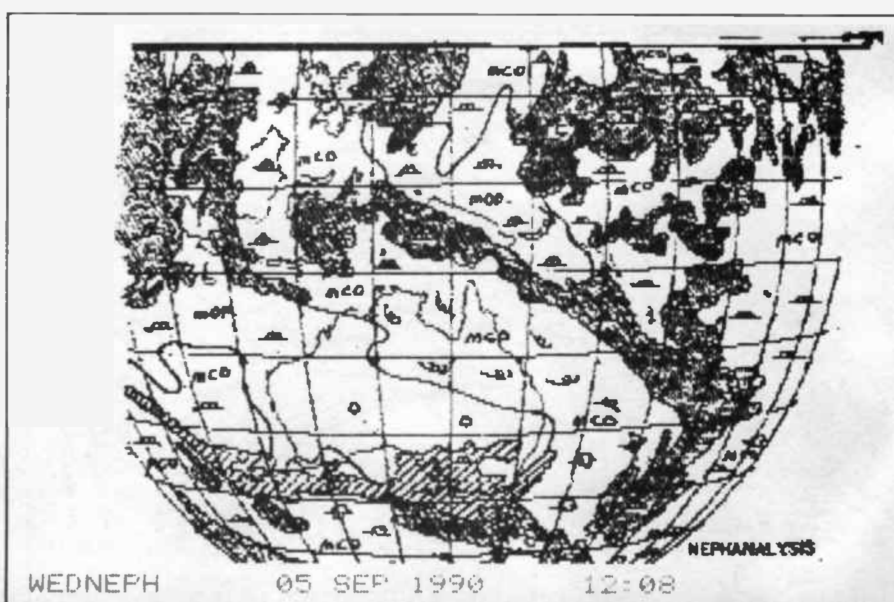
Modern receivers are all pretty good, so you can expect good Listening Post II performance from most of them. The newest middle-of-the-range receiver, the Icom R-72, works fine with Listening Post II.

A problem you may encounter is radio noise generated by the computer. This varies dramatically from machine to machine; my Unitron PC clone is awful, while the Toshiba laptop is quiet as a mouse.

To minimize radio noise you MUST use an outside antenna, even if it is a 10-metre scrap of wire draped out a window. Life will be easier if the wire leading to the antenna is shielded, and kept as far away from the computer as you can get it. The best antenna is a proper transmitting dipole fed at the centre and mounted as high as possible. If decent coaxial cable is used to connect the antenna to the receiver, it should provide years of trouble-free performance.

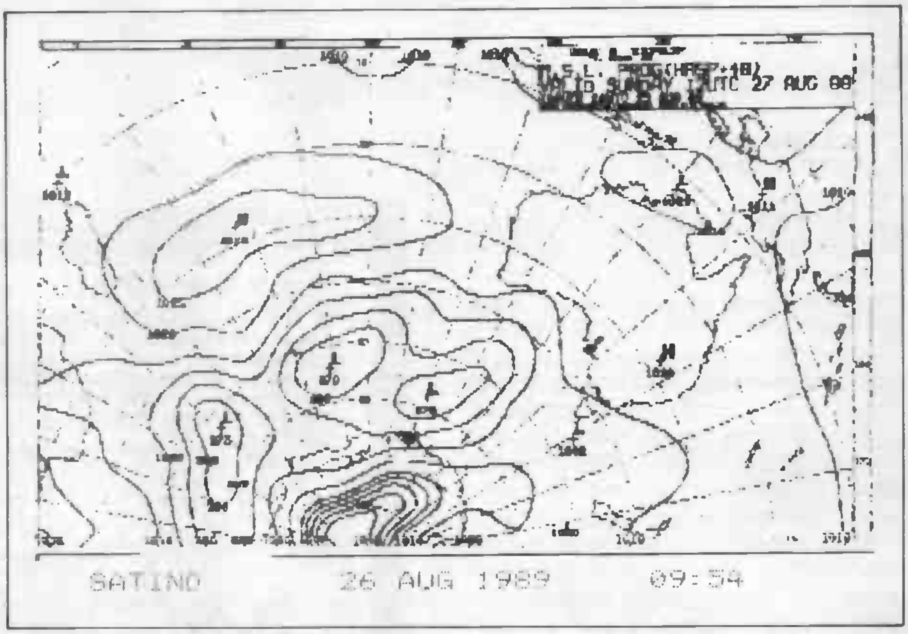


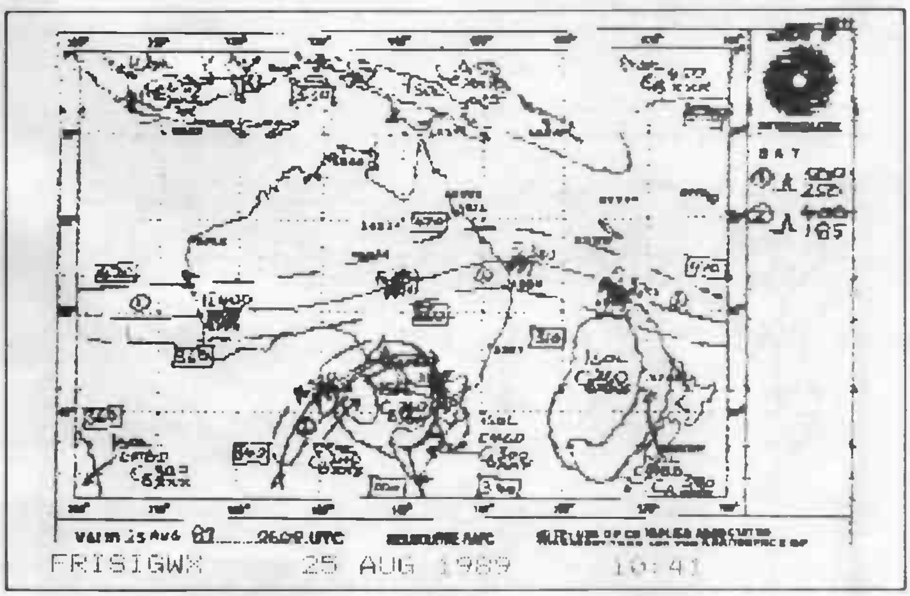
Picture 2 is a nephanalysis drawn with what looks like a big fat Textacolor. This style is very easy to read, even when the fax picture is received over a very poor path.



Picture 3 is another style of nephanalysis which looks much more like the satellite picture it came from. But it needs a pretty good radio path to make it easily readable. Picture 3 coincides with the last of the four charts in the analysis sequence in Picture 1. You can see the fronts and lows on that chart represented as cloud masses in the nephanalysis.

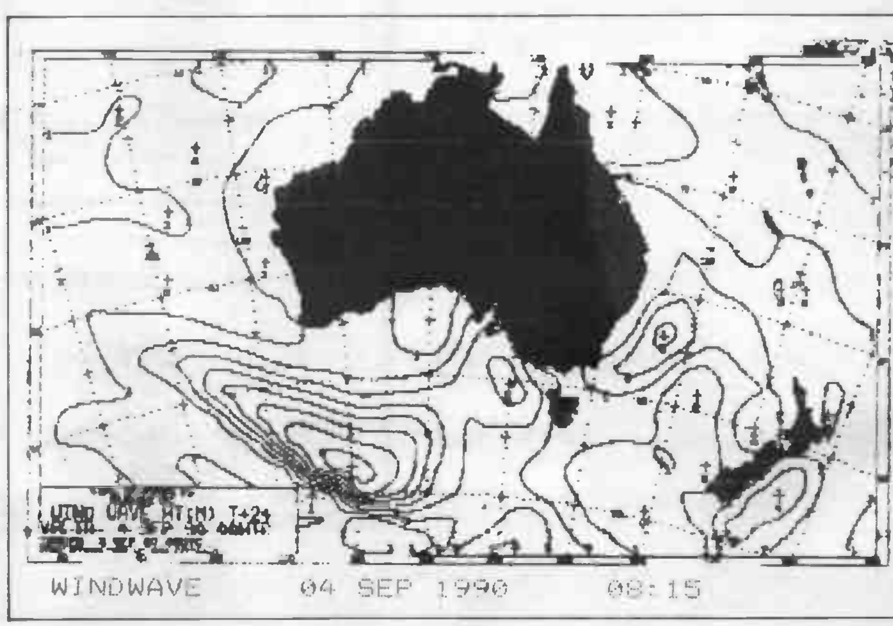
Picture 4 is a prognostic chart – a look into the future. This one is a wide angle view covering longitudes from 0 to 180 degrees, going up from the South Pole at the bottom of the picture. The highs and lows are what are expected 48 hours hence. There are no fronts shown – it's too early for that.





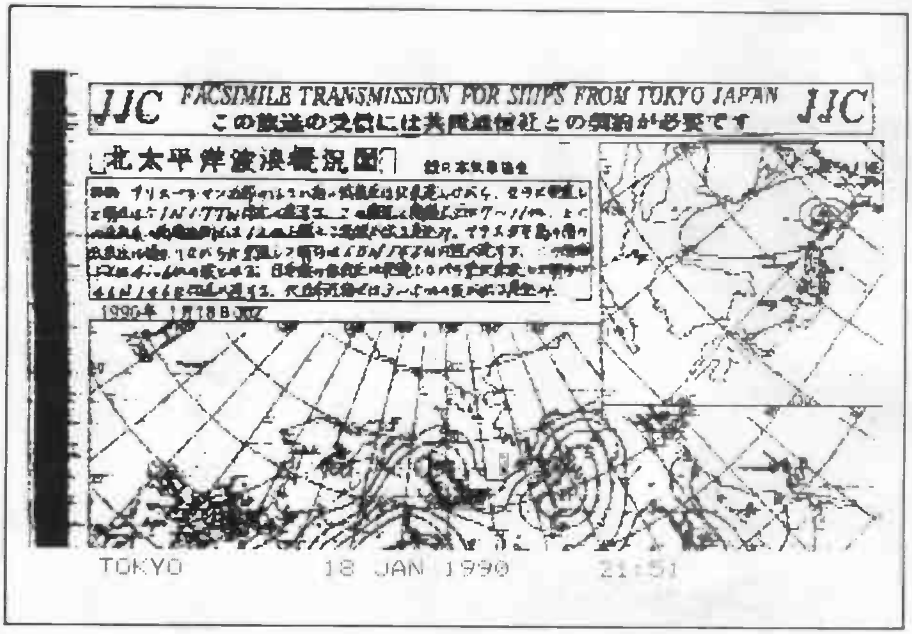
Picture 5 is a significant weather prognosis, a chart used mostly by pilots. It shows clouds, turbulence, fronts, and a jet stream going across the centre of Australia. (Note that Pictures 4 and 5 are over a year old, some of the first received with Listening Post II.)

Picture 6 is a wind-wave prognosis for 24 hours from September 4, so it would match up with the last of the sequence charts on September 5. The lines are contours of equal wave height. Note the very tight gradient in the area south of the Bight. The final chart in Picture 1 shows a pair of nasty-looking lows in much the same area, and the nephanalysis for the same time, Picture 3, shows storms there as well. Not a pleasant place to be in a ship!



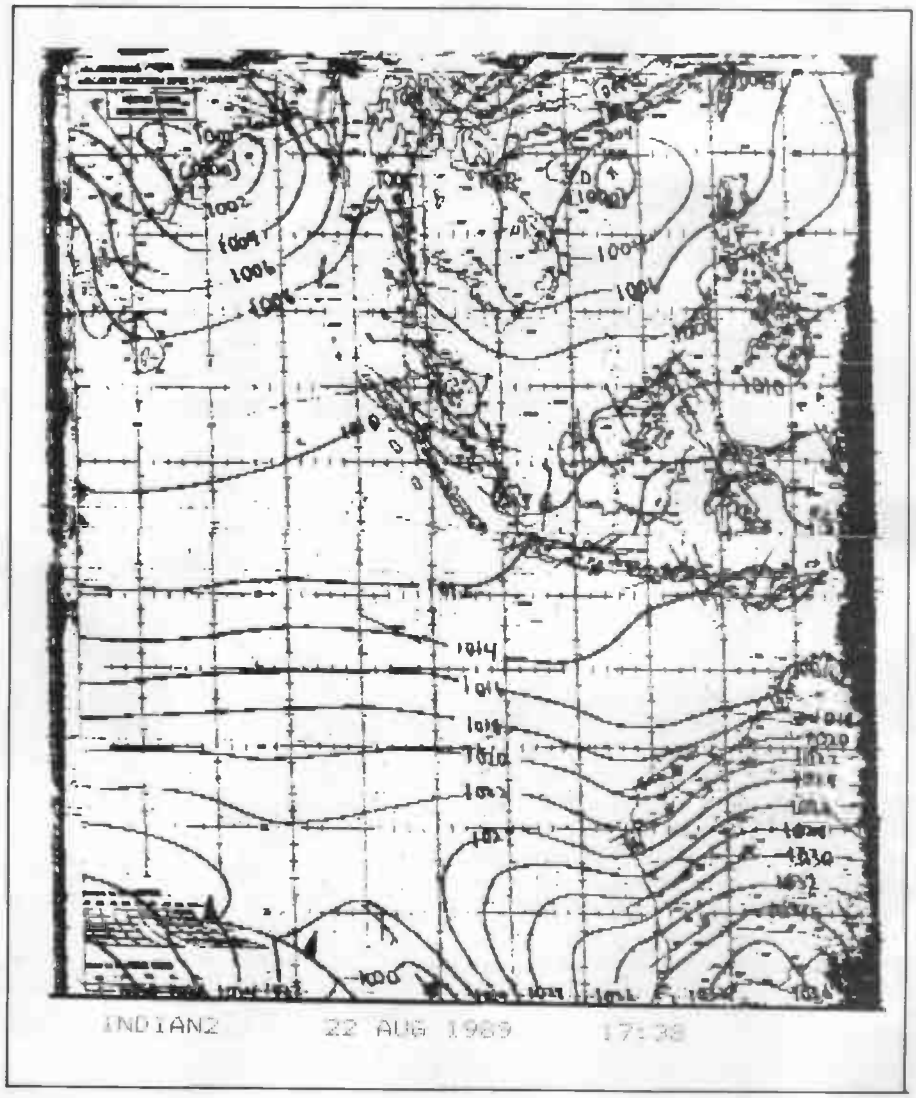
Picture 7 shows the type of stuff you can get from overseas. It's a 60 line-per-minute picture from JJC, a transmitter of the Kyodo news agency in Japan. The picture is sent with sync pulses, so Listening Post II is able to lock up to it anytime during its transmission. This is good because once it gets going, this transmitter sends a continuous string of material non-stop. The writing isn't of much use if you don't read Japanese, but the pictures are still interesting. You can see Alaska and the USSR at the top of the big weather chart, but the screen fills up before you get much further.

Many overseas stations send pictures that extend over several computer screens. If there are sync pulses or any black edge you can wait until a screen is full, save that picture to disk, and then restart the fax program. You will have only missed a few seconds of picture, and the program should re-lock correctly. Once the picture is finished you can print out the individual pictures and then go after them with scissors and sticky tape to join them together.



This was done with **Picture 8**, a combination chart covering from Australia in the lower right to India in the upper left. In between are Indonesia, the Bay of Bengal, and just about the entire Indian Ocean. This chart is typical of the material that comes from AXI, the Darwin Weather Bureau transmitter. It's a good source of charts covering the area north of Australia.

The next examples aren't pictures, but we'll call them that since they're part of this discussion.



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TENDE DA MOLTE VALUTAZIQMI . IO CREDO , PERÒ , CHE SIA BENE CHE COMANDI
UNO SOLO , E MI AUGURO - HA CONCLUSO PINIFARINA COD ONA BATTUTA - CHE
TRA I DUE SIA IL GRUPPO PRIVATO . ALINEA ar ar ANSA 9 WASHINGTON II
WASHINGTON = LA CAMERA DEI RAPPRESENTANTI HA DETTO NON AL FINANZIAMENTO
DELLA BASE DELLA NATO A CROTONE II CROTONE , CHE DOVREBBE OSPITARE
LO STORMO DI CACCIA BOMBARDIERI F-16 II F-16 SFRATTATO DALLA SPAGNA
. CON 259 II 249 VOTI YONTRO I 174 II 174 I DEPUTATI AMERICANI HANNO
REPSINTO I LROGETTI OTZ PENTAGONO PER IL TRASFERIMENTO DELLO STORMO
S CROTONE : TROPPO ALTE LE SPESE , LA PREFERENZA É PER ORA UN RITORNO
DEGLI F-16 II O-16 IN USA . ALINEA ar ar ANSA 10 MOSCA II MOSCA = UN
' ESPLOSIONE HA PROVOCATO UN VASTO INCENJMO CHE HA LIBERATO GAS ESTREMAMENTE
NXCIVI , IN UNA FABBRICA SOVIETICA DI PRODUZIONE DI COMBUSTIBILE PER
LA CENTRALE NUCLEARE DI KAMENOGORSK II KAMENOGORSK , NEL KAZAKHSTAN
II KAZAKHSTAN . LO HA ANNUNCIATO L ' AGENZIM SOVIETICA TASS II TASS
PRECISANSO CHE LO SCOPPIO É AVVENUTO NEL SOTTERRANEO DI UNA UNITA DI
PRODUZIONE DI BERILLIO , UN METALLO MOLTO RESISTENTE AL CALORE , UTILIZZATO
NELLA COSTRSZIONE DI REATTORI NUCLEARI . ALINEA ar ar ANSA 11 6T ZGRADO
II BELGRADO = TRE ABITANTI DELL ' ETNIA ALBANESE DI UN VILLAGGIO PRESSO
PODUJEVO II PODUJEVO , NEL KOSOVO II KOSOVO , SONO RIMASTI UCCISI IN
UNX SCXNTRO CON FORZE DELLA POLIZIA . NELLO SCONTRO - INFORMA QUESTO
FOMERIGGIO RADIO BELGRADO - SONO RIMASTI FERITI ANCHE DUE AGENTI DELLA
MILIZIA . ALINEA ar ar ANWM 12 MOSDEA II MOSCA = UNDICI JOLDATI SOVIETICI
SONO MORTI E ALTRI SETTE SWNO RAMASTI FERITI OGGI IN LITUANIA , QUANDO
IL CAMION SU CUI VIAGGIAVANO SI É RIBALTATO , INCENDIANDOSI , NE DA
NOTIZIA LA EASS . ALINEA ar ar ANSA 13 ROMA II ROMA = LA CRISI DEL
GOLFO , LA QUESTIONE DELLA RIFORMA ELETTORALE E LA SITUAZIONE INTERNA
DEL PCI SONO STSK M ŏRINCIPALI TEMI AFFRONTATI DAL SEGRETARIO DEL PSI
, BETTINO CRAXI II BETTINO CRAXI , NEL DISCORSO CON CUI HA APERTO IERI
I LAVORI DELLA DIREZIONE SNTT ŏIALISTA . CRAXI HA AVUTO ACŏENTI PREOCCUPATI
PER LA SITUAZIONE VENUTASE A CREARE J O PO L ' INVASIONE DEL KUWAIT
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'Picture' 9: Morse code transmission; news headlines from ANSA agency.

Picture 9 is what the Morse code output looks like. It's a news feed from the ANSA news agency in Rome. Note the occasional accented E's and A's. Also note the lack of errors, even though the transmission came from the other side of the world. Good stuff, this Morse.

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   IN A STATEMENT, YEUTTER SAID THE USE OF BLENDS IN THE
DEPARTMENT'S CARS AND TRUCKS IS REQUIRED IF THE FUELS ARE
AVAILABLE AT PRICES COMPARABLE TO REGULAR UNLEADED GASOLINE.
   YUETTER REMARKED THAT "ETHANOL IS PRODUCED FROM AMERICAN CORN
AND OTHER AGRICULTURAL PRODUCTS, AND THAT'S GOOD FOR AMERICAN
FARMERS", ADDING "IT ALSO HELPS REDUCE U.S. DEPENDENCY ON FOREIGN
OIL."
   HE NOTED "THIS IS A GREAT WAY FOR EACH OF US, AS INDIVIDUALS
AND AS MEMBERS OF THE USDA, TO DEMONSTRATE OUR COMMITMENT TO
AMERICA'S FARMERS, AMERICA'S ENVIRONMENT AND AMERICA'S FUTURE."
   THE USDA HAS MORE THAN 33,000 CARS AND LIGHT TRUCKS IN KCCL50
STATES. EXPERTS BELIEVE THAT IF THESE VEHICLES USED
ETHANOL-BLENDED GASOLINE, THEY WOULD CONSUME ABOUT 1.7 MILLION
GALLONS OF ETHANOL A YEAR, REQUIRING 680,000 BUSHELS OF CORN
ANNUALLY.
   IN HIS MEMORANDUM, YEUTTER ALSO URGED THE DEPARTMENT'S 100,000
EMPLOYEES TO USE BLENDED FUELS IN THEIR PERSONAL VEHICLES.
   SPOKESWOMAN KELLY SHIPP SAID YEUTTER'S STAFF WAS "LOOKING
AROUND" FOR A LOCAL SOURCE OF BLENDED FUEL TO USE IN USDA CARS
CARRYING THE SECRETARY AND OTHER SENIOR OFFICIALS.  SO FAR, NONE
HAS BEEN FOUND, SHE SAID.  ENDITEM
14/09/90 0755GMT
NNNN

ZCZC
QL EEEEE
.AA
XNA0089T  EB089
       FESTIVE BEIJING ON EVE OF ASIAD
       BY SPORTS WRITER SHIDA ZHU

    BEIJING, SEPTEMBER 14 (XINHUA) -- TOURISTS WILL FIND A
BEIJING ENTHUSING WITH SPORTIVENESS, FEATURING STREET SCENE OF
FLOWER PATTERNS, A COLORFUL ASSORTMENT OF GOURMET FOODS AND ITS
BIGGEST EVER BAZAR, AS THE 11TH ASIAD IS DRAWING NEAR.
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'Picture' 10: RTTY news, exactly as received from Xinhua agency.

Picture 10 is a radioteletype news transmission from the Chinese news agency Xinhua. Sometimes these services send in French, or even languages like Vietnamese. Much of it is boring political dogma, but you see the occasional item like this one describing the use of ethanol in cars in the USA. I guess nobody's told Xinhua that the good ol' boys in the backwoods of Tennessee have been distilling corn juice for years. It just goes under a different name: White Lightnin'!

How to build a high gain vertical antenna for the UHF amateur or CB bands

You can use low-cost coaxial cable to make a simple, high performance, omnidirectional vertical antenna that is ideal for both home station and portable applications.

THE *collinear* antenna has been around a long time. Various versions enjoyed popularity on the amateur VHF and UHF bands in the eras before and after World War II. But the collinear fell out of favour when the Yagi array became popular since the late '50s. The Yagi's popularity is attributable to its feature of giving the 'best bang for the buck'. But it is a beam which requires rotating.

With the rise in popularity of FM operation on the VHF and UHF bands since the '70s, the proliferation of commercial amateur rigs, and the development of repeater networks around the country, the demand for omnidirectional antennas grew apace. A lot of FM activity is mobile, with a degree of base or home station operation, too. For the latter application, an omnidirectional antenna with gain offers distinct advantages, particularly where comparatively low-powered mobile rigs are used at home.

The growth of UHF CB has followed a similar path, boosted by the availability of locally-manufactured transceivers selling alongside imports. Open access repeaters helped the growth of UHF CB, too.

A home-constructed antenna can save you big bucks. Many constructors make up a simple *groundplane* or *coaxial dipole*, which have the advantage of simplicity. However, something that offers a respectable amount of gain and can be assembled with little more effort is a bonus.

The collinear antenna to be described offers considerable gain and improved bandwidth over the conventional groundplane, coaxial dipole, 'Slim Jims' or similar antennas. It is simple to construct and erect since it does not require tuning or pruning, and uses cheap, commonly available 'quarter-inch' RG58 coax.

The word *collinear* means 'in line', the elements of the collinear antenna being placed in line, end to end. Two half wave dipoles placed end to end and fed out of phase make the simplest two-element collinear.

A collinear from coax

To make a collinear antenna from coaxial cable, a number of elements, each an *electrical* half wavelength long, are joined together with the inner conductor and the shield braid transposed at each joint, as illustrated in Figure 1. An even number of elements is required. By transposing the coax's inner and outer conductors at each join, each half wave element is fed out of phase.

I first ran across this form of the collinear in a scientific publication in the early '70s. The published paper described a *monstrous*, 400 metre long, 104 element array used for a

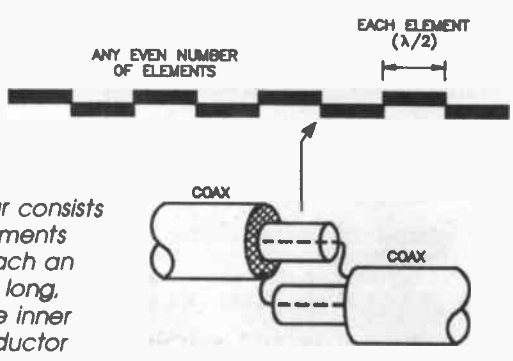


Figure 1. A coaxial collinear consists of an even number of elements made of coaxial cable, each an electrical half wavelength long, joined end to end with the inner conductor and outer conductor transposed at each joint.

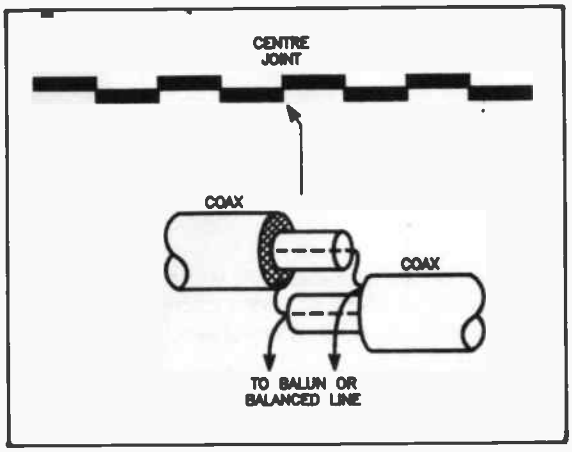


Figure 2. Coaxial collinears may be fed at the centre, as illustrated here, or at the end, which is used in the antenna described (see Figure 3).

50MHz radar located at Jicamarca in Peru, used for probing the ionosphere. The beamwidth of this wonder was reported to be just *one degree!*

The number of elements used determines the gain, beamwidth and bandwidth of a coaxial collinear antenna. The gain increases by 3dB every time you double the number of elements. Two elements provides a gain of 3dB compared to a dipole, four elements would give 6dB, eight elements 9dB, etc.

For the technically inclined, the bandwidth is generally defined as the point at which the gain degrades due to phase variations greater than one-sixth pi radians on the end elements. You can calculate the bandwidth from:

$$\text{bandwidth} = 2f/(3n + 1)$$

where 'f' is the centre frequency of operation, and 'n' is the number of elements in the array.

The interesting thing is, if you use lossy coax, the antenna's performance improves without markedly decreasing the gain or increasing the beamwidth. Hence the use of common-or-garden RG58!

Feeding It

You have two opportunities to connect a feedpoint to the coaxial collinear – in the middle, or in the end. When centre fed, the feedline is connected across the centre joint, as illustrated in Figure 2.

As you may already appreciate, this is a balanced connection and requires a balanced line or a balun transformer to connect unbalanced coaxial feedline. The feedpoint impedance is a few hundred ohms, allowing the use of a simple 4:1 balun.

But feeding a collinear in the middle is awkward when you want to mount it vertically. The feedline must come away from the array at right angles. So, feeding it from the bottom is the solution, *and* you get a direct match to 50 ohm coax!

However, you can't just connect the coax to the end of the array, the radiation from the elements will couple onto the outer conductor (shield braid) of the coax and you get a 'hot' line. There are various ways to overcome this, but one of the simplest to implement is the addition of two groundplane elements at right angles, a quarter wavelength below the feedpoint. These groundplane elements, just like those on a conventional quarterwave groundplane, are a few per cent longer than a half wavelength tip-to-tip. You can use more than two if you wish.

Making It

This is one of my favourite do-it-yourself antennas as it's easily made, is not critical on dimensions, needs no tuning adjustments, matches directly to 50 ohm coax and goes together in quick-smart time. You can buy all the bits and make it in less than a day and have it on the air the same evening.

The general arrangement and dimensions of an 8-element coaxial collinear array are shown in Figure 3. The dimensions shown put the antenna's centre frequency on 436.5MHz for the 70cm amateur band; the dimensions in brackets put the antenna's centre frequency on 476.9MHz, the middle of the UHF CB band. This makes the array of a size which is readily handled – about two metres tall for the 70cm version, and about 1.8 metres tall for the UHF CB version.

There are two band segments 'reserved' on the 70cm amateur band for FM simplex and repeater operation, these being 433.025-434.975MHz and 438.025-439.975MHz. Thus, 436.5MHz is in the middle.

As I said earlier, each element is an *electrical* half wavelength long. That is, the *velocity factor* of the coax must be taken into account. As electromagnetic energy travels slower in the dielectric of the coaxial cable, a wavelength is *physically* shorter. The velocity factor of common RG58 is approximately 0.65-0.66.

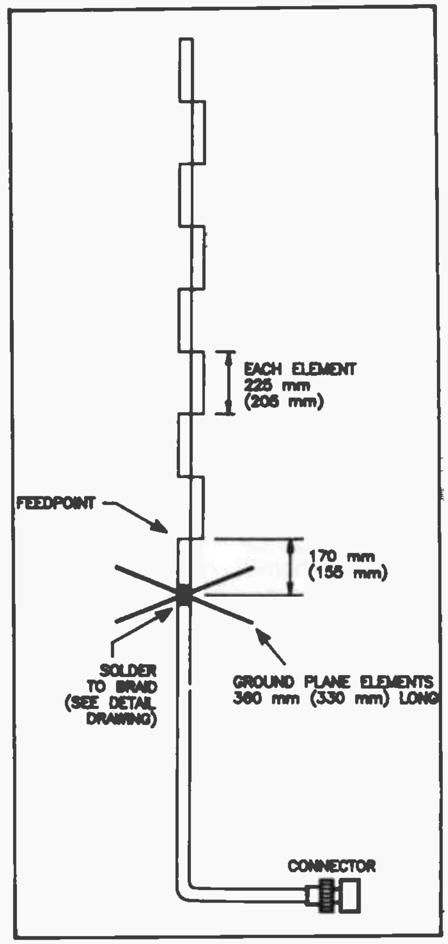


Figure 3. The general form of the UHF coaxial collinear antenna described. Dimensions are shown for the 70cm amateur band and the UHF CB band (in brackets).

It is fortunate that the bandwidth of the collinear is quite broad – about 35MHz, or around 8 per cent – as this allows plenty of tolerance in the dimensions. Around plus/minus 5mm, actually.

Buy three metres of RG58CU coax and get good quality cable, such as one with a 'MIL-C-17F' specification (it's often referred to as 'RG58CU Commercial'). Retailers such as Dick Smith Electronics, Captain Communications and Emtronics carry suitable RG58. In addition, you will need 500mm of 9.5mm or 12.7mm diameter heatshrink tubing and about 50mm of 6.4mm heatshrink.

As you would appreciate, the collinear is not self-supporting; it's distinctly floppy. To hold it up, attach it to any non-conducting support. Dowelling rod from your local hardware store is great for this job and it comes in standard two metre lengths, which is just right. Choose 12.7mm or 19mm diameter dowel, to suit yourself.

Now, go through the following procedure step by step and you'll find your collinear goes together quite easily.

1) The very first thing to do is prepare the collinear's support, using a 12.7mm or 19mm diameter wooden dowel rod. This is cheap, readily available and strong enough for the job. The dowel should be thoroughly sealed with an outdoor wood stain or linseed oil, paying particular attention to the ends. Stand it aside to dry properly.

2) Now for the collinear itself. The 'working' length of each element is the distance between the ends of the *braid*. To simplify matters, and to allow for the odd error, cut eight lengths of RG58, each 250mm long for the 70cm amateur band, or 230mm long for the UHF CB band. These lengths make allowance for cutting and stripping back the ends of the elements to make the joints.

3) Prepare each end of *seven* elements, and only one end of the eighth element, as detailed in Figure 4. The eighth element will become the 'top' element of the antenna.

Cut the coax's outer sheath 16mm back from the end using a blunt penknife or hobby knife. It should be blunt so as to avoid nicking the shield braid here. *Do not* unravel the shield braid.

4) Now cut the braid, this time using a sharp knife, 8mm back from the end. Take care not to cut through the dielectric to the centre conductor. Combined use of a sharp knife and sharp, pointed sidecutters can be effective and result in a neat cut.

5) Next, cut back the dielectric 8mm back from the end to expose the centre conductor. Do this carefully so you don't nick the stranded centre conductor wires. Otherwise, later you may get a break in the centre conductor, or a stray strand may short the joint. Either way, your antenna won't work properly.

6) With the ends of all the elements prepared as per Figure 4, now tin the exposed centre conductor and shield braid on each. Use a hot iron, preferably a temperature controlled type. A flat-faced ('spade') tip is best for this job. Apply the tip to the part to be tinned for a few seconds to heat it, then apply the solder. Use thin gauge, resin-cored solder. But remember to only apply enough solder to lightly 'wet' the conductors.

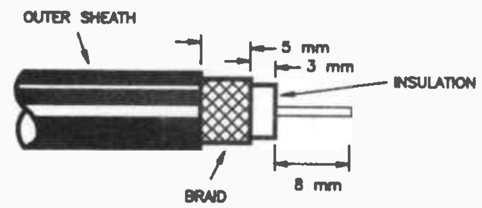


Figure 4. Each element is cut from a piece of RG58 50 ohm coaxial cable and the ends prepared like this.

7) Now to solder the elements together. First slip a 35-40mm length of 9.5mm or 12.7mm diameter heatshrink on each element. Solder the elements together, end to end, as shown in Figure 5. With each joint, after it has cooled, apply silicone sealant to the area of the joint to seal it, then, while the silicone is still plastic, slip the heatshrink tubing over the joint and apply a blast of hot air (hair dryers are great for this). But don't overdo the hot air, though, or you're likely to soften the outer sheath of the coax and possibly damage it.

8) The top element needs to be sealed. Apply a dob of silicone sealant to it, slip on a 30-40mm length of 6.4mm heatshrink while it's still soft, then apply a short blast of hot air to shrink it in place.

9) The next step is to attach what you've just completed to its support. Plastic zip-up cable ties are great for this, as are the plastic zip-lock ties that come with packets of garbage bags. Tie the collinear to the dowel, starting with the top element, putting a tie either side of each joint. The top element should be tied about 50mm below the top end. The other elements should be near the joints.

While the collinear should be laid straight when tying it to the dowel, don't apply too much tension to avoid fracturing the soldering at the joints. Don't depend on the heatshrink for mechanical support, its prime purpose is protection.

10) Now for the feedpoint and groundplane. You'll have a short length of RG58 left over. Attach a suitable in-line connector, such as a BNC male, to one end and prepare the other end as per Figure 4.

Measure back along the cable, from the end of the shield braid, a quarter wavelength (this time, 'free space' wavelength). For the 70cm amateur band, this is 170mm; for the UHF CB band, 155mm. Mark this point.

Using a blunt knife, or carefully using a sharp knife, make two cuts around the cable's outer sheath, each a few millimetres either side of this point. Slit the sheath between the two cuts and remove the section to expose the shield braid. Using a hot iron, quickly and lightly tin the braid. Slip two 30-40mm lengths of 6.4mm diameter heatshrink down the cable, placing them either side of the exposed shield braid.

11) Cut two lengths of tinned copper wire or brazing rod to size: each 360mm long for the 70cm amateur band, and 330mm long for the UHF CB band (see Figure 3). If you're using tinned copper wire, straighten it first. This can be done by clamping one end in a vise, grasping the other end with a pair of pliers and giving it a good tug. It will bow a bit after you take it out of the vise, but then you can straighten it easily by hand. Tin the centre of each groundplane element.

12) Now attach the prepared cable to the feedpoint, making a joint as per Figure 5. Seal it and cover it with heatshrink. Put a tie either side of the

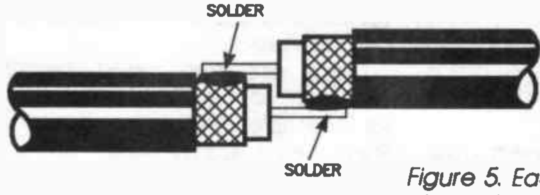


Figure 5. Each joint between the elements, and the joint at the feedpoint, is made like this.

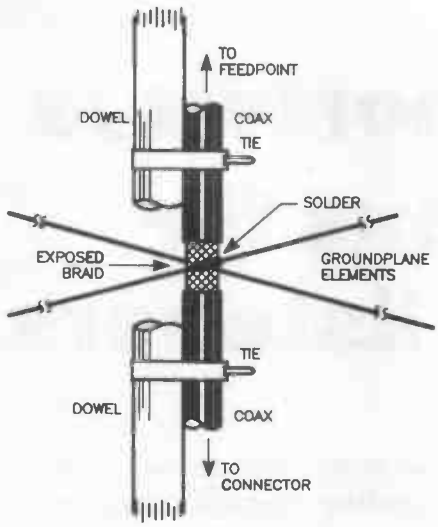


Figure 6. You make the groundplane in this manner. Be sure to thoroughly seal the area of the exposed braid, as described in the text.

joint to hold it securely to the dowel.

Now, temporarily tie the coax to the dowel near the exposed shield braid. This will secure it while you attach the groundplane elements. Position each groundplane element on the exposed braid and solder them in place at right angles to each other. Take care to solder them properly but not to damage the coax, either (a hot iron with a spade tip is best for this).

13) When the joint is cool, take off the temporary ties and apply a little silicone sealant around the groundplane joint. While the silicone is still plastic, slip the two pieces of heatshrink tubing along to cover the groundplane joint and apply a blast of hot air. Afterwards, cover the joint thoroughly with silicone sealant (you don't want water getting into the coax).

14) Put ties around the dowel and coax, either side of the groundplane, then another tie a little below the groundplane to secure the flying lead, leaving a slack 'kink' in the cable so that any tension is taken by the bottom-most tie.

15) Last of all, put some sort of cap over the top end of the dowel and seal it to prevent it weathering. A damp dowel degrades the collinear's performance, so use a rubber furniture bung of the right size. Or, a short length of heatshrink tubing of the right diameter, tied off and shrunk in place.

That completes the construction. Now to erect it. As individual circumstances vary widely, I'll just give a few hints and tips.

The bottom end of the dowel can be clamped to the top of a mast using hose or muffler clamps that are tightened with a worm-drive mechanism. Use two clamps spaced apart a little to properly support the dowel.

The feedline from your collinear to your rig should be a good quality, low-loss coax. The large diameter 'half-inch' variety is readily available, and affordable. For these frequencies, though, it's better to pay more and get a cable with the lowest-loss. Belden 9913 is the best of the flexible half-inch cables around and it's stocked by Dick Smith Electronics. You're next best choice would be 'RG213 foam', which is also available from Dick Smith Electronics.

You must mount the collinear well clear of other vertical structures, particularly if they're metallic. The antenna described is readily mounted on a standard TV chimney mount, or even a barge-board mount.

PARTS LIST

- Two metres of RG58CU (MIL-C-17F preferred)
- 500 mm of 9.5 or 12.7 mm diameter heatshrink
- 100 mm of 6.4 mm heatshrink
- in-line coax connector to suit (BNC suggested)
- 800 mm of 18 gauge tinned copper wire or brazing rod
- Two metre length of 12.7 mm or 19 mm diameter dowel
- Five or six cable ties
- Silicone sealant
- Solder
- Outdoor wood stain or linseed oil

TOOLS YOU'LL NEED

- Sharp penknife or 'hobby' knife
- Sharp, pointed sidecutters
- Soldering iron, preferably temperature controlled
- Small shifting spanner
- Pair of needle-nose pliers

Performance

An eight element array like this has 9dB of gain over a dipole. Your 10 watt rig will sound like an 80 watt rig on a Slim Jim, or like a 100 watt rig on a groundplane – it's cheap gain! A transistor power amp to take your rig's output from 10W up to 80- or 100 watts will cost you $2 per watt, or more. So this collinear costs about one-tenth the price of a power amp. So, how much power will it take? As much as you're legally allowed to run 'up the stick.'

If you live in a valley and hope this antenna will 'get you out', expect the unexpected. It may make things worse because of its low radiation angle. The gain is achieved by compressing the vertical radiation angle. Try it. If you don't get the improvement expected, chop off the top four elements and try again. It sounds weird, but I know of one constructor who successfully performed this operation, to his surprise, but not mine!

I have made various versions of coaxial collinears over the years, for both temporary, permanent and portable applications. A portable collinear is easily made by tying or taping the coax elements and lead cable to a length of hemp rope. In use, the top end of the rope is tied off to something suitable, like a tree branch or other form of 'skyhook', and the bottom end is either tied down or weighted so that the array is held vertical. When not in use, just roll it up.

I've made four-element coax collinears for 2m, in both 'fixed' and portable versions, an eight-element centre-fed horizontal monster some 15 metres long for six metres, and UHF versions ranging from a four-element job for mobile use to a 16 element phallic symbol nearly four metres tall. ●

Simple shortwave antennas for suburban listeners

There's no doubt that the shortwave bands been 3MHz and 30MHz abound with interesting signals these days, ranging from the international shortwave ('propaganda') broadcasters, through radio amateurs and maritime operators, to radioteletype news, weather services and radio facsimile picture transmissions. If you have a receiver, here's some simple antennas to help you 'get amongst it'.

MY INTEREST in the shortwave bands began when I was in high school. Over the years, I've travelled and lived in many locations, from the 'heart of suburbia' to the outright exotic – Antarctica at one extreme and the Cocos-Keeling Islands at the other! Almost everywhere I've been, I've tackled the problems of throwing up 'a bit of wire' and having a tune around the bands. I've tried antennas of various sorts that will fit in the standard, suburban quarter-acre block, and wrestled with how to put up an effective antenna in the pocket handkerchief blocks of an inner-city terrace.

The trouble is, there are a host of conflicting requirements. To be effective, any 'bit of wire' you throw up must be at least a quarter wavelength (or preferably half a wavelength) long at the lowest frequency of interest. This means that, for most suburban blocks, you'll probably run out of space in the five to seven megahertz region. You also want the antenna to be useful on as wide a frequency range as possible, and be simple to erect – no special tall towers, rotators or like paraphernalia is required.

If you are interested in listening across frequencies right down to the AM broadcast band, you'll probably have to consider putting up several antennas. Vertical whips and dipoles to cover the higher bands from 14-15MHz upwards can readily be fitted in most suburban home sites. With restricted space, and probably restraints on the budget – having spent a large wad on your receiver, no doubt – a simple antenna built and erected using common, low-cost components is the way to go.

Over the years, I've found a couple that fill the bill and suit different circumstances, and they're:

- The Long Wire
- The Inverted-L
- The Delta Loop, and
- The Wideband Inverted-V.

I have included circuits of simple tuners to use with each, and while a tuner is not an essential item, it certainly improves performance by providing a better match between the antenna feedpoint and the receiver's antenna terminals across the frequency bands you might be listening on.

The Long Wire

Everybody's 'old standby' is the Long Wire. Just a random length of wire, as long as possible, that can be erected in the space you've got. It should preferably be a straight length, although small-angle bends can be tolerated if it allows you to fit a longer length of wire. This antenna is a favourite for temporary or portable operation. If you can arrange it, the length should be at least a quarter wavelength long at the lowest frequency of interest.

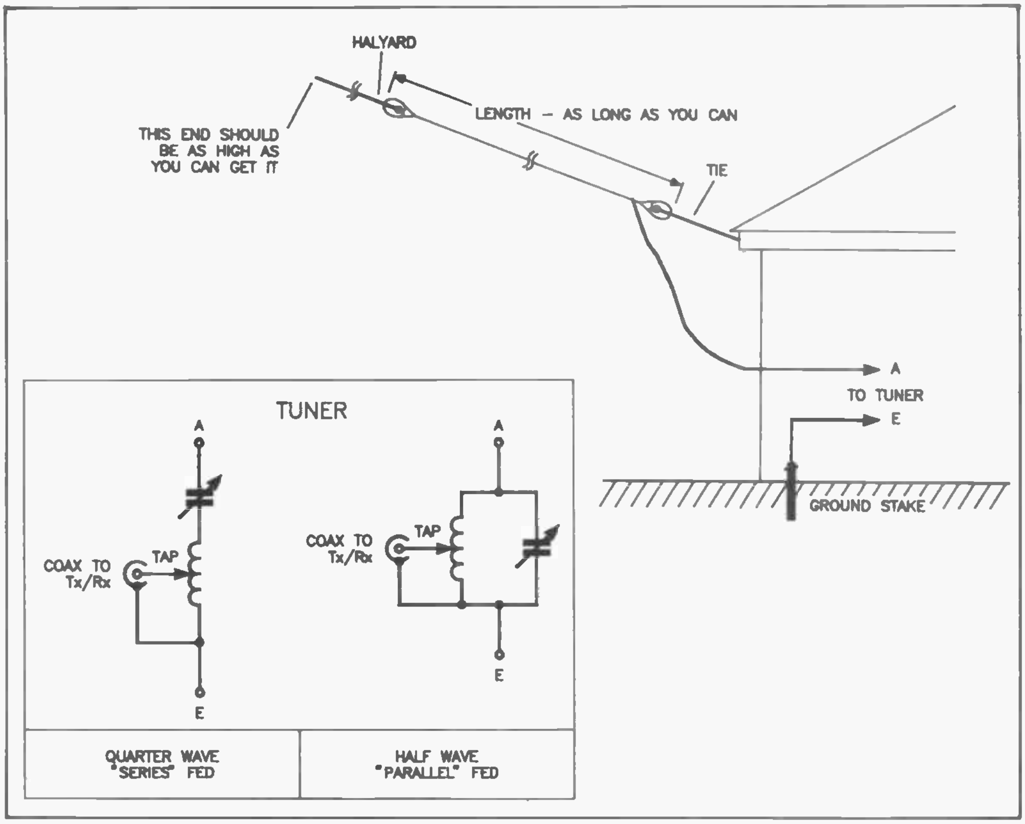
Erect it with the 'far' end as high as possible, or run it parallel to the ground. The 'business' end runs down to your receiver – the lead-in. The general arrangement is shown in Figure 1, along with tuner details. The beauty of the Long Wire is that it can be used over quite a wide frequency range, especially if used with a tuner.

The tuner circuit shows two different hookups – quarter wave 'series' fed and half wave 'parallel' fed. Which one you use depends on the frequency range of interest and the length of the antenna. At that frequency where the Long Wire is around a quarter wavelength long, the 'series' configuration is used as the antenna impedance will be low at the lead-in end (providing the lead-in is comparatively short, in terms of wavelength).

Around the frequency range where the Long Wire is about half a wavelength long, the impedance at the lead-in end will be high and you must use the 'parallel' tuner configuration. In either instance, you can match the receiver's input for best results by varying the tapping on the coil. Generally, this will be between 20-50 per cent of the turns from the 'earthed' end (E).

You can work out the quarter

Figure 1. That old standby – the Long Wire. Keep the lead-in to the tuner or receiver as short as possible. Run it away from house wiring and pipes to avoid signal loss. The coil and capacitor in the tuner should resonate across the frequency range of interest. An old broadcast receiver gang, with a range of 10-400pF or so, is ideal. The coil could be 20-30 turns of 20 gauge enamelled or tinned copper wire wound on a 50mm diameter former with tapping points arranged every couple of turns. Space the turns out, say, one or two millimetres between each turn. Use alligator clip leads to hook it up so you can change the configuration, as shown in the tuner circuit.



wavelength resonance of your antenna by plugging its approximate length into this formula:

f = 71.5/length (MHz)

where the length is metres.

Say your Long Wire antenna is about 17 metres long. Its quarter wave resonance will be:

f = 71.5/17
= 4.2MHz

The half wave resonance will be about twice that. The length of the lead-in will influence things somewhat, but this calculation gives you a 'ballpark' figure to work with.

Note that once you know the Long Wire's quarter and half wave resonance frequencies, you know that it will be effective on the odd multiples of the quarter wave resonance and the even multiples of the half wave resonance.

The Long Wire has little directionality around its quarter wave resonance. At the half wave resonance, its directional,

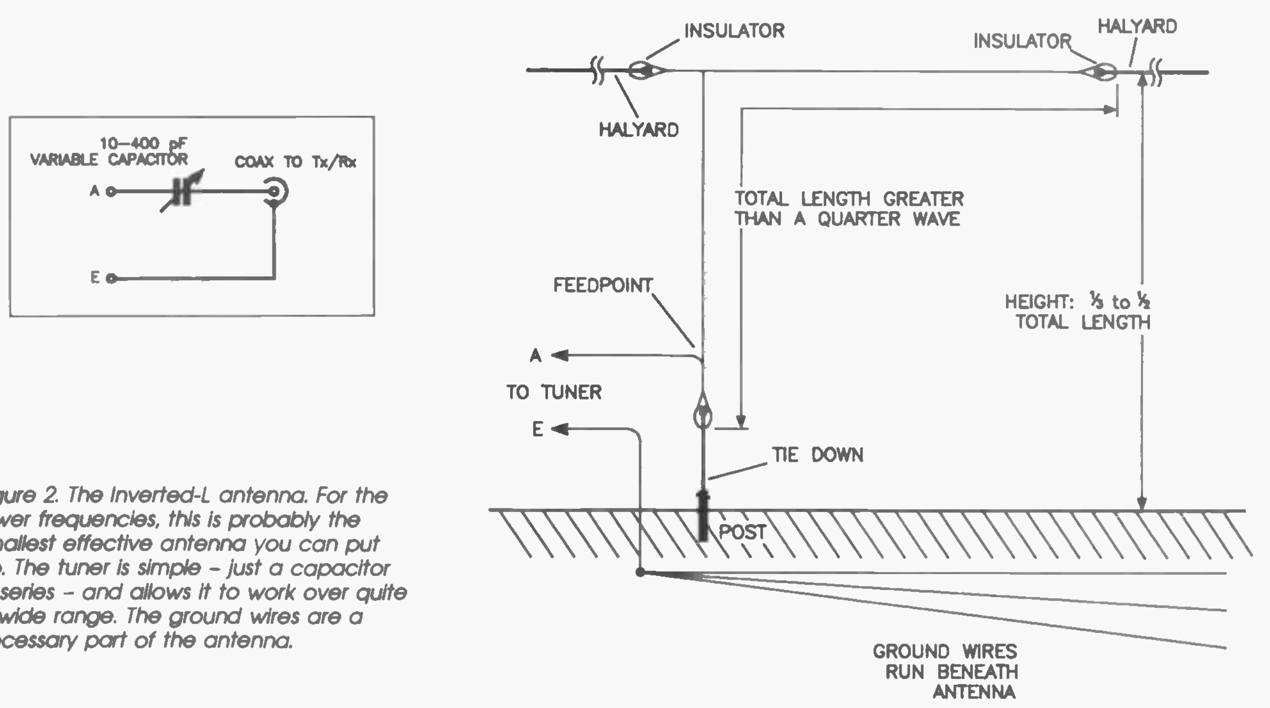


Figure 2. The Inverted-L antenna. For the lower frequencies, this is probably the smallest effective antenna you can put up. The tuner is simple – just a capacitor in series – and allows it to work over quite a wide range. The ground wires are a necessary part of the antenna.

being more sensitive to signals more or less broadside to the wire, and much less sensitive to signals in directions off the ends.

This antenna is directive at the higher frequencies, in directions more or less end-on to the antenna. You might consider putting up several Long Wires of the right length, aimed in different directions, about say, 60 degrees apart.

The Inverted-L

Another 'old standby', the Inverted-L, dates back to the early days of spark transmitters and crystal sets, and there are plenty who've come to swear by it over the years. It's a great antenna at the lower frequencies, particularly at 4MHz and below. You can see from Figure 2 where this antenna got its name.

The Inverted-L consists of a length of wire around 10-30 per cent longer than a quarter wavelength at the lowest frequency of interest – if you can fit it. Otherwise, the lowest frequency at which your Inverted-L will be effective is where its length is 10-30 per cent longer than a quarter wave. The good thing about it is, with a 'tolerance' range of 10-30 per cent, you can be a bit sloppy in your measurements!

The height to the 'corner' of the L only has to be about one-third to one-half the total length of the antenna. You can calculate the length required to cover the lowest frequency of interest from this formula:

Total Length = $(71.5/f) \times (1.1 \text{ to } 1.3)$

where f is in MHz. The answer will be in metres. So, if you are interested in the region down to 2.5MHz:

Total Length = $(71.5/2.5) \times (1.1)$

choosing it to be 10 per cent longer than a quarter wave. This gives:

$$\text{Total Length} = 28.6 \times 1.1 = 31.46 \text{ metres}$$

So, from this, your 2.5MHz Inverted-L need only be erected 10 metres high, which doesn't present too many difficulties.

Note the use of ground wires. Three as a minimum are recommended. These are run beneath the horizontal section of the antenna, for about the same length, or somewhat longer. At these frequencies, it's unlikely your soil will present anything approaching a decent ground for the antenna (unless you live in a swamp or in a house on stilts over the water), hence the use of ground wires. Fan them out a little as they don't have to be dead straight. Heavy gauge tinned copper wire is ideal. You can run them on top of the ground, but they're easy to trip over, so bury them. They only need to be sunk about 100mm or so in a slit cut with a shovel.

Join the ground wires at a point near the base of the vertical section of the Inverted-L. The feedline should be as short as possible. And, you can use coaxial cable if you like.

The tuner is simply a capacitor in series with the lead-in as this antenna presents an inductive reactance at the feed point. An old AM broadcast receiver tuning gang of 10-400pF or so range is deal. Most of these have two or three gangs. You can use just one gang, or connect them in parallel. The tuner is not essential and the Inverted-L can be used without it, but a tuner can certainly make a big difference.

From its construction, the Inverted-L will pick up both vertically and horizontally polarised signals and is sensitive to signals coming in at both low and high angles. It's a good 'all rounder' and works well under a variety of circumstances.

The Delta Loop

For some reason, this versatile antenna has not enjoyed the popularity it deserves. Illustrated in Figure 3, it

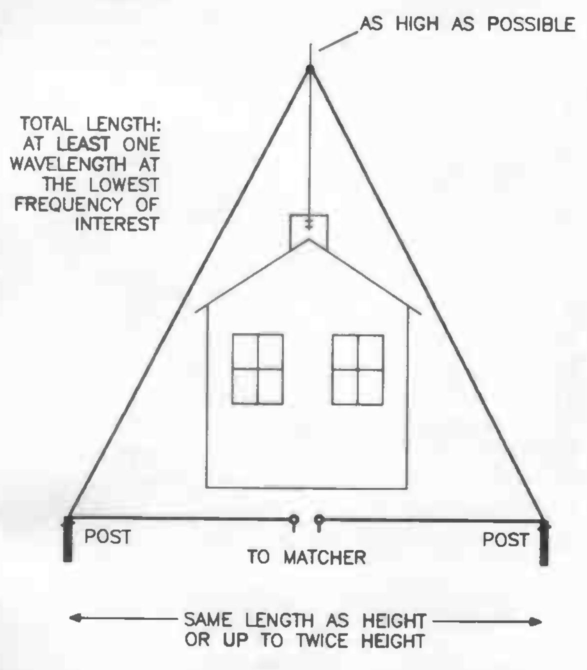
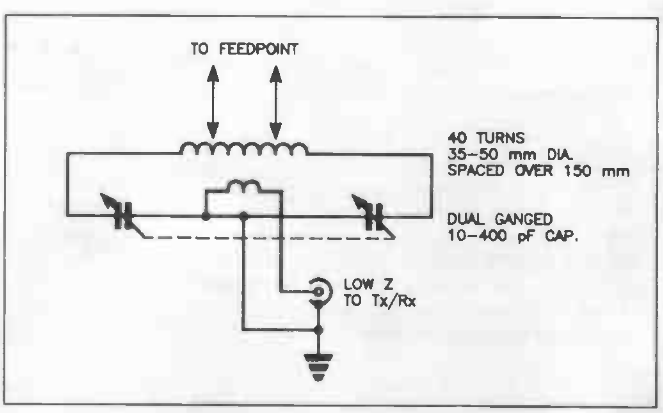


Figure 3. The Delta Loop antenna consists of a triangular loop, as big as you can make it, but at least one wavelength long at the lowest frequency of interest. Its feedpoint is in the centre of the base side. Alternatively, you can feed it at one of the lower corners, and generally presents a medium to high impedance. Because it has a balanced feedpoint, you'll need balanced feedline (I used 300 ohm TV ribbon) and a tuner which accommodates this, as shown.



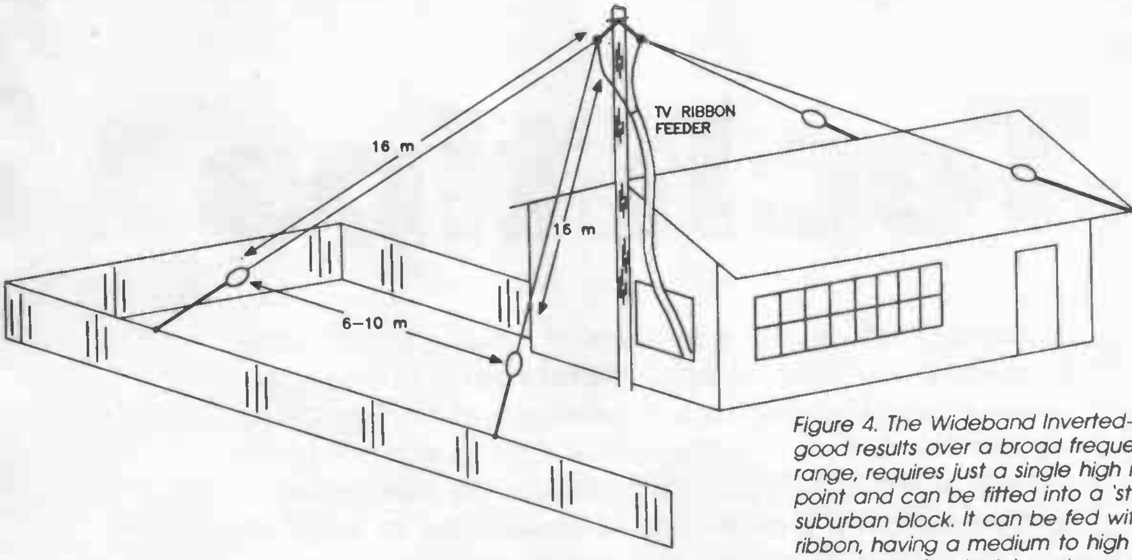


Figure 4. The Wideband Inverted-V gives good results over a broad frequency range, requires just a single high mounting point and can be fitted into a 'standard' suburban block. It can be fed with TV ribbon, having a medium to high impedance feedpoint, and you can use a tuner like the one shown with the Delta Loop.

comprises a triangular loop of wire with the apex erected as high as you can get it. It doesn't need to be an equilateral triangle. In fact, I've used quite 'squat' versions of this antenna where the base length has been a few times the height of the apex. The dimensions are not rigid ratios. However, once the total length of the loop reaches one wavelength, its effectiveness falls off below those frequencies.

While it might be preferred that you erect it with the plane of the loop vertical, this is not essential. It can be as much as 30 degrees off-vertical and still work well. This gives you the latitude to put the apex atop a chimney on your house and locate the two corners on your boundary fence or two suitably positioned short posts. The wires of the base of the triangle can be erected so that they're just above head height, if they must be located where people will walk. Otherwise, they can be erected around a metre or so above the ground.

The tuner shown copes with the Delta Loop's balanced feedpoint. Generally, this presents a medium to high impedance. For feedline, I used 300 ohm 'TV ribbon'. It's cheap and widely available (even from hardware and electrical stores).

The receiver end of the feedline is tapped into the coil at an equal number of turns in from each end. Enamelled or tinned copper wire may be used to wind the coil. I used an old 10-400pF dual-gang AM broadcast receiver capacitor to tune it. Despite the fact that the gangs have slightly different capacitances, it works. Or, you could use a three-gang type, connecting the two gangs of like capacitance (i.e., the 'RF' and 'mixer' sections).

You can also arrange a feedpoint at one corner, rather than in the middle of the base side, as illustrated. This might be more convenient in some circumstances. If you do this, a tuner is recommended, the one shown in Figure 3 being fine.

The Delta Loop 'throws lobes' in all directions, which is good for all-round reception. It works over an enormous frequency range and I've even used it successfully for making contacts on the 50MHz amateur band. One advantage is that it requires only a single high-mounting point. However, it can use comparatively more wire than the previously described antennas.

The Wideband Inverted-V

The Inverted-V dipole is popular among radio amateurs. It's comparatively easy to erect, requiring only a single high mounting point, like the Delta Loop. It has one drawback in that it's essentially a single-band antenna, or at best, a two-band antenna (the half wave resonance and three times that). However, a wideband form was described in the 1960s, gaining some popularity in the UK and Europe. Figure 4 shows the general arrangement.

It consists of four equal 'legs', each about 16 metres in length, spread six to 10 metres apart at the lower ends. With these dimensions, it will work right down to 3.5MHz. It can be fed with TV ribbon, having a medium to high impedance feedpoint, and you can use a tuner like the one shown with the Delta Loop.

You can shorten the dimensions to make it fit your property, but that raises the lowest effective frequency. Get the apex as high as you can, but the angle subtended by the 'arms' should not be less than about 100 degrees (i.e., not less than 50 degrees between the arm and the vertical). The angle between each arm and the vertical need not be the same.

The Wideband Inverted-V behaves rather like a multiband dipole, with reception better from directions broadside to the pairs of arms. With four arms, it gives pretty good coverage, though.

Some practicalities

Use egg insulators at the support points for your antenna and at the feedpoint, where it's not at one end. They are cheap and widely available through stores such as Dick Smith Electronics. Coaxial cable (RG58 – 'CB coax') and TV ribbon cable are also widely available.

For good, practical construction techniques and erection methods, the *ARRL Antenna Handbook* is hard to beat. ●

Tech tips

This section details a number of 'short circuits' that most radio enthusiasts should find useful in one area or another, covering both receiving and transmitting applications. Full constructional details are not given, but there is sufficient information to enable any enthusiast with a modicum of experience to build the circuits shown and get them going.

MANY older receivers, some VHF/UHF scanners, and some portable solid-state receivers do not have a signal strength meter fitted. An S-meter is an invaluable tuning aid, not to mention a useful source of information.

One of the simplest circuits for an add-on S-meter is that shown in Figure 1. You can add this to a valve or transistor type receiver. The circuit consists of a voltage multiplier rectifier coupled from the plate (valve receiver) or collector (transistor receiver) of the receiver's last IF stage. The 100pF coupling capacitor must have an appropriate voltage rating if this circuit is added on to a valve receiver. Typically, it should be rated at 250Vdc at least. Use a metallised polyester or polystyrene capacitor.

The signal at the plate or collector of the last IF stage is rectified by the two diodes, and voltage-doubled, the dc output smoothed by the 10n capacitor. The voltage level across this capacitor, a measure of the signal level, is then indicated by the meter circuit. RV1 allows setting the maximum reading to a known level. This is best done with a calibrated signal generator. Note that the meter reading is affected by the AGC and so a reading of 'S9', near full-scale on the meter, should be set where the input signal produces near maximum AGC action.

The meter to use is a common S-meter, such as the one sold by Dick Smith Electronics stores, cat. no. Q-2100.

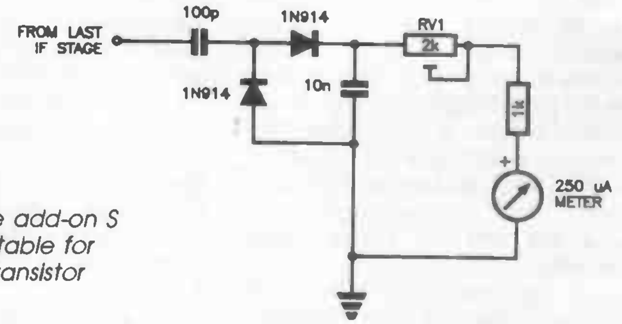


Figure 1: A simple add-on S meter circuit, suitable for either valve or transistor receivers.

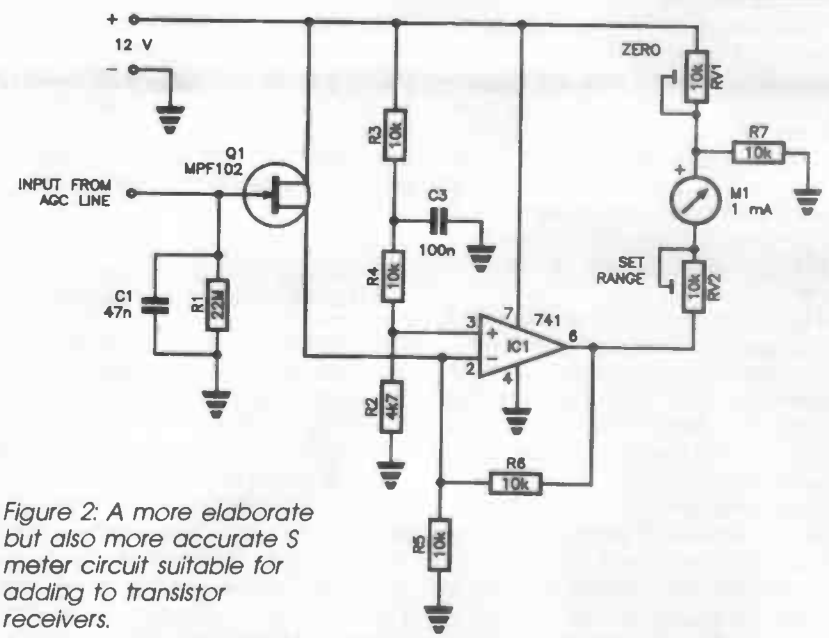


Figure 2: A more elaborate but also more accurate S meter circuit suitable for adding to transistor receivers.

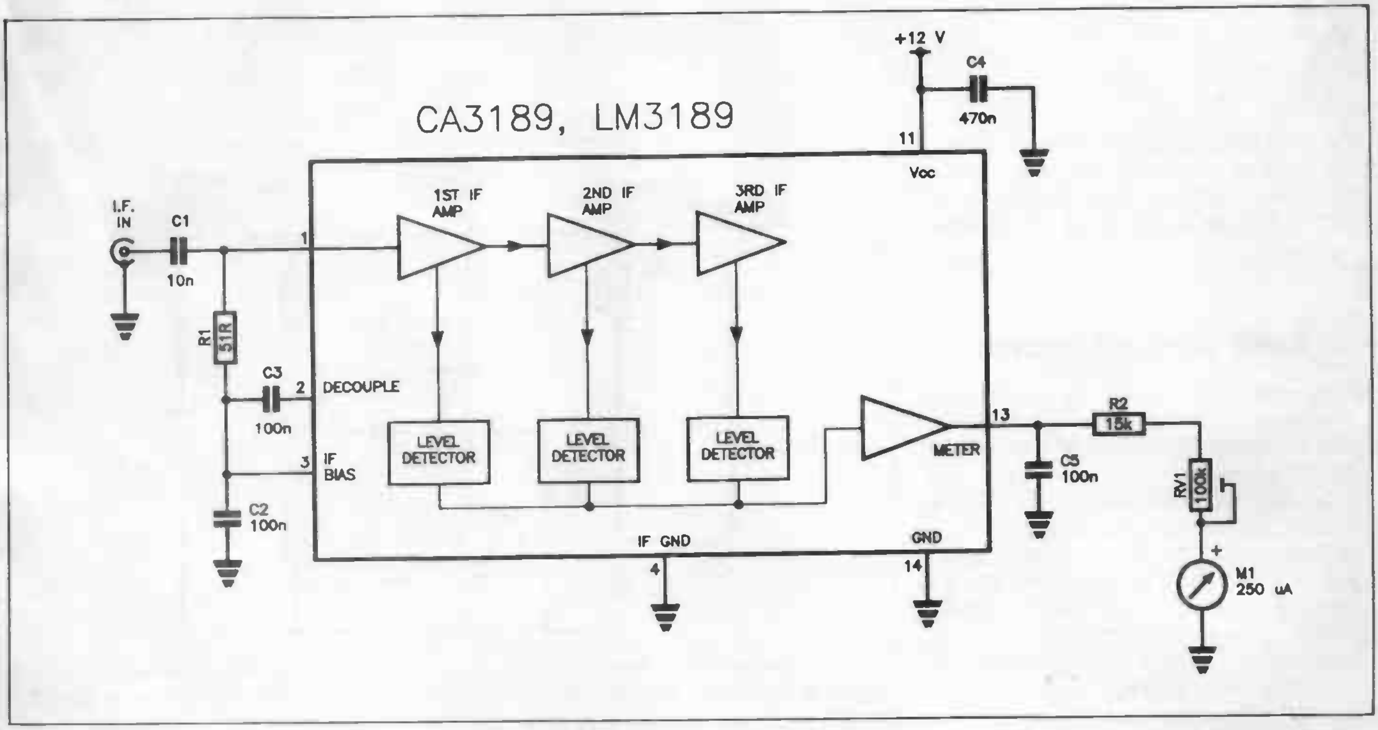


Figure 3: A circuit which makes the S meter entirely independent of the receiver's own IF amp, and provides true log-scale readings.

This is a 250uA meter with an impedance of 1000 ohms. Other meters may be used, but you may find a 1mA meter might not be sensitive enough, even if you take the 1k resistor in series with the meter out of circuit.

The circuit in Figure 2 is meant for adding-in to a solid-state receiver. The input is taken from the receiver's AGC line, which in most solid-state receivers is positive, generally varying between zero and 2V.

The FET, Q1, is connected as a source follower, providing a high impedance input. The drain-source current provides a variable dc current to the inverting input of IC1 as the input voltage varies. The output of IC1, a common 741 op-amp, drives the meter circuit. Resistors R5-R6 provide feedback so the 741 has a gain of 1. The non-inverting input of IC1 is biased up a bit to compensate for the dc bias on the other input which results from Q1's quiescent drain current.

The meter here is a common-or-garden 1mA panel meter. Its positive terminal is jacked-up a bit by the voltage divider RV1-R7 to compensate for the quiescent dc level at IC1's output. By varying RV1, the meter reading can be zeroed. Trimpot RV2 sets the maximum meter deflection. Set RV2 so the meter reads maximum with +2 V at the input. Layout of this circuit is not critical and it may be assembled on a piece of matrix board or Veroboard.

The circuit in Figure 3 is a little different and ideal for some VHF/UHF scanning receivers, or you can add it to a receiver you're building. This circuit makes the S-meter entirely independent of the characteristics of the receiver's IF amplifier stages which are controlled by the AGC, which would otherwise make the meter readings somewhat arbitrary; certainly neither linear, nor logarithmic in response. This circuit provides a true log-scale S-meter.

The Figure 3 circuit is based on the use of an FM receiver IF system IC, either a CA3189 (made by RCA) or an LM3189 (from National Semiconductor). This IC has a three-stage wideband amplifier inside with level detectors on each stage, providing a pretty good log-response dc output to drive a meter. The circuit comes from application notes issued for the chip.

You can take the input here from the receiver mixer's IF output. Note, however, that the input to the circuit is low impedance (established by R1). Use a 250uA meter, such as the Dick Smith Electronics signal strength meter, cat. no. Q-2100, or similar. However, a 1mA meter may be used. The trimpot RV1 sets the meter maximum reading. Capacitor C5 provides some smoothing of rapidly changing signal variations.

This circuit may be assembled on a piece of matrix board or Veroboard. Make sure you use solid supply rail buses and short leads on C1 to C4, and R1. Use ceramic types for C1 to C4 and run coax between the IF take-off point in the receiver and the 'IF IN' point on the circuit.

The meter scale is readily calibrated using a signal generator, having a calibrated output attenuator, supplying input to the receiver. A barely

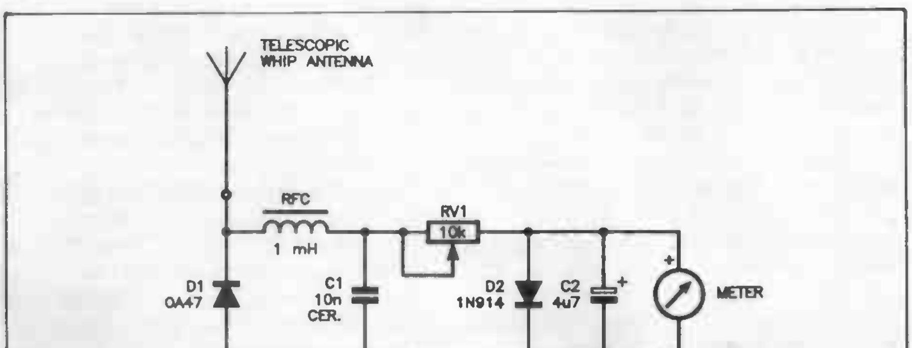


Figure 4: An elementary 'passive' field strength meter circuit – essentially a crystal set driving a meter.

discernible signal in the receiver should be a low reading on the meter. However, a high reading on the meter should be near the point of receiver overload.

Field strength meters

From receiver circuits to circuits for transmitter applications, a field strength meter can be an invaluable 'tool' in your 'chest' of test instruments. You can use it to test transmitters and antennas, check out the field pattern of mobile antennas, look for stray fields coupled into antenna mast guying wires, etc. It's also very useful for checking handheld transceivers and radio control transmitters. Figure 4 shows the simplest sort. This is a 'passive' field strength meter, thus no amplification is employed. It is also untuned, as are the other two to follow.

A telescopic whip antenna is used to pick up the transmitted signal's energy which is then rectified by the OA47 germanium diode. Positive-going half-wave pulses of RF appear across D1. The RF is blocked by RFC1 and the dc charges C1 to drive current through RV1 and the meter. Capacitor C2 smooths out modulation variations, while D2 prevents 'slamming' of the meter with very strong signals. The potentiometer RV1 varies the sensitivity of the instrument. Note that the sensitivity can also be varied by varying the length of the telescopic whip.

This circuit is useful for frequencies from 1MHz to about 30MHz. Note that an OA47 germanium diode is used because it has the least forward conduction voltage and is thus the most sensitive in this application. Likewise, for the following circuits.

Construction-wise, the meter can be conveniently mounted on the face of a suitable case, with the telescopic whip mounted on top, or wherever is suitable for the intended application(s). Keep the leads between D1, RFC1 and C1 short to obtain good performance at the higher frequencies. Note that D2 can be replaced by a high brightness LED, if you wish.

The general sensitivity of this sort of field strength meter depends on the meter you use – the more sensitive the meter, the more sensitive your instrument. A 50uA meter will provide the best sensitivity, but that doesn't mean to say a 1mA meter can't be used. If you're going to use this sort of circuit for applications with low power transmitters, get a 50- or 100uA meter.

Note that capacitor C2 will 'strip' any modulation from amplitude modulated transmissions. If this is not desirable in your application, simply omit it. It does slow down the meter's response to field strength variations and you may want to experiment with varying its value.

Suitable telescopic whip antennas are stocked by Dick Smith Electronics and Tandy. The DSE whip is known as cat. no. L-4902, while Tandy's is cat. no. 270-1401.

The field strength meter shown in Figure 5 works well from very low frequencies right through to VHF. Again, a short, telescopic whip does the same as the pickup antenna. Signals are half-wave rectified by D1, the resultant positive pulses of RF being applied to the base of Q1, which has a little bias applied via RV1-R3.

The meter is in a 'bridge circuit', the collector-emitter junction of the transistor and R2 forming two 'arms', and resistors R3 and R4 forming the other two arms. The voltage at the junction of R3-R4 is half the supply voltage. Applying a little bias to the base of Q1 (via R1-RV1) causes collector current to flow via R2. Setting the bias via RV1 allows setting the voltage at the junction of R2 and Q1's collector to half the supply rail. This 'balances' the bridge so that the meter reads zero.

When a signal is received, it is rectified by D1 and positive-going RF pulses increase Q1's base current. This increases its collector current in sympathy which 'unbalances' the bridge. The voltage at the collector of Q1 drops and current flows through the meter. The RF level on the antenna will determine the extra bias applied to Q1's base and thus the voltage drop at its collector. Therefore the meter reading is directly proportional to the field strength.

Capacitor C1 bypasses the RF pulses at the transistor's collector, leaving a dc level only. The diode across the meter prevents the meter 'slamming' if a very strong signal is inadvertently received.

Sensitivity of the instrument can be varied by altering the length of the telescopic whip. Alternatively, a 1000 ohm potentiometer could be connected in parallel with the meter. A common 1mA panel meter may be used – one with a large scale is ideal for viewing from a distance. Only a 3V battery is needed to power this very sensitive instrument. Note that D1 is a germanium diode for best sensitivity (as mentioned earlier), although an ordinary silicon diode such as a 1N914 will do, with some sacrifice in sensitivity on low field strengths.

Keep the leads to R1, D1, Q1 and C1 all short. A ceramic capacitor is recommended for C1 for its low inductance. You might also bypass the junction of R1 and RV1 to the common (-ve) rail with a 10n ceramic capacitor. It would pay to mount R1, RV1, D1, Q1 and C1 in a small all-metal enclosure, shielding this part of the circuit from the meter circuit which may be mounted in, say, a diecast box. This is a robust

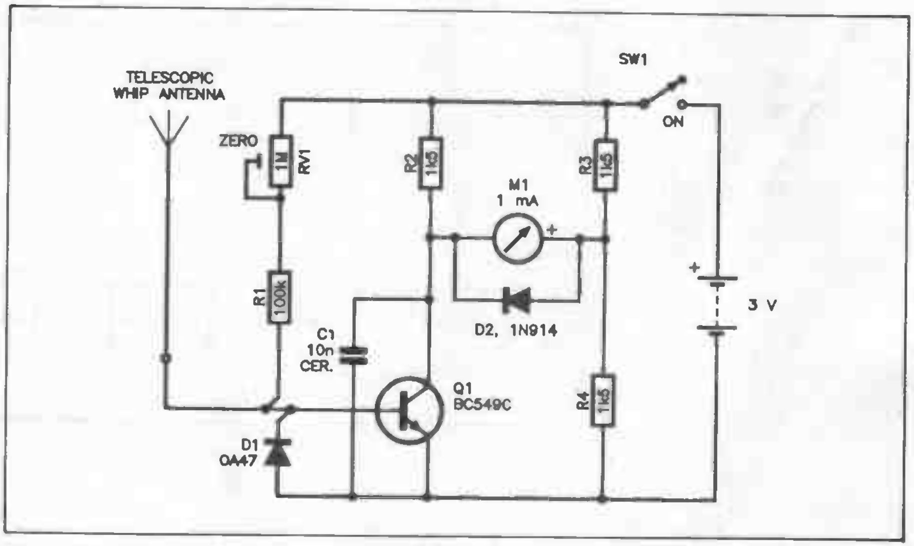


Figure 5: Still fairly simple, this 'active' field strength meter will provide good results from VLF up into the VHF region.

arrangement which also shields the meter from stray, strong RF fields.

Figure 6 is the circuit of a very versatile field strength meter that will work from quite low frequencies through to UHF if carefully constructed. The familiar telescopic whip and OA47 germanium diode rectifier are used here, too. Resistor R1 and capacitor C1 provide smoothed dc, C1 provides an effective bypass across the HF range into the lower VHF spectrum, while C2, a low inductance ceramic 'feed-through' type capacitor provides an effective bypass well into the UHF region.

The dc output of the rectifier appearing across C1-C2 is applied directly to the non-inverting input of one op-amp from an LM324 quad op-amp IC. This is a common, low cost IC that will operate from a single supply rail and has the facility so its inputs will work near ground (0V) while its output will go down almost to ground, hence its use in this circuit.

The op-amp acts as a dc amplifier. Feedback provided by RV1-R2 allows setting the gain and thus the instrument's sensitivity. With increasing field strength received, the voltage across D1, and this across C1-C2, rises. As the op-amp is configured as a non-inverting amplifier, its output also rises, in direct proportion. The 1uF capacitor across the supply rail is just a bypass. A 9V battery is used to power the op-amp.

The meter circuit is fairly straightforward. The output of the op-amp drives current through R2, Rx and the meter. Diode D2 prevents 'slamming' of the meter should a very strong field strength be inadvertently applied. The value of Rx depends on the meter you use. A 200- or 250 uA meter will have a resistance of around 2000 ohms. A value of 2k2 is recommended for Rx here. A 1mA meter will have a much lower resistance, in which case Rx may only be 100 ohms – or it can even be dispensed with altogether. The op-amp circuit has enough range and sensitivity for any meter, from 50uA to 1mA, to be used.

This circuit does not 'strip' the modulation from any amplitude modulated signals, and thus the meter will vary in sympathy with the modulation. If you want to get rid of this effect, add Cx as shown. An electrolytic or tantalum capacitor, with a value between 2u2 and 10u should do the trick without 'slowing down' the meter's response too much to field strength variations.

For good results, D1, R1, C1 and C2 should be mounted in a small shielded enclosure, which supports the whip, and the IC and meter circuitry mounted in a separate enclosure (which may be attached). I suggest you use a metal film resistor for R1 (1 per cent resistors are metal film types) as these work well at the upper frequencies.

Figure 6 has the best sensitivity and widest operating range, in terms of both frequency and field strength, of the other field strength meters described. Frequency-wise, it works well from about 2MHz right up to 1GHz.

A brace of crystal checkers

Expensive and a comparative rarity years ago, crystals are now a common component and widely used in RF

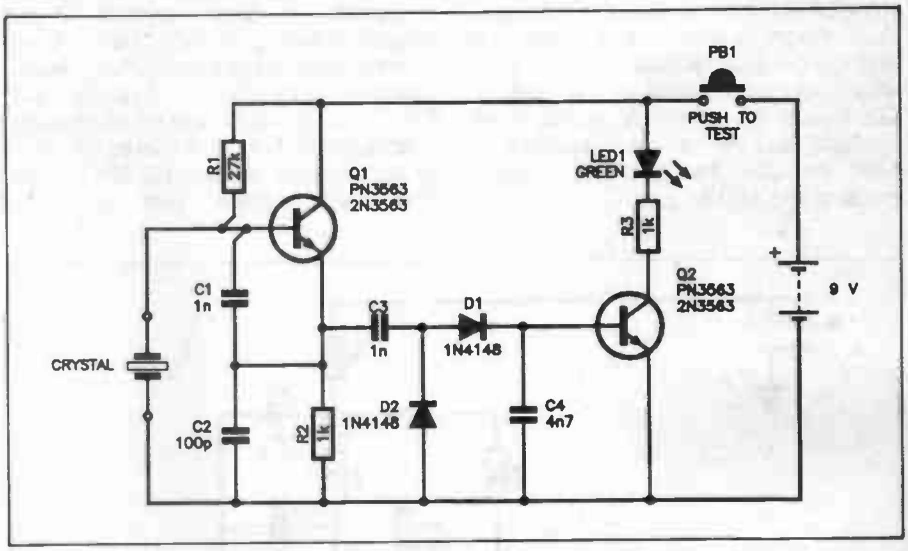


Figure 7: A simple 'Go/No Go' checker for quartz crystals. If the LED lights when PB1 is pressed, the crystal is OK.

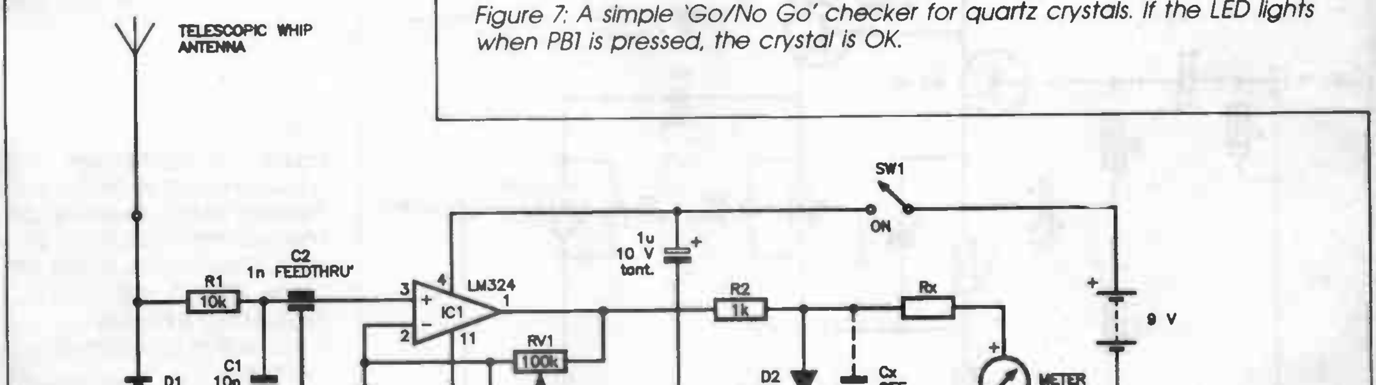


Figure 6: An even more versatile (and more sensitive) field strength meter, which will operate right up at UHF. Resistor R2 and diode D2 are to protect the meter from damage due to 'slamming'.

applications. Inevitably, the radio experimenter collects a handful or so, and may have equipment which bristles with crystals. So, there will be occasions when a crystal, or crystals, need to be checked. And they need to be checked out of circuit to determine whether it's the crystal or the circuit that might be faulty. Or, you may want to use a crystal from those you have collected over the years and need to check it first.

A multimeter is useless for this sort of exercise, however, a simple oscillator is ideal. The following two circuits provide two solutions.

Figure 7 is a simple 'go/no-go' crystal checker. Plug in the crystal and push the button. If the LED lights, the crystal is a goer. If not, it's probably a dud. This circuit works with crystals having a fundamental frequency up to 20MHz.

Transistor Q1 is connected as a standard wideband Colpitts oscillator. Output from its emitter is rectified by a voltage doubler rectifier – D1 and D2 – which supplies current to the base of Q2. Thus, if the crystal is 'good', it will oscillate and the resultant rectified RF turns on Q2, the collector current causing the LED to light.

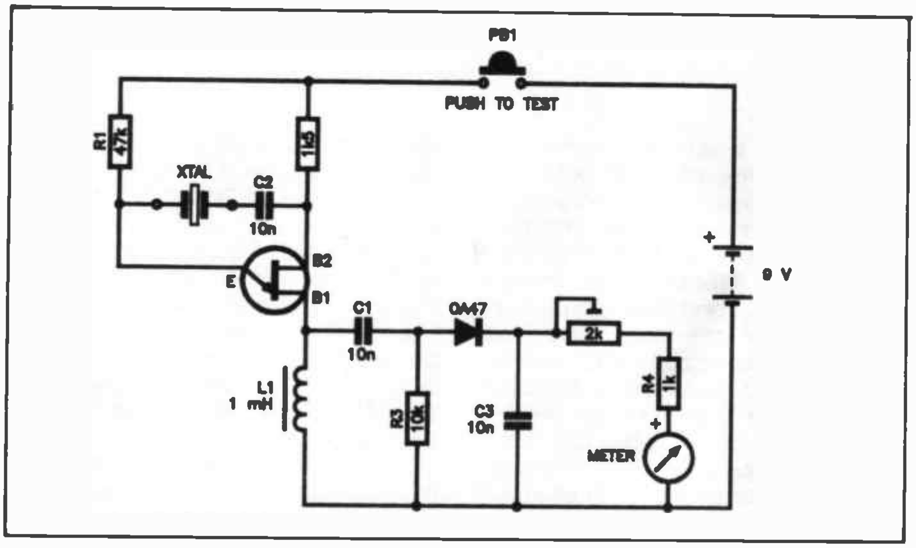


Figure 8: A circuit which will indicate the 'activity' of a crystal – how well it will perform in an oscillator circuit.

The circuit may be powered from a 9V transistor radio battery, although 4.5V or 6V batteries will work, too. A set of suitable crystal sockets may be wired in parallel to allow crystals to be checked; spring clips or binding posts can be used to take crystals with leads. Keep the leads from the crystal socket, C1, C2, Q1, R1 and R2 as short as possible. Capacitors C1 and C2 should be mica or polystyrene, or ceramic NPO types. The two diodes are common 1N914/1N4148 types. Capacitors C3 and C4 can be ceramic capacitors. Transistors Q1 and Q2 are common RF transistors.

The circuit of Figure 8 will provide you with an idea of the 'activity' of a crystal – how 'good' an oscillator it is. This particularly applies to older crystals in bakelite screw-together holders, and not so much to the more modern HC18 and HC36 style crystals in hermetically sealed metal cans.

A 2N2646/DS2646 UJT is connected here as a feedback oscillator. The RF choke in its base 1 (B1) lead develops an RF voltage across it if the crystal oscillates. This voltage is rectified by the OA47 germanium diode, charging C3. The voltage developed across C3 is read off by the meter circuit, comprising the 2k trimpot, R4 and the meter. Good meters to use for this circuit are the low-

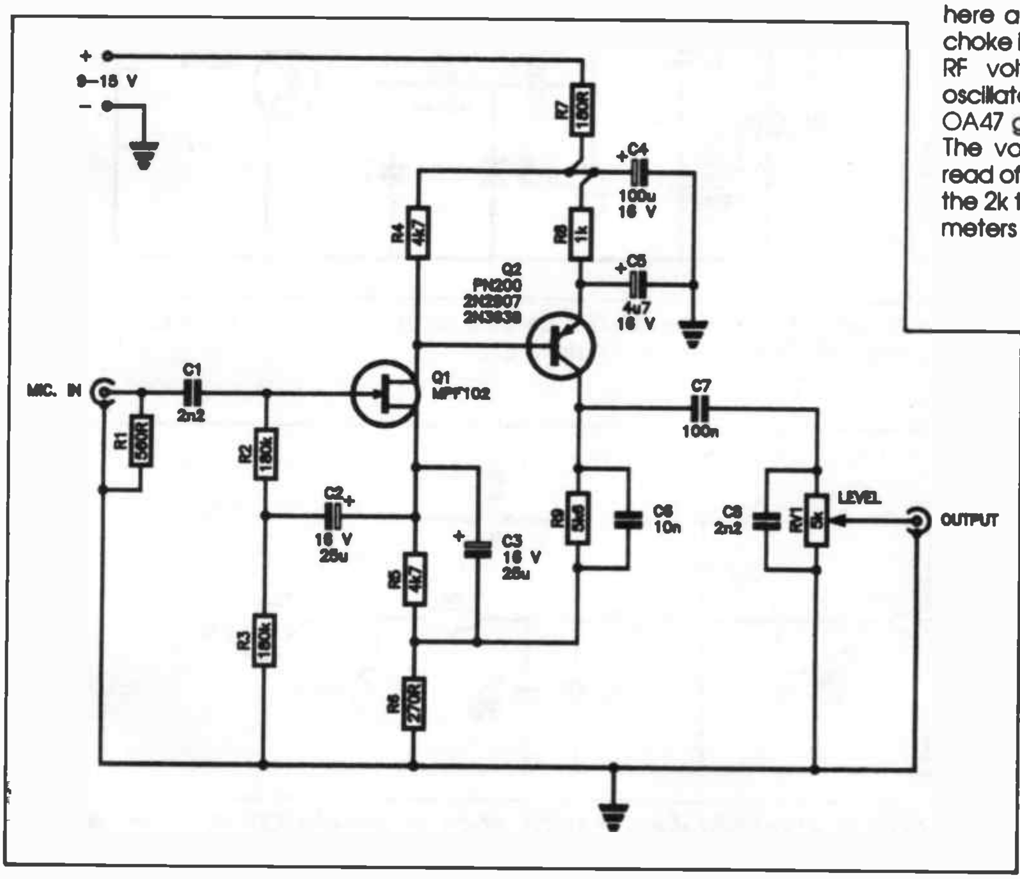


Figure 9: A microphone preamp which provides a 'tailored' audio response, to improve the intelligibility of your transmissions. It rolls off below 400Hz, and above 2kHz. Make sure you enclose it in an earthed metal box.

cost 'signal strength' meters or 'edge level meters' stocked widely by electronics retailers. The former have a sensitivity of 250uA, while the edge level meters have a sensitivity of 500uA.

The meter reading will give you an idea of the crystal's activity, although this won't be an absolute measurement and you can't compare the activity of crystals of differing frequencies, partly because of the way the RF choke's characteristics will vary across the frequency range.

The circuit is powered from a 9V transistor radio battery. A bank of suitable crystal sockets can be connected in parallel to take the various crystal pin spacings; spring terminals can be used for pigtail leaded crystals. The circuit works with crystals up to 7-8MHz, although this depends on the individual UJT's characteristics. Overtone crystals with a fundamental in the range below this will work, too. It's great for checking 'computer' clock crystals, 'TV' crystals and old 'military surplus' HF crystals.

A tailored response mic preamp

You can improve the intelligibility of speech communications by 'tailoring' the transmitted audio response, rolling off the low frequencies, which convey little in terms of intelligibility, and attenuating the high frequencies contained in 'plosive' sounds (P and T) and 'sss' sounds, none of which conveys intelligibility. It has been found that gently rolling off the low frequencies starting at around 300-400Hz, and rather more steeply rolling off the highs from above 1.7-2kHz does the job. Actually, you can also do the same at the receiver.

Figure 9 shows such a preamp that provides the appropriate roll-offs, and which you interpose between your microphone and your transmitter's mic input connection. Not only does it improve intelligibility, but the response this circuit provides will also reduce extraneous background noise pickup which can affect your signal.

The circuit comprises a cascade FET-bipolar amplifier. The input stage JFET (a common MPF102) provides a high impedance input. This is direct-coupled to Q2, a common-emitter stage with feedback boot-strapped to Q1.

The preamp is powered from a rail of 9-15 volts. It may be used with either low or high impedance dynamic microphones (or even a cheap crystal mic!). Resistor R1 here provides a load for low impedance mics. If you're using a high impedance mic, R1 should be removed. Output level control is provided by RV1. This should be set to provide a signal level to the transmitter's mic input that the mic alone would normally provide.

Construction is quite non-critical. The circuit can be easily assembled on matrix board or Veroboard. Use good quality polyester non-polarised capacitors. The polarised capacitors C2, C3 and C5, would best be tantalum types, while C4 can be an ordinary electrolytic. Mount the preamp in an all-metal enclosure to obviate possible RF interference. ●

Easy-to-build wideband discone antenna

The discone is the ideal antenna for covering the VHF-UHF bands without the complications of tuning an antenna or switching between antennas. And you can save yourself money by building your own, based on a locally made 'hub' casting that takes all the mechanical complication out of it.

FOR RADIO enthusiasts, experimenters and amateurs interested in the VHF-UHF spectrum, the advent of wide coverage scanning VHF-UHF receivers in the early 1980s was a boon. Here was the gear to do on VHF-UHF what shortwave listeners had been doing on HF for decades. But, every receiver needs a suitable antenna. For enthusiasts interested in VHF-UHF, the discone is it.

The discone antenna's name derives from its appearence. As you can see from Figure 1, it consists of a cone, arranged 'point' upwards, surmounted by a disc, which is not in contact with the cone. A coaxial cable feedline is employed, with the outer conductor connected to the apex of the cone and the inner conductor connected to the centre of the disc.

Clearly, it's a very simple antenna. It acts like a vertical dipole, but unlike that antenna, covers an extremely wide frequency range and maintains a nearly constant impedance of about 50 ohms, providing a close match to the common coaxial cable (see the accompanying panel). Now you understand what I mean by it being an 'ideal' antenna. But for home constructors, it presents mechanical problems.

I've been interested in the radio spectrum above 30MHz for many years. I've built, bought, borrowed and used a lot of gear – receivers and transmitters – over the years, and, needless to say, a lot of antennas, too. But building a discone for myself was something I never managed. One attempt convinced me that solving the mechanical problems required more sophisticated tools and techniques than I had at my disposal.

The disc and cone don't have to be solid, as illustrated in Figure 1. *Skeletal* forms have been described in the literature and made available by manufacturers over the years. This form reduces the disc and cone to a series of rods, forming a sort of skeleton, as illustrated in Figure 2. It's this form of the antenna I'll be describing, the finished product appearing in the lead photograph here.

Skeletal forms of the discone are available commercially. The cheapest I've seen comprise three rods each for the 'disc' and 'cone' – pretty minimal. They bear little resemblance to Armig Kandoian's original. They do 'work', but then so does some sort of dipole made out of a pair of coat-hangers!

A radio amateur colleague with similar interests and of practical bent, Tom Moffat VK7TM, described a skeletal discone in *Amateur Radio* magazine (journal of the Wireless Institute of Australia) in the early 1970s. Tom showed how to turn-up and drill a 'hub' of aluminium to take the rods for the disc and cone sections. The hub provided a means of mounting the whole antenna and terminating the coaxial cable feedline. The disc and cone sections were insulated by a piece of turned-up polytetrafluorethylene (PTFE to you!). It was a fine design which was copied commercially. The key element to Tom's discone was the design of that hub.

To make Tom's design yourself, you either need a lathe or have to approach a machine shop and have them make it to order. Those barriers are a bit much for many constructors, it seems.

I never did come to a satisfactory conclusion about the making of a discone, probably because I never spent enough time at the problem. Then, out of the blue a few years ago, I was contacted by another radio amateur colleague, Mike Rychter VK2NOW/VK2YUX. Mike and a few of his acquaintances had been going over the discone construction problems, too. They'd made a hub from heavy gauge sheet aluminium, to which the rods were bolted to form the skeleton disc and cone.

Mike's a metallurgist by profession and proprietor of a foundry, *Ashpoint Industries Pty Ltd*, which manufactures all sorts of complicated castings. Mike gained 'fame' among amateurs and CBers some time ago for producing a set of hub castings (known as 'Bandit') to make home construction of a cubical quad antenna easy.

Mike had produced some prototype castings for a discone hub and sought my advice and assistance. I built one, checked it out and we conferred on its design. The initial design was modified to make it easier to cast and use, resulting in the design Ashpoint makes and sells to this day.

The Ashpoint discone hub solves all the construction problems. It comprises three pieces – a disc piece, a cone piece and an insulator. The disc and cone pieces are cast in aluminium. The insulator is a toroid of a plastic known as acetal. This is a mechanically rugged material that is resistant to the rigours

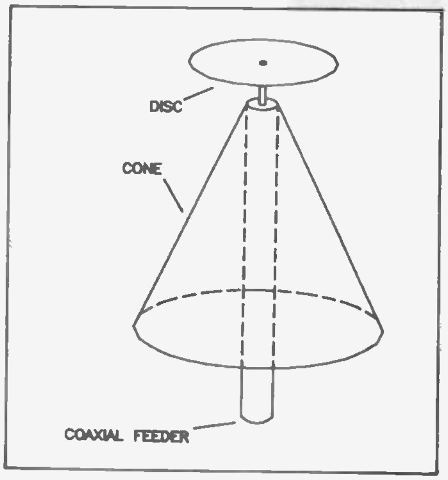


Figure 1. General form of the discone antenna – now you see where it got its name!

Build yourself a discone like this – every scanner owner or VHF-UHF enthusiast should have one! All the problems, and the hard work, are taken away by the locally made 'hub' from Ashpoint Industries.

of the weather. As the feedpoint of the antenna is quite low at 50 ohms, its loss characteristics at VHF-UHF are not of critical importance.

The accompanying photograph shows the hub kit sold by Ashpoint. The dimensions of the hub pieces are detailed in Figure 3. It is designed so that you can assemble a skeletal discone having eight rods each on the disc and cone sections. Note that the disc and cone castings have pairs of fillets which are used to locate the rods, or elements. Rather than using solid rods which are expensive, 9.5mm diameter (3/8 inch) aluminium tubing is used. It's cheap, widely available and can be cut with a hacksaw.

The cone piece is truncated. That is, it doesn't form a complete cone, but has a flat section at the top. It also features two posts which project down inside it from the apex (see the photograph of the hub pieces). These posts project a little beyond the bottom of the cone piece and provide the means by which the whole ensemble can be mounted. The posts are spaced 50mm apart on the inside dimension, allowing the discone to be mounted atop a 50mm diameter pipe. A large worm-drive hose clamp can be used to secure the antenna to the pipe.

Two small 'steps' on the inside edges of the posts, located near the cone piece's apex, provide stops which seat against the top of the pipe on which the discone is mounted, providing a secure mount.

The flat section atop the cone piece permits attachment of the insulator, and the disc piece mounts on the insulator. A coax socket is readily mounted on this flat section to permit connection of the feedline.

The Ashpoint discone hub kit allows you to economically construct a discone for yourself using nothing more sophisticated in the way of tools than a hacksaw and an electric hand drill.

Designing your discone

The dimensions of your discone antenna are determined by the lowest frequency of interest to you. Choose that, and everything else falls into place. A few simple calculations on a 'four-banger' calculator gets you the dimensions for the disc and cone elements.

From the details given in the panel on 'Background to the Discone', the hub alone, without the added elements, would have a cut-off of 500MHz. It does have an upper frequency limit, determined by the necessary mechanical dimensions of the hub. I would put it at around 2000MHz. Only a very few, very expensive, scanners go that high!

To perform the calculations, choose a frequency that is a few per cent lower than your lowest frequency of interest, so that the antenna's performance is maintained, even at that frequency. Now work out a value for C. This is obtained from:

C = 90,000/f(MHz)..................................(i)

where 'f' is the frequency just arrived at. The result will be in millimetres.

The best way to see how it's done is with a practical example. Say the lowest band of interest to you is the 120-130MHz aircraft band. For this exercise, I'll set 'f' at 118MHz, which is a little under two per cent lower than 120MHz. Thus, from equation (i):

C = 90,000/118
= 762.7

You can round this figure up or down a little, so I'll call it 760mm.

Now, consider Figure 4. The elements are cut shorter than the calculations that Diagram B would give. The disc elements each 40mm shorter than the disc diameter, A, to allow for the 80mm gap in the middle of the disc piece

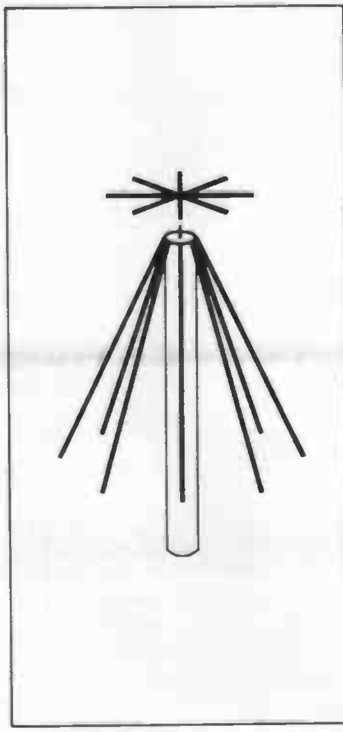


Figure 2. The disc and cone sections of the discone can be reduced to a 'skeletal' form, like this. Such an arrangement uses less in materials, is generally easier to make and presents considerably lower wind resistance.

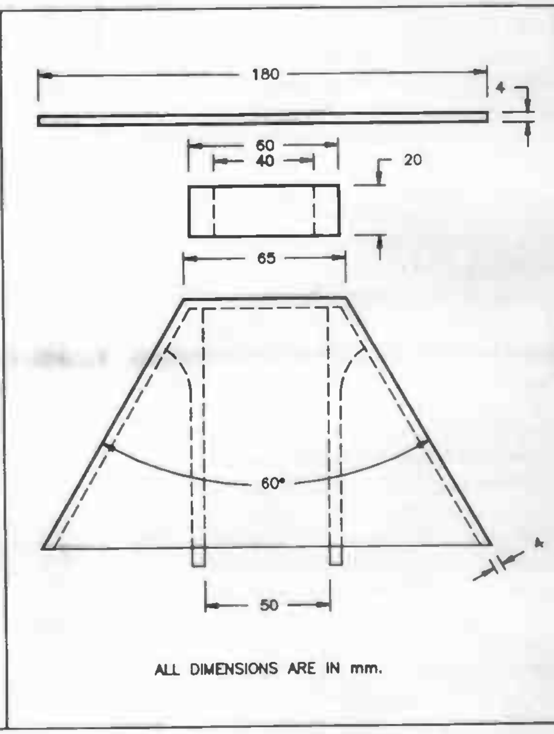


Figure 3. Dimensions of the discone hub pieces. All measurements are in millimetres.

casting. The length of each disc element, a, is given by:

$a = 0.5(A - 80mm)$ ....(ii)

The elements for the cone are 100mm shorter because of the design of the cone piece casting, as you can also see from Figure 4. Because the cone of the discone is formed from a rotated equilateral triangle, the virtual length of the cone elements, D, is equal to the base width, C. The actual length of the cone elements, d, is given by:

$d = D - 100mm$ ....(iii)

The cone elements are positioned by fillets on the inside skirt of the casting, the length of the element being held inside the casting being around 55mm, but this doesn't figure in the calculations.

OK. Now, I set the disc diameter, A, at 0.65 times the base diameter, C. (Diagram B) Thus:

$$A = 0.65 \times 760mm$$
$$= 494mm$$

So this gives you a value for calculating the disc element lengths from equation (ii):

$$a = 0.5 \times (494 - 80)$$
$$= 0.5 \times (414)$$
$$= 207mm$$

For ease of measurement, I'd round that up to 210mm.

As eight elements are required, you'll need a total length of 1680mm, plus a little bit to allow for the hacksaw cuts.

Now for the cone elements. Using equation (iii):

$$d = 760 - 100$$
$$= 660mm$$

For eight elements, you'll need a total length of 5.28 metres.

Now, it so happens that 9.5mm diameter aluminium tubing is obtainable in standard two metre lengths. Out of a single two metre length, you can cut the eight disc elements; three cone elements can be cut from a single two metre length. Four two metre lengths of tubing will cover your requirements with little wastage. If I'd chosen the corner frequency a little lower, the cone elements come out longer, thus not allowing three elements to be cut from a single two metre length of tubing.

To summarise the procedure:

(a) Decide your lowest frequency of interest and set your discone's cut-off frequency, f, a couple of per cent lower.

(b) Calculate the discone's base diameter, C, from equation (i).

(c) Calculate the cone diameter:

$$A = 0.65 \times C.$$

(d) Calculate the lengths of the eight disc elements, a, from equation (ii).

These are the pieces that make up the discone hub supplied by Ashpoint Industries. At front left is the disc piece and at top right, the cone piece; both are sturdy aluminium castings. The ring at the rear is the acetal plastic insulator. Note the fillets in both castings, used to locate the 9.5mm diameter aluminium tubing elements. Note, also, the 'dimples' in the disc piece casting which are used to locate the various holes to be drilled, thus making your job easier. There are also dimples in the flat section on the top of the cone piece casting.

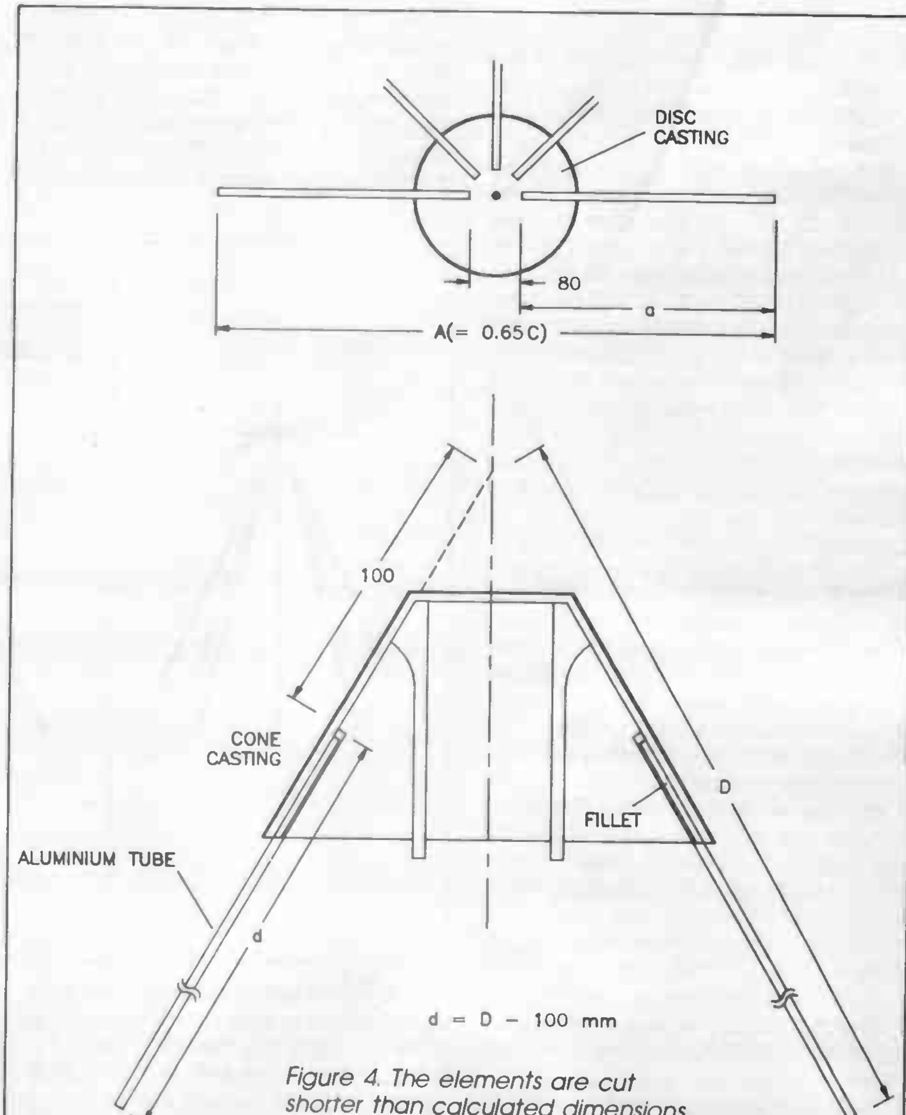
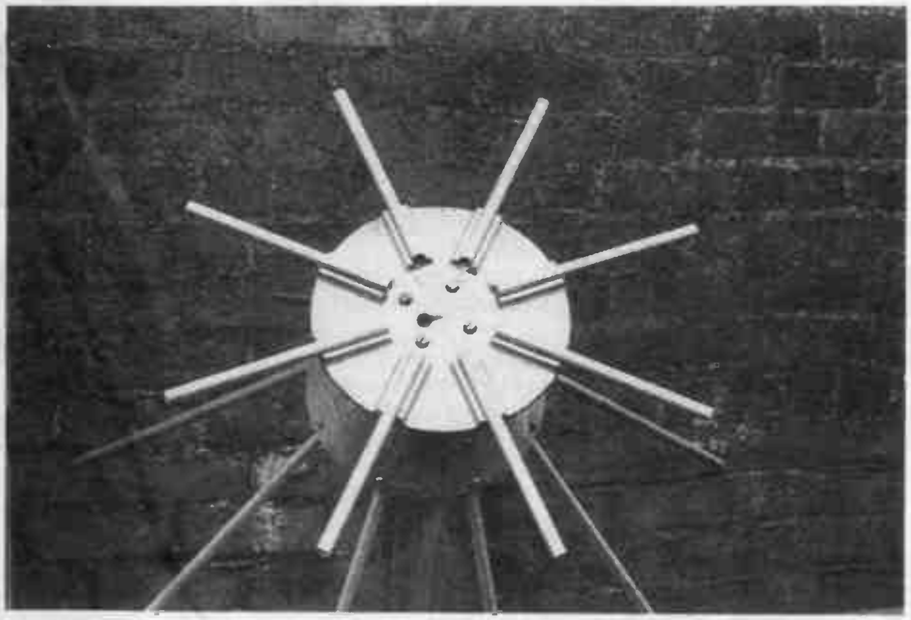


Figure 4. The elements are cut shorter than calculated dimensions, and this diagram shows you why.



View of the completed prototype. Note the four screws in the centre area of the disc casting – these hold the disc assembly to the insulator. Only three were used on subsequent units, as described in the text.

(e) Calculate the lengths of the eight cone elements, d, from equation (iii).

As mentioned earlier, I've summarised the dimensions for a few relevant cut-off frequencies in Table 1. The inclusion of a '43MHz' design might seem a little weird, but there is a good reason for it. As 9.5mm diameter aluminium tubing is obtainable in standard two metre lengths, this is the lowest frequency discone design that can be made using these standard lengths. Buy 11 lengths and you can assemble this design with minimum measuring and cutting and obtain coverage from the 40MHz region through to 2GHz.

Assembling your discone

First, buy the hub kit. Ashpoint Industries' address is 38-44 Birmingham St Alexandria NSW 2015; (02) 693 1866.

The manner and details of assembly are illustrated in Figure 5. The elements are best secured to the castings using 'PK', or self-tapping, screws. I have tried pop rivets, but found that PK screws were a better bet all round in this application. I used No.8 binding head types, 12mm long, which are available from hardware stores.

Follow this step-by-step procedure, and your discone will be completed quickly.

1) Locate all the dimples on each casting and drill them out to the necessary clearance diameter of the 8g PK screws, *with the exception of* the centre hole in the disc casting. This can be drilled 1.6mm (1/16 inch). As you can see from Figure 4, a wire from the coax socket's centre pin passes up through here for making the disc connection.

Note: where only short elements are required (e.g., for the 140MHz design, Table 1), a single screw is enough to hold them. It's best to drill the inner holes between the fillets.

2) Take a solder lug and position its solder hole end over the disc's centre hole. Mark the position of the lug's bolt hole, then centre punch it. Drill a clearance hole for the bolt that will hold the solder lug in place. I used a 1/8 inch (3mm) by 3/8 inch (9.5mm) plated steel bolt and drilled an 11/64 inch (4.4mm) clearance hole.

3) Take the cone piece casting next. On the lower rim of the cone piece, mark the centre point between each fillet. Take a 200mm length of string and tie a bolt to one end. Thread the free end of the string through the centre hole at the top of the casting and pull it tight. Now, lay the string down the skirt of the cone casting and line it up with the centre mark between one of the fillets. Run a pencil down the string to mark the centre line between the fillets on the skirt of the casting. Repeat this for the other seven and remove the piece of string.

On each of these centre lines, measure 10mm from the lower rim of the casting and make a mark. Then measure 50mm from the lower rim and make another mark. Do this on all eight centre lines, then centre-punch all the intersections. These mark the hole positions for the screws that secure the cone elements.

You can now drill all these to the required clearance diameter. This is best done by carefully clamping the skirt of the cone in a vise, in the end of the jaws and drilling with a handheld electric drill.

4) Take the insulator and lay it flat on the bench. Up-turn the cone casting and sit the apex end on it so that the insulator is properly centred within it. Take a well-pointed soft-lead pencil, push it through the three holes drilled earlier and mark their positions on the insulator.

Take the marked insulator and check the hole positions are more or less mid-way from the inner and outer edges. If not, scrub them off and repeat the exercise to get it right. If they're right, carefully centre-punch the hole positions and drill them to the root diameter of the PK screws.

5) Next, take the drilled insulator and mark the hole positions on the outside surface. Now, temporarily screw the insulator to the cone casting's apex. Next, sit the cone casting on the bench, apex upwards, using two small chocks of wood so that the mounting posts are clear of the bench.

Place the disc casting on top of the insulator (it's easier with the fillets face down) and carefully position it so that it's centred and that the three insulator securing holes in the centre area *do not* line up with the hole positions marked on the insulator earlier. You may choose to align the fillets on each casting so that they correspond, or are half-way between (22.5 degrees out of phase).

Having aligned the disc, use your soft-lead pencil and mark the hole positions on the insulator. Remove the disc casting and check the hole positions. Repeat the exercise, if necessary, scrubbing off the unwanted hole markings first to avoid confusion. When you're satisfied the hole markings are in the right position, centre-punch them and then drill to the root diameter of the PK screws. Finally, unscrew the insulator from the cone piece casting.

6) Now you can drill out the centre hole of the cone piece's apex end to take whatever coax socket you are going to use. The size of the hole may require you to drill the largest hole you can and then ream it out to size.

While you might use any connector you want, either of two types are ideal for the job – a BNC panel socket, or a Type-N. Both are 'constant impedance' connectors rated to work well into the GHz region. The Type-N is weather-proof and thus suited to outdoor applications.

Some coax sockets are of the 'single-mount' type, having a threaded end and secured with one large nut. Others have a square flange with bolt holes in the corners, in which case you use the socket as a template to mark the hole positions, then drill suitable clearance holes. Once you've prepared the cone casting's socket mount, complete by mounting the socket.

7) Tackle the elements next. Measure and cut them all to length. File the ends smooth as the rough-cut surface tears flesh quite readily!

Proceed methodically. Take one element and place it in a fillet so that the element's end lines up with the end of the fillet, or a millimetre or two beyond it. Holding it firmly in place, take your soft-lead pencil and mark the hole positions. Centre punch each and drill the holes to the root diameter of the PK screws. If you wish, you can number each fillet and its corresponding element as you go so that each element matches the fillet it was marked from, avoiding tolerance variations creating mismatches in the holes during later assembly.

8) Now solder a 40mm length of heavy gauge wire to the coax socket's centre pin, then screw the insulator back onto the cone casting. This wire must be of such a gauge that it will pass through the solder lug's solder hole.

Sit the cone casting back up on the two wood chocks you used earlier.

9) Now screw the disc elements to the disc casting. See that each screw is firm, but don't overdo it as you can 'strip' the hole in the element and the screw will

Background to the discone

THE STORY of the birth of the discone antenna can be found in any library which stocks back issues of the the US engineering publication *Proceedings of the Institute of Radio Engineers*. The February 1946 issue (Vol. 34) features a paper by Armig Kandoian, describing the discone in various forms and its characteristics. His summation went like this:

"... the Discone antenna is intended primarily for vertical polarisation, and, like a vertical dipole, gives an omnidirectional pattern in the horizontal plane. A distinctive feature of this antenna is its simplicity of construction and feeding. Its most important characteristic is satisfactory operation over a very wide band of frequencies (several octaves) without a substantial change of either input impedance or radiation pattern.

"This type of antenna has wide applications wherever extremely wide frequency ranges are encountered and simplicity of mechanical design and installation are required."

Now, for anyone who has a VHF/UHF scanner, that's a description of the *ideal* antenna!

Since its birth, the discone has been widely used in research and commercial applications. Various forms have been developed and a number of manufacturers make and sell discone-type antennas.

The discone has a radiation pattern the same as a vertical dipole and a frequency response like a high pass filter. It has a gain of 2.14 dB over an isotropic radiator. Below the cut-off frequency, its impedance, or its VSWR if you want to look at it that way, rapidly increases. This is illustrated in Diagram A. Exactly where the 'corner' is depends on the impedance mismatch you're prepared to tolerate. Usually, the cut-off is taken as that point where the VSWR is 2:1.

The controlling dimensions of a discone are shown in Diagram B. These are: the disc diameter, A, the overall height, B, and the base diameter of the cone, C. In his paper, Kandoian described models with a base angle on the cone of 60 degrees. That is, the cone figure was formed of a rotated equilateral triangle.

The diameter of the disc is smaller than the cone's base diameter, and Kandoian described models with the disc diameter varying from 0.9C down to 0.64C. It seems varying the disc diameter only affects the vertical radiation pattern to some small extent. Clearly, it's more economical on materials to have the smallest acceptable disc diameter.

For a VSWR at cut-off of about 2:1, C is about 0.3 wavelengths. If you can tolerate a VSWR of 3:1 at cut-off, then C can be about 0.2 to 0.167 wavelengths.

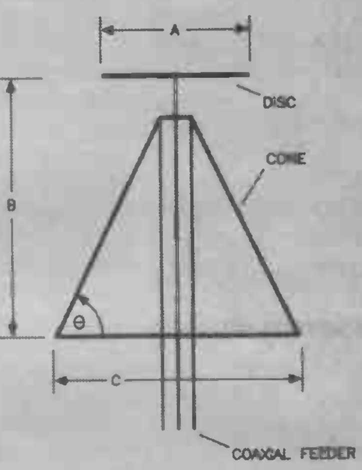


Diagram A. Sectional schematic drawing of a discone, showing the controlling dimensions.

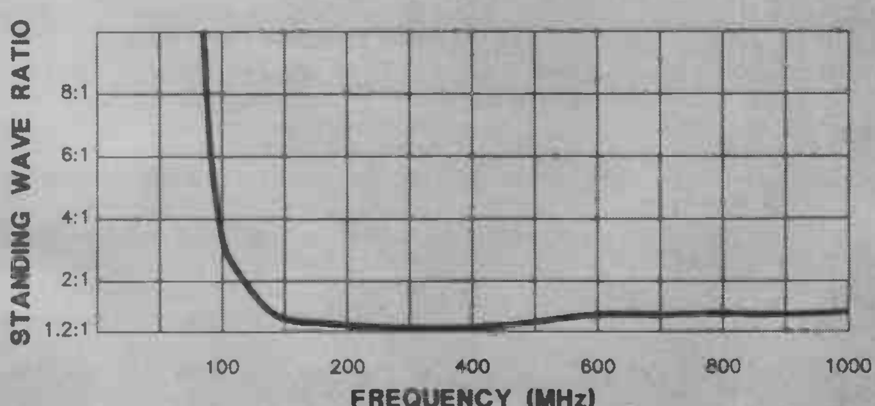


Diagram B. The discone has a high pass filter characteristic. This graph shows typical performance. Below the cut-off frequency, its impedance, and thus VSWR, rises rapidly.

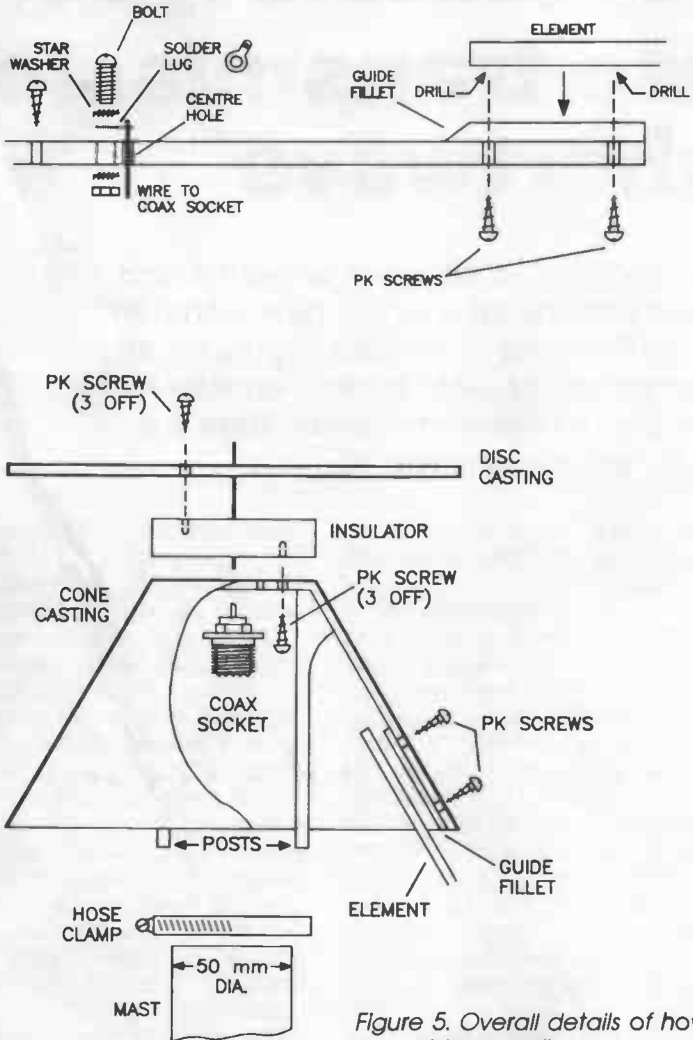


Figure 5. Overall details of how to assemble your discone.

CUT-OFF FREQUENCY	DISC ELEMENTS, a	CONE ELEMENTS, d
43MHz	645mm	2000mm
118MHz	210mm	660mm
140MHz	160mm	525mm
400MHz	none	125mm

Notes: eight disc elements and eight cone elements are required.

PARTS LIST
1 × discone hub kit
38 × PK screws, 8g × 1/2 inch, plated or passivated
1 × plated roundhead bolt, 1/8 inch × 3/8 inch
1 × solder lug
1 × coax socket (see text)
1 × worm-drive hose clamp, 70-75mm open diameter
silicone sealant

no longer hold.

10) Next, bolt the solder lug to the disc casting, locating the solder hole over the hole in the centre of the disc. Use two star washers, as shown in Figure 5. Place the disc assembly over the insulator atop the cone, threading the wire from the coax socket up through the centre hole and thus the solder hole in the solder lug. Position the disc assembly and then screw it to the insulator. (You can choose to mount the disc assembly with the elements facing either up or down. I elected to have them facing up.)

11) Trim and bend over the wire protruding through the solder lug's hole, then solder it in place. You'll need an iron with a flat or chisel bit and a fair amount of heat capacity.

12) The cone elements can be screwed in place next. As before, make sure the PK screws are firm, but don't overdo it.

13) Now, go around and apply silicone sealant to all the screw heads and seal the centre hole in the disc assembly. And that completes the assembly of your discone.

Putting it up

The discone, as explained earlier and as illustrated in Figure 5, is meant to sit atop a 50mm o.d. pipe mast. You can use a length of 50mm aluminium tube, somewhat longer than the discone is tall and strap that, with the discone on top, to the top section of an existing mast, if you have one. I mounted one on a two metre length of 50mm aluminium tube which I then bolted to the brick parapet atop the roof of our offices. You could, for example, use one of the more sturdy TV antenna chimney mounts to mount the pipe holding the discone.

Before placing the discone atop the 50mm pipe or tube, first slip the worm-drive hose clamp over the tube, then feed the coax up the tube and screw the connector into the discone's socket. Make sure you seat the discone on the tube properly before positioning the hose clamp and tightening it.

The discone's feedpoint impedance is close to 50 ohms, so use 50 ohm coax to feed it. Mount the antenna as high as you possibly can – height gives you more geographical coverage – and use a good quality, low-loss coax; the lower the loss, the better. In this regard, 'half-inch' coax is better than common 'quarter-inch' coax, such as RG58.

The antenna you see in the lead photograph was fed with Belden 9913, which has the least loss of the flexible coaxial cables commonly available. It is obtainable from Dick Smith Electronics and features a semi air-spaced construction which gives it its low-loss characteristic. The next best choice is 'RG213 Foam' which, as the name suggests, has a foam-type rather than solid dielectric as has common RG213. You'll pay more for a lower-loss cable, but the results are worth it. It's likely you'll have to spend more money on the coax than you did on the antenna, but that's as it should be.

When you've built this discone, you'll end up with a sturdy antenna that will give you years of trouble-free performance. It's equally suitable for transmitting as well as receiving, and is the only simple antenna to boast such a wide frequency range performance. ●

Guide to radioteletype, fax and morse transmissions on shortwave

A simple electronic 'decoder', a personal computer and some low-cost software opens up a whole new world on shortwave for radio enthusiasts — eavesdropping on all the 'non-voice' transmissions, that is radio facsimile (fax), radioteletype (RTTY) and morse code. Here's a guide to 'getting amongst it'.

AT ONE time, all a radio enthusiast could listen to on the shortwave bands between 3MHz and 30MHz was shortwave broadcast stations, radio amateurs, CBers and a few other 'voice' services. But the bands abound with all *sorts* of other signals – morse code, radioteletype (RTTY) and radio facsimile picture (fax) transmissions, a cacophony of burbles, rolling squeals and piping tones.

A few years ago, a couple of do-it-yourself project and commercially made 'decoders' appeared on the market. These decoders connect between a receiver's audio output and an input on a personal computer. Software run on the computer performs the decoding so you can view, on-screen or on a printer, the results. Thus, access to all the 'non-voice' services was opened up for radio enthusiasts. Many computer enthusiasts became radio enthusiasts, too.

Radio facsimile transmissions, in particular, can provide a fascinating interest. Many fax transmissions on the HF bands are from meteorological agencies, transmitting various weather synopsis maps and charts ('WX fax') which can provide interesting, if not useful, information that is not available from generally published sources. The weather bureaus of Australia and New Zealand provide strong, easily picked-up transmissions from which quite clear weather analysis charts can be received. Some oriental news services use fax to transmit news in kanji characters.

Radioteletype transmissions are legion. A great many are international news services or agencies. Weather bureaus exchange data in code, as well as transmitting information such as weather satellite orbit details.

To receive the non-voice transmissions, you'll need a receiver capable of stable single sideband (SSB) reception, with a switch for selecting upper sideband (USB) and lower sideband (LSB) operation. The transmissions almost invariably employ frequency-shift keying to carry the digital data. If you don't know what sideband (upper or lower) a transmission employs, there's a simple international convention you can follow to sort out the signal and resolve it: below 10MHz, use lower sideband (LSB); above 10MHz, user upper sideband (USB).

The different transmissions have a characteristic sound: RTTY is a staccato

```
E 040709 - INTRIGUE UNDER THE CLOAK OF RELIGION.

   PYONGYANG APRIL 7 (KCNA) -- THE SOUTH KOREAN "UNIFICATION
SOCIETY", A PLOT-BREEDING ORGANISAION OF THE "UNIFICATION
CHURCH", INFILTRATED INTO SOME AFRICAN COUNTRIES AND
```

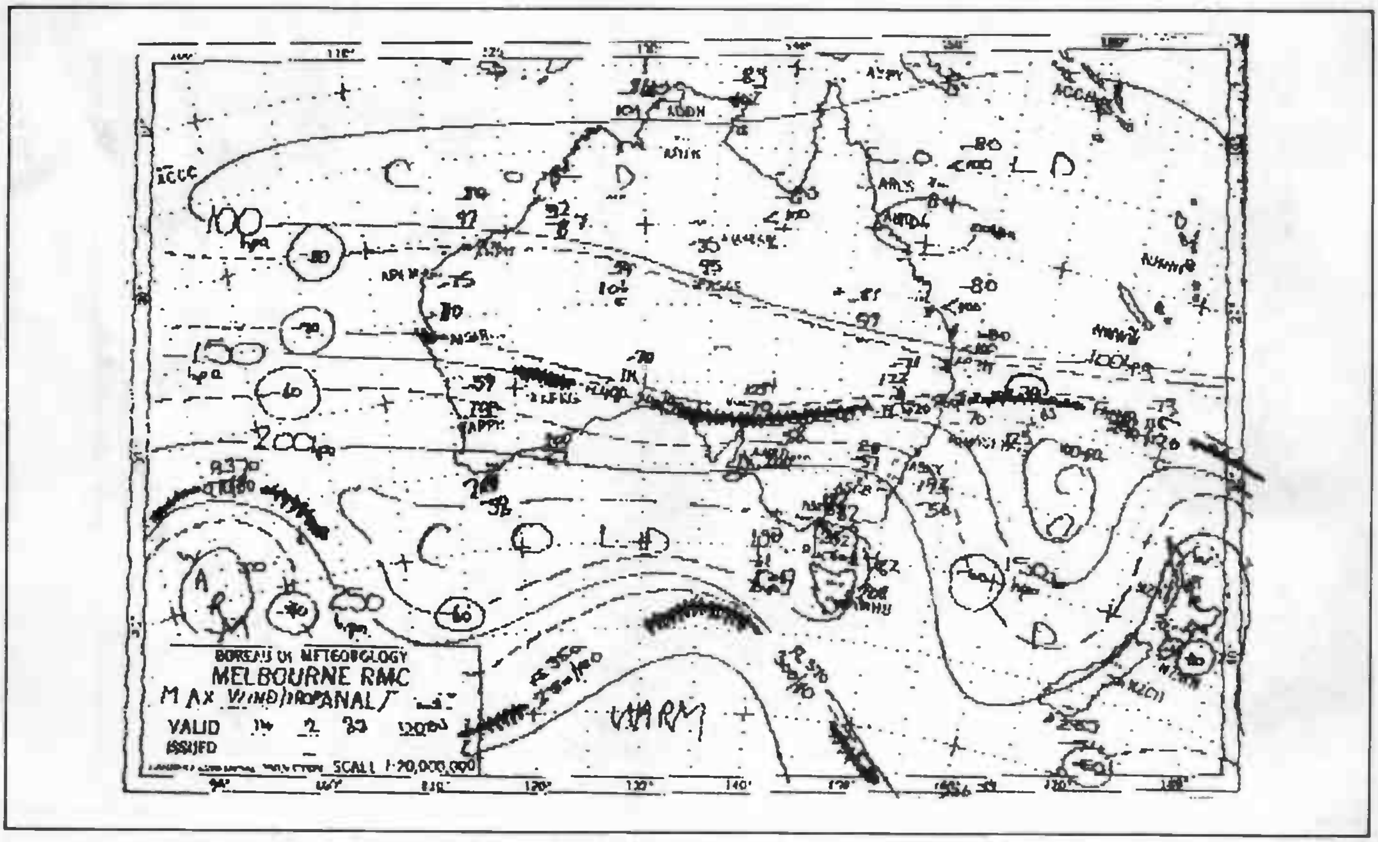
Part of a radioteletype (RTTY) news transmission. You certainly get a 'different view' of the news from these news services!

```
S JOS QSX 16MHZ K CQ CQ CQ DE JOS JOS JOS █ TSX 16MI ST * K C Q
DE VIS67/69/84 QSX 4 6 22 0 N R E Q UEST * K CQ DE VIS67/69/84 Q
SX 4 6 22 ON REQUEST * K CQ DE VIS67/69/84 QSX 4 6 22 ON REQUEST
 * K CQ DE VIS67/69/84 QSX 4 6 22 ON REQUEST * K CQ DE VIS67/69/
84 QSX 4 6 22 ON REQUEST * K CQ DE VIS67/69/84 QSX 4 6 22 ON REQ
UE ST * K CQ DE VIS67/6█ T T/84 QSX 4 6 22 ON REQUEST * K E E E
E E
```

Example of a transmission received from a maritime station, transmitting using morse code.

```
30005
USAA1 AMMC 260000
TTAA 2523/ 89611 99986 04561 ///// 00594 ///// 85174 07973
70648 18361 50514 28156 40670 40950 30859 56544 25974 58550
20116 54757 15299 55958 10553 603// 88284 58745=
```

RTTY transmissions are often sent in coded groups, like the above example. This was copied from a transmission by AXM, the Australian Bureau of Meteorology station.



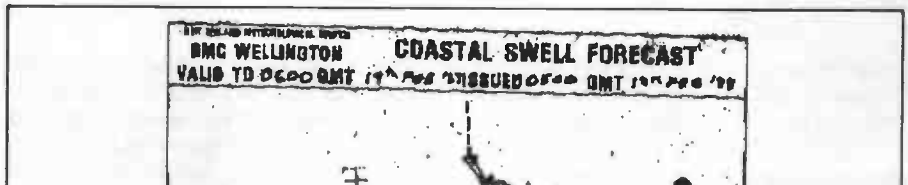
A radio facsimile (fax) weather map, received using a shortwave receiver, decoder, personal computer and dot matrix printer. This was transmitted by the Australian Bureau of Meteorology station, AXM.

'burble', while fax is a tone punctuated by a more or less regular 'tic-tic-tic' with an occasional burst of sustained high-pitched tone (the synchronising pulse). Fax is rather like television in that the picture is scanned and transmitted one line at a time, from left to right across the page, and top to bottom down the page. There are different transmission standards, given as 'lines per minute' (lpm). The common ones being 60 lpm, 12 lpm and 240 lpm.

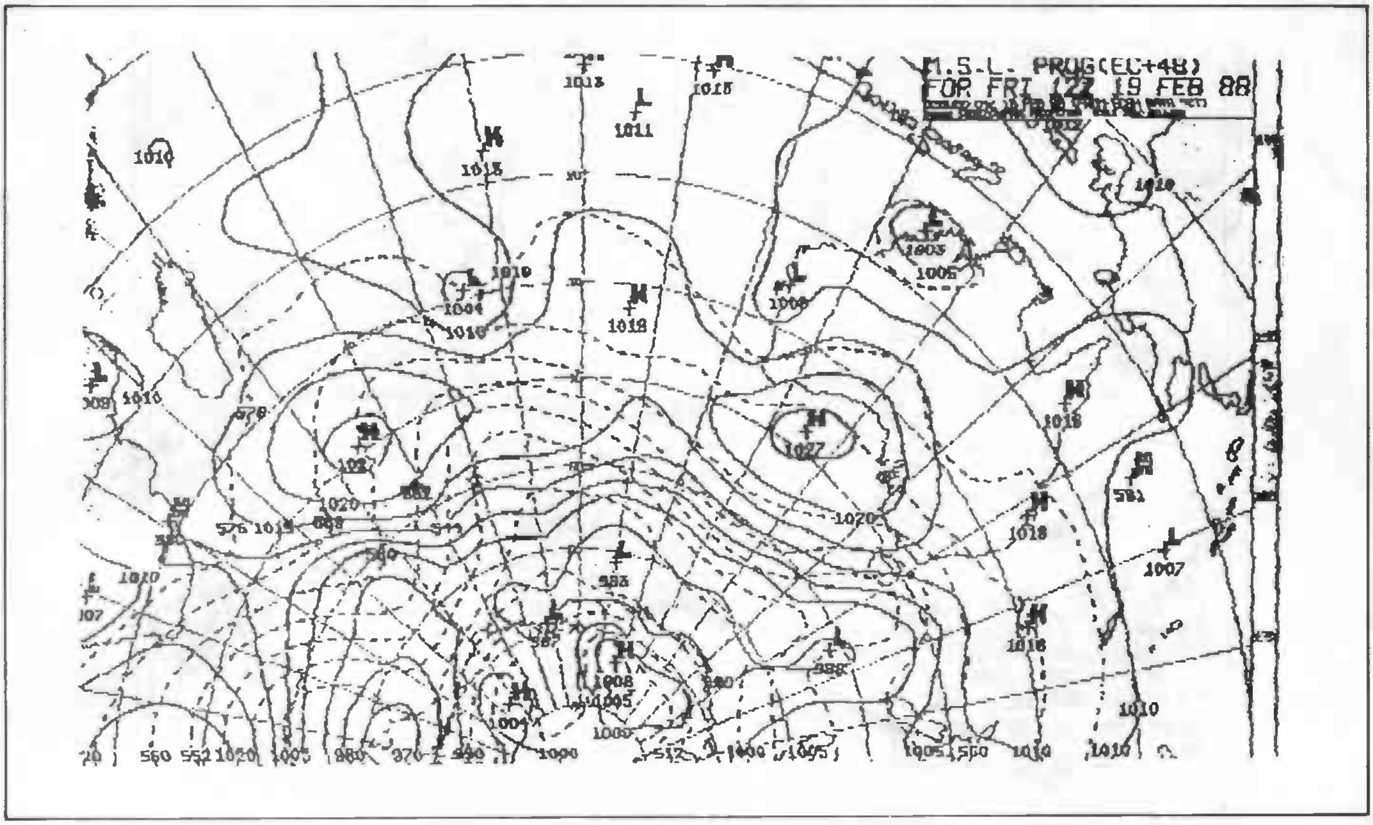
When receiving fax transmissions, it is best to first attempt reception at 60 lpm, as this seems to be the most common transmission standard, and see if you get something sensible (patience, patience!). If not, then try another lpm rate.

Radioteletype also has different transmission standards, the transmission rate (quoted in bauds) and the frequency shift. Most decoders provide suitable settings to cope with the different frequency shifts and the software can be set to decode the different baud rates. The most commonly used RTTY transmission rate is 50 baud.

The following frequency/service listings are not intended to be exhaustive, but to provide a guide to knowing transmissions and 'active' frequencies. Whether you hear some-



This is an example of a weather fax transmission from the New Zealand weather bureau station.



This is more like the weather maps you're used to. This shows a large section of the southern ocean, with isobars (at sea level) depicted. The outline maps of Australia and New Zealand are discernible at the right, and the southern tip of South Africa and the island of Madagascar can be seen on the left. This was received from AXM. Reproduction has reduced the clarity here.

thing on a particular frequency or not depends on a number of factors, including your latitude and longitude, the latitude and longitude of the station you are trying to receive, the time of day and season of the ionosphere, etc. So if you attempt receiving a transmission on a particular frequency and are unsuccessful, try again at another time. There are plenty of alternate frequencies to try. Even if your receiver has a digital frequency readout, it is best to tune a kilohertz or so either side of the given frequencies when searching for a transmission, as well as trying both settings of the sideband switch.

Fax

Undoubtedly the best fax transmissions to 'cut your teeth' on when starting out are those from the Australian Bureau of Meteorology stations – AMX near Canberra and AXI near Darwin, and the New Zealand Meteorological Service's station, RMC Wellington. They all transmit on continous schedules, mostly fax but there's a little RTTY thrown in giving weather and satellite orbit data in code.

AXM. You'll find this station on two frequencies: 5100kHz, and 11,030kHz.

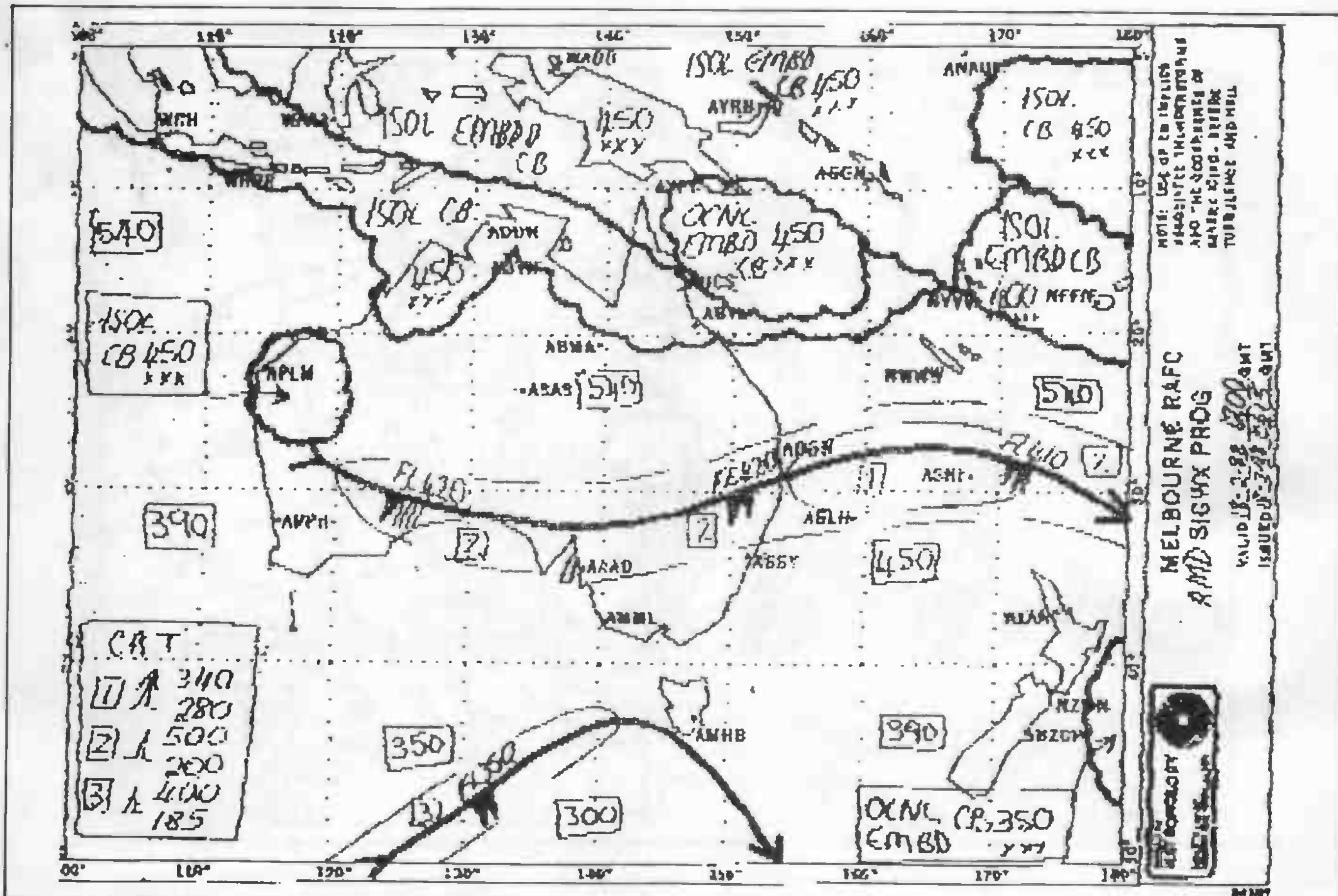
This is the Bureau of Meteorology's main one. On 5100kHz it is generally well received on the eastern seaboard, day and night, but generally better at night. Although, the further out you are, the more likelihood there is that reception will be poor or non-existent during the day owing to absorption in the ionosphere's D-region. If it's no good on 5100, try 11,030kHz.

AXI. This Bureau of Meteorology station can be found on three frequencies: 7535kHz, 10,555kHz and 13,920kHz.

The 7MHz transmission is readily received in the north of Australia during the day, but can be swamped by layers of Asian broadcast stations during the night. The 10kHz transmission is often well received up and down the east coast, across South Australia and south Western Australia.

RMC. This New Zealand weather bureau station puts quite a strong signal into Australia. It may be readily heard up and down the Australian east coast, often at good strength. You'll find it on 13,550kHz.

An example of a picture fax transmission from a news fax station. Hold this page at arm's length and you can readily discern three faces in this picture.



Another of the sort of maps you see transmitted by AXM and other weather fax stations. Good clarity printouts can be obtained (the original is somewhat clearer than this).

International weather fax

A number of WX fax transmissions originating to the north of Australia can be heard, often at good strength. There are three frequencies that will provide fruitful results with patient listening: 14,826kHz, 17,068kHz and 18,130kHz.

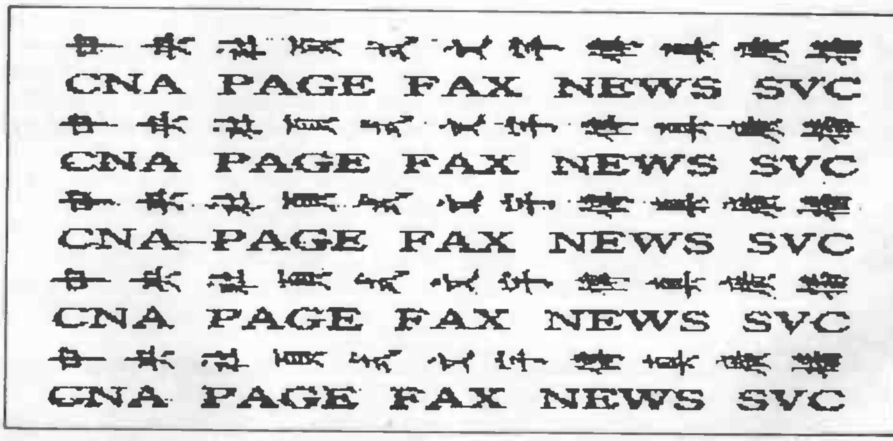
On these channels you can receive weather synopsis charts of the Japan-Korea and east China region, and tables of upper wind and temperature data. The weather fax pictures received on these frequencies will often contain noise 'stripes' and show distortion. You will also often see 'ghosting' on the pictures, the result where the signal crosses the equator (known as transequatorial paths).

Weather fax transmissions from the North American continent can be received here, too. Two good frequencies to try are 13,510kHz and 17,150kHz.

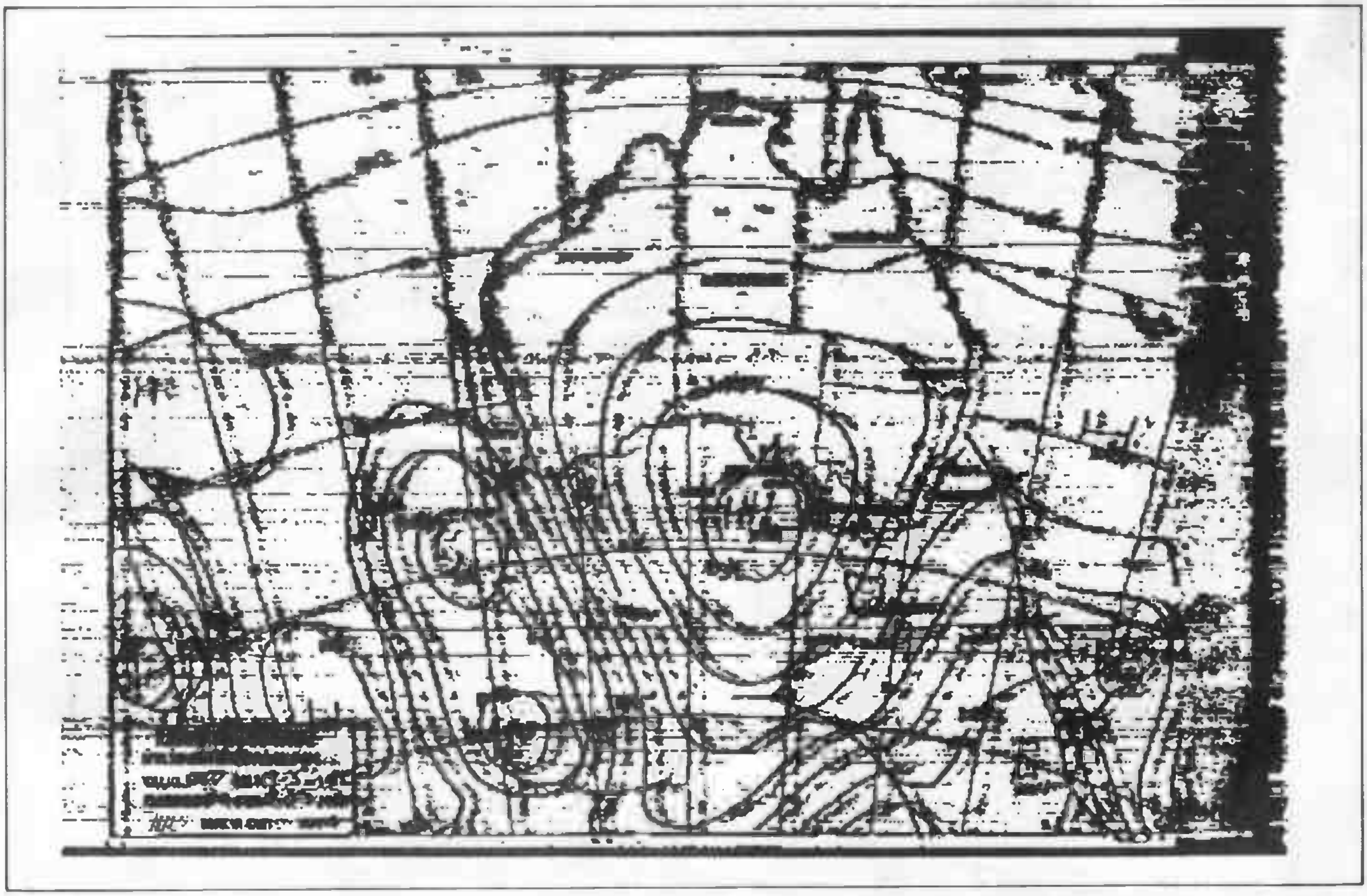
The 13kHz transmission originates from Canada. Monitoring this channel, you'll pick up a lot of synopsis and analysis

MONSIEUR LE SECRETAIRE GENERAL, DES VOTRE NOMINATION A LA HAUTE FONCTION QUE VOUS OCCUPEZ VOUS AVEZ MARQUE AVEC FORCE L'IMPORTANCE QUE VOUS ATTACHIEZ A CE QUE L'ORGANISATION RETROUVE LES PRINCIPES QUI L'AVAIENT FOÑDEE : ''NOUS NOUS SOMMES, DISIEZ-VOUS, SANS CONTESTE, BEAUCOUP ECARTES DE LA CHARTE CES DERNIERES ANNEES. NOUS SOMMES PERILLEUSEMENT PROCHES D'UN NOUVEL ETAT D'ANARCHIE INTERNATIONALE''. ET UN PEU PLUS LOIN VO

Copy of a speech carried on a diplomatic channel (16,106kHz); a RTTY transmission.



Example of a fax news transmission from the Taiwan News Agency station, CNA. What follows is the news in Chinese kanji characters, if you can read it.



Sometimes, reception of fax signals is not so good and you get weird results like this. The distinct 'ghosting' you see here is caused by multipath propagation via the ionosphere.

charts covering the North American continent. The 17kHz transmission appears to carry charts that originate from San Francisco, California.

European weather fax transmissions may be copied on 16,320kHz.

This channel yields some spectacular synoptic charts covering from the polar region to North Africa, and from Spain to the Middle East. It's worth 'keeping an eye' on this channel.

Other fax stations

As mentioned in my preamble, some fax transmissions originate from news services. The most prevalent is Taiwan's CNA. This is to be found on 14,685kHz, which is readily heard over most of Australia and New Zealand. For something a little different, try 18,045kHz, where you can find news fax pictures being transmitted. You'll have to hold the print at arm's length, though, to see what it's all about!

Once you've had a little success at receiving fax, you'll easily recognise fax transmissions as you tune around and eavesdrop at will.

RTTY. There's a veritable legion of radioteletype stations to be found on the HF bands. Trouble is, many send strings of code – letters and numbers – that have no meaning unless you can decipher them. As mentioned earlier, there are a considerable number of news agencies transmittng stories, along with diplomatic networks and the like, all in plain text (albeit in a foreign language from some). Eavesdropping (or 'reading the mail') on these transmissions will certainly give a different slant on the news.

There are a number of transmission frequencies that are readily received at good strength and provide excellent sources, particularly if you're new to this.

For listeners located in the Australian southern states and in New Zealand, the following stations are regularly heard:

- Agence France Press (AFP), on: 7542.5kHz & 10,730.6kHz.
- Allgemeiner Deutscher (ADN), on: 9968kHz, 10,552kHz & 10,545kHz.
- Central News Agency (CNA), Taiwan on: 7695kHz, 9088kHz, 13,561.5kHz & 13,563kHz.
- Kuwait News Agency (KUNA), on: 12,076.5kHz & 15,645kHz.
- Maghreb Arabe Presse (MAP), on: 14,573kHz & 18,495kHz.
- North Korean News Agency (KCNA), on: 13,780kHz.
- Reuters, on: 6845kHz, 9120kHz, 10,960kHz & 14,514kHz.
- Tsushin News Service, Kyodo Japan, on: 8173.5kHz & 17,596kHz.
- USSR news service (TASS) in English, on: 6870kHz, 6950kHz, 7760kHz, 9110kHz, 10,270kHz, 11,470kHz, 12,085kHz, 12,313kHz, 13,410kHz, 14,510kHz, 14,700kHz & 15,708.5kHz.
- United Press (UPI): 9985kHz, 16,232.7kHz & 19,520kHz.
- Xinhua News Agency, on: 7250kHz, 9491kHz, 11,680kHz, 12,265kHz & 14,923kHz.

If you want to look in on a diplomatic network, try 16,106kHz. Traffic in French has been copied on this frequency.

In conclusion

If you watch on a few favourite news transmissions, you'll find a new world of news not seen in the local papers. Often you'll get the news before it becomes news here, and with what's been happening around the world lately, that can be pretty exciting. ●

Thanks are due to Neil Duncan VK3OK, Tom Moffat VK7TM and Tony Wood VK6ATW for supplying examples of RTTY, fax and morse transmissions used to illustrate this article.

Sunspots, the ionosphere and reading the propagation 'weather' forecasts

Solar cycle 22 is rolling through its peak at the moment. The HF bands to 30MHz (and beyond) have shown spectacular propagation in recent years and will continue to do so for a year or so yet. To make the most of the conditions, you need to know a little of what's behind it, where to find and how to read the 'forecasts'. Here's the drum!

BACK IN January 1987, my supervisor from my days at IPS, Dr Leo MacNamara, and I published an article titled *Kiss Your Last Big Solar Maximum Goodbye!* The article looked at then-current research on the size (or amplitude) of solar cycles and concluded that they were decreasing. I'm happy to say: that was wrong!

Research subsequent to that article painted a much more optimistic picture. And we're currently enjoying conditions not experienced on the HF bands since the late 1950s.

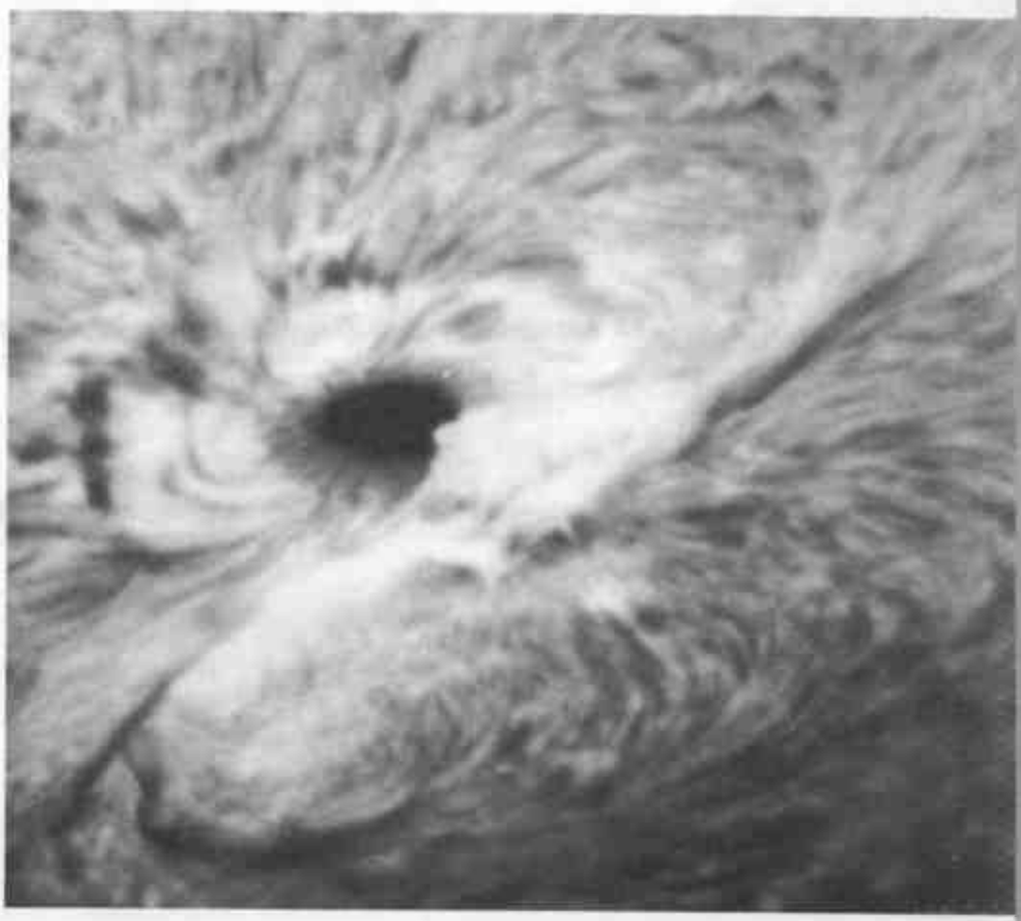
Monthly sunspot numbers have exceeded the peak of the last maximum in 1979 and have remained above it since April 1989. And they're predicted to remain above it until late 1991.

But first, let's look at what all this solar activity is doing to the ionosphere and how to exploit it.

Sunspots are small, dark patches that appear on the visible surface (the 'photosphere') of the sun. They appear dark because they are cooler than their surroundings. The Chinese made the earliest known historical recordings of sunspots, back in the first century BC.

But it was Galileo who made the first systematic observations of sunspots in 1610, using the telescope he invented. Unfortunately for him, he told the truth to the world – the sun was spotted. Heresy! ("Galileo", called the Pope. "Curses", said Galileo hiding in the garden, "I'm spotted". "Why are you wearing that leopard skin cloak?" asked the Pope. "Now I know why I'm spotted!" exclaimed Galileo.) He was thought to be a silly old bugger, so they threw him in gaol and made him recant.

While scientific interest in, and



Photograph of a large sunspot taken in H-alpha light (at a wavelength of 6563 Angstroms). Note the swirling, fibrous structure around it, created by the magnetic fields associated with the spot. The diameter of a typical sunspot is greater than the diameter of the earth, large ones may be six or seven times as large as the earth. (Picture courtesy of Big Bear Solar Observatory, USA.)

observations of, sunspots date from Galileo's time, reliable systematic observations only really got under way in the mid-nineteenth century. A German amateur astronomer, Henry Schwabe, noted in 1834 what appeared to be a 10-year cycle in the number of sunspots, based on observations he'd made over the previous seventeen years. Not another soul had noticed, or at least commented on, any periodicity to that time, despite some 200 years of astronomers observing the sun through telescopes.

I should add a note of warning here. *Never* look directly at the sun, and certainly *not* using binoculars or a telescope as you will damage your eyes – *permanently*. To view the sun using a telescope, project the image onto a sheet of white paper that is shielded from direct and reflected light so you can clearly see the image.

A little after Schwabe's time, Rudolf Wolf of the Zurich observatory organised a worldwide program of regular solar observations among professional astronomers, and a similar program continues to this day. From a search he conducted through earlier solar data, Wolf concluded that there was a cycle in the numbers of sunspots, the average period being around 11 years. Wolf also devised a method of counting sunspots and sunspot groups, to come up with a term known as the *sunspot number*, which is designated by the capital letter R.

The Wolf sunspot number counts the individual spots and the number of spot groups, making one sunspot group as important as 10 individual spots. The sunspot number is expressed as a *weighted sum:*

$$R = 10 \times \text{number of spot groups} + \text{number of individual spots.}$$

It might look like a bit of jiggery-pokery, but it has stood the test of time. The sunspot number will be zero when no spots are apparent, 11 with one sunspot visible (which is also regarded as one group) and so on. The sunspot number doesn't mean much in itself, but it is a useful indicator of solar activity.

Each month, a mean of sunspot observations from around the world is taken to produce a 'monthly observed sunspot number'. As you'd might expect, this fluctuates substantially from month to month. The monthly sunspot number is statistically 'smoothed', or ironed-out, to produced a 'yearly smoothed sunspot number' which is

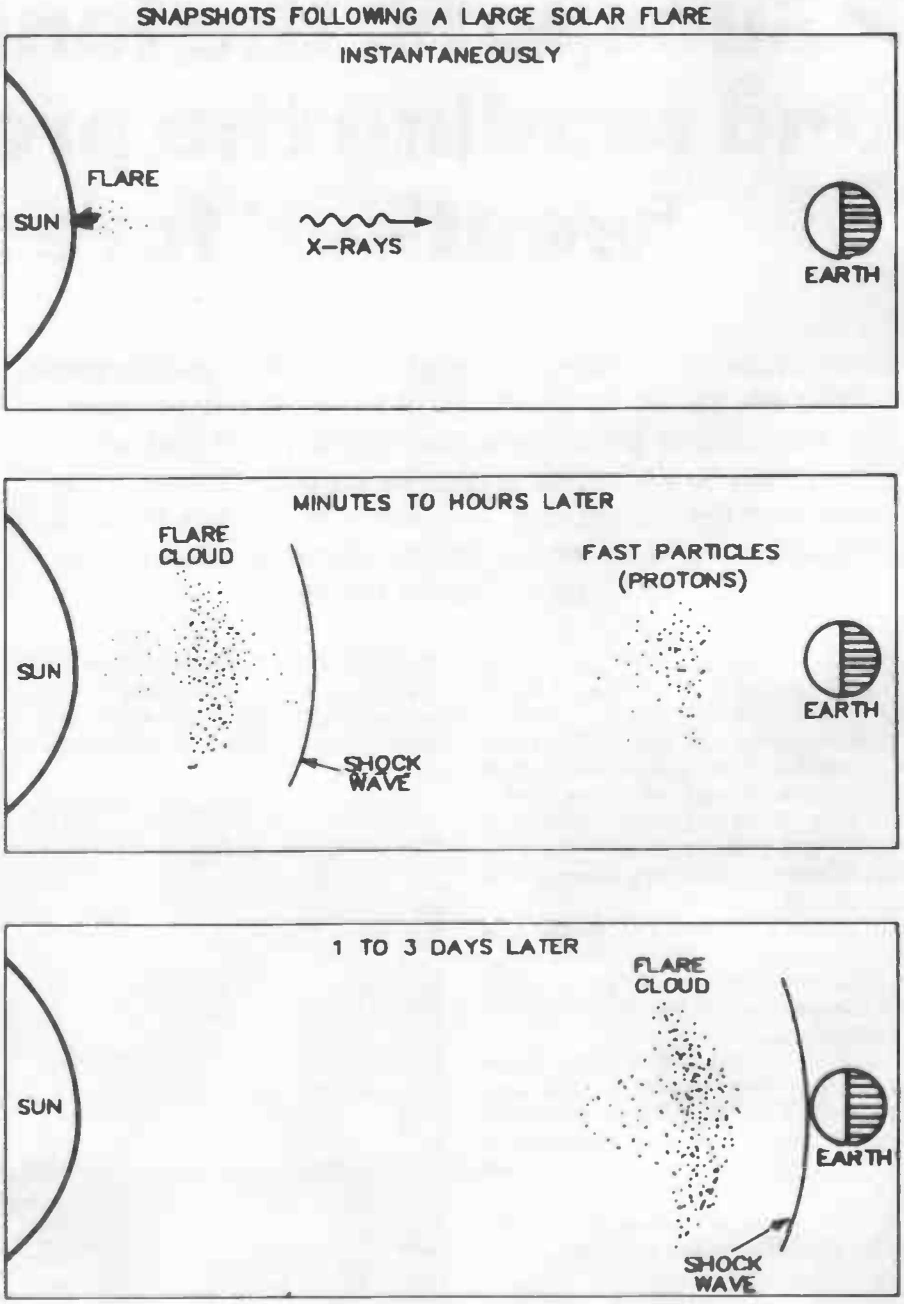


Figure 2. 'Snapshots' of the three events which follow a large solar flare. First, X-rays are emitted which travel in straight lines and take around eight minutes to hit the earth. Second, fast protons are emitted which reach the earth after a delay of only minutes to hours. Lastly, the flare cloud follows. This is plasma – a cloud of positive and negative ions. It follows days later, preceded by a shock wave where the cloud meets the quiet solar wind.

The surge of a solar flare, seen here erupting from near a spot group. (Photograph courtesy of Big Bear Solar Observatory, USA.)

used to chart the progress of solar cycles such as the one we're going through right now.

No doubt you've noticed the solar cycles are numbered, the current one being number 22. The numbering is arbitrary, but it helps to identify the individual cycles since the time regular scientific records have been kept. The current solar cycle began in September 1986 when the yearly smoothed sunspot number reached a minimum value of 12.4. Since then, the yearly sunspot number has risen rapidly, in fact faster than the previous 21 cycles observed.

In December 1987, the yearly-smoothed sunspot number was 51.4. The December 1988 value was over 130. By July 1989 it reached 158. In eighteen months we shot from solar minimum to within 20 per cent of the solar maximum.

What goes on?

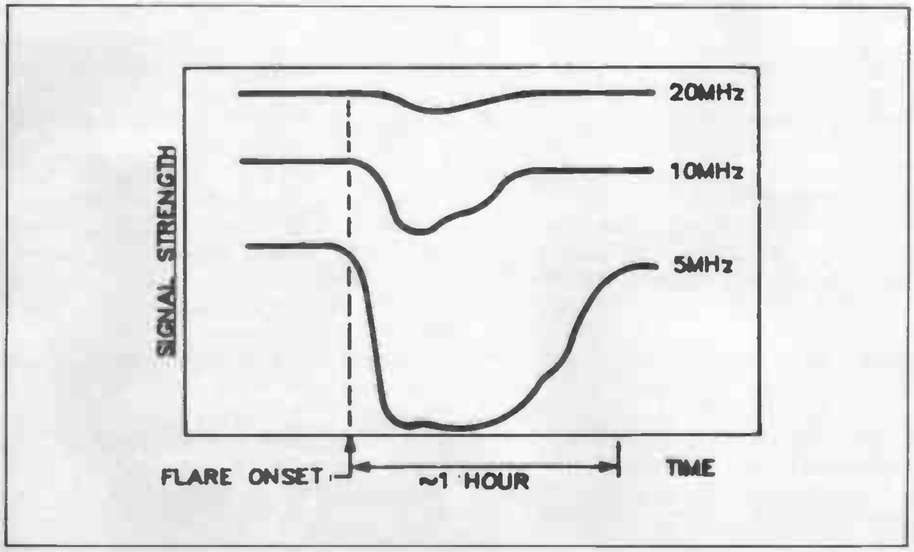
The peak of a solar cycle brings with it a number of events that affect matters on earth, bringing both benefits and problems. Ultraviolet radiation from the sun ionises the upper layers of the atmosphere, from around 60-100km upwards, creating that complex, electrified layer known as the ionosphere. As you know, HF radio propagation is dependent on the state of the ionosphere at any one time.

The higher levels of ultraviolet radiation from the sun during the peak of a cycle produces greater ionisation of the ionosphere. This brings higher maximum usable frequencies and a wider spectrum of the high frequency (HF) bands propagated via it.

There are two important events more common during large solar cycles: energetic solar flares, and large geomagnetic disturbances.

Solar flares are an enormous 'explosion' on the sun, caused by a sudden release of magnetic energy. Magnetic fields thread the surface features on the sun, and are constantly in motion. These fields can get contorted, literally knotted, in places that it takes less energy to blow out the ionised material entrapped by the twisted field lines and settle back to a non-contorted state than it does to stay contorted.

This cycle has been very 'active' in terms of the number of flares observed. The effects on the ionosphere and HF communications has been quite dramatic. There are several sources



The graph shows the progress of the fadeout and how it affects different frequencies. Note how the lower frequencies are affected most. The X-rays cause a sudden, large increase in ionisation in the ionosphere's D-layer on the side facing the sun, which increases absorption of the signals.

which provide information on the effects of solar activity on propagation etc, including short-term forecasts, which can be very useful (this will be discussed later). But back to the sun.

The sun is regularly photographed, from observatories around the world, through a telescope fitted with a special filter that only selects light emitted by hydrogen called H-alpha emission. This has a wavelength of 65.63 millionths of a metre (or 6563 Angstroms). At this wavelength, what we see is the higher layers in the sun's 'atmosphere'. It's called the

Figure 1. This is a view of the sun, in H-alpha light, taken by the solar observatory located at Culgoora in north-western NSW on March 7, 1989. A large prominence on the east limb is arrowed. This region comprised an intense group of 75 to 100 sunspots from which a massive flare erupted two or three days later. The 'latitude' and 'longitude' lines have been added to the photograph. (Photograph courtesy of IPS Radio and Space Services.)

Time. *Times quoted are invariably in Universal Time (UT) which is the same as what you might know as Zulu (Z-time) or GMT (Greenwich Mean Time).*

Solar activity. *This is a measure of the number of solar flares and their strength. Solar activity is classified as being:*
(1) Low (the usual, no problems expected),
(2) Moderate (disturbances likely), or
(3) High (fadeouts, and magnetic field disruption very likely).

Ottowa 10.7cm Flux. This is a measure of the radio output of the sun at 2800MHz, a wavelength of 10.7cm. This value is often a better indicator of solar activity than the sunspot number.

SUNSPOT NUMBER	10cm FLUX
0	67
20	78
40	93
60	110
100	147
150	195
200	243

The values are measured by the Ottowa Radio Observatory. Unlike the sunspot number, the 10cm flux never drops to zero during solar minimum. With no sunspots visible on the solar disc, the 10cm flux will still have a value of around 67.

Critical frequency. The highest radio frequency that can be reflected vertically from an ionospheric layer. Higher critical frequencies usually mean higher maximum usable frequencies for radio propagation.

Ionospheric disturbances refer to measurements made at Sydney, but are generally applicable to mid-latitude southern hemisphere conditions.

Flare. Flares, as explained in the article, are likely to produce 'shortwave fadeouts' in HF radio propagation, and may be associated with disturbances to the earth's magnetic field.

Flares are classified in terms of X-ray production and also by apparent optical brightness. X-ray flare classification is on the following scales:

M (1 to 9), and
X (1 upward)

as these are the ones most likely to produce effects on the ionosphere.

M-class flares, particularly the less energetic ones, are likely to cause a fadeout on only the lowest frequencies. X-class flares are stronger, and produce more noticeable effects than M-class flares. They can cause fadeouts that affect the entire HF spectrum.

It should be noted that a fadeout will only occur on those circuits having a reflection point in the daylight hemisphere of the earth. Circuits having reflection points only in the night hemisphere will not be affected, no matter what the energy of the solar flare or flares happens to be.

Optical classification includes an area measurement (sub, 1, 2, 3) and a brightness indication (faint, normal, bright: F, N, B, respectively). Large bright flares are more energetic, although optical brightness and the effect on the earth are not directly linked.

chromosphere, because we're looking at a single wavelength, or colour.

The chromosphere shows an extensive range of very detailed structures. If you get the chance to view the image through a telescope at a solar observatory, do so. These various structures are called plages, prominences, sunspots, filaments and fibrils (see Figure 1). This is a view of the Sun, in H-alpha light, taken by the solar observatory located at Culgoora in NSW on March 7, 1989.

Sunspots do not show up well in H-alpha light as they are lower in the sun's atmosphere, often being hidden by overlying chromosphere. Those sunspots that do show up are usually the larger ones.

Plages, from the French for beach, are large, irregular bright areas often (but not always) associated with sunspots. Plages emit copious amounts of extreme ultraviolet (very short wavelength) radiation and thus play a role in the formation of the ionosphere and its variations. Regions containing plages and sunspots are known as 'active regions' as they are continually changing.

HF-FIELD STRENGTH ESTIMATED BY MINIFTZ4.1

CIRCUIT : CANBERRA - HONSHU
LOCATION: 35.5S 149.2E 36.0N 138.0E
AZIMUTH : 350.5 DEG. 170.4 DEG.
DISTANCE: 8035 KM
MIN-ANG.: 3.0 DEG.

MONTH : MAR. 90
SSN : 175
POWER : 0.400 KW
TX-GAIN: 2.2 DB

FIELD STRENGTH IN DB ABOVE 1 UV/M FOR 50 PERCENT OF TIME

UTC	MUF	DBU	FOT	3.0	4.0	5.0	6.0	8.0	10.0	12.0	15.0	18.0	22.0	26.0
1	33.6	-8	27.8	...	...	...	...	...	...	...	-37	-21	-11	-7
2	33.8	-8	25.6	...	...	...	...	...	...	...	-39	-23	-12	-7
3	34.0	-8	28.4	...	...	...	...	...	...	...	-39	-23	-11	-7
4	33.8	-8	28.0	...	...	...	...	...	...	...	-37	-21	-11	-6
5	33.6	-7	27.5	...	...	...	...	...	...	...	-33	-18	-9	-5
6	32.9	-6	26.7	...	...	...	...	...	...	...	-26	-14	-6	-4
7	31.5	-5	25.3	...	...	...	...	...	...	-35	-16	-7	-2	-2
8	29.9	-3	25.2	...	...	...	...	...	-21	-9	1	4	5	2
9	28.2	-1	22.4	...	...	...	-31	-8	3	8	11	11	8	3
10	26.3	0	20.9	...	...	-26	-12	3	10	12	13	11	7	0
11	24.6	0	19.5	...	-26	-9	0	10	14	15	14	11	5	-3
12	23.7	0	18.7	-31	-9	2	9	15	17	17	15	11	4	-5
13	22.8	1	18.1	4	13	17	20	21	21	20	16	11	3	-7
14	21.7	1	17.3	4	13	17	19	21	20	19	15	9	0	-11
15	20.4	1	16.0	3	12	17	19	20	19	17	13	6	-4	-16
16	19.2	1	15.0	3	12	17	19	20	19	16	11	4	-8	-22
17	17.9	0	13.9	3	12	16	18	19	17	14	8	0	-13	-29
18	16.5	0	12.7	3	12	16	18	18	16	12	5	-5	-21	-40
19	16.8	0	12.9	3	12	16	18	18	16	13	6	-4	-19	-37
20	17.8	0	13.6	3	12	16	18	19	17	14	8	-1	-14	-31
21	21.4	-9	16.3	...	...	...	...	...	-28	-15	-7	-6	-9	-17
22	29.5	-8	22.8	...	...	...	...	...	...	-37	-18	-9	-5	-5
23	32.3	-7	25.8	...	...	...	...	...	...	...	-27	-14	-7	-4
24	32.9	-8	26.8	...	...	...	...	...	...	...	-33	-19	-9	-6

MUF (FTZMUF2) FOR 34.7 S 138.6 E

JUNE SSN=175 50% GYRO=1.1 MHZ

UTC	FOF2 MHZ	M3000	MUF4000 MHZ
1	10.5	3.0	34.3
2	11.1	3.0	36.3
3	11.5	3.0	37.4
4	11.5	2.9	37.1
5	11.3	2.9	36.3
6	10.8	2.9	34.5
7	9.9	2.9	31.6
8	8.8	2.9	28.1
9	7.5	2.9	23.5
10	6.1	2.8	19.0
11	5.0	2.8	15.0
12	4.1	2.7	12.1
13	3.5	2.6	10.2
14	3.3	2.6	9.5
15	3.5	2.5	9.8
16	3.6	2.6	10.3
17	3.8	2.6	10.8
18	3.4	2.6	9.9
19	3.1	2.7	9.1
20	2.9	2.8	9.0
21	3.8	2.8	12.0
22	5.5	2.9	17.7
23	7.7	2.9	25.0
24	9.4	3.0	30.7

MODES AND ELEVATION ANGLES ESTIMATED BY MINIFTZ4.1

CIRCUIT : CANBERRA - HONSHU
LOCATION: 35.5S 149.2E 36.0N 138.0E
AZIMUTH : 350.5 DEG. 170.4 DEG.
DISTANCE: 8035 KM
MIN-ANG.: 3.0 DEG.

MONTH : MAR. 90
SSN : 175
POWER : 0.400 KW
TX-GAIN: 2.2 DB

MODES AND ELEVATION ANGLES

UTC	MUF	MODE	FOT	3.0	4.0	5.0	6.0	8.0	10.0	12.0	15.0	18.0	22.0	26.0
1	33.6	3F11	27.8	....	....	....	....	....	....	....	3F11	3F11	3F11	3F11
2	33.8	3F11	25.6	....	....	....	....	....	....	....	3F11	3F11	3F11	3F11
3	34.0	3F11	28.4	....	....	....	....	....	....	....	3F11	3F11	3F11	3F11
4	33.8	3F11	28.0	....	....	....	....	....	....	....	3F11	3F11	3F11	3F11
5	33.6	3F11	27.5	....	....	....	....	....	....	....	3F11	3F11	3F11	3F11
6	32.9	3F11	26.7	....	....	....	....	....	....	....	3F11	3F11	3F11	3F11
7	31.5	3F11	25.3	....	....	....	....	....	....	3F11	3F11	3F11	3F11	3F11
8	29.9	3F11	25.2	....	....	....	....	....	3F11	3F11	3F11	3F11	3F11	3F11
9	28.2	3F11	22.4	....	....	....	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11
10	26.3	3F11	20.9	....	....	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11
11	24.6	3F11	19.5	....	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11
12	23.7	3F11	18.7	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11	3F11
13	22.8	3F10	18.1	3F10	3F10	3F10	3F10	3F10	3F10	3F10	3F10	3F10	3F10	3F10
14	21.7	3F10	17.3	3F10	3F10	3F10	3F10	3F10	3F10	3F10	3F10	3F10	3F10	3F10
15	20.4	3F09	16.0	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09
16	19.2	3F09	15.0	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	....
17	17.9	3F09	13.9	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	....
18	16.5	3F09	12.7	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	3F09	....
19	16.8	3F08	12.9	3F08	3F08	3F08	3F08	3F08	3F08	3F08	3F08	3F08	3F08	....
20	17.8	3F08	13.6	3F08	3F08	3F08	3F08	3F08	3F08	3F08	3F08	3F08	3F08	....
21	21.4	3F08	16.3	....	....	....	....	....	3F08	3F08	3F08	3F08	3F08	3F08
22	29.5	3F09	22.8	....	....	....	....	....	....	3F09	3F09	3F09	3F09	3F09
23	32.3	3F09	25.8	....	....	....	....	....	....	....	3F09	3F09	3F09	3F09
24	32.9	3F10	26.8	....	....	....	....	....	....	....	3F10	3F10	3F10	3F10

Prominences and filaments are the same thing seen from different perspectives. A prominence is a large cloud of relatively cool gas which is suspended above the sun's surface by magnetic fields which prevent its collapse back into the surface. When such a cloud is seen on the edge (or limb) of the sun, against the dark background of space, it appears quite bright and is called a prominence. When seen against the face of the sun it appears relatively dark as it is cooler than the chromosphere it is viewed against and is known as a filament.

Filaments and prominences can be up to 300 million kilometres in length and can reach heights of 100,000 kilometres above the sun's photosphere. They can be very stable, lasting for months, moving across the face of the sun as it rotates from 'east' to 'west' (left to right in Figure 1), disappearing over the west limb and reappearing over the east limb 13 or 14 days later. Note that the sun has an average rotation period of 27 days; it rotates faster at the equator and slower towards the poles.

A filament may suddenly erupt in a flare and send a cloud of solar particles out into space. If this cloud strikes earth it causes changes to the magnetic field and the ionosphere, affecting HF communications.

Particles are 'captured' by earth's magnetic field and spiral down the field lines to plunge into the ionosphere in an oval-shaped arc or a complete oval on the night side of our planet, surrounding the north and south magnetic poles. Colliding with the thin atmosphere, these particles cause such intense ionisation that the gases fluoresce, that is, they emit light – the 'northern and southern lights'. The more intense and energetic the shower of particles, the greater the effect in the magnetic field and the greater the expansion of the auroral oval in length and breadth.

The 'background' chromosphere between the various features just mentioned shows a great deal of fine detail called the *fibril structure* because of its fibrous appearance. Near and around active regions this is often ordered into large swirling patterns by the associated magnetic fields.

Flares range considerably in size, a big one occupying as much as one-thousandth of the sun's disc, and can last for several hours. They can occur alone or be grouped closely together in time originating from a single active region.

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HF-FIELD STRENGTH ESTIMATED BY MINIFTZ4.1

CIRCUIT : CANBERRA      - ADELAIDE                MONTH   :    SEP. 90
LOCATION: 35.5S 149.2E   34.7S 138.6E             SSN     :        160
AZIMUTH : 272.2 DEG.       98.3 DEG.              POWER   :   0.100 KW
DISTANCE:   968 KM                                TX-GAIN:      2.2 DB
MIN-ANG.:  10.0 DEG.

      FIELD STRENGTH IN DB ABOVE 1 UV/M FOR 90 PERCENT OF TIME
```

UTC	MUF	DBU	FOT	1.8	3.6	7.1	10.1	14.1
1	15.9	10	13.3	...	...	2	14	13
2	15.6	10	13.3	...	...	1	13	12
3	15.5	10	13.2	...	...	1	13	12
4	15.3	10	12.9	...	...	3	13	12
5	15.1	10	12.4	...	...	5	14	12
6	14.6	11	11.9	...	-38	8	16	12
7	13.8	12	11.1	...	-22	14	18	11
8	13.0	15	11.1	-23	11	24	22	10
9	11.7	16	9.4	-10	16	25	21	5
10	10.8	16	8.6	-3	18	25	18	1
11	9.8	17	7.8	3	21	24	14	-4
12	8.9	17	7.2	4	21	23	9	-8
13	8.4	17	6.7	4	21	21	6	-9
14	8.0	17	6.4	4	21	20	4	-10
15	7.5	16	6.0	4	21	18	2	-11
16	7.3	16	5.7	4	21	17	0	-11
17	6.8	16	5.4	5	21	14	-4	-12
18	6.5	16	5.1	5	21	10	-6	-13
19	7.1	16	5.5	4	21	16	-2	-12
20	8.8	17	7.0	4	21	22	8	-8
21	11.2	14	8.7	...	1	20	17	2
22	13.4	12	10.6	...	-25	12	17	9
23	15.0	11	12.0	...	-40	8	16	13
24	15.6	11	12.8	...	...	4	14	13

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MODES AND ELEVATION ANGLES ESTIMATED BY MINIFTZ4.1

CIRCUIT : CANBERRA      - ADELAIDE                MONTH   :    SEP. 90
LOCATION: 35.5S 149.2E   34.7S 138.6E             SSN     :        160
AZIMUTH : 272.2 DEG.       98.3 DEG.              POWER   :   0.100 KW
DISTANCE:   968 KM                                TX-GAIN:      2.2 DB
MIN-ANG.:  10.0 DEG.

                    MODES AND ELEVATION ANGLES
```

UTC	MUF	MODE	FOT	1.8	3.6	7.1	10.1	14.1
1	15.9	1F34	13.3	....	....	1E11	1E11	1F34
2	15.6	1F35	13.3	....	....	1E11	1E11	1F35
3	15.5	1F35	13.2	....	....	1E11	1E11	1F35
4	15.3	1F35	12.9	....	....	1E11	1E11	1F35
5	15.1	1F34	12.4	....	....	1E11	1E11	1F34
6	14.6	1F34	11.9	....	1E11	1E11	1E11	1F34
7	13.8	1F34	11.1	....	1E11	1E11	1F34	1F34
8	13.0	1F34	11.1	1E11	1E11	1F34	1F34	1F34
9	11.7	1F34	9.4	1F34	1F34	1F34	1F34	1F34
10	10.8	1F35	8.6	1F35	1F35	1F35	1F35	....
11	9.8	1F35	7.8	1F35	1F35	1F35	1F35	....
12	8.9	1F36	7.2	1F36	1F36	1F36	1F36	....
13	8.4	1F36	6.7	1F36	1F36	1F36	1F36	....
14	8.0	1F36	6.4	1F36	1F36	1F36	1F36	....
15	7.5	1F36	6.0	1F36	1F36	1F36	....	....
16	7.3	1F36	5.7	1F36	1F36	1F36	....	....
17	6.8	1F36	5.4	1F36	1F36	1F36	....	....
18	6.5	1F36	5.1	1F36	1F36	1F36	....	....
19	7.1	1F35	5.5	1F35	1F35	1F35	....	....
20	8.8	1F34	7.0	1F34	1F34	1F34	1F34	....
21	11.2	1F34	8.7	....	1E11	1F34	1F34	1F34
22	13.4	1F34	10.6	....	1E11	1E11	1F34	1F34
23	15.0	1F34	12.0	....	1E11	1E11	1E11	1F34
24	15.6	1F34	12.8	....	....	1E11	1E11	1F34

HF-FIELD STRENGTH ESTIMATED BY MINIFTZ4.1

CIRCUIT : NORTH QLD - STHN JAPAN
LOCATION: 20.0S 149.0E 34.0N 134.0E
AZIMUTH : 345.0 DEG. 162.9 DEG.
DISTANCE: 6211 KM
MIN-ANG.: 3.0 DEG.

MONTH : MAR. 90
SSN : 180
POWER : 0.400 KW
TX-GAIN: 9.0 DB

FIELD STRENGTH IN DB ABOVE 1 UV/M FOR 50 PERCENT OF TIME

UTC	MUF	DBU	FOT	14.2	18.1	21.2	24.9	28.5
1	36.5	4	29.7	-23	-4	3	7	8
2	35.1	3	29.0	-25	-6	1	5	6
3	34.4	3	28.9	-25	-6	1	5	6
4	34.1	3	28.4	-24	-5	2	5	6
5	34.1	3	28.1	-20	-3	4	7	7
6	34.4	4	28.2	-13	1	7	9	8
7	33.9	6	27.6	-4	7	11	11	10
8	33.3	8	26.8	11	16	17	16	13
9	32.1	9	25.6	22	23	22	18	14
10	31.3	10	25.0	25	25	22	19	14
11	30.8	10	24.5	27	26	23	19	14
12	31.3	11	24.9	29	27	24	20	15
13	33.0	11	26.2	32	29	27	22	18
14	34.5	11	27.3	32	30	28	24	20
15	32.6	11	25.7	32	29	26	22	17
16	30.4	11	23.8	31	28	24	20	14
17	27.6	11	21.5	30	26	22	16	9
18	23.9	11	18.6	27	22	16	9	0
19	22.2	10	17.2	25	19	12	3	-7
20	20.1	9	15.4	22	14	6	-5	-18
21	23.7	4	18.1	10	10	8	2	-6
22	32.6	4	25.2	-4	7	10	10	8
23	38.4	6	30.4	-12	3	9	12	12
24	38.0	5	30.7	-19	-1	5	9	10

HF-FIELD STRENGTH ESTIMATED BY MINIFTZ4.1

CIRCUIT : NORTH QLD - STHN JAPAN
LOCATION: 20.0S 149.0E 34.0N 134.0E
AZIMUTH : 345.0 DEG. 162.9 DEG.
DISTANCE: 6211 KM
MIN-ANG.: 3.0 DEG.

MONTH : MAR. 90
SSN : 180
POWER : 0.400 KW
TX-GAIN: 9.0 DB

FIELD STRENGTH IN DB ABOVE 1 UV/M FOR 10 PERCENT OF TIME

UTC	MUF	DBU	FOT	14.2	18.1	21.2	24.9	28.5
1	36.5	11	29.7	-18	1	8	12	13
2	35.1	10	29.0	-20	-1	6	10	11
3	34.4	10	28.9	-20	-1	6	10	11
4	34.1	10	28.4	-19	0	7	10	11
5	34.1	10	28.1	-15	2	9	12	12
6	34.4	11	28.2	-8	6	12	14	14
7	33.9	13	27.6	1	12	16	16	16
8	33.3	15	26.8	16	21	22	21	19
9	32.1	16	25.6	27	28	27	23	20
10	31.3	17	25.0	30	30	27	24	20
11	30.8	17	24.5	32	31	28	24	20
12	31.3	18	24.9	34	32	29	25	21
13	33.0	18	26.2	37	34	32	27	23
14	34.5	18	27.3	37	35	33	29	25
15	32.6	18	25.7	37	34	31	27	23
16	30.4	18	23.8	36	33	29	25	21
17	27.6	18	21.5	35	31	27	22	17
18	23.9	18	18.6	32	27	22	17	12
19	22.2	17	17.2	30	24	19	14	6
20	20.1	16	15.4	27	20	15	8	-6
21	23.7	11	18.1	15	15	14	10	7
22	32.6	11	25.2	1	12	15	15	14
23	38.4	13	30.4	-7	8	14	17	17
24	38.0	12	30.7	-14	4	10	14	15

An active region comprised of 75 to 100 sunspots came round the east limb of the sun on March 6, 1989 (see Figure 1). A massive flare appeared on the 9th, followed by another on the 10th, the first one being the strongest *ever* recorded. On the 10th, the region was facing earth directly; it ejected particles that reached here on the 13th and 14th, giving rise to a severe magnetic storm and creating enormous auroral activity seen as far north as the Tropic of Capricorn in Australia and as far south as Texas in the US.

Flares and HF

Flares have three major effects on high frequency communications, each brought about by different things emitted or ejected from the flare site: X-rays, protons and a plasma cloud.

X-rays travel in straight lines and move at the speed of light, reaching earth in just over eight minutes.

Protons emitted by a flare can travel at tremendous speeds and can reach earth in as short a time as 10 minutes. These are followed by a more slowly moving plasma cloud (or flare cloud), which is preceded by a shock front where the cloud hits the quiet solar wind. The flare cloud reaches earth any time from a few days to a week after being ejected from the flare. The sequence of events is illustrated in Figure 2.

Providing a flare has sufficient energy, some of the X-rays emitted will hit the earth's atmosphere and increase ionisation. That might sound like what you want to improve HF propagation, but it increases ionisation in the D-layer of the ionosphere at 50-90km, which increases the absorption of radio waves passing through it. The result is a considerable loss in signal strength for a period.

It affects the lower frequencies most, and can be so severe as to cause complete absorption. This is known as a *shortwave fadeout* or SWF. It can last as long as the flare causing it, that is, up to an hour or so. A small flare will only have a small effect, however, the effect of a large flare will be felt across the whole shortwave spectrum, with a general lowering in signal strengths.

As X-rays travel in straight lines, a shortwave fadeout will only be felt on that side of the earth facing the sun. For this reason, the effect is also known as a *daylight fadeout*. A shortwave fadeout is felt the most during the middle of the day and where signals from a distant transmitter travel through low (that is, equatorial) latitudes. Figure 3 tells the story.

Very energetic flares also eject a stream of protons which are the core particles from hydrogen atoms, the sun's 'fuel'. This stream of protons can hit earth if they are ejected in the right direction, and can travel at velocities up to 80 per cent of the speed of light. To reach earth, they can take 10 minutes to a few days, depending on the size and site of the flare. On their way here, they may cause severe damage to unshielded satellites or astronauts.

When the protons arrive in our vicinity they encounter the earth's magnetic field and, being a charged particle (positive), they cannot travel across a field line, so they swing around it. As the field lines are horizontal near the equator and vertical near the poles, the protons don't reach the equatorial ionosphere, but readily penetrate the ionosphere at the magnetic poles.

Once they penetrate into the D-layer, they cause a massive increase in ionisation and hence a massive increase in absorption of radio signals passing through the polar regions. The effect is known as a 'polar cap absorption event' (PCA) or a polar blackout.

A PCA can last for several days to a week, depending on the size of the flare and will usually completely destroy HF communications within, and to, the polar regions, and on any communications circuits which pass through there. Fortunately PCAs are rare, occurring about half a dozen times or so a year, but they are more frequent

Magnetic activity. Magnetic activity (of the earth's magnetic field) is classified as either: quiet, unsettled, active, minor storm, or major storm.

Activity in the earth's magnetic field can have a considerable effect on HF radio propagation, as explained in the article, and is also important in planning geomagnetic surveys.

Geomagnetic K indices. The K indices are a measure of disturbance to the earth's magnetic field. Values are determined for three-hourly intervals. Typical figures are 0 to 1 (quiet), to 5 and above (major storm).

HF-FIELD STRENGTH ESTIMATED BY MINIFTZ4.1

CIRCUIT : CANBERRA	- W.GERMANY	MONTH :	SEP. 90
LOCATION: 35.5S 149.0E	54.0N 7.0E	SSN :	160
AZIMUTH : 317.1 DEG.	70.5 DEG.	POWER :	0.400 KW
DISTANCE: 16443 KM		TX-GAIN:	2.2 DB
MIN-ANG.: 5.0 DEG.			

FIELD STRENGTH IN DB ABOVE 1 UV/M FOR 50 PERCENT OF TIME

UTC	MUF	DBU	FOT	3.6	7.1	10.1	14.2	18.1	21.2	24.9	28.5
1	12.5	-40	9.3	...	...	...	-32	-25	-26	-33	...
2	12.5	...	9.5	...	...	...	-35	-25	-26	-31	-40
3	13.1	...	10.0	...	...	...	-40	-28	-26	-30	-38
4	15.3	-39	11.1	...	...	...	...	-29	-25	-26	-31
5	18.4	-32	14.2	...	...	...	...	-33	-26	-24	-26
6	21.3	-26	16.4	...	...	...	...	-36	-27	-22	-22
7	23.4	-22	18.0	...	...	...	...	-36	-26	-21	-20
8	24.1	-19	18.6	...	...	...	...	-32	-23	-18	-18
9	25.0	-14	19.3	...	...	...	...	-25	-18	-14	-15
10	25.0	-11	19.2	...	...	...	-32	-17	-12	-11	-13
11	23.3	-9	18.5	...	...	...	-20	-10	-8	-10	-14
12	21.4	-7	16.9	...	...	-34	-12	-6	-7	-11	-18
13	19.9	-5	15.8	...	...	-18	-4	-3	-6	-13	-22
14	18.7	-3	14.8	...	-31	-8	0	-2	-7	-16	-26
15	17.6	-1	13.9	...	-11	2	4	-2	-9	-19	-32
16	16.4	1	12.9	-36	3	9	6	-3	-12	-25	-40
17	15.7	2	12.2	-18	9	11	6	-4	-14	-29	...
18	14.5	3	11.2	-5	12	12	4	-8	-20	-37	...
19	13.4	4	10.3	-1	13	11	1	-13	-27	...	...
20	14.4	4	11.0	-1	14	12	4	-8	-20	-37	...
21	15.6	2	11.3	-17	9	11	5	-5	-15	-30	...
22	14.4	-8	10.8	...	-36	-13	-8	-13	-22	-35	...
23	14.0	-20	10.2	...	...	-37	-19	-19	-24	-35	...
24	13.3	-30	9.8	...	...	...	-27	-23	-26	-34	...

MODES AND ELEVATION ANGLES ESTIMATED BY MINIFTZ4.1

CIRCUIT : CANBERRA	- W.GERMANY	MONTH :	SEP. 90
LOCATION: 35.5S 149.0E	54.0N 7.0E	SSN :	160
AZIMUTH : 317.1 DEG.	70.5 DEG.	POWER :	0.400 KW
DISTANCE: 16443 KM		TX-GAIN:	2.2 DB
MIN-ANG.: 5.0 DEG.			

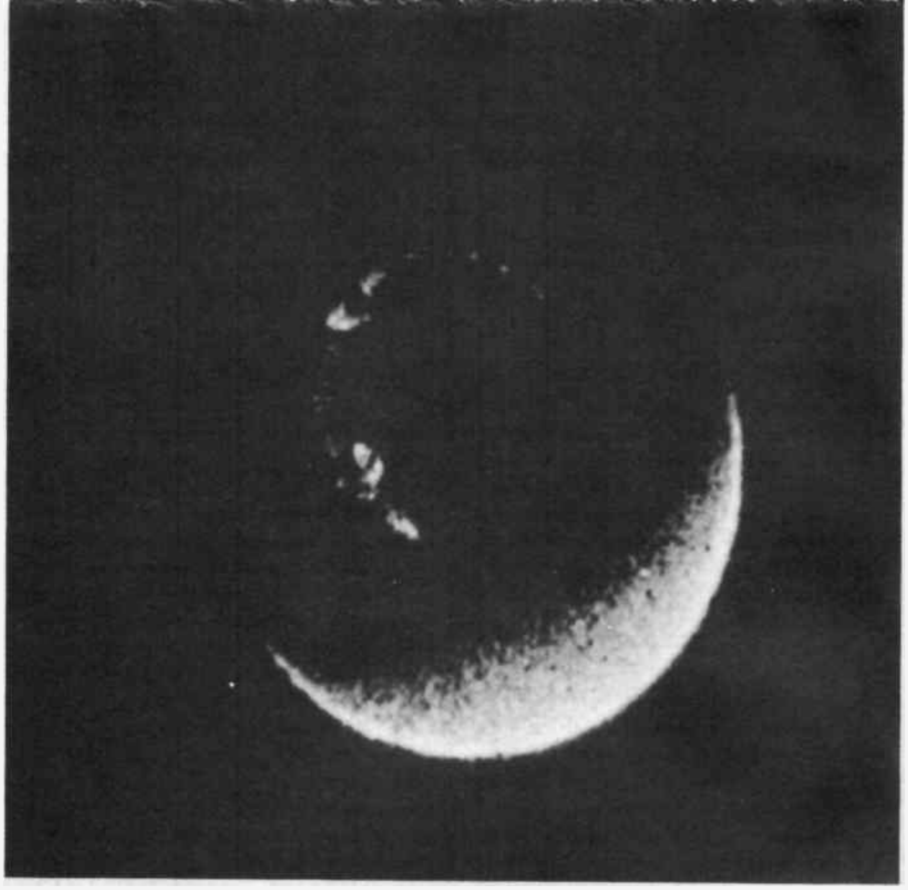
MODES AND ELEVATION ANGLES

UTC	MUF	MODE	FOT	3.6	7.1	10.1	14.2	18.1	21.2	24.9	28.5
1	12.5	6F09	9.3	....	....	....	6F09	....	....	....	....
2	12.5	....	9.5	....	....	....	6F09	....	....	....	....
3	13.1	....	10.0	....	....	....	6F09	....	....	....	....
4	15.3	6F09	11.1	....	....	....	....	6F09	6F09	....	....
5	18.4	6F09	14.2	....	....	....	....	6F09	6F09	....	....
6	21.3	6F09	16.4	....	....	....	....	6F09	6F09	6F09	6F09
7	23.4	6F09	18.0	....	....	....	....	6F09	6F09	6F09	6F09
8	24.1	6F09	18.6	....	....	....	....	6F09	6F09	6F09	6F09
9	25.0	6F09	19.3	....	....	....	....	6F09	6F09	6F09	6F09
10	25.0	6F09	19.2	....	....	....	6F09	6F09	6F09	6F09	6F09
11	23.3	6F09	18.5	....	....	....	6F09	6F09	6F09	6F09	6F09
12	21.4	6F09	16.9	....	....	6F09	6F09	6F09	6F09	6F09	....
13	19.9	6F09	15.8	....	....	6F09	6F09	6F09	6F09	6F09	....
14	18.7	6F09	14.8	....	6F09	6F09	6F09	6F09	6F09	....	....
15	17.6	6F09	13.9	....	6F09	6F09	6F09	6F09	6F09	....	....
16	16.4	6F09	12.9	6F09	6F09	6F09	6F09	6F09	6F09	....	....
17	15.7	6F09	12.2	6F09	6F09	6F09	6F09	6F09	....	....	....
18	14.5	6F09	11.2	6F09	6F09	6F09	6F09	6F09	....	....	....
19	13.4	6F09	10.3	6F09	6F09	6F09	6F09	....	....	....	....
20	14.4	6F09	11.0	6F09	6F09	6F09	6F09	6F09	....	....	....
21	15.6	6F08	11.3	6F08	6F08	6F08	6F08	6F08	6F08	....	....
22	14.4	6F08	10.8	....	6F08	6F08	6F08	6F08	....	....	....
23	14.0	6F08	10.2	....	....	6F08	6F08	6F08	....	....	....
24	13.3	6F09	9.8	....	....	....	6F09	6F09	....	....	....

around the peak of a sunspot cycle, which means now. Figure 4 illustrates what happens.

The third effect from a large flare is a plasma cloud, a mixture of positive and negative ions. A plasma cloud travels slower than protons emitted from a flare, and for the plasma cloud to reach earth, the flare must be in the right location on the sun (generally on the side facing earth).

When a plasma cloud hits the earth, a number of complex interactions takes place. It changes the electric field in which the ionosphere is embedded and alters the chemistry and large-scale motion of the ionosphere's F-region (which lies between 200 and 600km above the ground). These complex interactions generally bring wide-scale disturbances, particularly to the radio frequencies which the ionosphere supports. The overall effect is called an *ionospheric storm.*



Active aurora, as seen from space. Energetic solar particles plunge into the atmosphere in an arc around the north and south magnetic poles. Colliding with the thin atmosphere, these particles cause such intense ionisation that the gases fluoresce, that is, they emit light – the 'northern and southern lights', or aurorae borealis and aurorae australis. (Picture courtesy of Dr L. A. Frank, USA.)

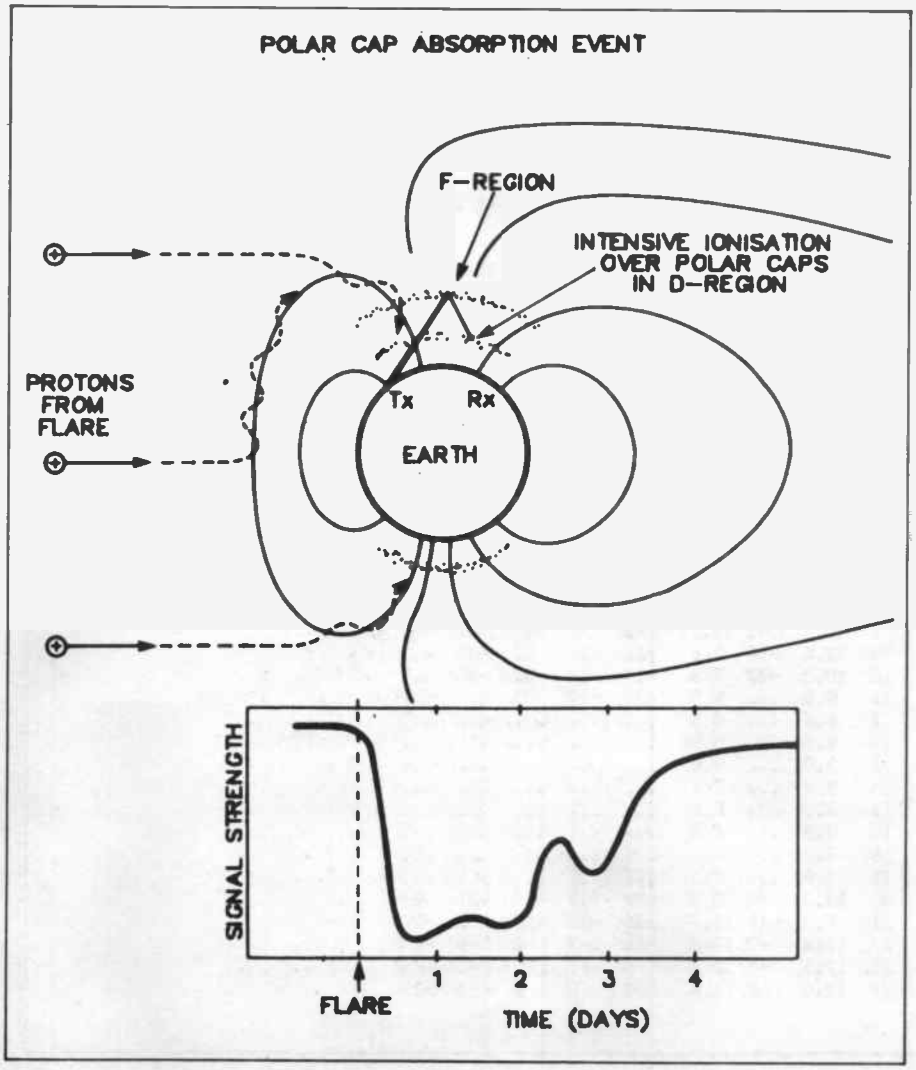


Figure 4. A solar flare will shoot out high energy protons. When they reach the vicinity of the earth, they are 'captured' by the earth's magnetic field and spiral down the field lines to penetrate the lower regions of the atmosphere over the magnetic poles. This increases ionisation in the ionosphere's D-layer causing massive absorption of signals which pass through the region, as shown in the graph. This causes a polar cap absorption event, or PCA. Signals may be non-existent or very weak, with some slight recovery during hours of darkness. The diameter of the path of the spiralling protons may be in the order of 100km!

Radio 'conditions' during an ionospheric storm may improve for a period, but they will also deteriorate. In other words, change is to be expected, hence the analogy with the weather we experience on the ground. Figure 5 illustrates the effects on the ionosphere experienced during a large ionospheric storm.

Solar prominences, or filaments when seen face-on to the sun, are often seen to disappear within a few hours after being observed for weeks. It seems that all or part of the matter contained in the filament is blown out into space in a fashion similar to solar flares.

These *sudden disappearing filaments*, (SDFs) can affect the earth's magnetic field, the ionosphere and HF communications, although the effects are much less than what is experienced from solar flares.

When the earth's magnetic field is affected by particles ejected by solar flares and SDFs, we experience what is called a *geomagnetic storm*. The shock front that precedes the cloud of ionised particles compresses the earth's magnetic field on the side facing the sun and causes a 'sudden commencement'. The earth's magnetic field increases slightly initially (called the 'initial phase') which is followed by a large decrease, called the 'main phase'.

The initial phase of a geomagnetic storm may last some hours, while the main phase will persist for up to 3-4 days. Geomagnetic storms caused by other solar features commence gradually and are generally shorter-lived. During a geomagnetic storm, the magnetic field doesn't change all that much, usually less than 1 per cent of the undisturbed value.

Continuous recordings of the earth's magnetic field are made at various locations around the world from which an index of magnetic activity is derived for intervals of three hours. This is called the *K index*.

The K indices from all over the world are assembled and collated at Fredericksberg in the US, which calculates an index of overall planetary magnetic activity for each day, known as the *A index*.

Magnetic disturbances occur more often in the equinoctial months of March-April and September-October because the earth's magnetic field is more nearly at right angles to the direction of flow of the solar wind and more susceptible to disturbances. A small flare that occurs during an

HF-FIELD STRENGTH ESTIMATED BY MINIFTZ4.1

CIRCUIT : CANBERRA - BRITAIN MONTH : JUNE 90
LOCATION: 35.5S 149.2E 52.0N 0.0E SSN : 165
AZIMUTH : 316.7 DEG. 65.1 DEG. POWER : 0.400 KW
DISTANCE: 16973 KM TX-GAIN: 9.0 DB
MIN-ANG.: 5.0 DEG.

FIELD STRENGTH IN DB ABOVE 1 UV/M FOR 50 PERCENT OF TIME

UTC	MUF	DBU	FOT	14.2	18.1	21.2	24.9	28.5
1	15.4	-28	11.3	-35	-19	-15	-16	-20
2	14.8	-36	10.9	-40	-22	-17	-17	-21
3	15.0	-38	11.1	...	-24	-18	-17	-20
4	15.1	-40	11.3	...	-26	-19	-17	-19
5	16.0	-38	12.0	...	-27	-20	-17	-18
6	17.1	-33	12.9	...	-29	-20	-16	-17
7	17.4	-31	13.2	...	-28	-19	-16	-16
8	17.8	-26	13.5	...	-25	-17	-14	-16
9	17.6	-23	13.4	...	-21	-15	-13	-16
10	17.8	-18	13.5	-31	-17	-14	-15	-20
11	15.4	-19	11.6	-23	-15	-15	-21	-30
12	13.0	-22	9.7	-18	-16	-20	-30	...
13	11.2	-23	8.4	-16	-19	-27	...	...
14	10.3	-21	7.7	-14	-22	-33	...	...
15	10.3	-15	7.7	-13	-23	-37	...	...
16	10.5	-10	7.9	-11	-23	-38	...	...
17	10.7	-2	8.1	-8	-23	-40	...	...
18	9.7	0	7.4	-12	-32	...	...	...
19	8.6	3	6.6	-19	...	...	...	...
20	8.4	6	6.5	-20	...	...	...	...
21	11.8	10	9.2	1	-17	-34	...	...
22	17.2	7	12.5	10	5	-1	-12	-24
23	16.6	-7	12.0	-12	-5	-6	-10	-18
24	15.9	-19	11.6	-26	-14	-12	-14	-20

HF-FIELD STRENGTH ESTIMATED BY MINIFTZ4.1

CIRCUIT : CANBERRA - BRITAIN MONTH : JUNE 90
LOCATION: 35.5S 149.2E 52.0N 0.0E SSN : 165
AZIMUTH : 136.7 DEG. 245.1 DEG. POWER : 0.400 KW
DISTANCE: 23058 KM TX-GAIN: 9.0 DB
MIN-ANG.: 5.0 DEG.

FIELD STRENGTH IN DB ABOVE 1 UV/M FOR 50 PERCENT OF TIME

UTC	MUF	DBU	FOT	14.2	18.1	21.2	24.9	28.5
1	16.4	1	11.7	0	1	-3	-10	-19
2	15.8	2	11.0	2	1	-4	-12	-22
3	15.2	4	10.7	4	1	-4	-14	-25
4	14.6	7	10.3	7	2	-5	-16	-29
5	14.8	11	10.5	12	5	-3	-15	-29
6	15.0	9	10.7	10	4	-3	-14	-27
7	15.9	7	11.0	8	4	-1	-11	-22
8	15.5	-3	12.1	-2	-5	-11	-22	-35
9	12.4	-14	9.6	-12	-14	-22	-35	...
10	10.3	-30	7.9	-17	-19	-27	-40	...
11	9.0	...	6.9	-26	-27	-35	...	...
12	8.6	...	6.6	...	...	...	...	...
13	8.8	...	6.9	...	...	...	...	...
14	9.0	...	6.9	...	...	...	...	...
15	9.2	...	7.1	...	...	...	...	...
16	8.5	...	6.6	...	...	...	...	...
17	7.9	...	6.2	...	...	...	...	...
18	7.7	...	6.1	...	...	...	...	...
19	9.6	...	7.3	...	...	...	...	...
20	13.3	-34	10.6	-29	-19	-18	-21	-29
21	18.0	-17	12.7	-30	-16	-13	-15	-20
22	17.8	-7	12.6	-16	-7	-6	-9	-14
23	17.5	-1	12.2	-5	-1	-3	-7	-15
24	17.0	0	11.9	-2	0	-2	-8	-16

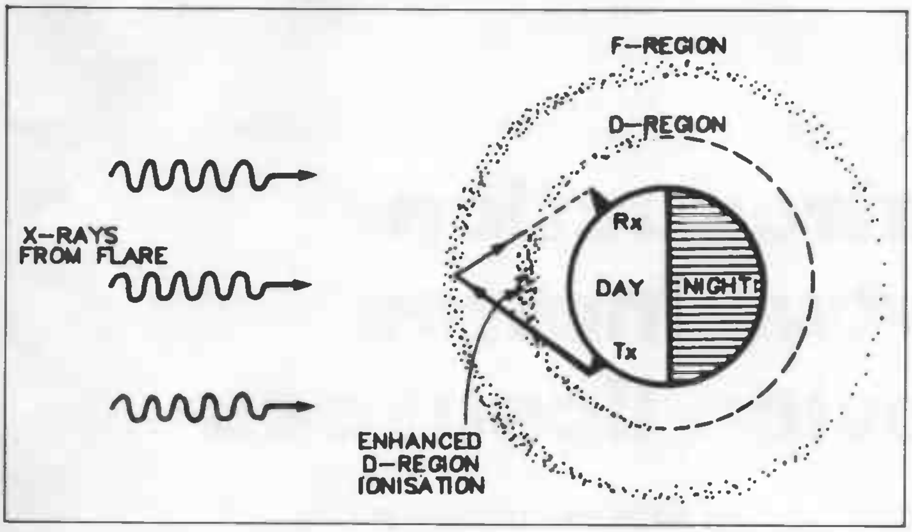


Figure 3. This diagram shows how X-rays from a flare affect HF signals, causing a shortwave fadeout on signals travelling via the dayside ionosphere.

equinox may cause a larger disturbance than a larger flare that occurs during a solstice (June and December).

Reading the 'weather' reports

From Figure 2 you can see, that monitoring the sun at solar observatories, it is possible to predict or forecast when solar flares etc, will affect the earth's ionosphere and magnetic field and what those effects might be. This is, naturally, of interest to anyone involved in HF communications, professional or enthusiast alike. Such forecasts or ionospheric and geomagnetic 'weather' are provided by various scientific agencies around the world.

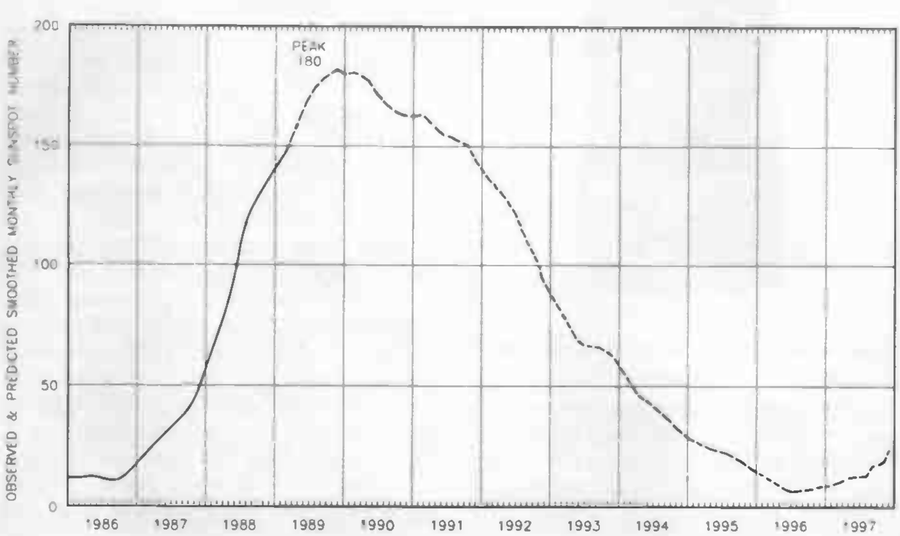
Flares occur more often around the peak of a solar cycle, thus the current interest. There were only two significant flares observed in December 1987, but there were 25 in January 1990. The Australian IPS Radio & Space Services has a daily recorded solar and geophysical report available which you can hear by calling (02) 414 8300. This report can provide useful information to the radio enthusiast who's keen on making the best of prevailing conditions.

In addition, weekly summaries of activity and short-term forecasts from IPS are read out on the VK2WI Sunday broadcasts from the NSW Division of the Wireless Institute of Australia. These broadcasts can be heard at 1045 and 1915 EAST on a variety of HF, VHF and UHF amateur bands. Further details are available from them at PO Box 1066, Parramatta NSW 2150.

Another source is Radio Australia, which broadcasts a 'Daily Propagation Report' in a sir 'ar format to IPS's. This is transmitted ut a set time each day. Check the Radio Australia schedules issued from time to time, which you can get through the ABC in each state capital.

The reports from these services all provide the data summarised in the panel here. With a little experience and frequent checking of the ionospheric and propagation 'weather reports', you'll soon get the feel of what goes on and what to expect in the week ahead, as well as what happened in the days or week gone by.

Thanks to IPS Radio & Space Services for supplying material and photographs used in the compilation of this article.



Fredericksberg A index. The Fredericksberg A index is calculated from the three-hourly K index values and represents an overall magnetic activity index for a particular day. Fredericksberg is a mid-latitude observatory located in the US, and this A index value is used as a worldwide standard. The values reported are generally applicable to mid-latitude areas.

Large values for the A index correspond to disturbed conditions. Levels of magnetic disturbance are described in the following table:

A INDEX VALUE	DESCRIPTION
0 up to 7	quiet
8 up to 15	unsettled
16 up to 24	active
25 up to 35	minor storm
36 and above	major storm

Ionospheric index. The ionospheric I index is a measure of the average level of the ionospheric critical frequencies available on a particular day. The higher the value of the I Index, the higher the values of the critical frequencies, and thus the maximum usable frequencies on HF, for that day.

The I Index quoted in the IPS reports is based on data from Australian ionospheric stations and so is most applicable to HF circuits with reflection points in the Australian region.

Introduction to two metres for Novice licensees

The two metre amateur band was popular among amateurs before Novice licensees were granted use of 146-148MHz on June 1, 1988. It's another world from the Novice HF bands, and here's a guided tour for 'novices' to the world of two metres.

BY GENTLEMENS' agreement, the 'top half' of two metres, 146-148MHz, is set aside for narrowband FM operation. And that covers a multitude of activities! The FM mode is quite unlike SSB for voice operation, and the propagation characteristics of two metres quite unlike the HF bands. For a start, the FM mode provides 'readable 5' signals almost all the time. Once your receiver has 'acquired' a signal, it actually *suppresses* noise. Except for the weakest signals, voice is received with the utmost clarity. Hence, you'll often hear a half-salutory, half-derogatory reference to two metres FM as 'the two metre telephone'.

FM is the perfect mode for mobile operation, and that's the reason two metre FM activity grew rapidly through the '70s and '80s. 'Surplus' commercial service FM transceivers were sold in great numbers at low cost in the early years. Then affordable Japanese-made multi-channel two metre FM transceivers made their debut. At the same time, repeaters were developed and installed at sites high above surrounding terrain, to give mobile stations a 'boost'. Apart from its popularity for mobile use, many amateurs have two metre FM facilities at home, and in recent years, with the advent of ever-greater miniaturisation, handheld transceivers have become popular.

Repeaters were established with 'free access', that is, anyone who had a transceiver to operate on a repeater's input and output frequencies could use them. But repeaters in different areas employed different standards. So, if you could use a repeater in NSW, you would not be able to use one in Victoria. Eventually, common standards for channel frequencies and repeaters were adopted, falling into line with standards adopted virtually throughout the world.

Handheld rigs can make an economical first rig. This is the standard model C150, sold through Emtronics stores. It features 5W output and a 20-channel memory facility.

With the standards question settled, clubs and other groups established a network of repeaters across the country, and not just the most populous areas, either. The growth of this repeater network fuelled the growth of two metre FM activity.

Two metres FM is popular for 'local chat' activities, whether that be keeping in touch with friends and acquaintances, with work colleagues, or whatever. Amateurs travelling interstate or intrastate often pop up on a local repeater. Overseas amateurs visiting here often do the same, using handheld transceivers which are convenient to transport. For relieving the boredom of long car trips, the repeater network on two metres comes in very handy; especially when you might need directions, there's nothing like tapping-in to local knowledge from a local. And for emergency communications, two metres is a popular choice for the advantages and resources it offers.

But local chat doesn't preclude a little DX, in terms of VHF, not in the way it's meant on HF. Two metre FM users often work stations hundreds of kilometres away when prevailing atmospheric or ionospheric conditions are right, generally during the summer months. On occasions, stations on Australia's eastern seaboard manage to work into

New Zealand. Stations in Melbourne and Victorian coastal regions often work into Tasmania. All this with rigs running just a few watts and comparatively modest antennas.

Operation on two metres FM is 'channelised'; that is, on fixed frequencies at set intervals. VFOs, as used on HF rigs, have no place here. For a start, fixed channels make mobile operation much easier, and VFO facility and precision is an unnecessary complication. VFOs would make life difficult on two metres in other ways, as you shall see shortly. Early two metre transceivers used a pair of crystals for each transmit and receive frequency. The advancement of solid state technology brought digital synthesisers, which all modern two metre rigs are based on.

There are two methods of having a contact on two metres FM, known as *simplex* and *duplex*. Simplex means you transmit and receive on the same frequency, or channel, just as you do on most contacts on the HF bands. Duplex, or split frequency operation, means you transmit on one frequency and receive on another, which is much the same principle used by rare DX stations on HF when they work 'split', transmitting on one frequency and listening 'up 20kHz' or 'down 20kHz'. Duplex operation is essential for repeater operation.

To manage what goes on between 146MHz and 148MHz, a 'band plan' was worked out among amateurs in Australia, and settled on by gentlemens' agreement. That is, it has no force in law or regulation, but operators generally agree to abide by the plan. It's to everyone's advantage because everybody knows the channels and their usage are the same throughout the land. Figure 1 details the two metre FM band plan in its entirety.

The channels are known by the last four digits of their frequency. This is a very convenient mnemonic, as it allows swift setting of synthesised transceivers. So, if someone says, 'see you on repeater 7000', you simply dial up 147.000MHz. Or if they say 'I'll call you on 6500', then you know they mean 146.500MHz, the calling channel. Note from Figure 2 that the agreed-on channels are spaced at 25kHz intervals.

Note, also, that a number of channels are reserved for 'special' activities; e.g, the RTTY channel on 146.600MHz and the ATV liaison channel on 147.425MHz. And that brings us to the subject of *repeaters*.

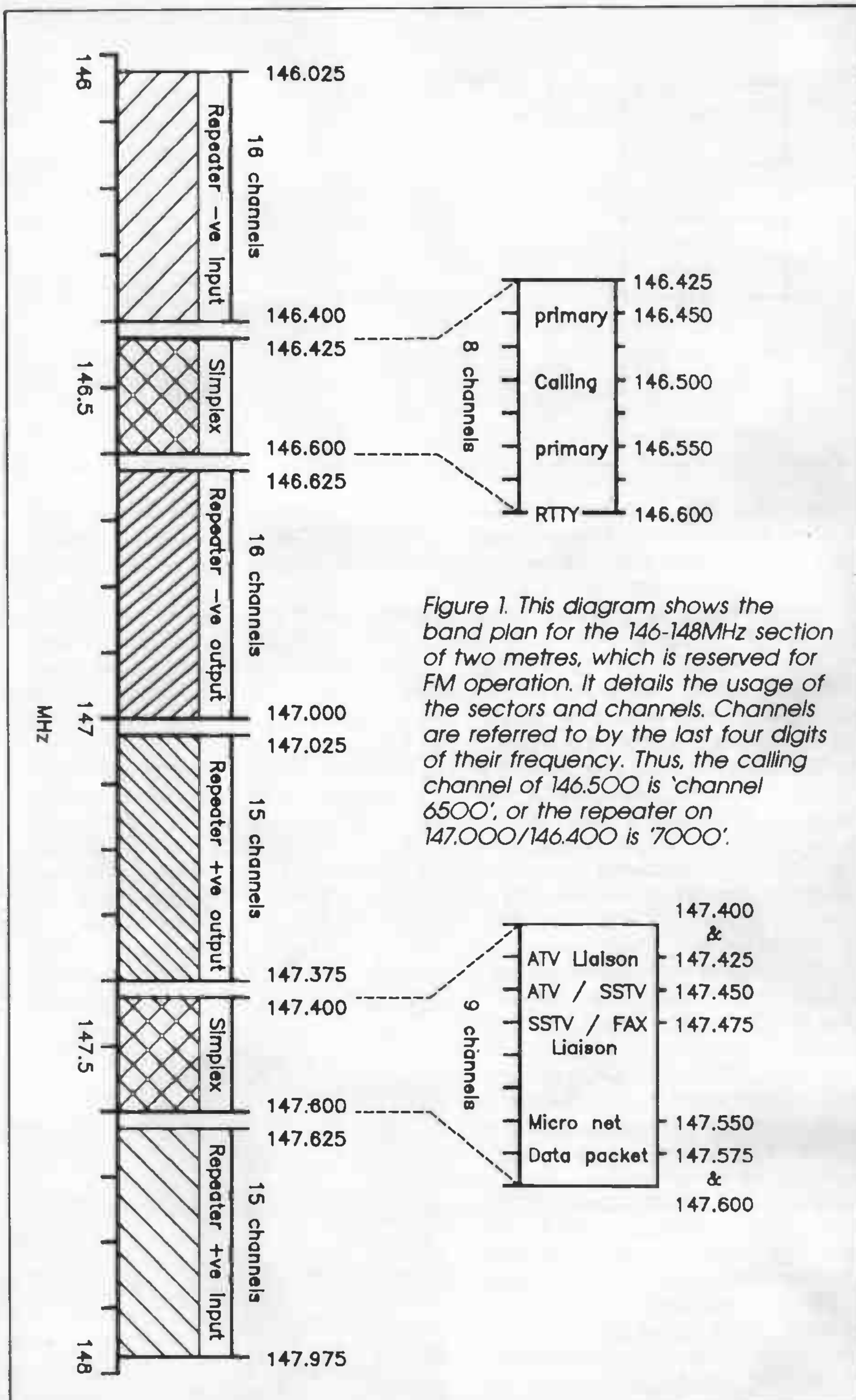


Figure 1. This diagram shows the band plan for the 146-148MHz section of two metres, which is reserved for FM operation. It details the usage of the sectors and channels. Channels are referred to by the last four digits of their frequency. Thus, the calling channel of 146.500 is 'channel 6500', or the repeater on 147.000/146.400 is '7000'.

Repeaters and you

We have the great good fortune in Australia that the amateur radio repeater network on two metres developed in an atmosphere of adventure and open sharing. Repeaters have been assembled, established, operated and maintained by amateur radio clubs and special interest groups and by state Divisions of the Wireless Institute of Australia. They are all 'open access', and if you have the licence and the gear, you can use any repeater you come within range of. But this free access, by its very nature, puts an onus on the operator to follow procedures that gives everyone a 'fair suck of the sauce bottle'. The accompanying panel summarises the conventions and courtesies applicable to the repeater operation.

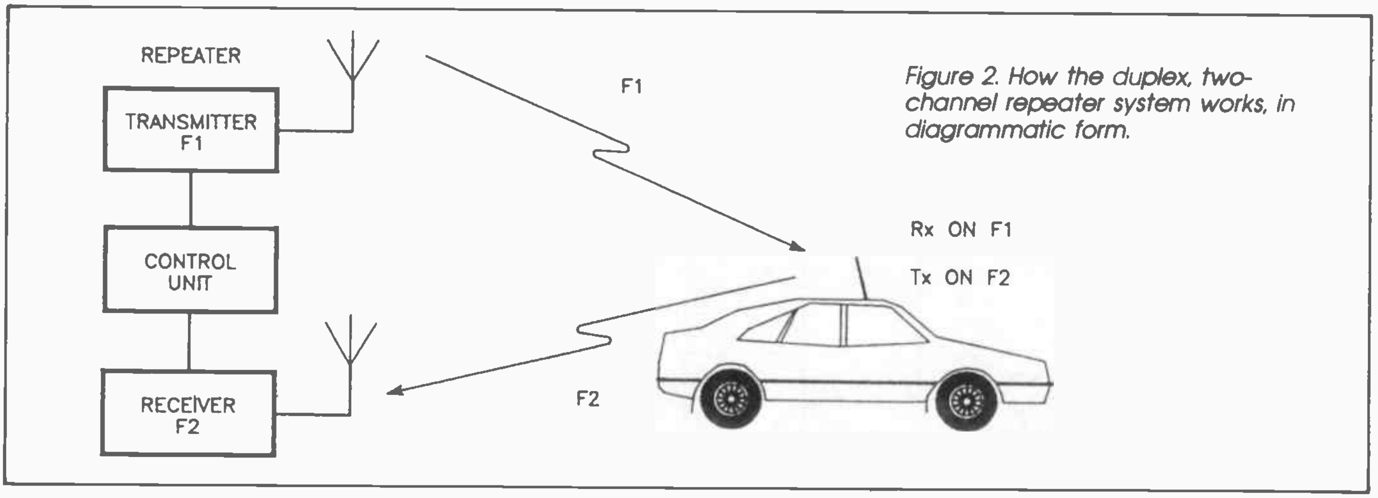


Figure 2. How the duplex, two-channel repeater system works, in diagrammatic form.

Having dealt with that, let us get on with a few technicalities. As I mentioned earlier, repeaters are there to provide a boost for mobile stations, to extend their communications range because mobiles can't carry large antennas and they travel through widely varying terrain which would otherwise preclude direct contact with other stations.

Repeaters are generally established at favourable sites, atop prominent hills or ridges, or even the roofs of city skyscrapers. The object is to obtain the best height above the average local terrain. Around Melbourne, repeaters are located atop Mount Dandenong to the east; in Sydney, at Dural in the north and Razorback to the south, for example. Altitude improves coverage because communications on two metres is more typically line-of-sight, as all the good textbooks say, than the HF bands, like eighty metres. Ground wave communications extends more or less to your immediate horizon. The higher you are, the further away is your communications horizon.

Repeaters, in the main, don't run high power outputs; typically, 20 to 50 watts. High altitude locations and efficient antenna systems having a little gain provide the desired coverage to give users good signal strengths and audio quality within their 'service area'. Gain antenna systems on repeaters not only increase the effective radiated power, but improve reception sensitivity, too.

A repeater 'listens' on one channel – the input – and transmits on another – the output. The system is illustrated in Figure 2. To use a repeater, you have to *transmit on its input* and *receive on its output*. The difference in frequency between the repeater's input and output channels is called the *offset*. Two metre repeaters use an offset of 600kHz.

Repeaters having an output in the segment 147MHz down to 146.625MHz, have a negative offset. That is, their input is 600kHz lower in frequency. Those with their outputs in the segment 147.025 up to 147.375MHz, have a positive offset – their inputs are 600kHz higher in frequency. Many modern transceivers feature a repeater offset switch or control marked something like '+/– 600', 'duplex +/–' or simply '+/–'.

To use a repeater on channel 7000, for example, simply set your transceiver to that channel's frequency (147.000MHz) and select duplex operation and negative offset. When you're listening, the receiver is on 147.000MHz. When you press the transmit button, your signal goes out on 146.400MHz. The repeater, conversely, is receiving on 146.400 and retransmitting your signal on 147.000MHz. Got it?

When you release the push-to-talk button, you will hear the 'tail' of the repeater transmission, because the repeater controls allow the transmitter to 'hang on' for half a second or so after your signal disappears from the input channel. This prevents erratic operation when a signal on the input is weak and may be rapidly fading or 'chopping' above and below the repeater receiver's threshold.

The general effect of this tail hang-on facility is that you hear a quiet second or so followed by a 'klunk' whenever you release the transmit button at the end of an over.

All repeaters are fitted with a *time-out* so that they cannot be accidentally or deliberately 'locked up' in transmit

Kenwood's TM-221A two metre mobile rig features 14 multi-function memory channels, extended receiver frequency coverage and pre-programmed automatic repeater offset.

mode if a signal persists on the input for longer than a predetermined period. Time-out periods vary between repeaters, generally ranging from three minutes to as short as one minute.

For this reason, it is good practise during a contact to pause between overs to let the repeater 'drop out'. That is, let the tail complete at the end of an over and allow a second or two before you press the push-to-talk button to reply. This is also good manners, as it allows others to join in or perhaps make a quick call to another station and arrange to use another channel for themselves.

Operating simplex on a repeater input channel is very bad manners, if not downright selfish. This annoys repeater users and you won't hear responses to you made on the repeater. Make sure you don't do it by mistake – use the allocated simplex channels. They're *rarely* all occupied simultaneously at any one time.

Calling CQ on a repeater is unnecessary. On HF, a CQ call establishes your use of that frequency and gives stations tuning around a chance to find you. On a two metre repeater, anyone within range who is listening will hear you instantly and at Q5! Listen briefly first to establish the repeater's clear. Press the transmit button and just announce your callsign followed by 'listening', or 'looking for a contact'. If you don't get an immediate reply, by all means repeat the call after five or ten seconds, but *never* make a prolonged CQ call on a repeater.

If you're unfamiliar with two metre FM operation and procedures. Spend a little time to see how 'old hands' make contacts. (But see that you don't pick up their bad habits!) Often, contacts proceed by means of quick, to-and-fro exchanges and callsigns are only announced every so often, usually just often enough to enable casual listeners to see who's on the channel and to satisfy regulatory requirements.

If you establish contact with a station on a repeater, who may be within simplex range, then vacate the repeater and use a simplex channel for direct contact. This particularly applies if you're operating from home.

It's a fact of life that two metres FM, and particularly the repeaters, attract antisocial individuals who gain some perverse satisfaction out of making various noises, unwanted and unidentified remarks and the like. The most effective way of dealing with them is to *ignore them*. If they won't go away, you can. Switch off, go to another channel. But don't give them the satisfaction of replying to them or even acknowledging their existence. Remember, for every operator talking, there are probably ten or a dozen listening ... and judging the behaviour of the participants.

If you are looking for a listing of repeaters in your area, or for the whole country, the WIA's *Australian Amateur Radio Callbook* contains a comprehensive listing which is also updated in the January issue of their magazine *Amateur Radio* each year. Contact your state Division of the WIA.

The IC-228, from Icom, features a multi-colour liquid crystal display, 20 memories and a facility that allows you to monitor the input of a repeater at the push of a button.

Getting on the air

To get amongst it on two metres, you have the 'usual' options: build, buy or borrow a rig. If you're reasonably skilled at assembling electronic things, and have the motivation, building your own rig can give a lot of satisfaction. For the builder, your best resource is Stewart Electronic Components in Melbourne, (03) 543 3733. The borrow option is a good way to 'get your feet wet', if temporary. But you need a willing lender, and they don't grow on trees. Most proceed with the buy option.

To buy a rig, you've got the choice of scanning the classifieds in the amateur magazines, or buying a rig new. Buying second-hand means the rig doesn't come with a warranty unless it comes from a dealer who offers a written warranty. If you get a working demonstration before making the purchase, then you can be satisfied the rig performs as it should, and meets your expectations or requirements. As you'll have to maintain the rig yourself, get all the manuals available – even circuits, if you can – it's good insurance. By scanning the classifieds, you get a good idea of prevailing prices on second-hand rigs of the type you want.

Buying a new rig is like buying any new equipment – fridge, hi-fi ... or transceiver. Do your homework, collect brochures and browse through the stores. Check out the rigs on-show at field days, conventions and exhibitions.

As a fully-featured rig can be a bit of an investment, many newcomers to two metres opt to buy a handheld rig because they cost the least. And there's a lot of sense in that. They are generally simpler to operate and some models can be mounted in a vehicle for mobile operation with an accessory microphone. Power outputs of handheld rigs range from around 1W, up to 5W. Many have dual power level capability, selected by means of a switch, providing a 'low' power of a few hundred milliwatts. Handheld rigs offer the most in terms of convenience and portability.

Portable rigs are available, too. These are virtually 'stripped down' mobiles, with a battery pack that snaps on the rear, carried by means of a shoulder strap. A whip antenna plugs into a front panel mounted antenna socket. While the power output of typical portables is much the same as their handheld cousins, they offer more features and functions.

Mobile two metre rigs come in a

A dual-band rig is a good investment for when you upgrade, and an incentive to do so! The Yaesu FT-4700RH, sold through Dick Smith Electronics, is a 2m/70cm rig which is literally almost two rigs in the one box – each section only shares audio and control electronics. A 'combo' rig such as this is cheaper than two rigs to do the same job and has some operational advantages.

variety of styles, boasting various features and facilities. These days, they all have dual power capability, putting out 5W on low power and from 25- to 50W on high power. So keep that switch on 'low'!

With digital technology all-pervading, many rigs offer a channel memory capability and scanning facilities. While these can be useful, they're not essential.

So much for generalities, let's take a look at some specifics. First, handhelds. The Yaesu FT23R from Dick Smith Electronics is a good example. It covers the complete band and has 10 memories which you can program for commonly used channels in your area. It has a six-digit LCD display, and boasts up to 5W output when using a 12V internal battery (NiCad). It measures 60 × 150 × 30mm (width × height × depth).

Contrast the Yaesu with the standard model C150, a 'supercompact' hand-held rig. It measures 55 × 124 × 31mm and boasts 20 memories plus 5W output using a 12V/600mAh battery pack. You get a choice of four battery packs. It, too, has a six-digit LCD display.

Icom claim to make the smallest handheld two metre transceiver in the world, the 'micro' 2A. However, Icom's IC-2SA is probably more representative. It sizes up at 49 × 103.5 × 33mm, 20mm longer with a bigger (more mAh capacity) battery pack. It boasts 48 memory channels and 5W output.

The mobiles on offer have a variety of features and functions. Take a look at the Kenwood TM-221A, sold by Emtronics stores around Australia – it's a good example of a value-priced two metre mobile rig. It provides 5W output on low power, and 45W for when you upgrade your licence. It won't strain your vehicle's electricals, and you should easily find a place to put it because it measures a compact 140 × 40 × 179mm. You can suspend it from the underside of your plastic dash, too, because it only weighs 1.2kg.

But what about its features you may ask? The TM-221A will receive across the range from 138- to 173.995MHz; and you can take it in steps of 5, 10, 15, 20 or 25kHz. The transmitter covers only the actual amateur band: 144- to 148MHz. This rig, like many others, has a microprocessor controller, pre-programmed for automatic simplex or duplex operation with 600kHz offset, up or down as required by the band plan.

There are 14 memory channels to store frequency, repeater offset, and other information. Memories A and B establish the upper and lower limits for programmable band scan. Memories C and D store, transmit and receive frequencies independently for operating repeaters having standard and odd offsets. The memories allow you to set up a host of functions, apart from the Tx/Rx frequencies.

You have scanning, too. Using memories A and B, the upper and lower limits of a band of frequencies to be scanned may be set, to maximumise efficiency in band scanning. When the frequency in memory A equals that in B, the receiver scans the whole band.

The amber liquid crystal display is specially designed to give high visibility in direct sunlight or, when backlit, in the dark. It displays frequency, memory channel, scan, repeater offset, REV, CTCSS, TONE, signal strength (S) and RF (output) meter, CALL, ON AIR and BUSY. The TM-221A is constructed on a rugged diecast chassis.

The Icom IC-228 covers the whole two metre band in 5, 10, 12 and 20kHz steps, transmit and receive. It features a multi-colour LCD boasting high daylight visibility, with backlighting for viewing in the dark. Orange, red and green colour patches highlight areas on the display, numbers and letters are shown in black.

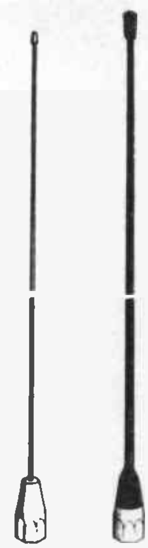
The IC-228 comes with 20 memory channels which are able to store multiple functions, so put all your popular repeater channels in there. It has programmable frequency and memory scanning facilities, too. And you can check a repeater's input frequency channel at the press of a button. It measures 140 × 50 × 159mm and weighs 1.1kg, thus there's no strain on the dashboard if you suspend it there.

Then there are dual-band rigs, providing 2m/70cm FM operation. These are an investment for when you upgrade your licence. The Yaesu FT-4700RH is a case in point. Dual power is offered on each band – 5W and 50W on two metres, 5W and 45W on 70cm. It has dual independent front ends, independent local synthesisers and IFs in the receivers and independent transmitter RF stages – two independent transceivers in the one box, they just share the audio and control blocks!

The FT-4700RH has 10 memory channels for each band, capable of storing multiple functions in eight. You can listen for calls on either band while working on the other. Naturally, it has the latest tuning and frequency/memory scanning features. You can select tuning steps of 5, 10, 12.5, 20 and 25kHz.

The 'business' end of the rig can be mounted in your vehicle's boot, or under a seat, while the detachable control panel is mounted in a convenient position on the dash. High contrast amber LCDs are the order of the day with two metre mobiles, and this rig doesn't buck the trend. It gives simultaneous displays for each band, including selected operating functions, repeater offset, signal strength and power output. All together, it measures 150 × 50 × 180mm and weighs 2kg.

Well, so much for rigs. But you won't be able to make any contacts without an antenna and feedline.



◀ *Typical quarter wave whips for two metres. At left is a stainless steel type, at right a tapered fibreglass type. This has copper braid stretched over it to form the radiator, protected by heatshrink tubing. The bottom ferrule is drilled and tapped 5/16 inch, 26tpi to mate with a standard antenna mount.*

A 5/8-wave whip, like this, is taller than the quarter wave whip and provides a little gain. They are generally constructed on a tapered fibreglass whip using copper braid as the radiator, with a 'matching' coil at the bottom. ▶

Whips and sticks

Vertically polarised antennas are the erstwhile 'standard' on two metres FM, because verticals are most easily installed on vehicles for mobile operation. Hence, repeaters and home station operators use vertical polarisation, too.

For the flat- or unit-bound licensee, mobile operation on two metres provides the means by which you can indulge your hobby without the hassles of running the gauntlet with the landlord or body corporate necessary to erect an antenna on the roof, or wherever. Even with the restriction of 10W power maximum, with most novices running 5W (because that's what the rigs provide), you can have plenty of fun on two metres using the repeaters.

Success in mobile operation is largely dependent on the antenna installation, so it's worth paying attention to getting it right. As with rigs, your options are: build, buy or borrow an antenna. Because mobile whips are cheap, most operators elect to buy. Later, I'll give you some tips on making something simple.

By far the most popular mobile antennas in use are the 1/4-wave and 5/8-wave whips. The former are around 480mm high, while the latter are a bit over 1200mm. Take into account above-roof clearance when considering the installation of a 5/8-wave whip, and make arrangements so that the aerial bends, folds, unclips or does something self-effacing if it is likely to collide with your garage door lintel, service station overhangs, low tree branches etc.

Your first problem will be to decide where to put the antenna on your vehicle. Drill a hole in the roof, so as to get the antenna central and as high as you can. Or don't go drilling holes, but accept a less efficient mount. The choice is yours – influenced by a host of things: like the car's age (and perhaps resale value), objections to its appearance (could anyone possibly object? Huh!), if you have a soft-top (just a wee problem), etc. At least you don't have to worry about great lengths of feeder lines with attendant losses.

One way out of the drill/don't-drill-the-vehicle dilemma is to buy a roof rack and mount the antenna on it. Incidentally, one of the advantages of two metres is that you don't have to go to all sorts of compromises and contortions squeezing a forty or eight metre quarter wavelength antenna into a short aerial, with resulting radiation losses. You get full efficiency from your two metre band whip.

Irrespective of how you mount your antenna, you should also pay attention to routing of the coax feedline. If you employ a mount that attaches to the vehicle body rather than a hole-mounted type and decide to pass the coax in through a door, route it such that it does not get crushed when the door is closed, but is cushioned by the door seal. Remember, keep in mind the purpose of the door seal – to keep water and dust out!

If you pass the coax into the vehicle via the boot, here too, you need to see the cable is not crushed. If the cable has to pass through the engine bay, ensure that it is routed well away from any component that carries engine heat such as the exhaust for example, and away from moving parts. The same applies if you need to route the cable under the vehicle – keep it well away from the tail shaft, brake lines and exhaust.

However you mount your antenna, it is essential to check the SWR and tune or prune the whip if necessary. Inefficiency in a mobile is counter-productive.

Then there's the matter of safety. Your safety. You needn't get carried away in your search for height. Think carefully before you put an antenna on the roof of your campervan, for example, because you could hit power lines.

Mounting mobile antennas

Mounting a two metre antenna on your vehicle throws up a number of considerations, RF-wise, as well as mechanical and aesthetic. But one of the main considerations is how the antenna's location on the vehicle affects its radiation pattern. Knowing something of how the antenna radiation pattern might be affected according to where you locate it may assist your choice on placement, or at least give you some idea of what to expect.

There are five basic locations and several different ways you can mount a whip on your vehicle. Let's look at mountings first.

If you're not afraid to drill a hole in your vehicle, or decide to use an existing broadcast antenna mounting hole, then a 'standard' VHF base, as illustrated here, is what you need.

This one features a coax cable termination and clamp on the underside, along with a chassis clamp that provides good grounding to the vehicle's metal body. There's a 5/16

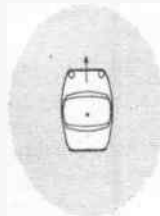


Figure 3. A centre-roof mounting position for your antenna is the 'best' position, resulting in a radiation pattern that gives stronger signals in the forward and rearward directions, compared to radiation off the sides.

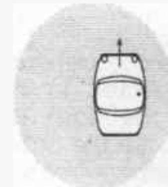


Figure 4. While gutter mounting places the antenna high up on the vehicle, the radiation pattern is distorted because the signal is enhanced in directions where it passes across the vehicle and degraded where it doesn't.

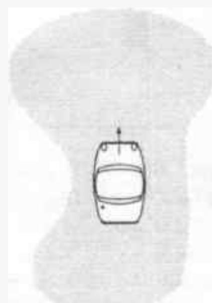


Figure 5. When you mount an antenna on a rear mudguard or cowl, or on the trunk lip to one side, the radiation pattern breaks up into a sort of peculiar figure-8 pattern.

Figure 6. As for Figure 5, mounting the whip on the front guard results in a distorted radiation pattern.

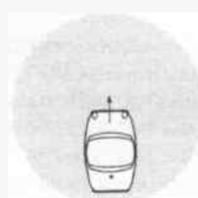


Figure 7. Mounting the whip on the trunk lip, placing it in the centre, gives a radiation pattern that favours the forward direction – but keep away from the roof rise.

inch, 26tpi threaded bolt on the top that takes a standard whip ferrule (female 5/16 inch, 26tpi thread) and the insulator is a durable, low profile plastic cone. A rubber ring gasket provides sealing on the top surface.

A gutter-mount bracket allows you to mount a whip high on your vehicle's roof without drilling a hole – but not all vehicles have roof gutters these days! Various versions are available, looking rather like this:

A standard VHF base is fitted to this, for mounting your whip.

One popular way to mount a whip on a vehicle without drilling a hole is to use a magnetic base to which you mount the whip and its base mount. This employs a large, powerful ring magnet housed in a plastic and metal assembly, constructed to provide strong but scratch-proof mechanical contact with the vehicle and 'capacitive' coupling to the vehicle body for a 'groundplane'. Magnetic bases can be obtained as a 'naked' component, or complete with antenna mount and coax lead, as illustrated.

A trunk-lip mount permits attaching the whip to the lip of a car boot or trunk. The assembly provides grounding to the car body via the mount.

If you use a stainless steel whip (which are very durable), it's advisable to install a light duty spring, like the one shown here, on your antenna base mount so that your whip and mount won't come to grief should the whip strike anything.

Mounting your antenna in the centre of your vehicle roof gets it in the highest position and provides the 'best' radiation pattern, as shown in Figure 3. Signals are somewhat stronger forward and rearward compared to off the side of the vehicle.

While the radiation patterns illustrated in Figures 3 to 7 are 'smoothed' for the sake of clarity, in reality they are a mass of small 'lobes' with minor peaks and troughs in all directions. If you don't want to drill a hole in your vehicle, use a roof rack and mount the antenna to it (adding some groundplane elements improves performance).

Gutter mounting also places the antenna high up, but the radiation pattern is distorted, being enhanced where it passes across the vehicle, degraded where it doesn't. Good signals front and rear are obtained, as you can see from Figure 4.

If you mount your whip on a rear mudguard or cowl, or on the trunk lip to one side, the radiation pattern may break into a peculiar figure-8 shape, like that illustrated in Figure 5. Likewise, with the whip mounted on a front guard or cowl, you get quite a distorted radiation pattern with deep 'nulls' either side of the vehicle, similar to a rear-guard mounted whip, as in Figure 6. Unless it's unavoidable, it's not a good practise to put your two metre whip where the traditional broadcast antenna is mounted.

A trunk-mounted antenna positioned on the vehicle centre line favours the forward direction (see Figure 7) provided the whip is not too near the passenger roof rise, which may break up the radiation pattern. The message is, keep your whip away from other vertical structures on the vehicle (AM/FM broadcast and other antennas included).

All you need to link the antenna and rig in a mobile installation is the required length of coaxial cable and the connector to suit the rig's antenna socket. I'll have more to say on connectors later.

Common RG58 coax is the popular choice for mobile rig installations. It's a

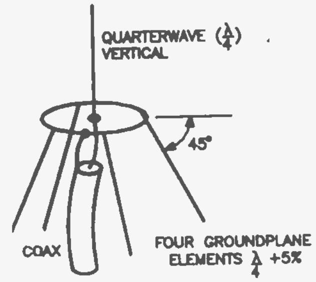


Figure 8. A groundplane with 'drooped' radials is a simple antenna that provides a good match to 50 ohm coax. This is the basis of a build-it-yourself 'quickie groundplane'.

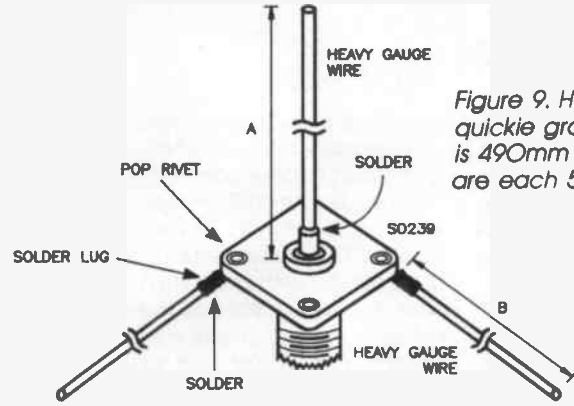


Figure 9. Here's how to knock up the quickie groundplane. The vertical, A, is 490mm long, while the four radials are each 515mm long (B).

'quarter-inch' (diameter) cable, is quite flexible and the loss factor is immaterial in the short lengths used in mobile installations. But ... there's RG58 and there's RG58, as they say. *Don't* use cheap 'CB' coax. Get 'RG58CU Commercial' coax specified 'MIL-C-17F', as it's sturdy and long lasting. Dick Smith Electronics stores and specialist communications retailers stock it.

Home base two metre antennas

The direct range of any VHF station – without recourse to repeaters – is decided by four factors:

- the antenna
- the feeder
- the receiver, and
- the transmitter.

So you get the best rig you can afford. That fixes the last two. The first two are more under your direct control. Getting the antenna as high as you can is the first requirement. The 'height of the antenna above average terrain', the HAAT, is a significant factor in VHF propagation range. While a self-supporting, 30 metre high tower is a worthwhile goal, this article's about an *introduction* to two metres, so let's keep matters comparatively simple.

Getting the antenna on the roof of your dwelling presents a practical solution. But if you live on the ground floor of a 10-story block of units, assuming you can get permission to put an antenna on the roof, the losses in the cable between it and your rig may be so as as to make it not worthwhile. A suitable low-loss cable to run down 10 storeys would bust your bank account, anyway. Your only solution is to move.

Alright, let's assume you can put up an antenna on your property. You have three options, as before: build, buy or borrow. The first option – building an antenna – is what quite a few operators do. Home station antennas for two metres are readily available from retailers of amateur radio gear, Emtronics and Dick Smith Electronics.

In the Dick Smith catalog, you'll find a 'Folded J' vertical for two metres, cat. no. D-4211. It's specified to cover the full two metre band with a VSWR of less than 1.2-to-1. This sort of antenna is easily mounted on your house using standard TV antenna mounting parts – also available in Dick Smith stores. As individual circumstances vary widely, I'll have to leave it to you to decide what you'd use and how you'd put it all up.

For a quick-and-easy antenna to get you on the air at minimum cost, you can build yourself a 'quickie groundplane'. This is a simple omnidirectional antenna consisting of a vertical element a quarterwave long with four horizontal 'groundplane' elements connected together and mounted at right angles to each other at the base of the vertical. It is conveniently fed with coax, the centre conductor to the base of the vertical, shield to the groundplane. The groundplane elements, or 'radials', are about 5 per cent longer than a quarterwave. However, its feedpoint impedance is around 35 ohms. The impedance is easily raised to match the coax impedance by the simple expedient of 'drooping' the groundplane radials 45 degrees from the horizontal. Figure 8 illustrates the general arrangement.

You can build a quickie groundplane using an SO239 panel-mount socket and some heavy gauge wire (e.g. 18 gauge tinned or enamelled copper wire). Construction details are shown in Figure 9. The vertical element is cut to 490mm in length, while the groundplane radials are cut 515mm long. As a minimum, 18 gauge wire is recommended. Brazing rod may be used in lieu of wire and has the advantage of being stiff and springy, but you'll need to use heavy duty solder lugs (such as automotive types) on the radials.

The quickie groundplane is easy to mount. Your feedline with PL259 connector on the end plugs into the SO239. You can erect a short length of pipe of about 20-25mm inside diameter and drop the feedline through it, letting the SO239 sit in the top of the pipe, as shown in Figure 10.

Alternatively, you could put a VHF mobile antenna mounting on a small, square metal plate (the baseplate) of, say, 1-2mm thick aluminium about 50mm a side, with the radials soldered to solder lugs pop-rivetted to the plate corners. The antenna can be mounted to a vertical pipe using a small length of aluminium angle bolted to one edge of the baseplate, and a U-bolt used to bolt the assembly to the pipe. For the vertical, you could then choose a suitable mobile whip. If you use a 5/8-wave whip, set the radials horizontal and you'll get a good match to your coax as well as a little gain.

The various amateur radio handbooks contain plenty of two metre antenna projects, plus hints and tips on antenna erection. The ARRL's book on *FM and Repeaters* is also a marvellous resource.

Erecting anything more elaborate, such as a beam, is beyond the scope of this introductory article and, in any case, the above-mentioned publi-

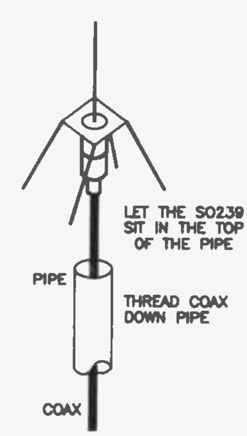


Figure 10. The quickie groundplane is simple to mount. The pipe can be part of a standard TV antenna chimney or wall mount fitting.

cations contain a wealth of information.

All in all, antennas for two metres are a delight to construct and install, largely because even comparatively elaborate beams with unheard-of gain on HF are of manageable dimensions. The quickie groundplane can be built, erected and have you on the air in a couple of hours. And the cost of materials for home-built two metre antennas is reasonable, too (unless you build a really *monster* array).

Before I move on to the next topic, I should mention safety. When erecting antennas on or around your house, heed the electricity authority's advice: *look up, and live!* Be aware of where the mains cables lead in to your house from the street, and take steps to avoid them. Pay particular attention when walking around carrying aluminium ladders or antenna structures.

Righto! You've got an antenna to put up, but it has to be connected to your rig. Which brings us to the matter of cables and connectors.

The importance of coax

As I said before, one of the things affecting the performance of any VHF station is the *feeder*. While you can save money building your own antenna, it definitely does *not* pay to skimp when it comes to the feeder. Coaxial cable is the preferred feeder, for a host of good reasons. It can be run almost anywhere, it's unaffected by weather (except in the very long term) and many antenna designs are made to provide a direct match to 50 ohms, a common coax cable impedance.

All feeders, coax or whatever, exhibit a loss. And this loss gets worse the higher the frequency. While common 50 ohm RG58 quarter-inch coax or TV-type RG59 (75 ohm impedance) can be used almost with impunity as feeders in HF antenna installations, the losses they exhibit on two metres render them useless, except for runs of just a few metres. Table 1 lists a number of coaxial cable types you might encounter, and their losses (in decibels) on various amateur bands per 30 metre (100 ft) length.

As you can see from Table 1, type 9913 (made by Belden and others) has the least loss of the flexible coaxial cables commonly available. It is obtainable from Dick Smith Electronics and features a semi air-spaced construction which gives it its low-loss characteristic. The next best choice is 'RG213 Foam' which, as the name suggests, has a foam-type rather than solid dielectric as has common RG213. The lower-loss cables cost more, but the results are worth the extra money. It's likely you'll have to spend more on the coax than you did on the antenna, but it's an equally important 'link in the chain', so do it!

Treat your investment in coax with respect and it will last you many useful years. Don't crush it when attaching it to anything during installation. Avoid tight bends. As a general rule of thumb, don't bend it with a radius any smaller than about ten times its diameter. Weatherproof any outdoor connections. Self-amalgamating tape (a 3M product) is excellent for this.

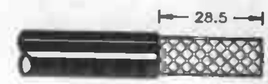
The run of cable between the

CABLE TYPE	Z (Ohms)	3.5MHz	21MHz	28MHz	146 MHz
"Quarter-inch" cables					
RG58	52	0.68	1.9	2.2	5.7
RG58 foam	50	0.52	1.4	1.7	4.1
RG59	72	0.64	1.6	1.8	4.2
RG59 foam	75	0.48	1.2	1.4	3.4
'Half-inch' cables					
RG213	52	0.3	0.93	0.98	2.5
RG213 foam	50	0.27	0.76	0.90	2.2
9913	50	–	–	–	1.5
RG11	75	0.38	0.98	1.15	2.8

TABLE 1. This lists the loss, in dB, for common coaxial cable types for various amateur bands. Note how the loss on two metres is always much higher than on HF. But as the two metre loss in dB goes down, the cost in $/metre goes up! For the most part, the cables listed have a solid dielectric (usually of polyethylene), except for those noted as 'foam' types. These employ a spongy dielectric having lower loss. The 9913 cable employs a special construction (see text).

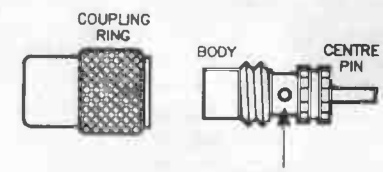
HOW TO ATTACH COMMON RF CONNECTORS TO COAXIAL CABLE

PL259 TO 1/2 INCH COAX



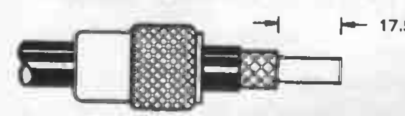
A

Cut the end of the coax square. 28.5mm back from the end, cut carefully around the cable's outer sheath, taking care not to sever the braid, then remove that length of sheath to expose the braid.



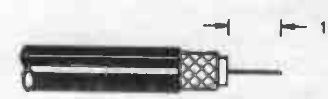
B

Disassemble the plug.



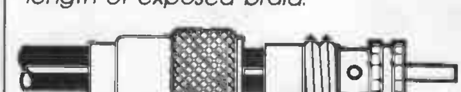
C

Slide the coupling onto the coax. Then, 17.5mm back from the end, carefully cut through the braid, but not the dielectric. Remove the unwanted braid.



D

Now, 16mm back from the end, remove the dielectric, taking care not to nick the centre conductor. Lightly tin the centre conductor and the remaining length of exposed braid.



E

Fit the PL259 plug body onto the prepared cable so that it seats 'home'. Solder the braid to the plug body through the solder holes using a hot iron with high heat capacity. Then solder the centre conductor to the plug's centre pin.

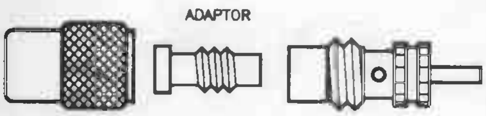
F

Slip the coupling ring down and screw it over the plug body.

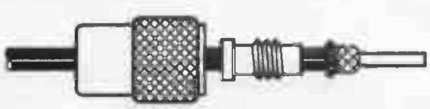
Certain aspects of the illustrations here have been exaggerated to the sake of emphasis or clarity, they are not 'engineering' drawings.

PL259 TO 1/4 INCH COAX

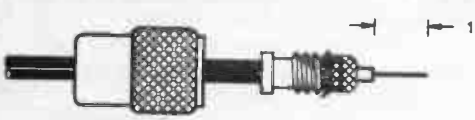
A
Cut the end of the coax square. 19mm back from the end, cut carefully around the cable's outer sheath, taking care not to sever the braid, then remove that length of sheath to expose the braid.



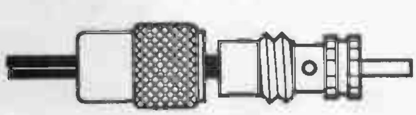
B
Disassemble the plug.



C
Slide the plug's coupling ring and adaptor onto the cable sheath. Fan back the braid over the sheath to expose the dielectric.



D
16mm back from the end, remove the dielectric, taking care not to nick the centre conductor. Lightly tin the centre conductor. Push the adaptor down to the braid and compress the braid over it, taking care not to cover the adaptor's thread.

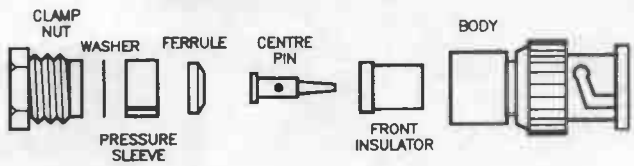


E
Screw the plug body onto the adaptor/cable assembly. You may solder the coax braid to the plug body through the solder holes using a hot iron with high heat capacity. Solder the centre conductor to the plug's centre pin.

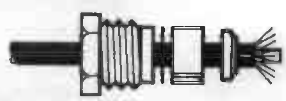
F
Slip the coupling ring down and screw it over the plug body.

BNC MALE TO 1/4 INCH COAX

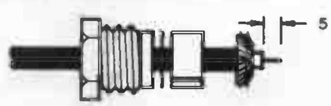
A
Cut the end of the coax square. 8mm back from the end, cut carefully around the cable's outer sheath, taking care not to sever the braid, then remove that length of sheath to expose the braid.



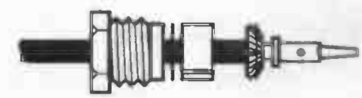
B
Disassemble the plug. Note that the front insulator is usually held captive in the BNC's body.



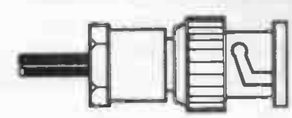
C
Slide the clamp nut, washer and pressure sleeve over the cable's sheath. Carefully comb out the braid.



D
Slip the ferrule up to the end of the sheath, then fan the braid back over the ferrule. 5mm back from the end, cut and remove the dielectric to expose the centre conductor, taking care not to nick the centre conductor. Lightly tin the centre conductor.



E
Push the BNC's centre pin onto the exposed centre conductor and sweat solder it in place.

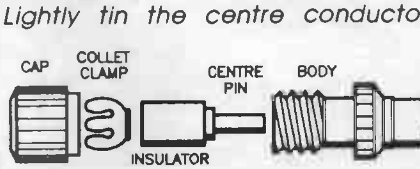


F
Fit the BNC's body onto the prepared end of the cable, push the pressure sleeve, washer and clamp nut down to it and screw the nut up tight.

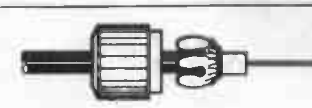
PAL PLUG TO 1/4 INCH COAX

A
Cut the end of the coax square. 22mm back from the end, cut carefully around the cable's outer sheath, taking care not to sever the braid, then remove that length of sheath to expose the braid.

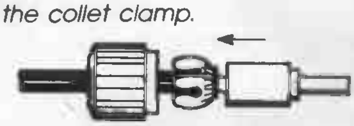
B
16mm back from the cable's end, cut through the braid and dielectric, right through to the centre conductor. Take care not to nick the centre conductor. Lightly tin the centre conductor.



C
Disassemble the connector.



D
Slide the cap and collet clamp over the cable's sheath. Seat the end of the collet clamp just at the end of the sheath and lightly squeeze the collet's fingers to hold it in position. Comb out the braid and fan it back over the end of the collet clamp.

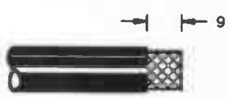


E
Slip the insulator/centre pin piece onto the cable, seating it well back against the braid and collet. Solder the centre conductor to the centre pin. Be quick because the insulator tends to melt.

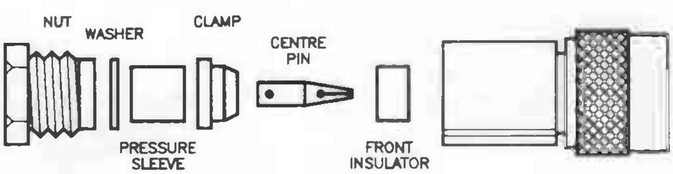
F
Push the plug's body onto the now-attached insulator/centre pin piece. Ensure that it seats properly home with the centre pin more or less flush with the open end of the plug body. Screwing the cap onto the plug body will force the collet fingers to close tightly on the coax outer sheath.

Tools: To attach a connector to coax, you should have on-hand a sharp 'hobby' knife or penknife, a pair of small, sharp, pointed sidecutters, a small adjustable spanner, long-nosed pliers and a soldering iron.

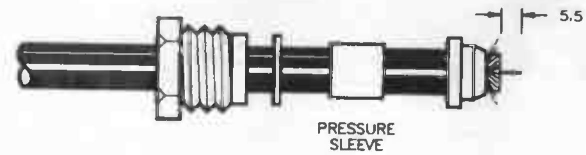
TYPE N TO 1/2 INCH COAX



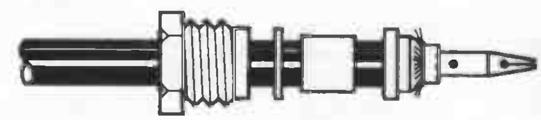
A
Cut the end of the coax square. 9mm back from the end, cut carefully around the cable's outer sheath, taking care not to sever the braid, then remove that length of sheath to expose the braid.



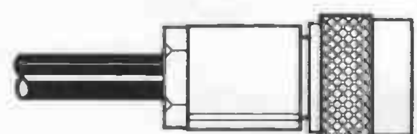
B
Disassemble the plug. Note that the front insulator is usually held captive in the BNC's body.



C
Slide the nut, washer, pressure sleeve and clamp over the cable's sheath. Carefully comb out the braid. 5.5mm back from the end, cut and remove the dielectric to expose the centre conductor, taking care not to nick the centre conductor. Lightly tin the centre conductor. Push the clamp up to the end of the sheath, behind the combed-out braid.



D
Fan the braid back over the clamp. Push the centre pin over the exposed centre conductor and sweat solder it in place.



E
Fit the plug's body onto the prepared end of the cable, seeing that it seats 'home' properly. Push the nut, washer and pressure sleeve down to the plug body and screw the nut up tight.

REPEATER GUIDELINES

This text has been adapted from guidelines developed and published by the Victorian Division of the Wireless Institute of Australia and available as an information sheet for Novices.

PROCEDURES

- Each transmission should not exceed two minutes. Repeaters have timers to limit transmission length.
- Before replying, let the repeater 'drop out' and wait at least three seconds before transmitting. This allows others immediate access.
- Do not reset the repeater's timer to extend your own transmission time by briefly dropping the push-to-talk button.
- Keep contacts brief and to the point. Limit your group's QSO to a maximum of 10 minutes.
- Avoid over-use of callsigns. They are required at the start and end of a contact, and at least once every 10 minutes – but callsigns can be dropped from the start and end of transmission during a contact. Phonetics are also over-used on repeaters, particularly in callsigns. Plain language is always better.
- To gain access to a repeater that is being used by others, simply announce your callsign during the pause between overs.
- If using a repeater and another station announces its callsign during the pause between overs, let the station go ahead immediately. They may have an urgent message.
- Do not transmit on repeater input frequencies. Use 'reverse' facilities only to observe another station's input signal strength. If satisfactory, then QSY to a simplex channel.
- Ignore annoying transmissions. Do not respond or comment on a transmission not identified by the person's callsign.
- There is no need to call CQ on repeaters. Just announce your callsign and say you are listening on the frequency.
- The use of repeaters for liaison to establish contact on another band is permissible, but cross-band contacts is not encouraged. Where cross-band contacts are made, all frequencies must be announced by all parties.
- Priority must be given to normal repeater usage. At all times, any emergency traffic takes absolute priority.

MANNERS

- Be courteous and unselfish at all times, and always be aware of the needs of other people who have an equal right to use the repeater.
- If you hear someone new to repeater operation, assist and educate them in a courteous manner.
- Remember that others, including new or potential radio amateurs, monitor repeaters – the image of amateur radio is important.

antenna and rig should be the shortest you can possibly arrange. Firstly, it keeps the losses as low as possible, and secondly, it keeps the cost down.

Connectors

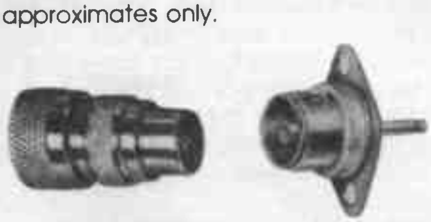
As coaxial cable is universally used on two metres, you'll encounter coaxial-type connectors of various types. This introduces you to the more commonly used ones. Following are a series of diagrams of how to correctly assemble, or terminate, the various connectors to coaxial cable.

The less expensive types simply afford a connection while maintaining the coaxial structure of an inner conductor surrounded by a cylindrical outer conductor. The more expensive 'precision' coax connectors have a *constant impedance* characteristic, which means that their construction preserves the characteristic impedance of the cable to which they're attached.

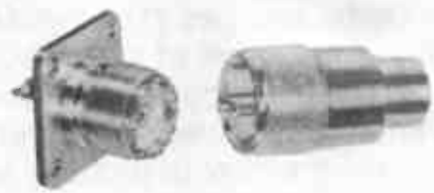
Clearly, the latter are preferred as they do not introduce sudden impedance 'bumps' in the line between the antenna and the rig, which is a source of loss. Though small, such losses can be important, particularly affecting the sensitivity of a low noise RF stage in a receiver. However, two metre FM operation can be fairly forgiving. If you're not after the last dram of performance, you can afford a few compromises – but perhaps not too many all together!

You'll encounter four common coaxial connector families, all of which may be found on two metre gear of some description, be it the latest commercial rig, homebrew gear or ex-commercial VHF 'high band' two-way equipment modified for operation on two metres. Let's take them one-by-one, from the least expensive to the most expensive.

I have listed 'price ratios', taking the least expensive connector (plug) as the reference. Thus, it this were $1, another connector with a price ratio of three would cost $3. The ratios are approximates only.



The PAL or TV series: This is the common, low-cost coax connector for TV installations. It's meant for small diameter 75 ohm coax (e.g. RG59), but is not a constant impedance connector. It is serviceable, but not very rugged. The plastic-bodied type plug is the cheapest with a price ratio of 1. (Non-solder versions are available, too.) The metal-bodied type is somewhat more rugged, but has a price ratio around 1.8.



The 'UHF' series: This connector series comprises the famous PL259 plug and SO239 socket combination which has a long and honourable history. They're widely found on commercially made amateur gear, are generally rugged and reliable, and feature a locking action when screwed together. They're not a constant impedance connector, despite the 'UHF' title. Non-solder and crimp-together versions are available, but are not recommended for use on two metre gear.

Originally meant for larger (half-inch) diameter coax, adaptors are available for the plugs to take the smaller coax along with models designed to fit the smaller (quarter-inch) coax directly. Both straight-through and right-angle plugs are obtainable. Price ratio for the cheaper versions varies from 1.5 to 2, and up to 4 for quality plugs.

The 'BNC' series: BNCs are precision, constant impedance connectors meant for smaller diameter coax (RG58, etc). Both 50 ohm and 75 ohm versions are obtainable. The BNC offers a quick-connect/disconnect facility, is rugged and reliable. It is often found on handheld rigs. Adaptors for the plugs are available to accommodate 3mm coax (RG174). The 75 ohm type BNC is a widely used video connector.

Like the UHF series, both straight-through and right-angle plugs are obtainable. A low-cost version of the socket features a split pin rather than the four-fingered collet of the 'true' BNC socket. It's not truly a constant impedance socket, but quite OK on two metres. Price ratio ranges from 2 for the lower-cost versions, up to 5 or so for the quality models.

Type 'N' series: Another precision constant impedance connector, meant for larger diameter coax (RG213, etc). This, too, is a rugged and reliable connector. It is weatherproof if all the seals are used and the connector is properly installed, thus making it ideal for outdoor installation.

Like the UHF and BNC series, the Type N has a long and honourable history. Plug adaptors to accommodate RG58-type coax are available as well as some versions made to fit, and both straight-through and right-angle plugs are obtainable. Price ratios start at around 6 or 7 and ranges to 10 and higher.

Adaptors: A variety of adaptors can be obtained to connect virtually any type of connector to almost any other type. Some types can be piggy-backed to provide required series adaptions. The most commonly used would be the PL259-to-BNC-socket, BNC-plug-to-SO239 and Type N/BNC combinations.

Wrap up

Two metres has a lot to offer. Propagation, people, performance and procedures are all quite different to what's experienced on the HF bands. For mobile communications, two metres FM is hard to beat. Things such as handheld rigs and repeaters offer something that is quite unavailable on HF. Give it a go and you'll soon see the band's features and benefits. ●

Antenna and antenna mount illustrations courtesy of RF Industries. Thanks to Emtronics, Dick Smith Electronics and Icom Australia for providing material used to compile this article.

Summer f

Spectacular contacts over ranges of hundreds to thousands of kilometres can be had on the VHF amateur bands of six (50-54MHz) and two (144-148MHz) metres in summer. Languishing for much of the year, these bands literally 'come alive' during the summer months when propagation via the ionosphere's E layer makes it possible. Here's how to join the fun.

VHF ENTHUSIASTS will tell you that the most fun you can have on the air is chasing DX (long distance contacts) during 'the season'. Generally this is taken to mean mid-summer (December-January) but it actually extends from October through to February, and occasionally March.

The 'fun' component arises from the largely unpredictable nature of the phenomenon. One moment you're talking to a VK6 station some 1800km away, the next you're talking to a VK4 only 800km away – and signal strengths can be very strong.

Six metres is the popular band for this sort of DX because the 'openings' are more frequent, but two metres is also involved at times. And it's brought to you courtesy of the ionosphere and its popular product known as *sporadic-E*.

If you acquired your licence in the time-honoured way, then I can assume you have had at least some passing acquaintance with the ionosphere. Just to refresh your memory and set the scene, here's a little tutorial.

The lowest reflective layer of the ionosphere, the E layer, lies in the height range between 90- and 120km. At certain times, very dense 'clouds' of ionisation will form in the E layer, the vast majority forming in a narrow height range between 95- and 105km. These clouds are relatively thin, being typically less than 1km thick. They can appear and disappear in the space of minutes, or last for many hours. The clouds can remain stable over a geographic position or drift, at speeds up to 300km/h, over considerable distances. They pop up at anytime, whether it be night-time or daytime. Hence the name, sporadic-E, or Es ('ee-ess') for short.

Sporadic-E has been observed for over 60 years by amateurs, scientific researchers and communicators. For some it's a curse, for others, a resource to exploit. Most of the low band TV interference (Channels 0 to 2) during the summer months is caused by interstate sporadic-E propagation. It's also responsible for the popularity of the six and two metre amateur bands during summer. So much for the tutorial, now for the nitty gritty.

Haunts and habits

Enthusiasts who've already observed the phenomenon will have noticed that sporadic-E is not quite as sporadic or random as its name suggests. While it can occur at any time, it has a tendency to occur more often at some times than others – summer, for example. Getting to know the quirks and characteristics of Es – its haunts and habits, if you like – can considerably enhance your chances of catching more of the DX contacts, and thus more fun.

Ionospherically speaking, the earth has each hemisphere divided into three regions. These are: the 'low latitudes', or the belt around the equator; the 'high latitudes', that is, the polar regions; and the bits in between, called the 'mid-latitudes', where most of Australia and New Zealand is located. The ionosphere has broad variations and differing characteristics in each of these regions. As Australia is largely situated in the mid latitudes, I will concentrate on the characteristics of mid-latitude sporadic-E.

Sporadic-E also shows a diurnal (daily) variation in occurrence. Mid-summer Es generally peak about three hours before and again six hours after local noon. You can work a little DX before a late breakfast, do your own thing during the day and come home from your job to work yet more DX in the early evening. Mid-winter Es obligingly peak around 1800-2100 local time when you should be warm and cosy inside your shack.

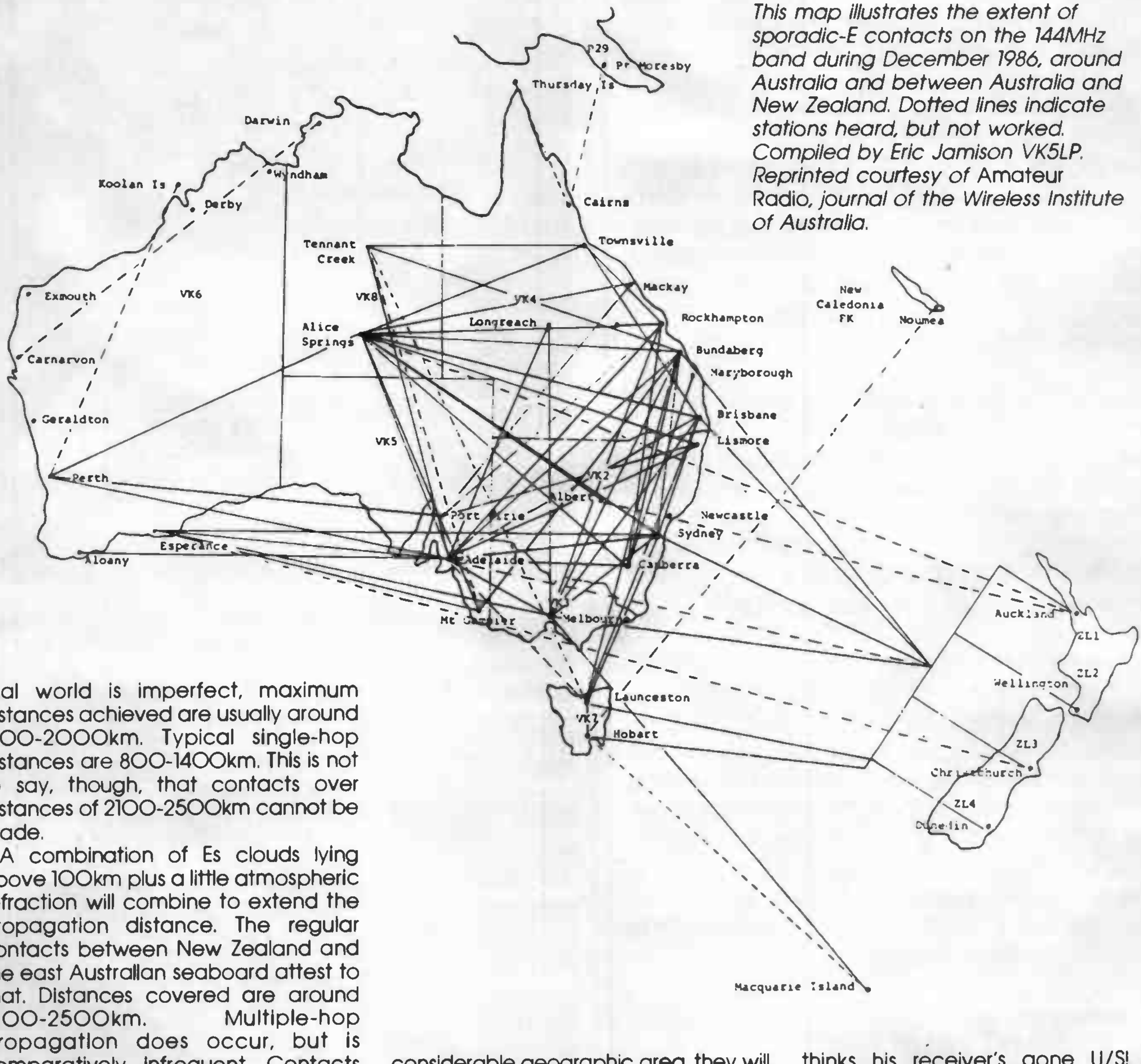
Intense Es activity often persists for three to four days following large magnetic storms. Keep an eye/ear on the ionospheric/geomagnetic forecasts put out by IPS Radio & Space Services. Magnetic storm warnings are issued as well as reports on storms in progress. The NSW Division WIA Sunday morning broadcasts on VK2WI include weekly ionospheric reports from IPS, or you can get information from the IPS recorded solar-geophysical message service anytime on (02) 414 8330, which is updated at regular intervals.

Researchers have classified Es into three types – weak, strong and intense. Strong Es will propagate six metre transmissions well, while intense Es permit 144MHz propagation. Intense Es are generally short-lived and almost invariably follow considerable strong Es activity.

High sporadic-E activity tends to be 'clustered' in two or three days. When you first notice a bit of DX activity on six metres, you can be fairly confident it will last for another day or two. Likewise, no Es activity tends to last for two or three days. Intense Es usually occurs late in the day, typically between 1800 and 2400 hours local time.

Since the Es clouds lie around 100km in height, a little geometry will tell you that the maximum distance for single-hop propagation is around 2200km for a zero radiation angle. But, because the

un on VHF



This map illustrates the extent of sporadic-E contacts on the 144MHz band during December 1986, around Australia and between Australia and New Zealand. Dotted lines indicate stations heard, but not worked. Compiled by Eric Jamison VK5LP. Reprinted courtesy of Amateur Radio, *journal of the Wireless Institute of Australia.*

real world is imperfect, maximum distances achieved are usually around 1800-2000km. Typical single-hop distances are 800-1400km. This is not to say, though, that contacts over distances of 2100-2500km cannot be made.

A combination of Es clouds lying above 100km plus a little atmospheric refraction will combine to extend the propagation distance. The regular contacts between New Zealand and the east Australian seaboard attest to that. Distances covered are around 2100-2500km. Multiple-hop propagation does occur, but is comparatively infrequent. Contacts over distances of 2800-4000km via Es are not unknown.

As mentioned earlier, sporadic-E clouds are usually quite dense and comparatively thin. To radio waves, the clouds appear as virtual mirrors. Signals propagated by Es are typically very strong and single-hop communications over widely differing skip distances is observed.

As the clouds can cover a considerable geographic area, they will conform to the curvature of the Earth. Thus, from the underside, large clouds will look like a concave shaving mirror and signals 'illuminating' a large area of the cloud will be *focused* at the termination of the path. This greatly increases the signal strength and results in two stations in adjacent suburbs experiencing greatly different propagation conditions – one gets a DX station at '20 over 9', while the other thinks his receiver's gone U/S! This focusing effect is illustrated in Figure 1.

While signals are generally very strong, they also experience very deep fades. It is the focusing effect and the fact that the clouds are not entirely stable that causes the fading; the focus point moves across the ground as the cloud moves.

Experienced VHF enthusiasts often talk about 'backscatter'. On such occasions, the signal is reflected by the

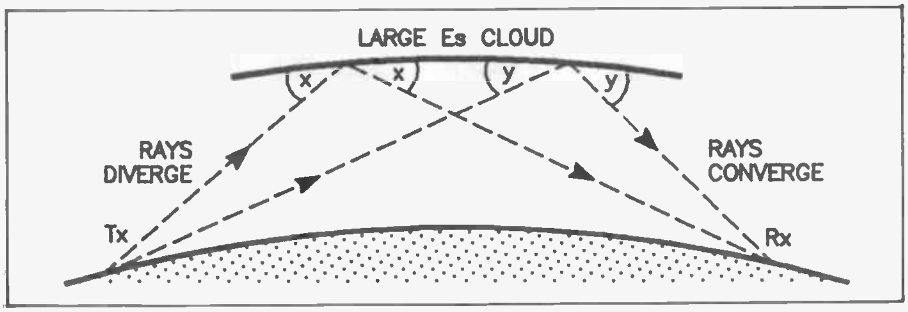


Figure 1. This diagram illustrates the 'focusing effect'. A large Es cloud is actually concave on the underside and acts like a shaving mirror. The rays are focused where they come down following reflection. Only two possible rays are shown for the sake of clarity.

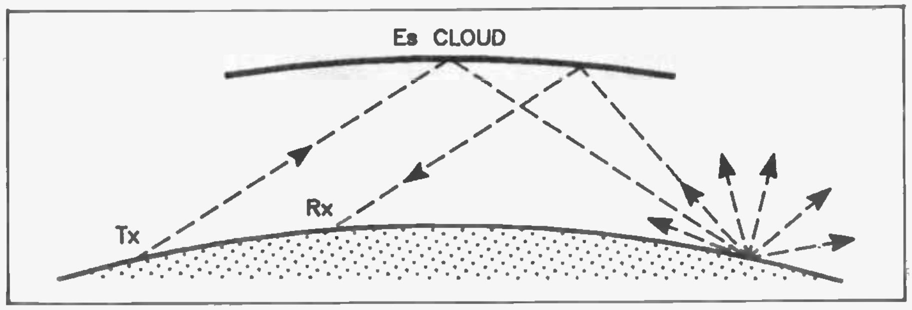


Figure 2. This shows the 'backscatter' phenomenon. Reflected signals are scattered in all directions from the distant reflection point. That part scattered back along the direction of the original path may be heard on occasions if the Es cloud is dense enough.

Es cloud, virtually without loss, to some distant point. Upon striking the ground, the signal will be scattered in all directions and that portion scattered back along the general direction of the original path is propagated via the Es cloud again. It may be heard by other stations that are located laterally some distance from the originating station, but all stations will be beaming in the same general direction. Figure 2 illustrates this interesting phenomenon.

Backscatter signals are weaker than normally experienced and generally suffer more fading. It is not unusual to work a station 1000km away by single-hop and be joined by a third station on backscatter who is hundreds of kilometres away and at right angles to your beam heading and beaming in the same direction! For example, it's common for Victorian stations to be working stations in Queensland *and* South Australia – the latter on backscatter who can't otherwise be worked on a direct path at the same time.

Backscatter usually appears when an Es cloud is at its densest or approaching it, and thus a propagation 'opening' is well developed. So, backscatter is a good precursor to developing intense Es. Hence, it is also a good indicator of a rising maximum usable frequency (MUF).

Just like the other, higher layers, of the ionosphere, Es has a maximum usable frequency. When the skip distance is near the maximum and you can't hear closer stations in the same direction, you're near the MUF (or there aren't any stations closer). When the signals get really strong and the skip distances shorten, the MUF is rising. When the skip distance shortens to about 750km or less, go to two metres and look for stations around 2000km away in the same direction. Such events are usually short lived, though six metres may stay open for hours.

It's possible to work short skip on six metres via Es, but few stations have antennas with a lobe at the required high radiation angle. Years ago, when I lived in Melbourne, I used a 3/4-wave groundplane, an antenna which sports two main radiation lobes – one low and one high. I could work Albury, Broken Hill, Hamilton and Adelaide while the locals couldn't hear them. If you think DX is getting the maximum distance, then think again! What's more, in those days I only ran a few watts power. You don't necessarily need kilowatts or repeaters to have fun on six metres!

Distances greater than 2000km can be covered via Es propagation, as mentioned earlier. Double-hop propagation is possible but requires either a cloud covering an extensive geographical area or several clouds strategically placed along the path. As Es clouds seem to form in 'arrays' over a considerable area and drift in the same direction, this is highly likely how most multi-hop propagation occurs.

In addition, recent research has shown that, with strong Es, horizontal clouds are extremely rare, they are almost always tilted just a few degrees. Thus, multi-hop propagation may also occur via reflection from two strategically placed clouds having tilts that face each other, two reflections occurring without intermediate ground

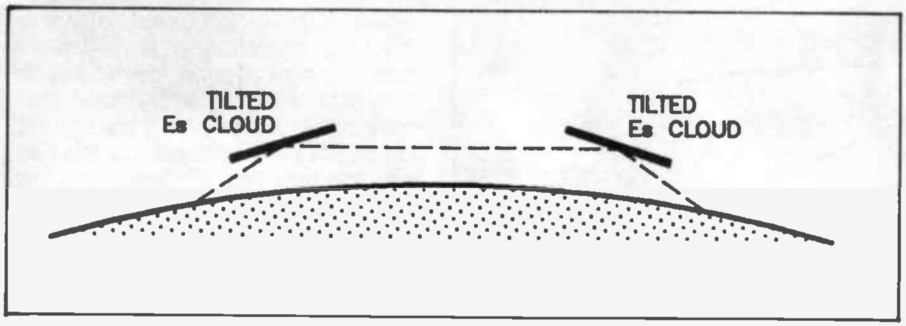


Figure 3. Long distances can be covered via multi-hop propagation without intermediate ground reflection. This may occur from widely separated clouds tilted so as to face each other along the path. Strong Es clouds are always tilted, according to recent research.

reflection (see Figure 3). But don't expect such happenings to be frequent or long-lived. Local research suggests that the largest tilts are observed around dawn and dusk.

Getting amongst it

To make the most of sporadic-E DX, you need to equip yourself with a few auxiliary 'tools'. A wideband receiver, such as a scanner, that covers the VHF spectrum, from 28MHz upwards, is useful for tracking the formation of Es and the likely MUF. An old, small screen monochrome TV set has served many an experienced VHF enthusiast well.

You'll need some sort of wideband listening antenna, preferably with an omnidirectional radiation pattern. Discone-type antennas are ideal for this. While it is vertically polarised, which might indicate poor response to horizontally polarised transmissions, signals propagated long distances have a somewhat jumbled polarisation.

If you're restricted to listening on the amateur bands, then a groundplane or small two- or three-element beam is useful – something with a fairly broad beamwidth so you can catch signals that may come from over a wide area. That monster 10-element Yagi for six metres can restrict your opportunities. First find the skirmish using the general coverage antenna, *then* bring in the cavalry.

It is very useful to research and compile a list of amateur band beacons and other VHF 'marker' signals in suitable geographic areas so you can identify the general geographic area of a band 'opening'. But remember the focusing effect. Just because you can hear the VK5 six metre beacon doesn't mean you're necessarily going to work Adelaide stations!

TV station sound and vision carriers can be good marker signals, but remember they roughly have a 20dB power advantage on amateur signals. A weak, fading Channel 0 sound carrier indicates a path is opening, but you may have to wait until the signal 'firms up' before making contacts on six metres.

A regularly updated list of beacons is published in the monthly column *VHF-UHF – An Expanding World* conducted by Eric Jamison VK5LP in the WIA's journal, *Amateur Radio*. You'll also find beacon and TV station information listed in the *Australian Radio Amateur Callbook* published by the WIA.

Overall success at getting amongst the DX fun depends on using successful operating techniques. Observe the usual operating courtesies during openings. To look for the presence of an opening, or a developing opening, tune across your selected marker signals, starting from the lowest frequencies and pay special attention to stations around 2000km away. (A handy distance chart is published in the *Callbook*.) Aimless 'frequency hopping' or band tuning might turn up something, but it's an inefficient technique.

The 28MHz band can be especially valuable. Look for interstate signals around Australia and/or stations from New Zealand and New Guinea if your location is right (not over 2500km away).

On hearing some likely signals, watch the progress of a possible opening. If the signals rise in strength and you start to hear stations at shorter skip distances, start monitoring higher frequency signals in the same general area(s).

If, or as, they appear, go up to six metres and start tuning around. If you can't hear anything, try the established calling frequencies. Note that there are different calling frequencies for CW and SSB. Short calls, with a longer listening time, repeated at frequent intervals, are better than long, drawn-out CQs. But remember, if everybody listens and nobody calls, you all miss out on the opening! If a colleague across town is on the air, have a brief chat from time to time and compare notes, but always leave a few second's break between overs to let any possible DX break in. But *don't* chat on a calling frequency.

During an opening, don't forget to use your 'tools' to look further afield or for further developments. See if you can chart the progress of the MUF and take special note of the skip distance. Keep a map handy and ask each station for their location. Plot it on the map (dress makers' pins are great for this if you mount your map on a piece of softboard).

If you notice the skip distance shortening, use your auxiliary listening aids to find stations at higher frequencies around 2000km away, as mentioned earlier. With Es, the MUF cut-off is characteristically abrupt – it has been observed to cut-off in 100kHz or so.

If you use a small beam, either as the main station antenna or as part of your auxiliary tools, swing it through the four compass quadrants and tune around from time to time. You could get a pleasant surprise.

It's wise to keep a log, if not for QSL purposes, then for keeping notes. The notes may be as brief or as detailed as you see fit (but detailed is better). It's a good memory aid when going back over events and you learn from that. It's also good for comparing notes with others and as a good source of information to the various magazine columnists reporting on VHF happenings – provided you send them something! The published reports of such columnists have often been an important source of historical propagation data, both factual and anecdotal.

Whenever you're in the shack, always turn on the gear, especially if you have a scanner or other auxiliary listening aid. Tune around and give the occasional call, but remember that Es can occur at any time. Many a surprise DX contact has been had on an apparently 'dead' band. ●