An ear to the void

Following the lead of Project Ozma 17 years ago, astronomers are now searching seriously for signs of intelligent life in space. We should be prepared to receive the first message from the stars—or to send one of our own that will evoke a response

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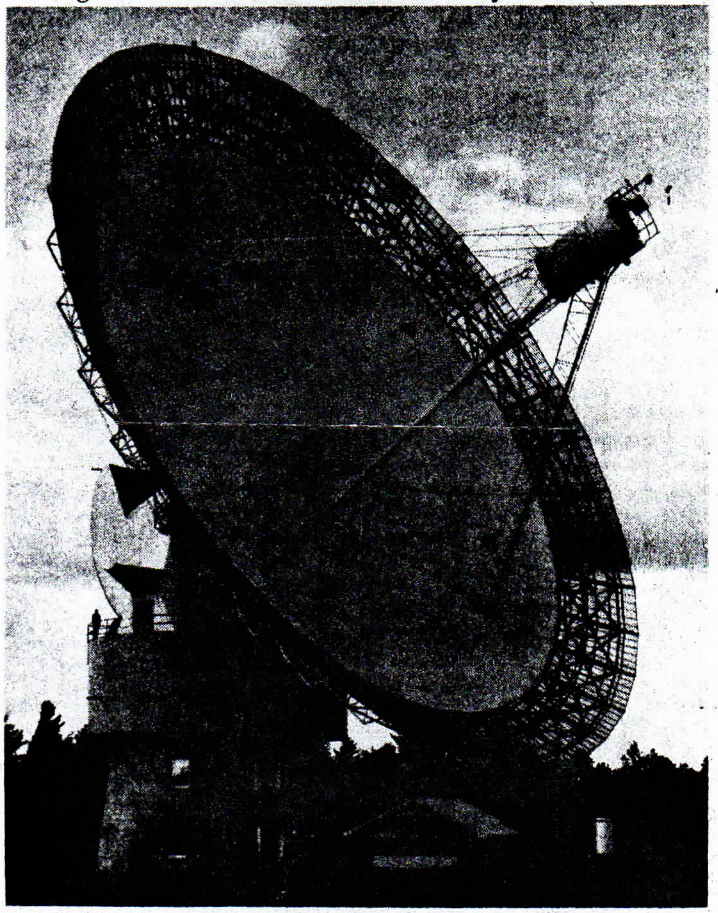
Mankind's quest for the first extraterrestrial message is now progressing on a broader front than ever before, at wavelengths ranging from radio to the ultraviolet, and with targets spread from nearby stars to other galaxies. This growing interest arises from the realisation that life elsewhere in the Universe could be very common indeed. Study groups of scientists, such as the Soviet-American congress on extraterrestrial life at Byurakan, Armenia, in 1971, have suggested that there could be as many as one million advanced civilisations in our Galaxy at present.

These estimates take into account the probable frequency of planetary systems, the likelihood that life can and will arise on one of these planets, and that it will grow to an advanced level capable of communicating with other civilisations. Even though a civilisation like our own (or in advance of it) may arise around only one star in 100 000, there are sufficient stars in the Galaxy—approximately 10^{11}—to make looking worthwhile. The stars most likely to harbour life are those similar to our own Sun.

The pioneer listening programme for extraterrestrial messages was Frank Drake's famous Project Ozma in 1960.



The 150-ft Algonquin radio telescope in Canada is being used by astronomers Alan Bridle and Paul Feldman to listen for radio messages from the stars at the wavelength emitted by water molecules (National Research Council of Canada)

Drake listened fruitlessly to Tau Ceti and Epsilon Eridani—the two nearest stars most like our Sun—for a total of 150 hours with the 85-foot radio telescope of the National Radio Astronomy Observatory at Green Bank, West Virginia.

Yet such is the pace of technological advance that five minutes of star-listening with the current Green Bank 140-ft telescope is equivalent to four days with the old Ozma equipment, according to calculations by the South African-born radio astronomer Gerrit Verschuur. He used the Green Bank 140-ft in 1972 for a 21-cm emission search of ten nearby stars, including Tau Ceti, Epsilon Eridani, and also Barnard's star, the second closest star to us and which is believed to have a planetary system. The previous year Verschuur had also snatched glimpses at Tau Ceti, Epsilon Eridani, and 61 Cygni with the giant 300-ft dish at Green Bank. "No signals of the order of one megawatt of power were being transmitted from a 300-foot diameter radio telescope orbiting any of the ten stars examined," he concluded.

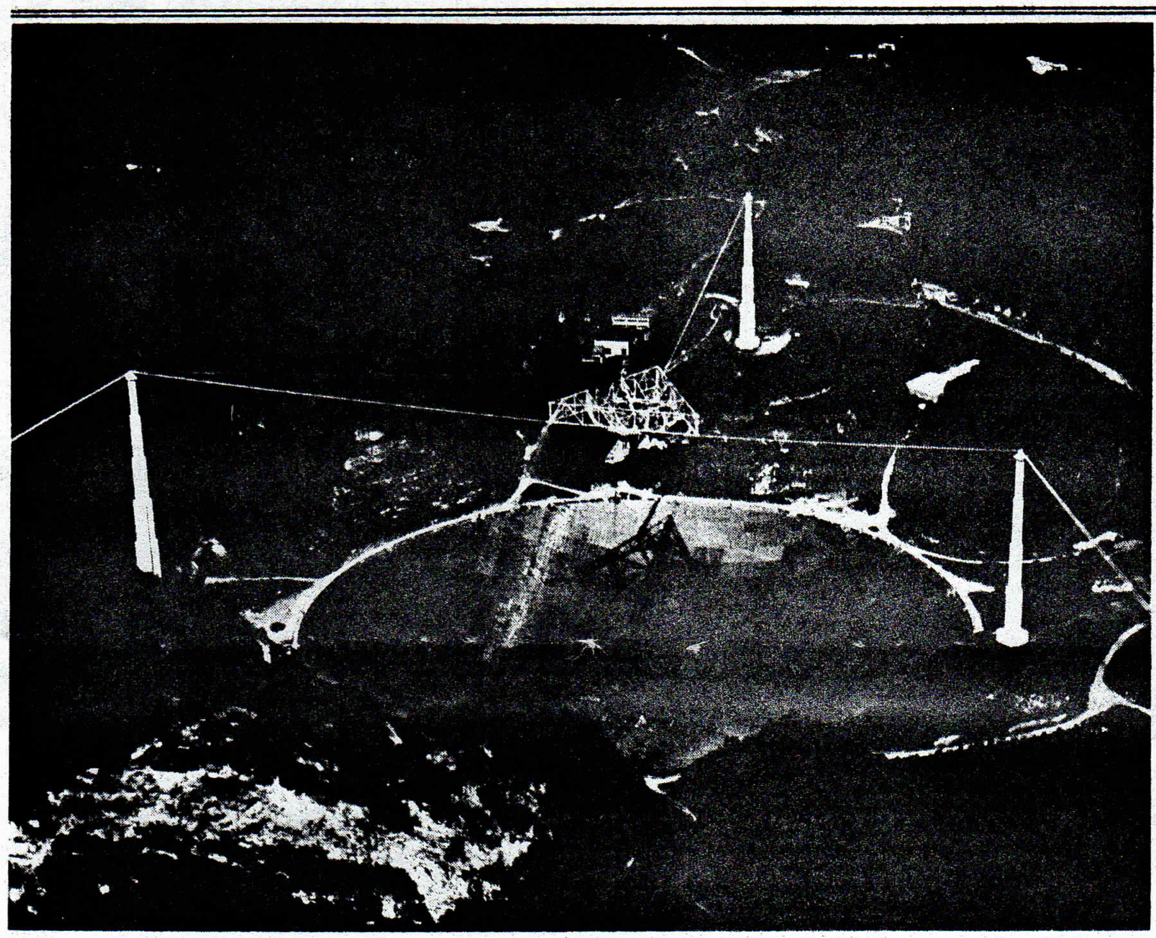
Astronomers have given considerable thought to the most likely channel on which an extraterrestrial civilisation would choose to communicate. The 21-centimetre line of hydrogen, the Radio 1 of the Universe, has long seemed the best bet—and, in any case, most radio astronomy receivers are already tuned to it. Recently, the discovery of numerous interstellar molecules has opened up several other likely frequencies, one of them being that emitted by the water molecule at 1·35 cm. Naturally, water-based beings might well favour such a wavelength (and transmissions at the ammonia wavelength would tell their own story . . .).

The first-ever search at the water wavelength is being undertaken with the 150-ft Algonquin radio telescope in Canada (see photo) by Bridle and Feldman. Their search began in 1974 with the examination of 13 stars and, although interrupted by equipment failures, they hope eventually to cover about 500 nearby stars like the Sun.

Bridle and Feldman, together with James Condon of Virginia Polytechnic Institute and State University, have also proposed a 21-cm search of up to about 50 nearby galaxies with the recently resurfaced 1000-ft Arecibo radio telescope in Puerto Rico. The three astronomers plan to use the new Arecibo 1000-channel correlator, which will give resolution of about 150 Hz per channel, thus enabling them to distinguish artificial narrow-band signals from the fuzzier emissions expected from interstellar clouds. Dr Feldman explains: "The unique feature of the experiment is that by pointing at galaxies, approximately 10^{11} stars are in the beam." Searching such an enormous number of stars simultaneously for a rare super-civilisation might produce quicker results than the slow sifting of nearby stars in our Galaxy for more modest transmissions.

At Easter 1975, Frank Drake and Carl Sagan began a more limited version of the same scheme by listening with the Arecibo dish to M33, a galaxy in our local group, in the hope, as one astronomer put it, "that a detection might come tumbling out". They are extending their study to other near galaxies, at wavelengths of 21, 18, and 12·6 cm.

The most radical avenue is that being explored by American electro-optical engineer Herbert F. Wischnia, a guest investigator on NASA's OAO-3 satellite, also called Copernicus, which since its launch in August 1972 has been



Left: The newly resurfaced 1000-ft Arecibo radio telescope is listening for transmissions from super-civilisations in nearby galaxies (National Astronomy and Ionosphere Centre) Below: Most stars in the Galaxy are arranged in a narrow band. Therefore we could transmit to most of the stars in the sky by regularly sweeping the plane of the Galaxy, like a lighthouse beam. Two lower-powered, omnidirectional antennas in space, each shielded from Earth, could cover nearby stars out of the galactic plane

providing valuable ultraviolet spectra of stars with its 32-inch telescope. For Wischnia, ultraviolet lasers present an effective and logical method of interstellar signalling. "Stars with a temperature near that of our own Sun radiate very little energy in the vacuum ultraviolet, so that the telescope receivers are not blinded by natural stellar radiation," he says.

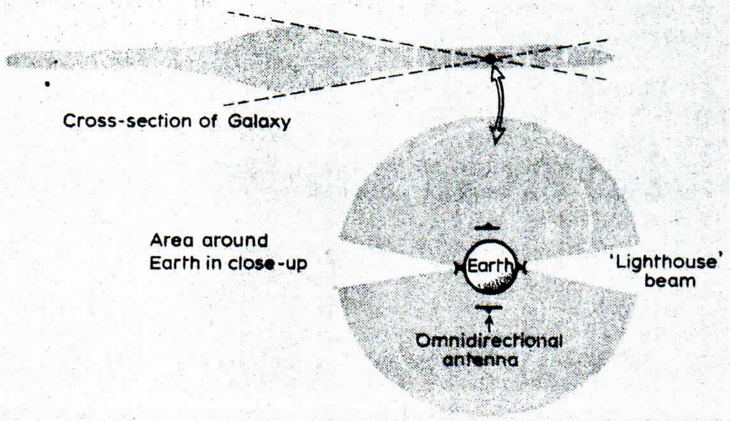
Wischnia made his first scans in November 1974, turning the Copernicus spectrometer for 14 orbits towards the nearby star Epsilon Eridani, 10·7 light years away and slightly cooler than the Sun. He has since scanned the stars Tau Ceti (11·9 light years away, similar to the Sun) the Epsilon Indi (11·2 light years, cooler than the Sun) in search of ultraviolet laser emissions, though without success.

The most comprehensive search of nearby stars in the Galaxy has just been completed at the National Radio Astronomy Observatory by Benjamin Zuckerman and Patrick Palmer, who began in 1972 to examine over 500 stars within 80 light years of the Sun, with the 300-ft Green Bank telescope. Zuckerman and Palmer estimated that they could take data 10 million times faster than in the original Ozma experiment, and they hoped to detect a civilisation with equivalent capability to our own—a 40-megawatt transmitter beaming through a 100-metre telescope—round any of the target stars.

Glitches but no beacons

In late 1975, they surveyed another 130 stars with the equatorially mounted 140-ft dish at Green Bank, bringing their total up to 659. The 140-ft was also used to resurvey 10 stars that, in the words of Zuckerman, "showed glitches". Some of these glitches were traced to terrestrial interference sources such as aircraft, while others remain a mystery; however, since they were unrepeatable they are unlikely to be due to interstellar beacons.

At Ohio State University, Robert S. Dixon has been con-



ducting continuous sky scans in search of possible 21-cm emissions from advanced civilisations since December 1973. Dixon's strategy is to tune to the exact frequency that would be received from a 21-cm transmitter at the centre of the Galaxy, as he believes that advanced civilisations would modify their beacon signals to eliminate the Doppler effects caused by motion of stars around the Galaxy. The telescope is the 100 ×31 m meridian transit instrument of collecting area equivalent to a 175-ft diameter dish, originally used for the Ohio Sky Survey. Dixon has so far scanned the sky between declinations +48° and +7°. "No objects have been discovered which we believe are emitting intelligent signals, within the constraints of our observations," he reports.

The lack of results to date is no surprise, since estimates suggest that we may need to search out as far as 1000 light years or so before intercepting the first extraterrestrial message. This means surveying perhaps 100 000 stars, rather than the less than 1000 already covered. Certainly, with the search for CETI (communications from extraterrestrial intelligence) advancing on a broad front, we should all be prepared for the receipt of that first message. What to do when that message is eventually received is a matter of current debate among scientists.

Soviet radio astronomers have been racing their American counterparts in the search for extraterrestrial communications. They were the first to follow up the lead of Project Ozma, when in 1968 and 1969 they searched a total of 11 Sun-type stars out to a distance of about 60 light years, at a wavelength of 30 centimetres. They also scanned the Andromeda galaxy, in case a super-civilisation of enormous power output were broadcasting there. The Soviet radio astronomers have since set up a network of aerials throughout the Soviet Union to detect sporadic emissions from space at wavelengths of 50, 30 and 16 centimetres.

In March 1974 a 10 to 15 year CETI programme was approved by the Soviet Academy of Sciences, split into two parts: CETI 1, from 1975 to 1985, and an overlapping CETI 2, from 1980 to 1990. CETI 1 includes all-sky monitoring from eight ground stations and from two satellites, plus studies of nearby galaxies. Features of CETI 2 are enlargement of the satellite antennae, and introduction of a pair of dishes of collecting area one square kilometre for examining selected objects.

The CETI programme recommends searching radio and infrared frequencies from 1 to 100 GHz. The new RATAN 600 radio telescope is planned to cover the wavelengths from 21 cm to 0·8 cm, and a millimetre-wave telescope is under development at Gorki for infrared studies. As well as searches of globular clusters and dense star fields of the galactic centre (both locations of old stars where we might find advanced civilisations), and galaxies of the local group, the Soviet CETI plans recommend monitoring "all appropriate stars" up to 100 light years distance, and eventually to 1000 light years. In future, Soviet researchers foresee automated probes being sent to investigate likely targets.

Of course, if everyone "out there" is listening without sending, then our own listening exercises become pointless and *we* should consider transmitting signals of our own. Already, the newly resurfaced 1000-ft Arecibo telescope can signal across the entire Galaxy. How would we—or a civilisation like us—go about setting up an interstellar beacon signal?

The simplest and most efficient way would be to sweep a lighthouse-beam of energy along the plane of the Galaxy, where most stars lie (see diagram). We could begin a limited form of such a system with current technology. The dishes, of the order of size of the big Jodrell Bank instrument, need not be fully steerable. Using 4 MW of power and a bandwidth of 1 Hz, we could be detected by existing terrestrial radio telescopes at distances of several hundred light years, or by larger collecting areas at distances of 10 000 light years or more. As our technology improved more dishes could be added and the power of the transmitters could be increased to send the message deeper into the Galaxy.

Radio telescopes in each hemisphere would sweep along the galactic plane every few minutes, transmitting in a noise-free band, such as the so-called water hole between the 21-cm and 18-cm emissions from H and OH. Anyone within the beam who is patient enough to listen to us for up to five minutes at a time (typically the length of time used by current signal-searchers) would therefore know that we are here. They can then lock on a reply beam to us, and two-way contact will become established.

To cover the full thickness of the Milky Way—about 20° —we would need to build up the system so that it became like an aperture-synthesis instrument aligned north-south. Such a transit radio telescope could have powerful astronomical uses; it could also be used to sweep for incoming CETI transmissions. Any number of countries could fix up their own dishes to sweep an agreed band of sky.

A number of civilisations in the galactic plane, not necessarily very advanced from our own, could be using this simple and efficient lighthouse-beam system at the moment—and we have the capability to detect and reply to them. We should therefore organise an international radio sky-survey project, like the *Carte du Ciel* of optical astronomy last century, with each nation allotted an area of sky whose solar-type stars they should survey at likely wavelengths for five to ten minutes at a time. After rechecking on each star for six months to a year, to take account of any possible eclipse of the transmitting planet by its parent star, we would know whether there were any beacon signals to be picked up.

The searchers should be encouraged in their task by the knowledge that the requirements of interstellar signalling are clearly not as extreme as some pessimists have declared. □

Teaching science – what is going wrong?

If "discovery" methods are to continue, pupils must be prepared so that they can use them correctly - which demands intellectual honesty from teachers and lecturers

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R. S. Peters said that the function of education was to produce an educated person. He then defined an educated person as one capable of constructive thought not only in those fields in which he or she had received specialist training, but in any other field of equivalent complexity. This could be rephrased to say that the purpose of education is to enable each pupil to become a thinking person to whatever level they are able by virtue of their individual capabilities.

From this it seems reasonable to define teaching as the process whereby the taught are encouraged to think constructively. It is a truism that any general population will contain a wide variety of abilities, and the attainable standards will be just as variable. If this is so, the concept of teaching as the instillation of information that has to be learned has a very limited range of validity.

Obviously the basic means of communication—reading, writing and elementary mathematical literacy—have to be instilled in such a way that they are automatic responses. This process is in itself not without problems! But once the basic literacies have been achieved to the highest standard with which an individual can cope, he or she must learn to use them constructively. No one could write a letter or keep track of their finances, even to the extent of counting their change, without this basic literacy.

Every subject has its own basic standard of literacy that must be achieved before meaningful progress can be made. No one can get far in studying a foreign language without learning the necessary vocabulary. A musician has to learn the basic scales, a geographer needs to understand that the Earth is round and that some places are hot and others cold. The historian has to be aware of the passage of time.