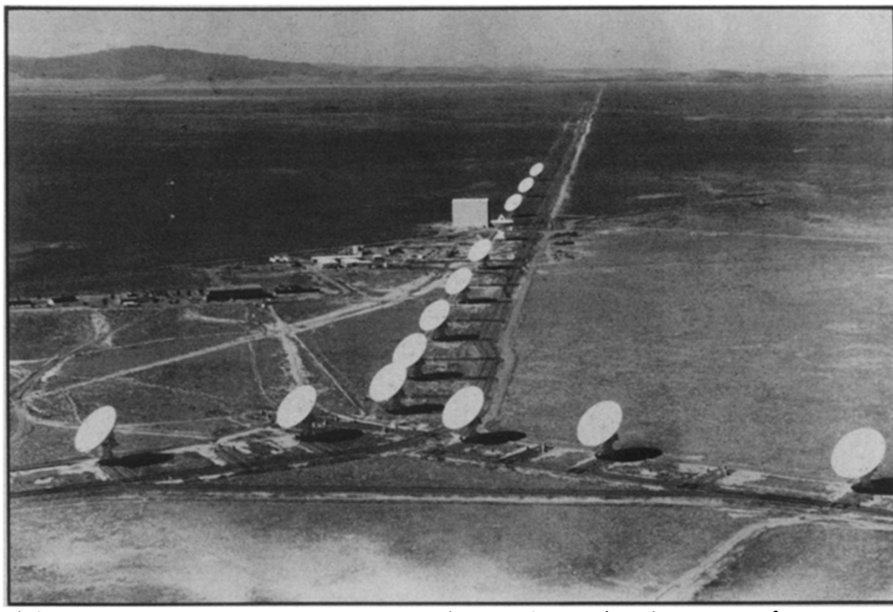
VLA Field Day

It was a warm day in January when 60-odd astronomers visited the Very Large Array



Illustrations: NRAO

A foreshortened array. Largest building is for erection and maintenance of antennas.

BY DIETRICK E. THOMSEN

"I think it's all papier mâché. I think all those papers that are coming out are hoaxes." So spoke an astronomer walking through the corridor at the recent meeting of the American Astronomical Society. He was joking, of course — or was he quite? It is hard even for experienced astronomers to truly assimilate the reality of an instrument like the Very Large Array of radio telescopes that stands on the plains of San Augustin in west central New Mexico.

Managers of many large astronomical observatories like to give occasional tours to visiting astronomers. It helps give the visitors, who are potential users, a feel for what they can do with the facility before they draw up plans for an observational program. It this case it may have meant even more. So, after the AAS meeting ended in Albuquerque, two busloads of astronomers with one SCIENCE NEWS reporter along set out for the VLA site. The route ran down the Rio Grande valley to the little town of Socorro, where the VLA's administrative offices are located.

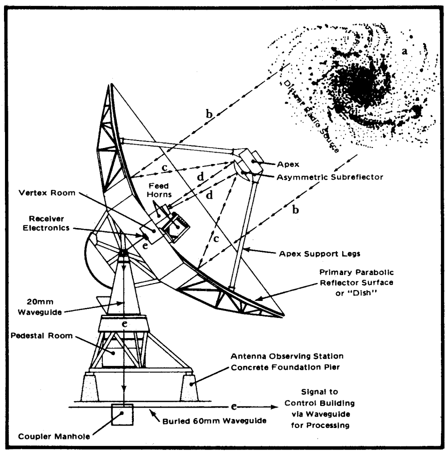
Socorro has the windswept appearance of so many far western towns. The houses and the few trees seem to huddle together for company against the wideness and openess of the landscape. The climb from Socorro to the VLA site leads past the village of Magdalena, which looks even lonelier amidst the landscape.

The Plains of San Augustin are an ancient lake bed at about 7,000 feet above sea level surrounded on all sides by mountains going as high as 10,000 feet. So flat are the plains and so complete the surrounding that drainage is a problem. When it rains shallow transient lakes appear here and there on the plain and persist for days.

The VLA is not a Potemkin interferometer. The 27 antennas that may be deployed at any one time may be white, but papier mâché they are not. From the center of the Y-shaped arrangement, they march off, 11.18 miles to the north, 13 miles to the southeast and southwest, like files of futuristic Dutch windmills, gleaming against the dunnish colors of the landscape. Some local residents have deplored the esthetic effect. A more serious complaint from neighboring ranchers is that the VLA's access roads make things easier for rustlers. The wild west never dies; it just adopts tractor trailers.

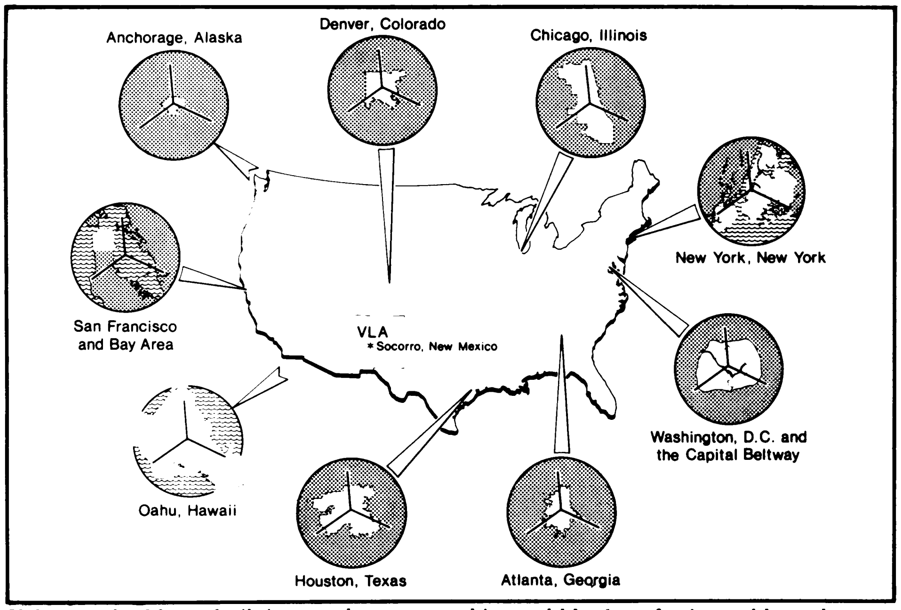
The location was chosen to be high, remote, lonely and bordered by mountains so as to minimize interference from terrestrial broadcasts and artifacts with the celestial emanations the VLA is made to observe. It does that. It also prompted comparisons by visiting astronomers. Over the bologna sandwiches at lunch came tales of the loneliness and altitude at places from Mauna Kea to Cerro Tololo to Sunspot, N.M., to interior Oregon. Perhaps one reason south central Arizona is a favorite spot for telescopes is that the astronomers can go home to Tucson when their observing is done. Most of the VLA staff choose to live in Socorro.

"A modern piece of astronomical equipment consists of a computer with a telescope attached." So runs another corridor comment. In radio astronomy the data never went directly from human retina to human brain for obvious reasons, but even in optical astronomy now the computer does everything but trigger supernovas. The VLA can be described as a complex computer system with 27 radio receivers hung at the foci of 27 reflecting dishes as its nerve endings.

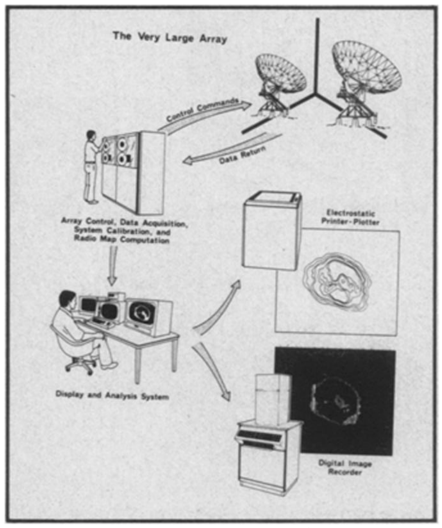


How an antenna observes a spiral galaxy.

Yet one should not neglect these nerve endings. It is at them that the physics and astronomy is done. Waves received from a given astronomical source at different points can be added together to give sum and difference waves. Generally the waves received at different points will vary in phase and in amplitude. Traditional interferometry, as this adding and subtracting of signals received is called, worked mainly with the phase difference. In visible light these differences produce a pattern of alternating light and dark lines called fringes when the addition of signals is visualized. The term is still used even though the work is mostly done with computers. Now more and more information is drawn



If the VLA *had been built in your hometown, this would be how far it would reach.*



Data flow from antenna to printer.

from amplitude differences as well as phase differences.

What comes out is geometric detail about the radio source: its shape and size and variations of brightness within it.

The usual interferometric set-up is a string of telescopes, any number from two to half a dozen or more, that may be anything from a few hundred meters to continents and oceans apart. These arrangements can give exceedingly fine detail, but they usually give it in one dimension only: along a line in the source that corresponds to the line joining the telescopes on earth.

The VLA was designed to get two-dimensional maps. Its Y shape, the daily rotation of the earth and various connections among the 27 antennas can be exploited to get a number of crisscrossing lines of information.

The resolution or the fineness of detail in the maps depends on the number and spacing of the antennas. To get different resolutions for different purposes the VLA was built with portable antennas. During observations each antenna sits on four pillars founded in the earth. For a change in the arrangement antennas are moved by specially designed transporters that run up and down the legs of the Y on double railroad tracks, spanning both tracks at once. Each antenna site is located at the end of a short spur perpendicular to the main track. The transporters do not use turnouts and gradual curves to get on the spurs as normal rail vehicles would have to. The antenna transporters lift themselves from the main rails, turn themselves 90° and set themselves down on the rails of the spur.

Interferometry needs precise time correlation. The data coming from each antenna must be labeled instant by instant so the computer can compare observations made at the same time. Otherwise the interferometric effect doesn't work. The visitors half expected to see some marvelous futuristic system for determining and counting the time. It isn't there. VLA's clocks are set to WWV just like a lot of other people's. That gives millisecond accuracy. For greater precision the broadcasts of the Loran navigation system from Searchlight, Nev., can give universal time to one microsecond accuracy.

The information trunks of the VLA are three waveguides running along the three arms. In these guides high-frequency radio waves carry both control impulses out to the antennas and data impulses back in a fast alternating sequence. Where it is desired to connect an antenna to these waveguides, a valve is inserted that literally lowers a metal scoop and scoops up some of the passing wave for the antenna in question. If data are being sent in at that moment the scoop adds a "certain amount of wave."

The three waveguide trunks run into the main control building and separate to go to the sections of the computing equipment responsible for them. Keeping track of the location of each antenna and sorting out its data is the work of the first part of the process. Then the data are added together in all possible combinations, and some on-line processing is done.

At this point either the observing astronomer or the telescope controller can order up a view of these partially processed data to check on how the program is going and whether any changes are necessary. Then the data go for off-line processing.

The control room for the VLA looks much more elaborate than that for a single telescope. It looks somewhat more like that of a small particle accelerator. That resemblance provoked comparisons and questions: "Are astronomers welcome in the control room?" Physicists doing experiments are definitely unwelcome in the control room of an accelerator. An accelerator's operation is precisely planned to do the best it can by 5, 10 or 15 simultaneously running experiments. An attempt by one experimenter to change that can cause mayhem. At the VLA only one observation can be going on at any one moment. The astronomer(s) responsible for that are therefore welcome in the control room, "provided they are good guys," and don't try to take control of the array away from the controller. Interaction between astronomers and controllers over the working out of a program and ways to improve it is welcome.

Where the astronomer is likelier to be is seated at the Interactive Picture Processor. This is a device that can produce maps, graphs, cross sections and pictures, made to order, from the information in the computer system's memory in response to requests written with a special pencil and pad. It is similar to one at Kitt Peak. In fact, the two are compatible and can exchange pictures. An IPP tends to fascinate astronomers who have never used one. If not at the IPP the astronomer may be at one of the other terminals where graphic or numerical data can be requested. It is at these points that the computer writes the bottom line to the whole operation. □