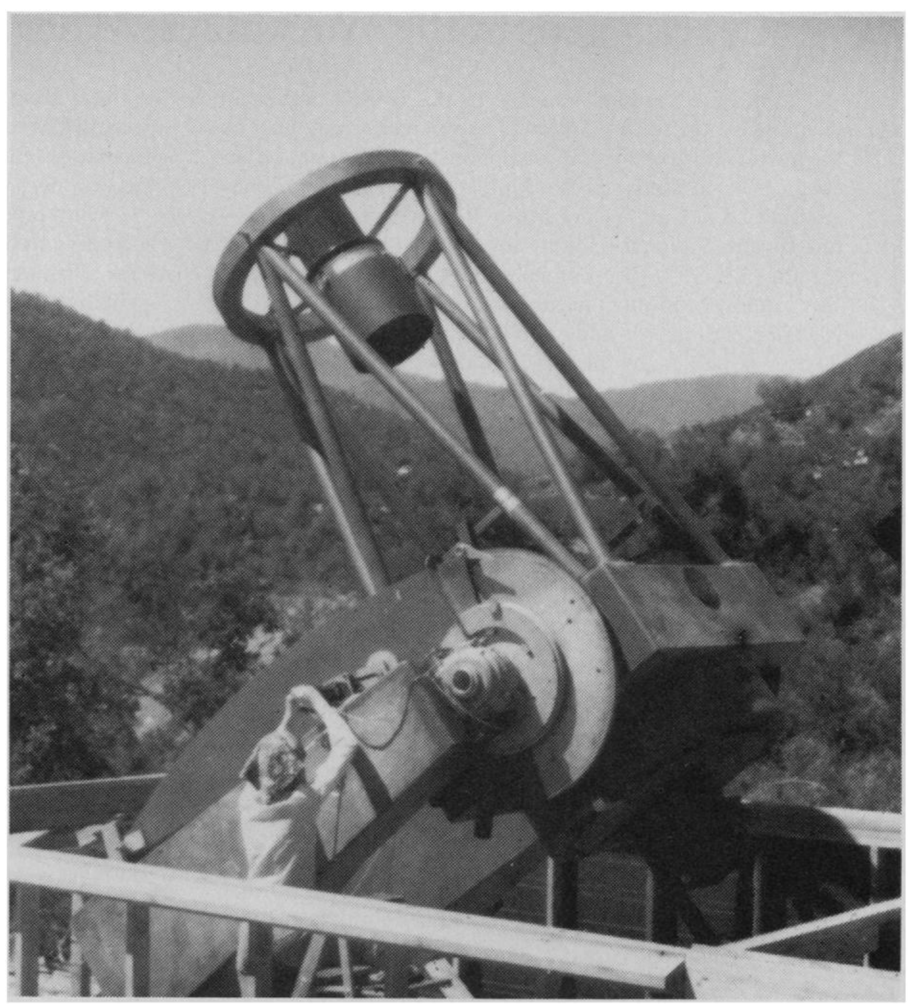
Alternative Astronomy: Experiment in Self-Sufficiency Blossoms

Half a dozen astronomy graduate students facing meager job prospects decide they would rather fight than switch. They drop out of the postdoctoral rat race, move to California, and establish a close-knit if impoverished community centered around astronomy. They build their own observatory complete with a telescope superior to those of many universities and incorporating the latest in modern electronic instruments, all the while maintaining their independence and doing without government grants. They undertake an ambitious research effort and win the respect, admiration, and even envy of prominent astronomers.

Monterey. It sounds like a fantasy, a dream conjured up on a high during a student party, but it is not. The young astronomers, spouses, and friends who comprise the Monterey Institute for Research in Astronomy (MIRA) last week installed a unique 36-inch telescope at a temporary site above the Carmel Valley. The instrument is of pioneering design, the fruit of 6 years of hard work, and is tangible evidence that the group has nearly succeeded in turning its bold dream into reality. MIRA itself is an improbable and unusual institution, stylistically akin to a counterculture cooperative but earnestly professional about its astronomy, a throwback at least in spirit to an earlier era when science was done for love and not for money. The research contemplated by the MIRA astronomers will not directly shed much light on quasars, x-ray sources, or the other remote exotica that now constitute high fashion in astronomy, but neither will it be trivial—a 5-year, 100,000-star spectral photometric survey of the brightest stars in the galaxy, for starters. The survey will help update the widely used Henry Draper catalog, on which stellar classifications are based, and will provide an unparalleled body of data on rare star types.

The origins of this venture in alternative astronomy are to be found in the unlikely precincts of the Warner-Swasey observatory of Case Western Reserve University in Cleveland, Ohio. The observatory is located in the suburb of East Cleveland, 4 miles from the main campus, on property that had been the residence of a telescope manufacturer and amateur astronomer before it was willed to the university. The relative isolation of the site contributed to an unusual closeness among the dozen or so graduate students who took most of their courses there during the day, used the telescopes at night, and spent a lot of time talking about the dismal job situation in astronomy. By the spring of 1971, the crunch between the leveling off of federal money for science and the explosion of student enrollments had begun to take hold—in astronomy as in many other fields—leaving many young astronomers jobless and bitter and propelling others into itinerant careers composed of temporary appointments, limited observing opportunities, and continuous uncertainty. The Case Western students saw the writing on the wall all too clearly—the faculty was not aggressive in seeking positions for their astronomy graduates, and they could not command the prestige of someone trained at a Caltech.

Craig Chester, one of the MIRA principals, remembers that the best he could look forward to seemed "a crazy life unrelated to why I was originally interested in astronomy." He and Bruce Weaver, another MIRA mainstay, brought up the idea of buying their own telescope, even if it were only a small one of the type sold to amateurs and hobbyists, so that they could maintain some contact with hands-on astronomy. Within a few weeks, the idea had escalated into the more ambitious one of building a complete observatory and thereby creating their own jobs. As the participants remember it, things came to a head one spring evening in May 1971, when six graduate students, two wives, and a roommate—the group that later became MIRA—met with a few others to talk over the idea seriously. They began to consider locations, means of supporting themselves, and telescope designs. They assessed themselves $100 each and $20 a



MIRA telescope at temporary site near Carmel Valley, California.

month to cover expenses and to start a mail-order, discount bookstore as a source of income. They pledged themselves to the project for a minimum of 2 years past their Ph.D.'s (a naive estimate of the time required, it turned out).

In March 1972, MIRA was incorporated as a nonprofit institution in California. The group dipped into their savings to make a down payment on 80 acres of land for auxiliary buildings near their intended observatory site in the Los Padres National Forest. The advance guard of the group—Weaver and Albert Merville and their families—moved to Monterey and found part-time jobs. By this time word of their intentions had begun to circulate through the astronomical community, and they were invited to give a presentation at the 1972 meeting of the American Astronomical Society. Through the auspices of Martin Schwarzschild of Princeton, they were able to borrow for an indefinite period an unusually high-quality 36-inch mirror, intended as a backup for a National Aeronautics and Space Administration (NASA) project but never used. The loan of the mirror propelled the group to upgrade their ambitions still further and aim for an observatory capable of making full use of the reflector's potential. It also set the style for many of their subsequent acquisitions, from electronic detectors to computers to the design of the telescope itself, all of which MIRA has obtained as gifts or for nominal sums. By the end of 1974, when all nine members had arrived in California, MIRA had landed a $76,000 grant to cover construction of the telescope from a private foundation, the Research Corporation, and had accumulated through donations new and used equipment worth more than $100,000. Monterey had become the scene of an experiment in finding new sources of support for basic science.

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The beauty of the Monterey area is justly famed. The spectacular coastline has long been a magnet for visitors and wealthy residents. Hunters and backpackers have known the nearby Los Padres National Forest and Ventana wilderness, now largely blackened by last month's huge fire, as one of the most rugged and untouched in California. There is another scarce natural resource, less widely appreciated, to be found here in more pristine form than anywhere else in North America, and that is the sky. More precisely, it is what astronomers call the "seeing," a measure of the clarity and lack of turbulent distortion of the atmosphere. The prevailing winds blow in off the Pacific, where there are no mountains to cause turbulence in the upper air and where the cold California Current flows along the coast, contributing to an arid, even climate. With no major cities or heavy industry, the dry, stable air above the inversion layer remains largely undisturbed by plumes of smoke and smog. At an altitude of 5000 feet on the summits of the coastal range, nighttime clouds are rare and the seeing is so good that distortions of less than 1 second of arc are frequently obtained. On the basis of detailed measurements, astronomers from the University of California's Lick Observatory describe the

Carcinogens in the Workplace: Where to Start Cleaning Up

The most hazardous industry in the United States, in terms of exposure of workers to carcinogens, may well be the manufacture of scientific and industrial instruments, according to a study prepared by John Hickey, James Kearney, and their associates at Research Triangle Institute for the National Institute for Occupational Safety and Health (NIOSH). The fabricated metal products industry was rated second most hazardous, and the manufacture of electrical equipment and supplies third. The chemical industry, which many people would consider an odds-on choice to head the list, was ranked a lowly 12th.

The study* was designed as a first step for controlling exposure of workers to carcinogens. But because of NIOSH's limited resources, it was first necessary to identify those industries where the potential hazard is the greatest, and therefore where the maximum effort should first be exerted.

The rankings in the study are based on two separate sets of data: the total amount of exposure to carcinogens, and the relative potencies of the carcinogens. The relative potencies of the carcinogens were estimated as accurately as possible from a comprehensive search of the available literature. The ranking for carcinogenic potential took into account the time required for tumors to appear after exposure to the carcinogen, the minimum amount of carcinogen required, and the method of administration. Some of the available data about individual carcinogens are contradictory and some are incomplete; most of the information, furthermore, is based on studies with animals. Each of these areas represents a potential pitfall of the study, particularly the need to extrapolate animal data to human exposures. But the data used, the report emphasizes, are the best now available.

The investigators ranked some 86 industrial chemicals according to their carcinogenic potential. The ten most potent chemicals, the report concludes, are *N*-nitrosodiethylamine, thallium, chromium, asbestos, nickel, coal tar pitch volatiles, methyl methane sulfonate, acetamide, yellow OB, and ethylenimine.

Information about the exposure of workers to carcinogens was obtained primarily from NIOSH's National Occupational Hazards Survey (NOHS). For this $6-million, 3-year study—which has not yet been completely published—a group of engineers went to manufacturing facili-

**The Development of an Engineering Control Research and Development Plan for Carcinogenic Materials* (Government Printing Office, Washington, D.C., in press).

Table 1. The most hazardous industries and some of the carcinogens used in them.

Industrial and scientific instruments (solder, asbestos, thallium)
Fabricated metal products (nickel, lead, solvents, chromic acid, asbestos)
Electrical equipment and supplies (lead, mercury, solvents, chlorohydrocarbons, solders)
Machinery except electrical (cutting oils, quench oils, lube oils)
Transportation equipment (constituents of polymers or plastics, including formaldehyde, phenol, isocyanates, amines)
Petroleum and products (benzene, naphthalene, polycyclic aromatics)
Leather products (chrome salts, other organics used in tanning)
Pipeline transportation (petroleum derivatives, metals used in welding)

mountains in northern Monterey County as the best remaining astronomical site in the United States, excepting possibly Hawaii.

It was these considerations that weighed heavily with the MIRA group in choosing to settle in Monterey, although they were not unaware of the region's more conventional attractions. Equally important, however, was the proximity to the library and professional stimulation of a major observatory (Lick) and to the technical resources of the burgeoning electronics industry concentrated in what is aptly called Silicon Valley, on the San Francisco Peninsula just an hour's drive to the north. Having settled on an area, the group spent days poring over topographic maps in the Cleveland public library. They came up with three potential sites, but only one seemed to meet all their needs. Chews Ridge, in the northern portion of the Los Padres forest, was potentially accessible, near an existing road. It was not in a wilderness area or near any known Indian ruins. The reach of the national forest, especially to the south and west of the site, guarded against any further development and hence seemed to guarantee a dark sky. And there was what Chester describes as the "comforting presence" of a Forest Service fire tower a half-mile away on the other end of the ridge, a sentinel to ward off unknown dangers. What with hikers of all descriptions prowling the woods and trigger-happy hunters taking advantage of the year-round season on wild pig in the Los Padres, this last would prove to be more than a fanciful concern.

The top of Chews Ridge, at least prior to the fire, was surrounded by dense chaparral, a nearly impenetrable brush that tore at the clothes of a MIRA scouting party sent out from Cleveland in the spring of 1972 to confirm the site choice. They found the site ideal and filed an application with the Forest Service for a use permit. Some 22 months later, and after a careful but persistent campaign by the astronomers to nudge their petition through the bureaucracy, the Forest Service agreed. MIRA was in fact fortunate, because a similar application by Lick for a new observatory has languished for years. The Lick site is in a neighboring portion of the Los Padres forest that has been proposed for inclusion in the Ventana wilderness, and the Sierra Club is opposing the construction of any roads or other facilities that might lessen the chances of obtaining the wilderness designation. A graded dirt road to the MIRA site proved not to be a problem, and in fact appeared gratis—an Army engineering battalion stationed nearby happened to be looking for a training project.

Choosing a site for an observatory that is to operate for many years is a chancy business at best. Observing conditions change, and even the most promising site is generally regarded by astronomers as uncertain until proved by years of use. But omens are not to be disregarded in this business, and Chews Ridge provided one that the MIRA astronomers found very reassuring. The first occasion when they actually saw the night sky from their observatory site was on 30 August

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ties throughout the country to determine, among other things, how many workers in each type of plant are exposed to chemical agents, what those agents are, how the exposure occurs, and the length of the exposure. Data from this survey were then combined with data on carcinogenic potential to produce two new lists, one ranking carcinogens by a combination of exposure and potency and the second ranking industries by the amount of exposure to carcinogens and suspected carcinogens.

In the first case, the investigators combined potency, amount of exposure, and annual production to conclude that the ten most hazardous industrial chemicals are, in order, asbestos, formaldehyde, benzene, lead, kerosene, nickel, chromium, coal tar pitch volatiles, carbon tetrachloride, and sulfuric acid. Similarly, the potency of the materials and the amount of exposure to them was used to rank American industries (Table 1).

The new results differ from the conclusions of previous studies, Hickey tells *Science*, because those previous studies generally considered only the volume of the carcinogens and not the amount of exposure. Previous studies have ranked the chemical industry very high, for example, because it manufactures hazardous materials in lots of tons or more. But the large quantities of materials may actually be manufactured by only a very small number of people, so that consideration only of the volume of carcinogens grossly overestimates the potential hazard.

In contrast, Hickey says, the manufacture of scientific and industrial instruments requires relatively small amounts of carcinogenic materials. But these materials are used in the hand fabrication of devices, so the total exposure—and thus the total risk—is very high. The fabrication of metal and electrical products both rank high for the same reasons. Hickey emphasizes that the total amount of hazard is very similar in the top ten industries, and the actual rankings could be altered by undiscerned factors such as the discovery of previously unrecognized carcinogens. But there seems little doubt, he adds, that these are the industries where research and cleanup efforts should first be directed.

The single most severe problem in many industries, the report says, is the presence of carcinogenic dusts in the workplace. These occur in the dry mixing of paints and pesticides, for example, and in many other processes where solids must be mixed. A major effort is thus needed, according to the report, to develop new ways to enclose the entire system of dry materials production, mixing, and transfer.

Another severe problem that seemingly could be easily solved is better venting of areas where carcinogens are used. In many cases, the report says, the venting system now in place does little good and, in some instances, it even blows carcinogens back in the faces of the workers. More attention apparently also needs to be given to the use of masks and protective gear now used only infrequently.

It must be emphasized that the Research Triangle Institute report is basically a library study. The investigators neither visited factories nor tested potential carcinogens. They also did not use any data about occupational cancer in the studied industries; many of the most potent carcinogens, in fact, have not been in use for the 25 to 30 years that would be required for cancers induced by them to begin showing up. It is also possible that better controls have been established in some industries since the NOHS study was conducted. Nonetheless, the results will give NIOSH a good idea where to begin emphasizing control procedures. The study should also give pause to many executives who now think they run clean industries.

—THOMAS H. MAUGH II

1975, after the road was in. They looked up to discover a new star in the Northern Cross—Nova Cygni, seen all over the world that night—the first naked-eye nova in 30 years.

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Naked-eye astronomy was not what the MIRA group had in mind as a principal mode of operation, but it has had to sustain them through a long struggle to design and build their telescope. In part the delay was due to their own ambitions, now very considerable—they intended to build the most modern and advanced instrument of its size in the world. MIRA hoped to prove that an inexpensive small telescope of high quality could help the have-nots of the astronomy community to compete better with the haves—the possessors of the huge telescopes that have dominated research in recent decades—and they intended to offer their design as a model.

It is not an entirely vain ambition. Small and intermediate-size telescopes are in fact undergoing something of a renaissance, making discoveries that a few years ago were not possible even with the giant 200-inch telescope on Mount Palomar. Not long ago, for example, several investigators had tried repeatedly but in vain with the 200-inch to measure the spectrum of light emitted from a particular dwarf galaxy in the Virgo cluster. Recently one of the investigators, Francoise Schweizer, was able to make the measurement with a 60-inch telescope at the Interamerican Observatory near Cerro Tololo, Chile. What made the difference was a new electronic device for sensing starlight, one of many now coming into use. The impact of the electronics revolution in astronomy is transforming the potential of large and small telescopes alike; it will not reduce the advantages of the Palomar giant, but it has given a new lease on life to its smaller cousins.

A telescope can be thought of as a device for collecting and concentrating the photons emitted by a star. The larger the telescope, the more photons from a given object can be focused on the eye of an observer and hence the brighter the object appears. Traditionally astronomers have recorded these photons on photographic plates, darkening the plate with exposures of an hour or more for faint objects. But the efficiency of the photographic process left much to be desired. Typically, less than 1 percent of the photons actually registered in the emulsion. With modern emulsions this figure has improved somewhat, but really dramatic steps have come with the accelerating use of electronic devices to detect the incoming light and amplify the resulting signal. These devices range from television tubes to semiconductor chips, and they have in common photon collection efficiencies much higher than those of photographic emulsions. In some cases they count and record the light nearly photon by photon, extending the light-gathering power of a telescope manyfold over that of photography. These new sensors make possible such things as sky subtraction, a technique pioneered by Lick Observatory in which the spectrum of the background light reflected into the telescope by the night sky is deducted from the observational signal of an astronomical object; with the background removed, the properties of objects heretofore too faint to be observed can be determined.

The benefits of these improvements have so far been confined largely to the major observatories, with the result that the promised renaissance has been slow to arrive at many smaller university observatories equipped with modest telescopes. The MIRA telescope is in fact one of the first small telescopes built specifically to exploit the advantages of computer control and electronic sensors. That a group of young astronomers without experience in telescope design could bring it off, as they appear to have done, is due to their nearly uncanny ability to enlist volunteer aid from some of the best talents in the astronomical community, as well as their own skill and perseverance.

An initial difficulty was that posed by the architecture of the 36-inch mirror. In the NASA experiment for which it was originally built the mirror was to have been used intact. For use as the primary mirror in a conventional telescope, however, it required a circular hole in its center through which light reflected first from the primary and then from a secondary mirror could pass—the so-called Cassegrain focus. But cutting a hole in a mirror after its surface has been ground and polished is a risky venture that may unleash pent-up stresses within the glass, changing its shape and destroying its optical quality. Weaver asked the Optical Sciences Center of the University of Arizona, one of the best in the country, if they would cut the hole, and they agreed to undertake the project for nothing, but with no guarantee that they would succeed. It was a tense moment, and the MIRA astronomers say that it will be a long time before they forget the strain of waiting to hear whether their ambitions had evaporated overnight. The mirror survived the operation with its unusually good optical "figure" unharmed.

The mechanical elements of the telescope came next. The MIRA astronomers plodded along on the design for a while themselves—"learning how much we didn't know," one of them says. Then they met Frank Melsheimer, an experienced telescope designer, and got him so interested in their project that he contributed his services essentially free. Melsheimer is a mechanical engineer who is also versed in electronics, optics, and computer techniques and is an amateur astronomer as well. He was then on the staff of Lick Observatory and had just finished designing a new 60-inch telescope for them—the one intended for the not-yet-approved site in the Los Padres. Working on his own time, he modified the design to fit MIRA's needs, including a novel driving mechanism capable of moving the telescope from one position to another in a matter of seconds.

Money to build the telescope came from a Research Corporation grant on the strength of endorsements by several prominent astronomers, including Bart Bok of the University of Arizona, who was at the time president of the American Astronomical Society. Bok had been an enthusiastic supporter of MIRA from its inception, and he and his wife also donated their astronomical library to the new institution. Fabrication of the telescope was undertaken by Melsheimer's brother Tom, owner of a firm specializing in heavy steel construction. Because the two brothers could communicate specifications with sketches and shorthand notes, MIRA was able to bypass formal engineering drawings at a saving of an estimated $30,000.

The MIRA group developed their own computer control system for the telescope, which is capable of completely automatic operation, using hardware donated by a variety of firms. The five microcomputers in the system, for example, came from a major semiconductor manufacturer whose vice-president is an amateur astronomer; he heard of MIRA through friends and called up to ask, "Is there anything I can do?" Other equipment, such as the minicomputer that will eventually oversee the automated operation of the telescope and analyze the observational data, was the product of persistent solicitation by the MIRA group, some of whom have become very polished at asking for gifts.

Construction of the telescope was completed this summer. The MIRA astronomers, ecstatic at getting their hands on a telescope after what has been for some of them five long and fallow years, are tuning the instrument and conducting shakedown tests. They are also finishing the instruments and sensors that will be attached to the telescope. These consist of a spectrometer to sort out the incoming light by wavelength and a detector known as a Reticon, a linear array of supercooled silicon diodes that will count the number of photons received in each of 512 regions of the spectrum. As many as 85 percent of the photons striking the diodes produce an analog electrical impulse, which is then amplified and converted to a digital computer record. In combination, the two instruments will allow MIRA to make quantitative spectral measurements of starlight—spectral photometry—with unusual precision.

The system is well adapted for MIRA's planned survey of the Henry Draper stars, a project which the young investigators see as a way of paying their dues to the astronomical community. The original Draper study of 250,000 bright stars in the portion of the galaxy nearest the sun was done in the early decades of this century and became part of the basis for the present classification of stars into spectral types. Draper classified stars according to their temperature and later surveys recorded size or luminosity as well. Nancy Houk of the University of Michigan is now resurveying these stars—a 10-year project—recording their spectra on photographic plates as a step toward revising the several hundred recognized categories of stars. The MIRA work is to complement and extend this qualitative, spectroscopic survey by providing quantitative, photometric data that may show more subtle differences between types of stars. MIRA will be able to determine the abundance of heavy metals in the stars and their relative brightness or distance. Even with exposure times as short as a few minutes per star and with automated operation of the telescope, the MIRA astronomers expect the project to occupy half of their observing time for 5 years. Later they expect to apply the wealth of data to such problems as stellar evolution and the local structure of the galaxy, which is not well known. This is not glamorous astronomy, in today's terms, but the group is confident that by applying modern methods to classical problems they will come up with some surprises.

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There are two reigning styles in astronomy in the United States. One is to be found in large, private institutions such as the Hale Observatories of the Carnegie Institution of Washington and Caltech, which over the years have successfully cultivated wealthy patrons and thus have the facilities and resources to make available to their staff members hundreds of hours of observing time per year. This abundant access to telescope time has an influence on the type of research that can be conducted; Hale, for example, has pioneered in the time-consuming field of cosmology. A second and newer style has been engendered by the federal government's support of big astronomy and the creation of national observatories open to any investigator. Competition for access to national telescopes is intense and time is usually allocated in brief chunks—10 to 20 hours over a few nights. There is considerable pressure for astronomers using the national observatories to choose projects likely to yield a publishable result quickly.

As graduate students, the MIRA group became all too familiar with the frustrations and uncertainties of dependence on federal support for their research. Determined to avoid that dependence if at all possible, they chose to follow the older model and, as Hale and others before them had done, to create their own private institution. (Like other private observatories, MIRA plans to make some telescope time available to outsiders.) But if MIRA is in part a throwback to an earlier era, it is also clearly a creature of the 1970's. MIRA, for example, functions as a cooperative. The nine members of the original group* comprise the board of directors and all nine names are on the deed for their land. There is no preeminent individual and decisions are arrived at jointly in the course of lengthy meetings, somewhat in the town-meeting style of direct democracy practiced by many counterculture organizations. There is also some sharing of economic fortunes. The nine are equal partners in their mail-order book service, Omnibooks, which is legally distinct from MIRA but uses the observatory computer, and there have been some informal "loans" from members of the group with full-time jobs to those working nearly full time on the observatory. The group is also close-knit socially but, conscious that Monterey is a conservative community and eager to be taken seriously by the astronomical world, they are very careful to avoid the word commune.

In the early months of the group's existence in Cleveland, they did toy for a while with the idea of establishing a rural commune. But after some investigation of rabbit farming and similar livelihoods, they rejected subsistence agriculture on the grounds that it was too time-consuming to allow for astronomy. The loan of the large mirror and the venture's enthusiastic reception by the astronomical community buried what was left of the idea. In fact, MIRA has been successful beyond the group's expectations, and several members say that they feel considerable pressure to live up to the expectations of those who have supported them.

The source of that support seems to have been their ability to convince people that they were serious. Schwarzschild remembers that when the group came asking for the mirror, "they were clearly a serious bunch, devoted to astronomy despite the difficult circumstances in which they found themselves personally." Bok, who has been MIRA's longest and most ardent supporter, says that he was originally impressed because "they showed a great deal of imaginative initiative." Bok adds that he had been afraid the group would split up after a year or so, as many communal efforts do. "What has amazed me is that they have stuck together," he says, and he finds it "remarkable that they have seen it through on their own."

The MIRA group has in fact survived economic stresses and work schedules more severe than those on which many a rural commune has foundered. To support themselves, members of the group work at jobs ranging from computer programming to part-time teaching at Soledad State Prison to running the front desk at Asilomar State Campground. Their incomes average $7500 apiece and have often been less. Most evenings and weekends are spent working on MIRA or on Omnibooks, which is just beginning to return a profit. They raise additional money for MIRA by selling time on the observatory computer. The nonastronomers of the group are active participants in the venture. Sandra Weaver did the legal research for MIRA's incorporation and is now taking over as the institution's treasurer, in addition to a full-time job in the county welfare department.

The long hours take their toll. Hazel Ross—a native of Scotland and the mainstay of the Omnibooks operation—says that she tries not to think about the fact that she must spend a large part of every day in a monotonous job, just to support herself, because it is too depressing. "Graduate school was a picnic compared to this." Others in the group admit to cyclic bouts of the blues over how long it is taking to reach their goals—"Soon, dammit, soon!" one put it.

The astronomers of the group give different reasons why they decided to commit themselves and their professional careers to the project. Cynthia Irvine remembers that for her, at least, it seemed clearly better than the alternative of

(Continued on page 1305)

*Astronomers in the MIRA group include Bruce Weaver, Craig Chester, Albert Merville, Hazel Ross, Cynthia Irvine, and Nelson Irvine; the other members are Sandra Weaver, Ann Merville, and Donna Burych.

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abandoning her career altogether. "What did we have to lose? At least we would have tried once in our life to make it on our own." Others did see a substantial risk, particularly some of the older members of the group, who might now have difficulty finding another job in astronomy. Merville says that a major factor in his decision was that he had known all of the people involved for several years under conditions of some stress and "I felt I knew how they would perform, that the personalities were compatible." Ross recalls that "the founding motivation was practical; we felt that it was better to hang together than separately," and besides, she liked the idea of independence from the government and other institutions.

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MIRA is in fact very near to achieving its goals. Its major needs now are money to build the permanent observatory building and some further improvement in the bookstore business so that it can begin to support the group. By one measure MIRA has already proved itself a viable astronomical institution—it has begun to attract additional recruits. Despite the fact that MIRA could offer him no support, Lee McDonald, a recent graduate of Lick, decided to come to work for MIRA rather than take one of several possible jobs at other observatories, because he liked the prospect of long-term research projects, more telescope time, and fewer "bureaucratic hassles."

The MIRA principals believe that their do-it-yourself model could be applied to other areas of science where there is also a shortage of jobs in traditional institutions. In any case MIRA is, as Bok puts it, "a very interesting experiment, and so far a successful one." The MIRA experience would seem to prove that there is still room for the initiative of individuals in this era of big science: that the Horatio Alger character is not dead, so to speak, but has just dropped out and is living in Monterey disguised as an astronomer.—ALLEN L. HAMMOND