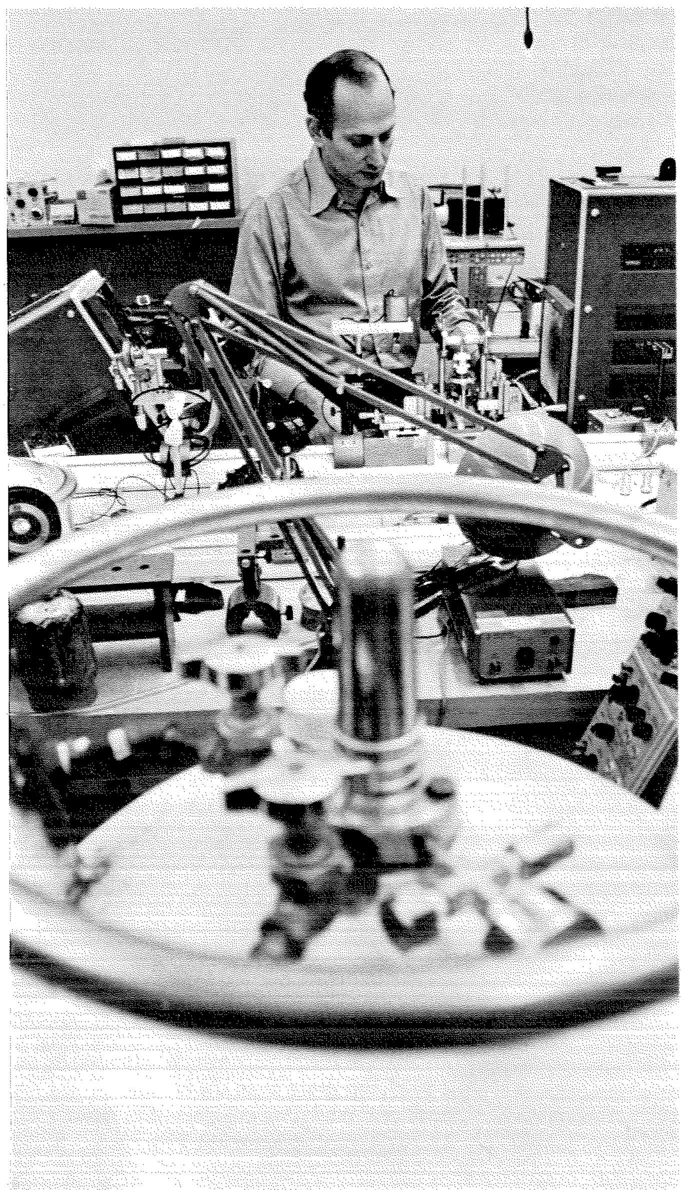
A Revolution in Communications



Amnon Yariv and his Caltech co-workers are producing small, simple devices to process light the way electronic circuits now process electricity.

Ours is a civilization based largely on the ability to communicate, process, and use vast amounts of information. But our communication needs, and the volume of information we produce, keep outstripping our capability to cope with the load.

Miniaturization has saved us in the past. Transistors and integrated circuits have made it possible for us to build extremely small electronic devices, which in turn let us handle more and more information in less and less space. But now it is clear that we are going to have to find a new way to handle even more information.

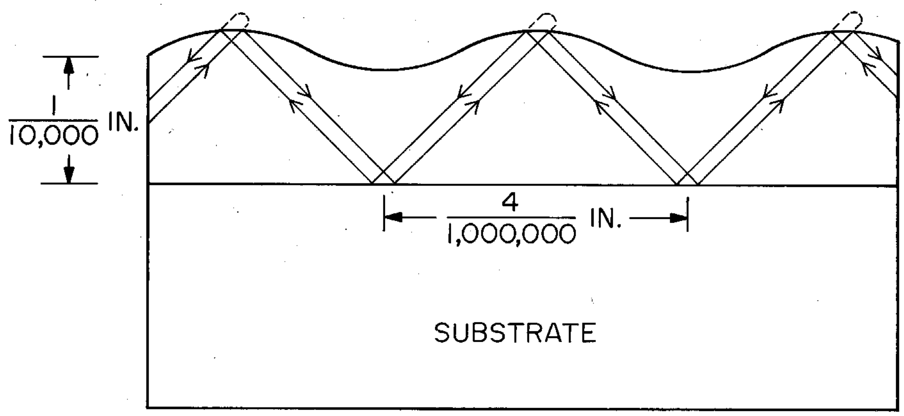
Light waves, in theory, can carry 10,000 times more information than electrical signals in electronic circuits. Today, the shafts that carry telephone, computer, and radio messages in skyscrapers are often as large as those needed for elevators. But "optical cables" of glass or plastic, carrying information-laden laser light, could handle the same amount of information in about one square inch of space.

For such a laser communication system to work, miniaturized optical terminals are needed to launch, remove, distribute, and otherwise process the light as it travels through the optical cables. But this requires a new technology that does not now exist—integrated optical microcircuits.

Amnon Yariv, professor of electrical engineering, and a group of co-investigators at Caltech have worked for almost five years to develop such an optical circuit. Already the team has developed detectors, switches, amplifiers, couplers, and the like to duplicate for optics the array of components available in integrated electronic circuits. Now, with the construction of the latest and most crucial element, the researchers have demonstrated that optical microcircuits are a practical possibility within the near future.

Their latest achievement is probably one of the world's smallest lasers. It uses tiny surface corrugations for continuous operation rather than end mirrors. A step toward reducing the size of present optical systems, this miniaturized corrugation laser is less than an eighth of an inch long, four-hundredths of an inch wide, and ten-thousandths of an inch thick.

Instead of mirrors, the laser uses a grating of 27,000 corrugations, each four-millionths of an inch wide, etched on the upper surface of a thin-film waveguide made of gallium arsenide. These corrugations reflect light back and forth until it reaches the proper power and intensity—lases. This occurs because the depth of the waveguides is so small that the corrugations exert a strong influence on the light traveling in the guides. If the light has the



CORRUGATION LASER

The corrugation laser is a crucial element in optical microcircuits. One of the world's smallest lasers, it is less than an eighth of an inch long, four-hundredths of an inch wide, and ten-thousandths of an inch thick. Instead of mirrors, it uses a grating of 27,000 corrugations, each four-millionths of an inch wide, to bounce light beams back and forth until they lase.

right mathematical relationship to the corrugations, its direction is reversed; that is, it is reflected as if there were a mirror in its way.

The corrugation laser was originally devised because it is amenable, like transistor circuits, to photolithographic fabrication techniques. These processes, which are something like those used to develop photographs, are what makes it so easy to mass-produce transistors. But the corrugation laser is also potentially more efficient, and this may provide the solution to one of the problems that has dogged the designers of lasers for optical communications: the unreliability of traditional gallium arsenide lasers. The enormously high currents required to trigger laser action cause destructive heating that reduces their operating lifetime to the point where they are not practical economically.

To excite the gallium arsenide to the lasing point, a corrugation laser has to be pumped externally by a beam of red light from a "dye" laser. But work is now in progress on a simpler system that would allow the Yariv team to stimulate the corrugation laser electrically.

Working with scientists at the Hughes Research Laboratories for the past five years, the Caltech team has used gallium arsenide as the basic building material for all the elements they have developed for an integrated optical circuit—lasers, switches, detectors, waveguides, distribution networks, and modulators to place information on the light. Over the short term, it would have been easier to build each of these components out of whatever material would do the job best and then attempt to "glue" the disparate elements together into an optical circuit. Instead, the researchers took a clue from integrated electronics and decided to build all the components out of the same material, thus increasing the likelihood that they will all operate together as an integrated unit.

With the construction of the corrugation laser, it now appears likely that one of a number of research groups across the country will build a complete miniaturized optical circuit. Eventually, when the technology is worked out, long-distance optical communication systems between cities—with miniature integrated optical circuits to transmit, amplify, and receive the light signals—should be possible.

In addition to Yariv, the group working on integrated optical microcircuits at Caltech includes Elsa Garmire, senior research fellow in applied science; Michihara Nakamura, research fellow in electrical engineering; graduate students Sasson Somekh, Harold Stoll, Avraham Gover, and H. W. Yen; and Desmond Armstrong, a member of the technical staff. The Hughes scientists participating in the project are Drs. Robert Hunsperger and Hugh Garvin. □