COMMUNICATION
LASERS
HOLOGRAPHY

CIBA–GEIGY
Journal

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COVER DISPLAY: It's all done with lasers, together with Ilford ultrafine grain emulsion technology and processing chemistry. "It" is a hologram, a 3-D image that allows us to view a recorded object from different angles. The object shown is part of a *Terasil*® dye molecule.

BETWEEN OURSELVES

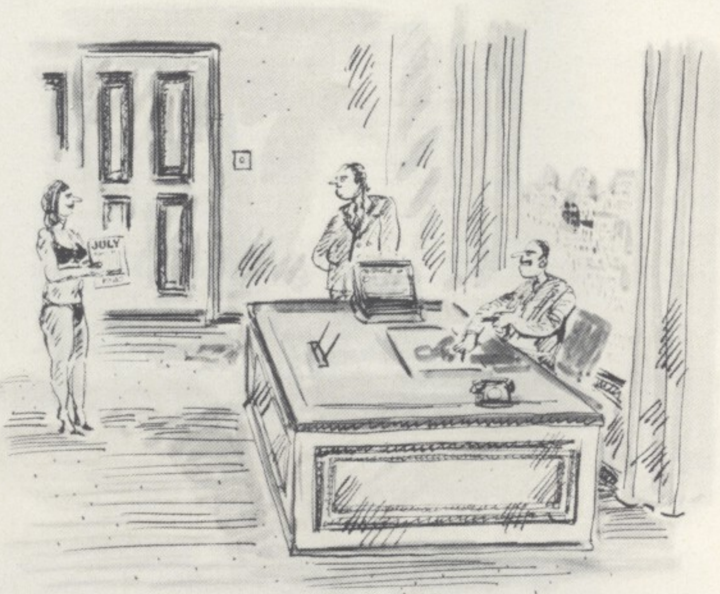
A KISS, a sigh, a sight

The golden rule of what communicators call communication boils down to a four-letter word: KISS—for Keep It Simple, Stupid. Like the original Golden Rule, it is both compelling and practically impossible to live up to.

Especially, we feel (as of course we would), when it comes to communicating the "chemical" industry, so protean an entity these days that you almost have to set it in inverted commas. Consider, as we hope you will, what-all comes under that heading in the next 40 pages alone: vision care, biotechnology and site-specific drug development, laser technology, holography and more, including the one that preoccupies everybody particularly—environmental protection. Plus the act that no-one has yet succeeded in putting perfectly together, though not for want of trying: corporate communication itself. A daunting span of subject matter, and one that bears only just so much simplification. Ours is not a simple line of endeavor. Sigh.

On the other hand it never fails to bring forth something new under the sun. We've said it before and shall again (that too belongs to communicating): scarcely any other industry interfaces as variously or dynamically with life on earth as ours. That defines the fascination but also the complexity, which increasingly turns those of us who try to transmit it to a broad audience into generalists—that is, people who know less and less about more and more.

Yet somehow a running overview must be attempted and imparted, even when it does not turn out to be as complete or as flawless in every detail as specialists would desire. "Holography made too simple" might be an honest title for the light reading on page 20, for example. Despite the good help of Ciba-Geigy experts in preparing it, we frankly still do not understand what a hologram *is.* But if the presentation sets you, and not only us, to wondering at the phenomenon and wanting to know more, then perhaps another of our four annual Group sightseeing tours has made simple sense.



"She's only a hologram but she sure beats the old wall calendar!"

Features

Departments

Round-up

It was Albert Einstein who, 70 years ago, speculated that under certain conditions atoms or molecules could be excited through light absorption or collisions and then be stimulated to shed energy in a coherent wave train. "A splendid light has dawned on me," he exclaimed. But not until more than four decades later did Einstein's prevision of the laser take on actual form in a rod of synthetic ruby. Even then its practicality was doubted, and many more years still were needed to overcome the initial dismissive view of the new device as "a solution in search of a problem." The sceptics mock no longer, for lasers have since become indispensable tools of high technology—not least in the chemical industry.

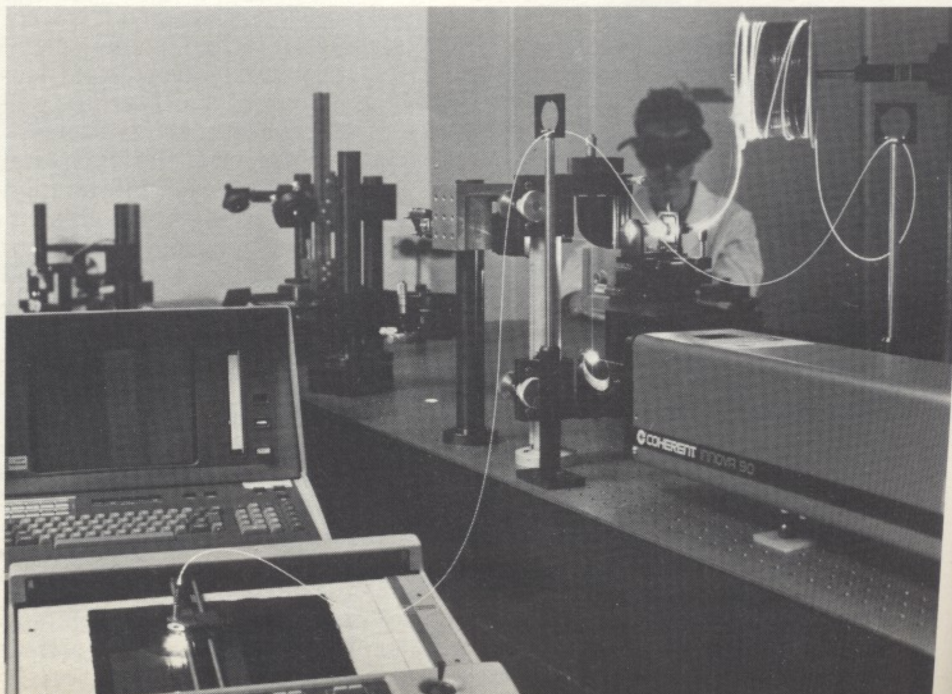
At a recent seminar, scientists of Central Function Research in Basel reviewed some of the many present and prospective uses of lasers in our operations. Gerhard Wittmer sums up the highlights.

LASERS

Light-Harnessers of Unsurpassed Precision and Versatility

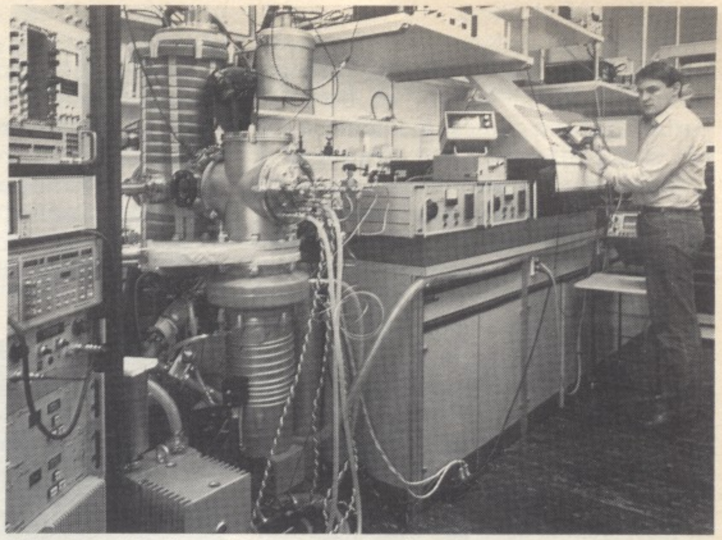
Let us leave aside "Star Wars" and think instead of the myriad beneficial earthly applications that lasers have made possible. Music recorded to perfection on compact discs and impeccably reproduced. Psychedelic spectacles in discothèques and animated light shows under the open sky. Uncanny three-dimensional images—holograms, a specimen of which is featured on this issue's cover and discussed in greater detail in the next article.

But the laser has far more than entertainment potential. Scarcely any other precision instrument, states Central Function Research's Dr Xaver Fink, can match it for diversity in use. It can cut, drill, plate, heat-treat, weld and vaporize materials. It has brought sur-



Christopher Schroeder of Central Function Research's Physics Department sets up an experiment with optical fibres. The computer writes with a laser beam on photosensitive sheets.

In the Pharma Division's Solid Dosage Form Department, Hans Seiffert checks the laser-drilled drug-release openings of an *Oros*® medication.



With the aid of multiphoton ionization in a molecular beam Dr Werner H. Gerber of CF Research's Analytics Department can run analyses of minute samples rapidly and with extremely high selectivity.

gery a marvellously delicate scalpel. It can measure minute extensions and deformations but also very great distances with the utmost accuracy. It can analyse vibrations, particles and currents. It can read, process, transport and store information and then write it out. The laser's ability to detect and recognize substances has opened up new paths to chemical analysis and synthesis. Laser chemist Richard Zare of Stanford University has described this wonder tool as "A new searchlight revealing things we could never before see, make or measure."

Count us in

Stanford University—Silicon Valley territory, home of Spectra-Physics. Besides its stake in and working relationship with this, the world's leading laser company, Ciba-Geigy is becoming more and more involved otherwise in laser technology. Lasers are being used to "work" materials in our production. Gretag, our Electronic Equipment Group company, has introduced a family of flexibly programmable automatic laser devices for engraving a wide variety of parts and tools *(see inside back cover)*. The tiny openings that release the active ingredient in the Pharmaceuticals Division's *Oros*® advanced drug delivery system are laser-drilled.

Dr Dieter Hauenstein sees other promising in-house applications in the machining of composite materials or the engraving and processing of photocurable films for the electronics and graphics industries.

Lasers harness light by storing energy in atoms and molecules, concentrating it, and then releasing it in powerful, coherent waves. "Lasing" occurs when photons—quanta of light—bounce off mirrors in a laser tube, gathering and synchronizing the energy that emerges as an intense concentrated beam *(see diagram page 22)*. It is this ability to deliver extremely high energy with speed and precision to the surface of a workpiece that has already made lasers indispensable in industry.

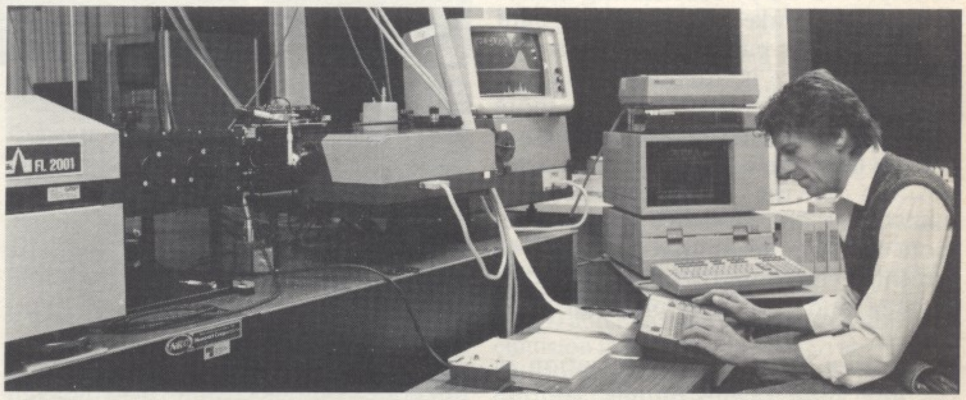
They also offer our scientists a broad spectrum of new possibilities as instruments for measuring and analysing. Heinz Spahni points to their potential use in materials assay or in the investigation of dynamic processes such as plant growth, the curing of casting resins and photo-lacquers, or the diffusion of spray clouds.

Further likely-seeming areas of use include the measurement of microscopic structures such as fibres, textiles or coatings; determination of refraction, polarization and other optical properties of substances; process surveillance, production control in the manufacture of contact lenses, and so on.

Wrap-around vision

Lasers have revolutionized optical measuring technology and led to the development of extremely precise techniques. A signal example is holography, which is considerably more than an optical "novelty." By means of holography it is possible to examine three-dimensionally and free from contact the form and structure of complicated surfaces, the size and distribution of particles and droplets, flows, vibrations, deformations and growth. A related example is laser interferometry, with which scientists can measure short distances with maximum resolution and accuracy, the speeds of particles in currents or, in combination with fibre technology, the slightest rotations, temperature differences, pressures, tensions, vibrations, etc.

In the Plastics and Additives Division's Research Department in Marly, special properties of resins and their components are measured. Constant Pharisa is pictured examining photo-initiators with pulsed lasers.



Laser beams also serve as probes for measuring distances or scanning surfaces and contours—for example, in keeping watch over premises, in determining distance and direction in surveying, in measuring tolerances in production control and expansion in materials control, in laser tomography and scanning microscopy.

Inside the organism

Using lasers, numerous physiological processes can be tracked in the living organism directly. In endoscopy, points out Dr Guido Ebner, the intense beam of laser light makes it possible to zero in on exactly cirumscribed parts of the body, directing the probe to the target area via optical fibres.

For precise kinetic studies of physiological processes pulsed lasers have become a valuable tool of both experimental and clinical medicine, notably in the diagnosis and treatment of certain cancers and skin diseases.

Utilizing the Doppler effect*, the speed of small particles can be determined with great accuracy when they are illuminated with laser light. By this means the movement of cells in the blood vessels, bacteria in various media, or the plasma stream in a single cell can be traced.

Surgery turns the high energy density of laser light in the thermal range to effective account. The pinpoint accuracy of laser beams used as "bloodless scalpels" that can be focused on just a few selected cells has proved a boon in brain and eye surgery particularly. Moreover, closing large surgical wounds with lasers helps substantially to ameliorate the healing process. Pharmacotherapy, too, can benefit from the thermal effect of laser light: active ingredients are fixed to liposomes (fat particles), which are then split with lasers, so that the active substance is released at the place and time desired.

Remote sensing capability

According to Dr Werner H. Gerber, every classical spectroscopic method can be improved on by substituting a laser for a lamp. To take an example: the light reflected from particles suspended in the atmosphere is attenuated through varying absorption at two or more wavelengths. From the resultant differences it is possible to calculate the composition of the atmosphere several miles away. This so-called Lidar, or remote sensing, technique is suited to screening emissions over a whole factory area and can even pinpoint their sources.

Utilizing multiphoton ionization in the molecular beam, minute samples can be rapidly examined and analysed with extremely high selectivity. And with laser-induced fluorescence one can detect traces of biological molecules in minute samples of liquid.

Lasers have disclosed new dimensions in photochemistry as well, as Dr Achim Roloff points out. Photochemistry—any chemical change driven by light, such as photosynthesis—was first used as a preparative method in laboratory synthesis around 70 years ago. Some 50 years were to pass before it was enriched with a versatile new tool—the laser, whose finely focused searchlight power has disclosed new perspectives, above all in polymer photochemistry.

The very good monochromaticity of laser light makes it possible to induce specific "tailor-made" linkages in molecules. This property is used in separating isotopes, for example, but can also be applied so as to effect a photochemical transformation, as in the synthesis of vitamin D.

Revolutionizing information transmission

Light signals have been used for transmitting information ever since antiquity. Here again the advent of lasers, together with optoelectronics and novel light-wave conductors, has broached altogether new dimensions in the technology of conveying information—and energy as well.

Light can spread unhindered over great distances only in space, as in communication via satellite. On the surface of the earth varying meteorological conditions and topographic features—fog, mountains, buildings—set limits to how far light can be transmitted. But with the development of optical fibres as low-loss light conductors this barrier has been overcome. The transmission of voice and data signals via modulated semiconductor lasers and photodiodes is far superior in every respect to transmission by coaxial cable. It is more compact and economical; there is scarcely any fall-off in signal strength; the transmission capacity is high; and it is not vulnerable to electromagnetic disturbances.

The possibility of incorporating various components and conduits in a chip is now being exploited in optics as well as electronics, notes Dr Harald Danigel. Fibre optics and integrated optics will, between them, supersede the traditional, cable-bound transmission of information.

By utilizing non-linear optical effects integrated optoelectronics also bids fair to blaze new pathways in data processing. The optical computers of the future will have a far higher processing and storage capacity and very fast transmission speeds.

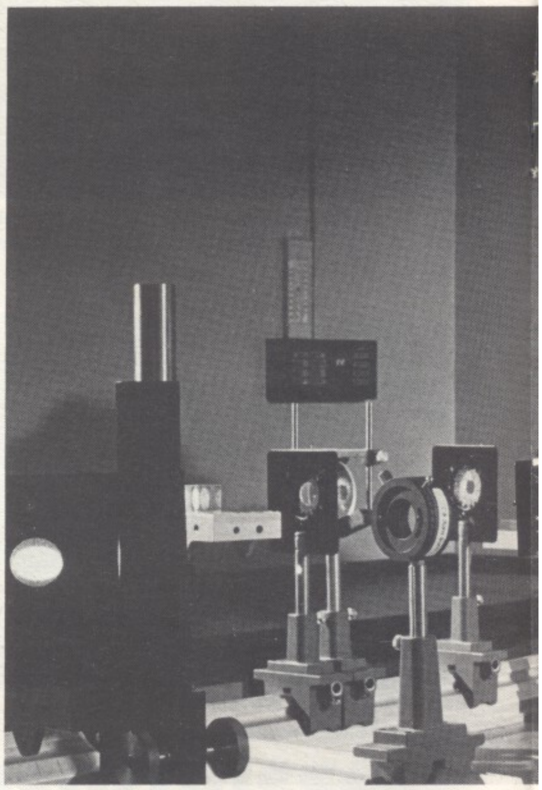
Nor does this exhaust the list of advanced optical systems based on laser technology. Others include erasable optical storage disks with microminiaturized lasers; holographic data storage, capable of recording huge amounts of rapidly accessible information in a tiny space; improved versions of laser scanners such as those already manufactured by Spectra-Physics that read the bars and stripes of the Universal Product Code; and even laser printers.

* The apparent increase or decrease in frequency of sound or light waves when the source and observer draw closer or more distant, as when two cars cross and one car's horn is blaring.

Gerhard Wittmer is editor of CIBA-GEIGY *Magazin,* our sister publication in German.

Holography

Ilford technology helps open the way to a wealth of applications



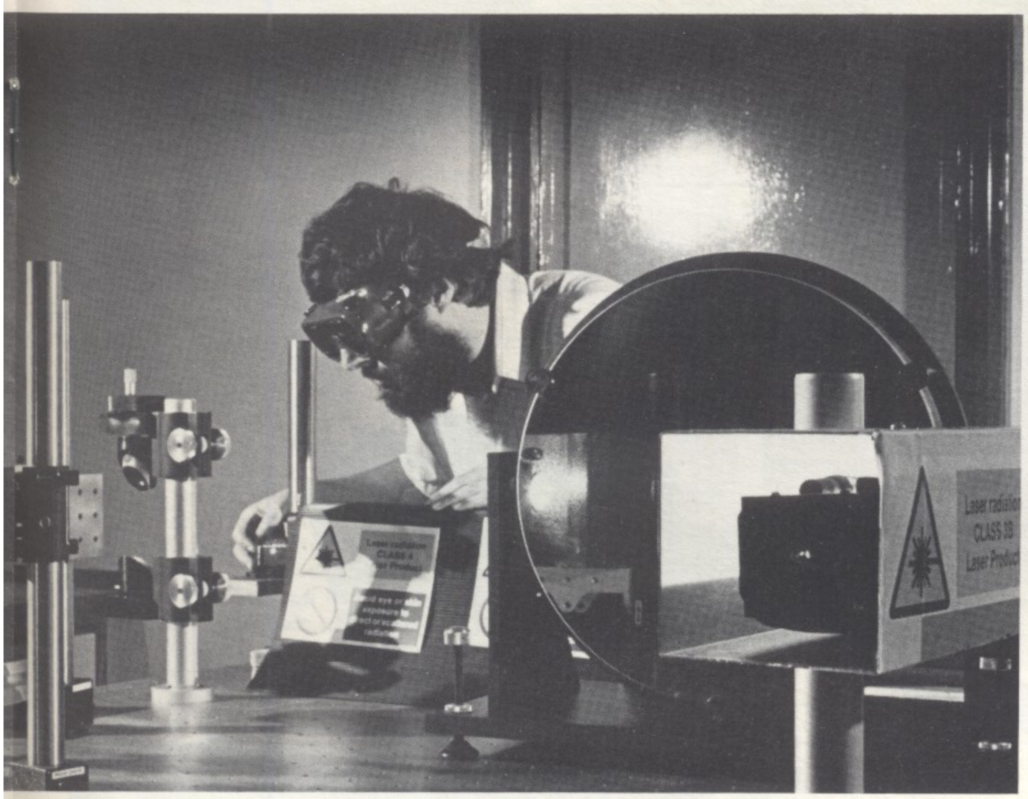
The unusual in-depth image which is the centerpiece of this issue's cover depicts the secondary amine of *Terasil*®™ Navy Blue, a dyestuff originated by Dr Paul Rhyner, the late head of Central Function Research in Basel. The image is a hologram—more precisely, a reflection hologram—and until a short time ago it could not have been reproduced in even a modest print run.

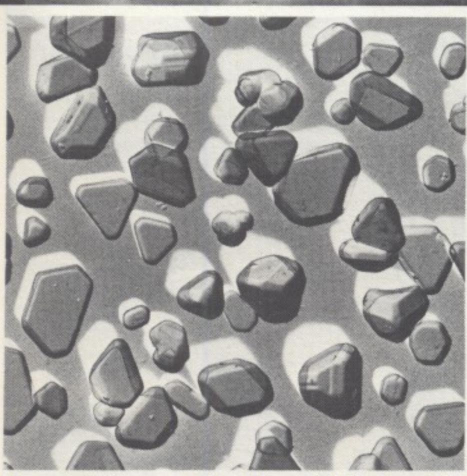
Just what is a hologram? When Dennis Gabor invented holography in 1949, he coined the name of his novel photographic technique from the Greek words meaning "whole message." There's the first clue. As Heinz Spahni, whose Basel laboratory for Coherent Optics in the Measuring Technology and Automation Section produced the master hologram of our dye molecule, explains, "Though stored in two dimensions, a hologram is virtually a three-dimensional visual record that shows an object in depth and in microscopic detail. Very simply put, the process is called holography because it makes use of the whole of the optical information coming from the subject photographed and then 'reconstructs' the space."

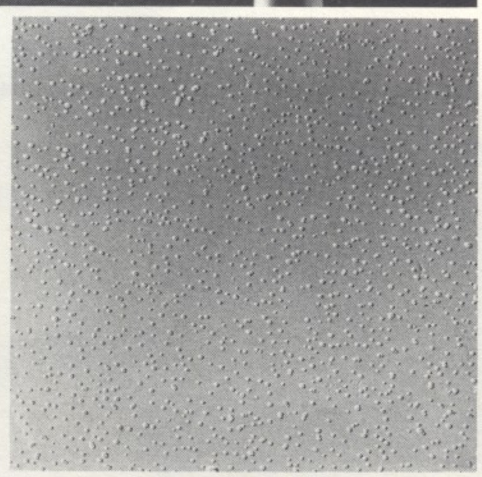
The photography in question bears little resemblance to what the layperson associates with the word. It uses no lens, which in a way harks back to the oldest method of recording pictures—the pinhole camera. But only in that way. What has made holography technically feasible is coherent laser light, which in the recording process is directed to both the object and a photographic plate *(see diagram overpage).*

y conveys the whole message

Massive and sensitive: Even though the holography table at which physicist Alan Adshead works in his Mobberley laboratory was constructed using lightweight honeycomb materials from Bonded Structures, it weighs a ton. The custom-built table is mounted on an air spring to minimise ground vibrations and has a "greenhouse" superstructure to exclude atmospheric disturbances. The physicist's playful term for the phenomena which he conjures up: "pseudoscopic."







A vast difference: the silver halide crystals in the emulsion of a conventional film (l.) are relatively large and also show a wide variety of sizes. Those in a holographic film are extremely small and uniform. Shadow electron micrographs, both ×20,000, allow direct comparison.

Combined know-how

120,000 copies of the cover hologram were made for the three editions of our Group magazine. That is a far cry from the "one-off" specimens which until quite recently were all that holography buffs could manage. Now a joint effort has made mass replication possible, and thereby hangs a tale of neighborly collaboration—the collaborators being Ilford UK and an entrepreneurial firm called Applied Holographics.

Ilford is no newcomer to holography. The company was already involved in the new imaging technique during its "cottage industry" phase and came out with holographic plates in the 1970s. As it happened, a newly created company at nearby Braxted in Essex—then Ilford home territory—was experimenting with a Xerox-like concept which would allow the serial reproduction of holograms, and it saw in Ilford a suitable partner for developing the film and processing chemistry that the copier would require.

Ilford shared that perception, and the two companies' combined efforts have resulted in a system which, for the first time, takes holography from a rarefied and expensive art form to a viable commercial and technical medium with a wide potential range of practical applications. With Applied Holographics' Holocopier both single-specimen holograms and huge runs can now be produced cheaply and rapidly, at a rate of one copy every five seconds.

The Holocopier, which looks like a conventional roll film copier, is based on the contact copying of a master hologram using the light of a pulse ruby laser which, by drastically reducing the exposure time required, has overcome the problem of stability. The "software" which has made consistently good replication possible consists of "Holofilm" and "Holochem" (Applied Holographics trademarks). These are Ilford's contributions to the unique new system.

Ultrafine emulsion

Although Holofilm is based on silver halide technology, it differs vastly from conventional film. In the latter, explains chemist Tony Bond, who led the film design team in the holography project, the silver halide crystals in the emulsion are one micron or more in diameter and vary considerably in size.

A holographic emulsion, in contrast, must resolve detail down to a fraction of the wavelength of light. This requires a minuscule particle size of 0.04 microns. "So the trick in developing a holographic emulsion," Bond says, "is to get the crystals very small and very uniform, with no rogue population of larger crystals, because these destroy the very property—coherence—of the laser light used to record a hologram. It needed a lot of work for us to find out how to do this consistently."

By dint of its ultrafine grain emulsion technology the Ilford team succeeded in creating an emulsion in which the crystals are remarkably uniform in size *(see photos at left)* and free from scattering centres. The emulsion is also very stable and able to survive long periods of storage. "During the difficult pilot phase, incidentally, Lyon did an excellent job of helping us," Tony Bond adds.

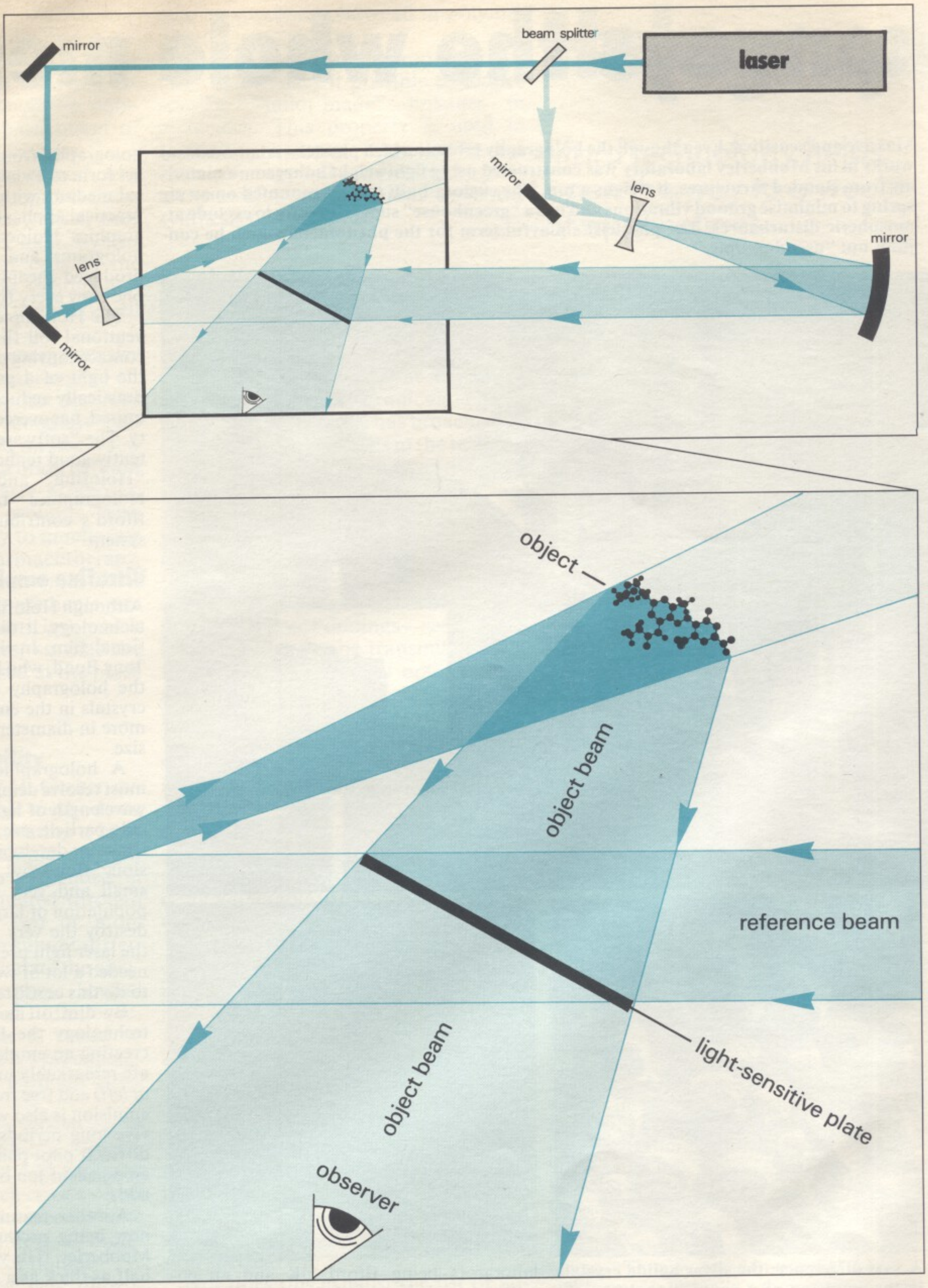
Another feature of Holofilm, which is now being produced to high standard at Mobberley, is its very thin base. This is only half as thick as a conventional 35 mm film base, enabling holograms produced on the Holocopier to be laminated. The other component of the Ilford-developed "package"—replenishable chemistry—likewise differs greatly from the norm. "The processing regimes used in holography," says Tony Bond, "are quite unlike those used in any other area of photography."

If proof were needed that holography has now come of marketing age, a TV-backed promotional campaign in the UK last winter provided it beyond any doubt. Supermarket shelves across the country were stocked with ten million holograms of "Dungeons and Dragons" figures packed in NABISCO breakfast food boxes and awaiting eager buyers. It was a short wait: with

How a master hologram is made

Basically, a hologram is made by illuminating a light-sensitive plate with two beams of laser light which are directed through a beam splitter. One, the reference beam, reaches the plate directly. The other, the object beam, strikes the object and is then reflected back onto the plate. Together the two beams create standing waves, or interference patterns, which strike the plate and expose the photographic emulsion. To provide even illumination the beams are passed through lenses.

Using mirrors, the holographer can direct the two beams anywhere on the table. Their path lengths must be more or less equal, however, because the wavefronts can stay in step with each other only for a limited distance. Also, the set-up must be totally stable. The holographer who breaks for tea after having made everything ready and positioned the plate is therefore only doing what he must: allowing for settling time until all vibration has subsided.



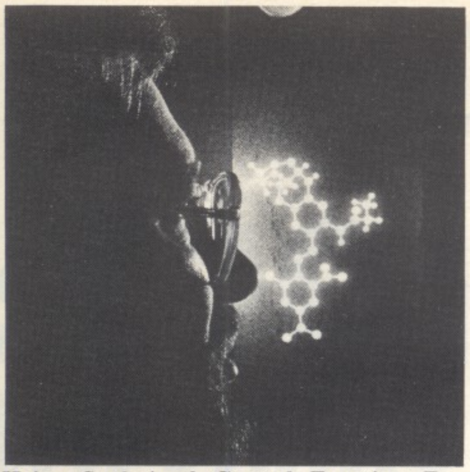
the juvenile audience clamoring to acquire the complete set of six holograms, the cereals moved so quickly that the sponsor requested a further run of three million from Applied Holographics before January was out.

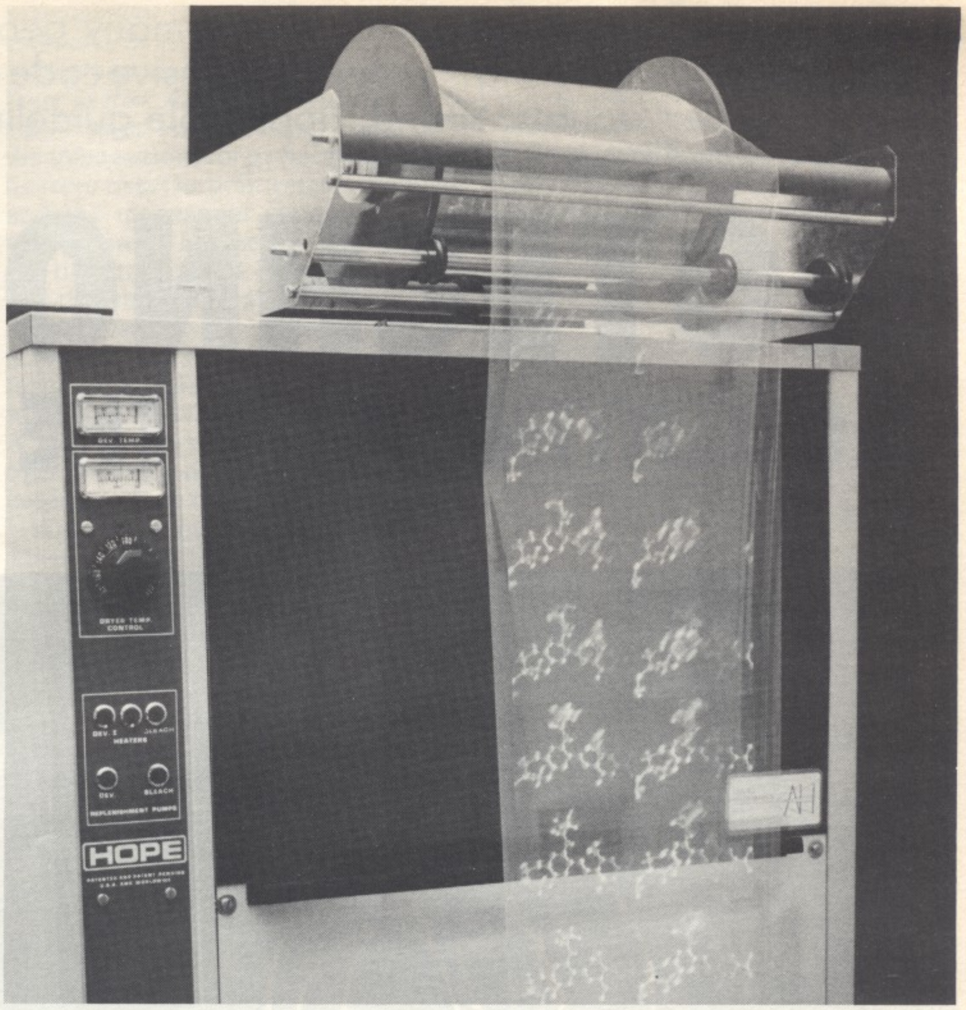
Applications galore

Eye-catching artistry and gimmickry by no means exhaust the potentialities of holography. Dr Glenn Wood, Ilford's holography specialist in Marketing, foresees a wealth of practical applications to come in a few years' time. Holograms are already incorporated as optical elements into machines, he points out—notably military aircraft, where a "head-up" display on the windscreen gives the pilot vital information on attitude, altitude, velocity, etc. "We think the next generation of application will be in motor cars," he says, "where such information as speed, or perhaps petrol level or, more importantly, maps will be reflected off the windscreen as an aid to the driver in navigating an unfamiliar town, for example."

Holography also promises to be used more and more in medicine as in aid to accurate diagnosis, for example in helping surgeons decide whether or not to undertake exploratory surgery. It will most certainly prove a boon to security, too, in the form of either machine-readable or eye-readable, forgery-proof information for authenticating cheques, travel documents, driver's licences, passport photos and, not least, branded products such as Rolex watches or Levi's jeans in which a flourishing counterfeit trade now exists.

Another lucrative business in the offing is the production of holographic scanner discs for optical readers used either as bar code readers for checking goods or in laser scanner printers. "In both applications," states Dr Wood, "Ilford SP [for "Special Product"] 672 film is capable of producing light-stable, optically perfect elements





Heinz Spahni of Central Function Research's Physics Department in Basel contemplates our cover project in space by laser light . . .
. . . and here it is emerging from the end of the Holocopier chemical processor as a continuous length of holograms.

which can now be mass produced using an essentially photographic process."

Finally, there is what Glenn Wood describes as "one of the most exciting prospects in the whole of image recording": the ability to write directly from the computer on to recording material in holographic form, suggested by our cover design. Aerodyne Products, Inc. of Boston have already produced holograms of computer-aided design images in a matter of a couple of minutes, and that, asserts Dr Wood, is only the beginning. "The application here would be in any area where designers create wire-frame model pictures—in the aircraft and motor car industries especially."

All of these applications were on exhibit at the Ilford stand during the latest Photokina in Cologne, and they roused a lot of curiosity. As did one of the world's first totally computer-generated company logos (Ilford's, of course), created digitally on the computer and then printed on SP 673 film using a helium-neon laser—and so real you wanted to reach out and touch it. Only it was literally untouchable. "It doesn't exist, it's just an image!", exclaims Glenn Wood.

That sums up the whole baffling fascination of holography—and "you ain't seen nothin' yet." Meanwhile, we hope you will enjoy the small foretaste on our cover of the exciting things to come. To get the full effect it should be viewed under a spotlight or in sunlight, by the way.

A crowd-catcher at the 1986 Photokina: Ilford's holography exhibit, showing the uncanny effects achievable with the technique and previewing the many applications in store.