

of the refracted beam (as we were moving in the opposite direction to that considered by Jenkins and White) would be considerably smaller than the width of the incident beam. In fact, for the case considered, the reduction in the width of the beam would be by a factor of about 20. The brightness of the refracted beam would therefore be greater than that of the incident beam — a rather unexpected result. If we define here the brightness as the energy per unit cross section, or as the flux per unit cross section, then the increase would be about five times. There is nothing in this that contradicts the second law of thermodynamics as the divergence of the brighter refracted beam will be greater than the divergence of the incident beam.

I asked R. P. Chambers to calculate the gain in brightness for various angles of incidence. He computed the ratios of the cross-sectional areas of the incident and refracted beams, L/W , and had the computer plot this against the fraction of energy, $1-Y$, that is refracted out from the dense medium. A graph has also been computed for the flux per unit area of the refracted beam relative to the flux per unit area of the incident beam, $(1-Y)(L/W)$ versus $1-Y$. Brightness gains of a factor of 6 or more are quite possible. These curves have been computed for one value of refractive index, ($\mu = 1.6$), and we have chosen that plane of polarization of plane polarized light that gives the greatest effect.

While these computations were being made, I talked about the general principles with L. E. Hargrove and with E. Eisner. L. E. Hargrove suggested that one might use two such devices in planes at right angles to one another. One could then obtain a gain in brightness of up to 40 times (for maximum effect, one might need to add also some component that would appropriately rotate the plane of polarization before allowing the beam to enter the second device).

Hargrove and Eisner and I went to our laboratory and put a prism in the path of the beam of light from a helium neon gas maser. We could, quite easily, see that one could obtain an increase in brightness when the angle of incidence was just less than the critical angle for total internal reflection. As the refracted beams diverged more than the incident beam, we found that the image was only detectably brighter at positions close to the point of emergence from the prism.

Similar increases in flux per unit area could of course be obtained using convergent lens systems. The novelty of the idea resides in the fact that here this has been done by the use of plane surfaces only. There could be cases in various branches of optics, perhaps in spectrography, where this new system might be an advantage.

Later experiments by H. M. Janus, while a temporary employee at Bell Telephone Laboratories (under the provisions of the IAESTE Program), showed a brightness gain of three times with a single prism near the plate of a spectrograph, and an overall gain of eight times using two prisms working in the same plane in series.

Pulse Extraction From Masers

By J. S. COURTNEY-PRATT and L. E. HARGROVE

We have considered a question concerning the energy in a pulse of light in an intracavity-modulated gas laser. If, for example, the transmission coefficient of one of the end reflectors is one per cent, then the energy in the pulse inside the maser is about 100 times the energy of any one pulse emitted through the end reflector. Hargrove suggested that it was possible to extract the pulse from his intracavity-modulated gas maser, by any one of a number of means, and use the pulse so extracted for photography or for other purposes.

A convenient method of extracting such an internal pulse might be by means of a rotating glass prism which at some instant will have turned to such an angle that the pulse of light inside the maser will no longer suffer total internal re-

flexion. The prism could well be a Porro prism or other retro-reflecting design and could act as one of the end reflectors of the maser. This arrangement has the advantage that the prism can act as a good retroreflector for some significant and sharply bounded range of rotation (say 15 degrees). During rotation through this angle, the intracavity maser pulse would have time to build up to full strength. As soon as the prism passes the critical angle, the transmission rises suddenly (over a rotation of say one-hundredth of a degree). The device thus can allow the relatively slow buildup of a high energy pulse followed by the rapid extraction of this pulse. The process could repeat on the next rotation of the prism, or could easily be suppressed if desired as the repetition rate (which equals the rotation rate of the prism) could be low enough even for use of a mechanical shutter.

Typically, if the prism rotates at say 2,000 revolutions per second, the time between pulses would be 0.5 milliseconds, the time for buildup of the pulse in the maser would be about 20 microseconds, and the time for switching to extraction of the pulse would be about 10^{-8} seconds.

This general principle of extraction of energy from inside the maser is not restricted to gas masers, and is not restricted to "continuously" operating masers. In fact, there could be useful applications of this principle in most other kinds of masers. For example, consider a naturally occurring spike in a small ruby maser. The energy that is transmitted through a partially reflecting end mirror associated with this spike will be much lower than the energy within the ruby maser associated with this spike. It would probably be useful on occasion to insert inside the ruby maser cavity some device which could be switched so that the energy within the maser could be extracted. In a typical case, one might then get a spike out which was 20 times as large as that ordinarily available from the small ruby maser. The gain would be largest in those masers that have high reflection and low transmission end coatings, but might be significant even in other masers that have relatively low reflection coefficient reflectors. One could make use of the idea in ordinary pulse-operated masers as described, or (with some greater attention to the timing) in Q-switched masers. The duration of the pulse so extracted will not be longer than the time for light to travel twice the length of the maser, but the peak power will be high.

Multiple Level Recording — Maps, Plans, Etc.

By J. S. COURTNEY-PRATT, R. P. CHAMBERS
and H. M. JANUS*

We have been interested for some time in unconventional methods of storing information on photographic films. C. Wyckoff, who works with Edgerton, Germeshausen & Grier, Inc., developed some years ago a triple layer film called XR film. The three emulsion layers in this XR film had different sensitivities chosen so that one layer would record very faint signals, the next layer would record medium brightness levels and the third layer would respond only to very intense light levels. The characteristics of the three layers were so chosen and adjusted that the total latitude of the film was the sum of the latitudes of the three layers considered independently. This film could record signals that were different in illumination level by a factor of $10^3:1$, or even more.

We think that composite emulsion layers could be assembled following different criteria to make up film that would be useful in other respects. These ideas were stimulated by consideration of the XR film, but are different in that the products we suggest are not formed as the assembly of emulsions chosen to increase the latitude of the composite film, but are chosen

* At the time this work was done, temporarily at Bell Telephone Laboratories.

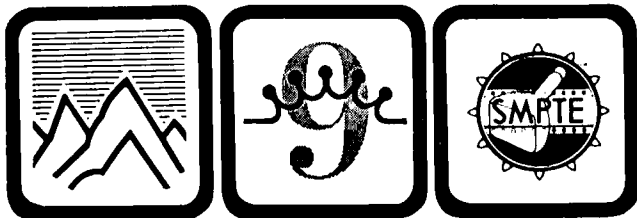
to allow the more appropriate recording of different levels of information density, or in another case of different wavelength bands. Perhaps the simplest of these would be a two-layer composite film. The top layer could be an ordinary fast emulsion like a TRI-X or perhaps a medium emulsion like a micro-film emulsion and could be used to record say a road map or a rail map of a country. The second emulsion should preferably be a very fine-grained emulsion such as one of the new aerial recording emulsions or even a maximum resolution graticule emulsion. This second emulsion could carry a complete aerial photograph on it of the region under consideration, to the same scale as the road map. One could use the same principle as Wyckoff has used of color coupling the images and bleaching out the silver so that the two pictures were of different colors and could be viewed together or independently by suitable choice of a color filter in the viewing device. Perhaps simple colored spectacles would do. One could use such a map in the way that one ordinarily used a road map to find one's way to a given town and could then, by simple shift of the color filter and the use of a magnifying device, examine the area in the other color for viewing say a complete street map of the town or even an aerial photograph of any section of it. The idea could obviously be extended to the superficial in addition to the detailed recording of large tracts of country as required in military reconnaissance and surveillance. These ideas can be extended for projection systems and possibly even for the direct

viewing of transparencies to allow multiple image levels of different detail even in color.

Summarizing, the idea is to use XR film to take or record pictures in three degrees of detail rather than in three degrees of brevity of exposure. This would be useful in say metallographic records where one may wish to see, for example, the general position of a fatigue crack and also to study how this crosses individual grains.

Similarly, one could record an aerial photograph and on it have superposed a coarse road map and a city street map. Print and lettering need not interfere with the detail of the readings. Such a "supermap" could be examined without filters quite usefully, but would be better studied with filters. One could use a fine detailed substrate map and add, say, rail features on one of the overlying emulsions and road features or contour lines on another. If there are several such features that it seemed desirable to record (and they need not be of differing detail levels) one might consider building up films of more than three layers, and the layers could be of the same or different speeds and resolution capabilities. Polaroid vectograph film seems equally suitable for this kind of work, though polarizing rather than color filters are needed. We made a number of examples of two-level records at Bell Laboratories using monochrome vectograph film. Some colored vectograph transparencies were also made for us by Dr. Bruce de Palma at Polaroid; and these may be examined directly, or simply projected using an overhead projector and a Polaroid sheet.

9TH INTERNATIONAL CONGRESS ON HIGH-SPEED PHOTOGRAPHY



DENVER, COLORADO • AUGUST 2 THROUGH AUGUST 7, 1970

9th Congress Papers Program

Organization of the technical papers sessions are now complete for the 9th International Congress on High-Speed Photography, announced Congress Chairman **Carlos H. Elmer** and Program Chairman **Robert D. Shoberg**. Over 100 technical papers from participating nations have been arranged into sessions. The complete program of titles and abstracts will be published in the *July Journal*. Countries represented are the U.S., England, France, Germany, Japan, the Netherlands, the U.S.S.R., Bulgaria, Switzerland, Canada, Australia, Sweden and Czechoslovakia. The official languages of the Congress are English, French, German and Russian. All technical sessions will be supplied with four-language simultaneous interpretation.

The Congress will open on Monday, August 3, with a brief ceremony. The entire morning technical session will be devoted to a group of invited papers and a panel discussion on the subject of formal training for careers in photographic science and technology. This seminar will be chaired by Herbert E. Farmer, SMPTE Vice-President for Educational Affairs.

Additional topics scheduled for technical sessions are: holography and lasers; rotating mirror and raster cameras; image converters; equipment papers by exhibiting firms; lighting, flash and x-rays; and high-speed applications.

Each technical paper is to be preprinted and will include

abstracts in French, German and English. All papers written in a language other than English will be preprinted in both the original language and in English. Preprints will be given to all Congress attendees. Papers and resulting discussion will be published in hard-cover book form as the official proceedings of the Congress.

Congress Arrangements

A comprehensive exhibit of specialized high-speed photographic equipment will be shown in conjunction with the Congress. Approximately 40 companies are expected to display their products.

The Final Announcement is now available from Society Headquarters. This sixteen-page booklet describes the Congress activities. Complete registration information can also be obtained. All-inclusive registration fees for the week are \$90.00 for delegates and \$45.00 for accompanying persons. A full and interesting schedule of events for families accompanying delegates has been planned. The schedule will be of interest to older children as well as wives, with visits to points of interest in scenic Colorado including an excursion to Colorado Springs. For more information, write to Society Headquarters.

Authors are reminded that their manuscripts are due at Society Headquarters by June 1. Format sheets and instructions have been sent to all authors for this.