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 reflection. The prism could well be a Porro prism or other retroreflecting 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 10^8:1, 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

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