If some of the above difficulties can be overcome, the use of thallium compounds as γ-ray counters seems quite promising since such crystals are quite dense (TlBr 7.56, TlI 7.09). They are also interestingly complementary to diamond counters[3,4] since pair production and the photoelectric process have a high probability in the thallium salts, while at γ-energies below about eight million electron volts the Compton process is the only one of moment in diamond.

It is also interesting that an "impurity" of bromine in the iodine compound (or *vice versa*) still permits the crystal to count.

This work has been supported in part by U. S. Navy contract N6ori-105 Task I. I wish to thank Dr. H. C. Kremers for the crystal and Messrs. J. C. D. Milton and Chester Grove for their kind help with these experiments.

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A Calibration for Eastman Proton Plates

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A BATCH of Eastman nuclear research plates (NTB emulsion No. 347,126) has been calibrated by determination of the emulsion stopping power as a function of proton energy. Until there is some assurance of the reproducibility of Eastman NTB plates, it seems necessary to repeat the calibration procedure for every new batch received.

A thin boron target was bombarded with 3.7-Mev deuterons from the cyclotron, and Eastman plates were used to record the long-range protons from $B^{10}(d, p)B^{11}$. Several exposures were taken with different thicknesses of aluminum foil interposed in the path of the protons. Thus the same group was measured in each plate, with a different effective proton energy in every case. The extrapolated range of the group was determined from each exposure and identified with the extrapolated air range, suitably reduced according to the absorbers used. In this way the emulsion stopping power was determined at each of several proton energy values. The form of the curve so obtained is independent of the deuteron beam energy and the Q-value of the reaction. The absolute values of stopping power will, however, depend on these parameters.

The calibration function obtained is presented in Fig. 1. The errors shown are those which are effective in determining the form of the curve. To them must be added an uncertainty in the level of the curve as a whole, amounting to ± 1.4 percent at 9 Mev. The stopping power function here obtained is constant down to about 5 Mev, below which it rises with decrease of energy. At 3 Mev the slope is -356 per Mev. Similar data obtained for Eastman Experimental Proton emulsion No. 340,506 (same composition as NTB plates) show a stopping power which is constant over roughly the same region, but which increases somewhat more rapidly at low energy.

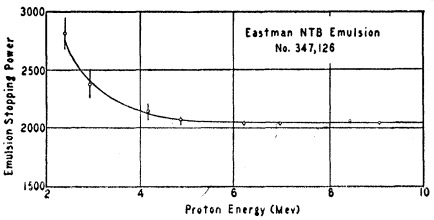

FIG. 1. Stopping power *vs.* energy (Mev) for protons in Eastman NTB emulsion No. 347,126.

For Ilford Nuclear Research emulsions ($B1$ and $C1$) Lattes, Fowler, and Cuer[1] have published a curve which is constant down to 5 Mev, below which it drops with energy decrease. Its slope at 3 Mev is $+70$ per Mev, roughly $\frac{1}{5}$ the corresponding slope for the Eastman emulsion. For Ilford halftone plates Richards[2] found stopping power slightly rising with decreasing energy, and a slope of -19 per Mev at 3 Mev, while Guggenheimer, Heitler, and Powell[3] have observed no energy variation of S for plates of the same type (Ilford halftone) between 2 and 6.5 Mev.

In attempting to account for the difference in direction of the stopping power variation at low energy as found for Ilford and Eastman plates, any slight differences in emulsion composition are of considerable importance. Thus the hydrogen and carbon in the gelatin exhibit a stopping power energy curve with negative slope, while for silver and bromine that slope is positive.[4] Since moisture content influences the amount of hydrogen present, relative humidity also has a considerable effect in determining the effective stopping power of an emulsion. From the different stopping power gradients reported for Ilford emulsions, and the two here found for the Eastman product, it appears that the quanties which vary from batch to batch of plates of a single type are able to evoke some variation in the energy dependence of the stopping power of such plates.

Sincere thanks are due Professor R. F. Humphreys for valuable discussions and suggestions.

* Assisted by the Office of Naval Research, under Contract N6ori-44.
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Saturation Effect in Microwave Spectrum of Ammonia

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IN his investigation of absorption line shape in the inversion spectrum of ammonia, Townes[1] has found that at low pressures and powers of the order of 1 μw a saturation effect occurs, causing the absorption to decrease and the width to increase with increase in power. Gordy and

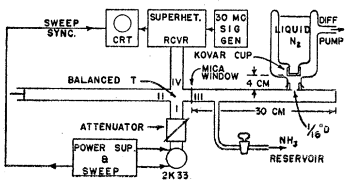

FIG. 1.

Kessler,[2] and Smith and Carter[3] working at approximately the same power levels, have failed to observe any such broadening, although the latter confirmed the saturation of the absorption. We have made an investigation of the 3,3 line at low pressures and powers of the order of 1 μw and find both effects are present.

The equipment is shown schematically in Fig. 1. The output of a frequency-modulated 2K33 reflex klystron is fed through attenuators into arm I of the balanced T. The construction of the T[4] is such that the r-f power divides equally between arms II and III, and none enters IV. Further, if II and III are electrically identical, their fields, after reflection from the ends, will cancel in IV. However, when the absorption in III is changed by introducing a gas, a signal proportional to the change in absorption enters IV and is detected by a superheterodyne receiver with a balanced mixer and band width of 8 Mc, giving an oscilloscope plot of frequency *vs.* absorption. Frequency differences on the oscilloscope are measured by introducing a signal of approximately the intermediate frequency (30 Mc) into the second detector. Each time the i-f sweeps across this signal it produces a video pip around the zero beat which can be positioned on the frequency axis by changing the frequency of the injected signal, allowing calibration of the trace. The ammonia is introduced into the wave guide at atmospheric pressure, then pumped out through a hole $\frac{1}{16}$ inch in diameter. The final pressure is determined by a deposit of solid ammonia at liquid nitrogen temperature on the Kovar cup. From the known variation of absorption with pressure we conclude that this pressure is not greater than 8×10^{-4} mm Hg and may be much less.

Our data on line width at half-intensity ($\Delta\nu$), and attenuation at the center of the line (α_0) as a function of incident power (P) are shown in Fig. 2. Absolute power measurements are accurate to within approximately a factor of 2; relative power measurements, 10 percent; line widths, 20 percent; attenuation, 30 percent.

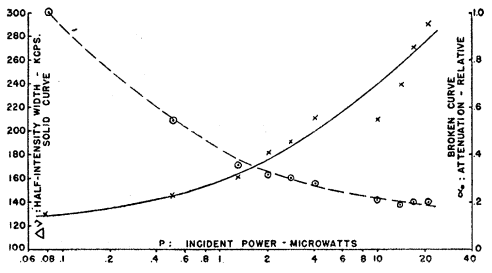

FIG. 2.

According to Townes,[1] saturation sets in when the rate of transition per molecule is approximately equal to the rate of collision. In view of his equation for this condition, which contains the assumption that the distribution of molecules is not affected by the incident power, saturation effects should be evident in our apparatus at powers less than about 100μ watt. Thus our data appear to be in agreement with Townes.

We wish to acknowledge the invaluable assistance of Professor R. H. Dicke in this work.

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A Double Modulation Detection Method for Microwave Spectra*

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THE recent publication of a note on the above subject by Gordy and Kessler[1] has suggested to us the desirability of reporting some results of other experiments with a similar arrangement. The arrangement consists of applying a radiofrequency modulation voltage to the reflector of a Klystron in addition to the usual low frequency saw-tooth modulation voltage. The modulated microwave output power is allowed to pass through a wave guide section containing the absorbing gas and is then fed to a communications receiver tuned to the radiofrequency used for modulation. The receiver output is then displayed on an oscilloscope, the horizontal plates of which are synchronized with the low frequency saw-tooth voltage. This scheme has apparently occurred to numerous workers in different laboratories and was apparently first tested by Wilson and his colleagues,[2] who applied a 50-kc square wave to the reflector. They reported that the scheme reduced the crystal noise but did not show marked advantages over the usual low frequency system. The voltages used were apparently high enough to start and stop the Klystron at 50 kc per second. Hershberger[3] was the first to give a public report on this method of detection. In his first work Hershberger used a low voltage modulation frequency of 100 kc and has since worked at 50 kc with most satisfactory results.

In our own experiments we have, in general, used low modulating voltages and have used 20 kc and 600 kc for the modulation frequency. Although low modulating frequencies are to be desired from some points of view,** the results we obtained at 20 kc were disappointing. However, the lack of a good receiver for this extremely low frequency was a contributing factor to our lack of success. Our work at 600 kc has been more successful. In our experiments we found that the gains in signal-to-noise ratio over that obtainable by low frequency methods depend upon how much distortion of signal can be tolerated. Measurements made on one of the weaker ammonia lines indicate that a gain of 30 in signal-to-noise ratio could be