values found this year it would appear that an E_0 slightly larger than this may be necessary, but not as large as $E_0=10.66$ for $r_0=1$.

The observed values at 45° in Fig. 5 and Table I clearly show the minimum required by Breit, Condon and Present at approximately the value of energy predicted on the basis of our higher voltage data. The observed value at 45°, 450 kv, goes almost to zero. This offers a striking confirmation of the existence of a short range *attractive* interaction between protons.

It is seen from the curves in Fig. 5 that the scattering is nearly classical at 220 kv. The effect of the attractive force becomes quite appreciable at 335 kv in the region of 45°. At 450 kv and 45° scattering the effect of the attractive force almost completely neutralizes the Coulomb force. With increasing energy of the incident proton the attractive force becomes predominant, giving rise to an increase in the scattering until at roughly 650 kv it exceeds the Mott value.

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The 4.3μ Fundamental Band in the Spectrum of CO_2

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The fundamental absorption band due to the oscillation ν_3 in the CO_2 molecule has been remeasured and almost completely resolved into its rotational fine structure. The lines are found to fit the formula $\nu=2350.1+0.780N-0.0031N^2$. The convergence factor -0.0031 seems to fit our data a little better than the value -0.0035 given by Martin and Barker, and is in agreement with the theoretically determined value given by Adel and Dennison.

THE spectrum of carbon dioxide has been very carefully investigated in the infrared by several investigators[1] who have succeeded in resolving the majority of the most interesting bands into rotational structure. One band, however, which has been only very imperfectly resolved is that occurring near 4.3μ in the spectrum of CO_2 and due to the fundamental oscillation ν_3 of the molecule. The frequency ν_3 may be thought of as arising when the carbon atom oscillates unsymmetrically along the figure axis of the molecule relative to the center of mass of the oxygen atoms and it is accompanied by an intense change in the electric moment. The intensity of this band is in fact so intense that

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[1] P. E. Martin and E. F. Barker, Phys. Rev. **41**, 291 (1932); E. Barker and A. Adel, Phys. Rev. **44**, 185 (1933); E. F. Barker and T. Y. Wu, Phys. Rev. **45**, 1 (1934).

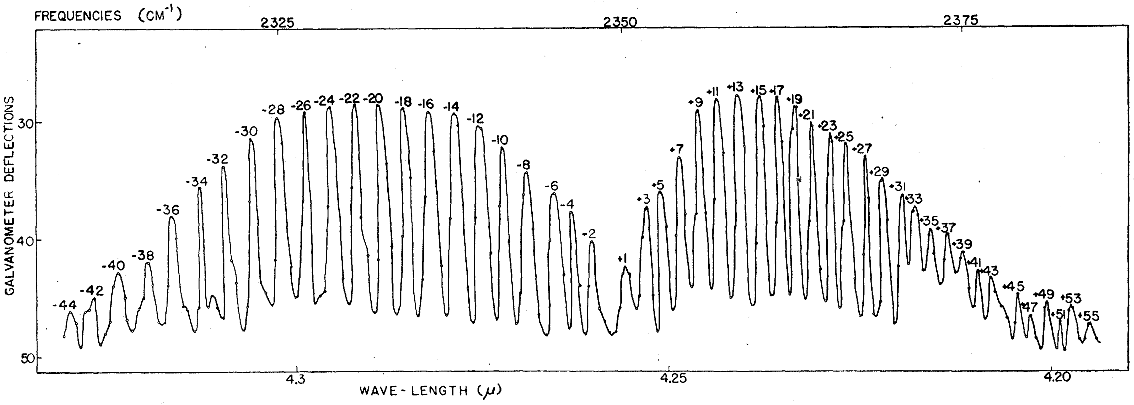

FIG. 1. Galvanometer deflections taken of the fundamental absorption band in CO_2.

the usual amount of CO_2 in the atmosphere will suffice to absorb out completely all the radiant energy of this wave-length coming from the light source. In order, therefore, to make measurements on the absorption by other molecules which have bands in this region we have found it necessary to surround our spectrometer by an air-tight box from which most of the atmospheric CO_2 could be removed. Under these conditions it was found, by the use of a grating ruled with 3600 lines per inch, that the absorption band due to the remaining atmospheric carbon dioxide resolved itself much more completely than has been reported by earlier investigators. We wish here to report on a set of measurements we have made on the absorption band due to CO_2 in this region after narrowing the spectrometer slits down to about 0.5 cm^{-1}, galvanometer deflections being taken at settings on the spectrometer circle separated from each other by intervals equivalent to 0.5 cm^{-1}. The data are shown graphically in Fig. 1 with galvanometer deflections plotted as ordinates and with scales of frequencies and wave-lengths as abscissae and it will be seen that almost complete resolution has been effected. The number of settings made on any one line may be determined by referring to the above figure where for convenience the experimental points have been indicated by small circles.

The frequency positions of the lines in the band may be found by referring to Table I and it is found that these positions are well represented by the formula

$$\nu = 2350.1 + 0.780N - 0.0031N^2, \qquad (1)$$

where N is the ordinal number of the line measured from the center of the band. It is easily shown that for the P branch N takes numerically the value of J in the initial state while for the R branch it takes numerically the values of J in the final state. Since the nuclear spin of the identical oxygen atoms is zero, half of the rotational levels are absent; in the initial state only those where J is even occur and in the final state only those are present where J takes odd values. It is clear, therefore, that half of the rotational lines will also be missing, N being permitted to take only the values $+1$, $+3$, $+5$, $\cdots$ etc. in the R branch and the values, -2, -4, -6, -8, etc. only in the P branch. Eq. (1) is the same as that given by Martin and Barker for the lines in this band except that a convergence factor -0.0031 appears to fit our data definitely better than the value -0.0035 given by them. The value -0.0031 is moreover in agreement with the value predicted by the theory for the CO_2 molecule given by Adel and Dennison.[2]

TABLE I. *Line positions in the 4.3μ CO_2 fundamental.*

N	OBSERVED ν	COMPUTED ν	DIFFERENCE
+55	2383.7	2383.6	+0.1
+53	2382.4	2382.7	− .3
+51	2381.7	2381.8	− .1
+49	2380.9	2380.8	+ .1
+47	2380.2	2379.9	+ .3
+45	2379.0	2378.9	+ .1
+43	2377.8	2377.9	− .1
+41	2376.9	2376.9	0
+39	2375.9	2375.8	+ .1
+37	2375.0	2374.7	+ .3
+35	2373.6	2373.6	0
+33	2372.5	2372.5	0
+31	2371.4	2371.3	+ .1
+29	2369.9	2370.1	− .2
+27	2368.8	2368.9	− .1
+25	2367.3	2367.7	− .4
+23	2366.3	2366.4	− .1
+21	2364.8	2365.1	− .3
+19	2363.7	2363.8	− .1
+17	2362.3	2362.4	− .1
+15	2361.2	2361.1	+ .1
+13	2359.4	2359.7	− .3
+11	2357.9	2358.3	− .4
+ 9	2356.5	2356.9	− .4
+ 7	2355.0	2355.4	− .4
+ 5	2353.6	2353.9	− .3
+ 3	2352.5	2352.4	+ .1
+ 1	2350.9	2350.9	0
− 2	2348.5	2348.5	0
− 4	2347.1	2346.9	+ .2
− 6	2345.9	2345.3	+ .6
− 8	2343.9	2343.7	+ .2
−10	2342.1	2342.0	+ .1
−12	2340.3	2340.3	0
−14	2338.6	2338.6	0
−16	2336.8	2336.8	0
−18	2335.0	2335.1	− .1
−20	2333.2	2333.3	− .1
−22	2331.5	2331.4	+ .1
−24	2329.7	2329.6	+ .1
−26	2327.9	2327.7	+ .2
−28	2325.8	2325.8	0
−30	2324.1	2323.9	+ .2
−32	2322.0	2322.0	0
−34	2320.2	2320.0	+ .2
−36	2318.1	2318.0	+ .1
−38	2316.4	2316.0	+ .4
−40	2314.3	2313.9	+ .4
−42	2312.6	2311.9	+ .7

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[2] A. Adel and D. M. Dennison, Phys. Rev. **44**, 99 (1933).