No. 34 LABORATORY SPECTRA FOR TESTING THE PRESENCE OF MINOR CONSTITUENTS IN PLANETARY ATMOSPHERES, I: CH_4, NH_3, N_2O, CO, COS, REGION 1–2.5 μ

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As the power of spectrometric devices for the observation of IR planetary spectra increases, new opportunities arise for testing these spectra for the presence of hitherto undetected minor constituents. For most common gases the sensitivity of such tests is minimal in the ordinary photographic range, and increases both for $\lambda << 0.3$ μ, where the electronic bands appear, and $\lambda >> 1$ μ, where the rotation-vibration bands occur. This paper is concerned with part of the second region, 1–2.5 μ, which is readily observed with a PbS spectrometer. The tests become sharper with still longer wavelengths, where the fundamentals and low overtones occur, but the difficulty of obtaining planetary spectra with adequate resolution also increases there, so that criteria must be developed for each spectral region separately. Further reasons for this are that the atmospheric windows in the IR spectrum are limited so that otherwise favorable criteria may be unavailable, and that strong masking absorptions may be present in the planetary atmospheres obscuring large regions altogether. Multiple test criteria are therefore required.

The laboratory spectra here presented were made with the PbS spectrometer described by Kuiper *et al.* (*LPL Comm. 1*, 119). Absorption cells of various lengths were used made of glass tubing since some of the gases would react with galvanized iron. The light source used was an incandescent laboratory lamp. The windows of the cells were either glass or Suprasil (Englehard Industries, Inc.), and glass lenses (total thickness up to 3 cm) were used in the optical system. In the spectral region covered these lenses had no appreciable selective absorptions.

The spectra show, in addition to the absorptions of the gases under study, absorptions caused by CO_2 and H_2O in the spectrometer and the laboratory (with some enrichment of CO_2 due to evaporating dry ice). The total path in the spectrometer and laboratory was about 3 meters.

The present paper is limited to the gases listed in the title. CO as a minor constituent has been treated previously (Kuiper, *LPL Comm. 1*, 114–115). The tests for NO_2 are insensitive in the region considered here and are no match for the very rich photographic spectrum. The latter is considered in *Communication* No. 35.

The records in the present paper have been used in *Communication* No. 31 and will be referred to in other studies in preparation.

Acknowledgments. The program of infrared planetary spectroscopy is supported by the National Aeronautics and Space Administration through Grant No. NsG 161-61.

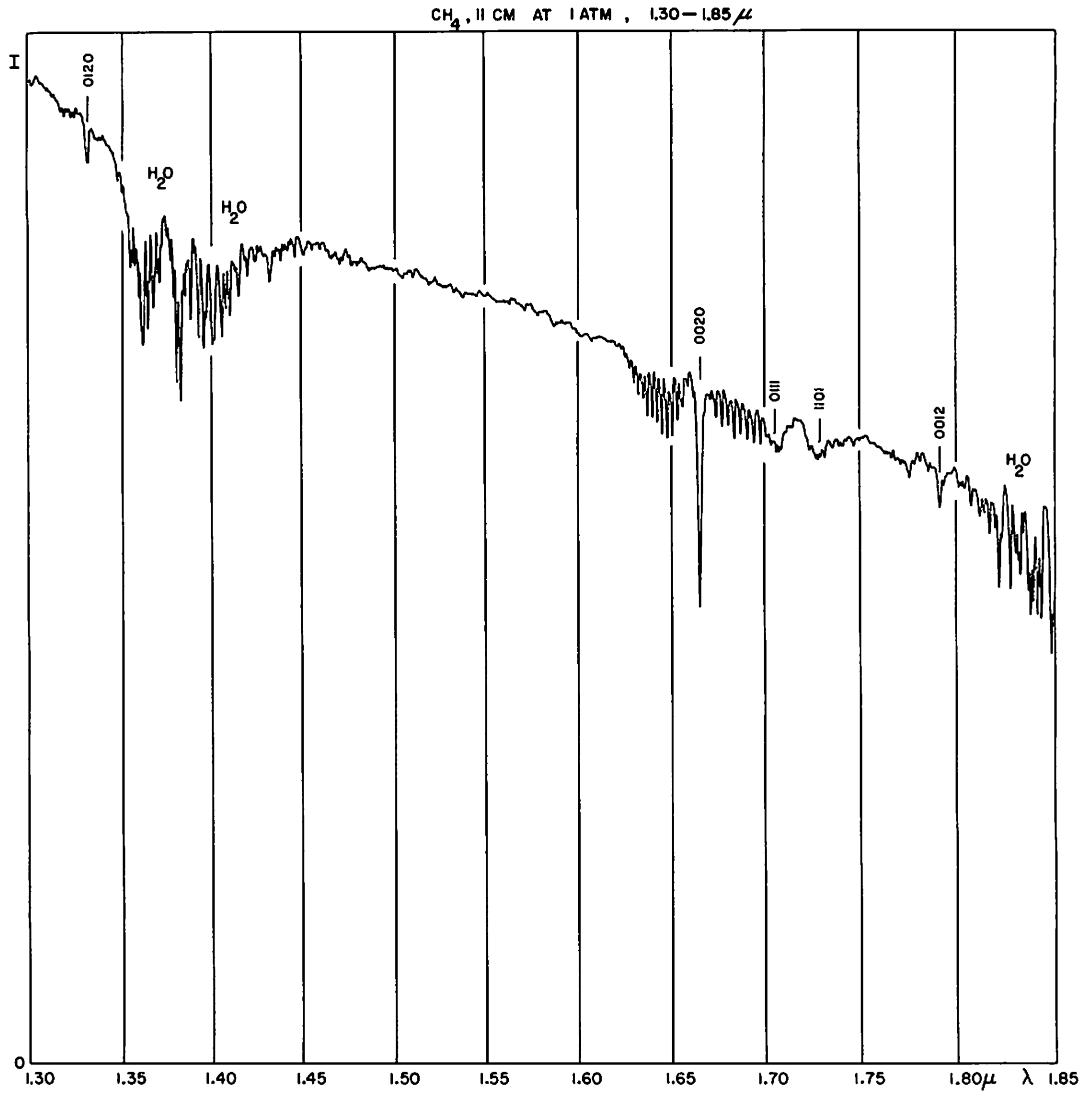

Fig. 1. CH_4, 11 cm at $p = 1$ atm, 1.30–1.85 μ, 1.6 μ grating, Corning 2540 filter, detector cell 0.1 mm, slit 0.18 mm, scan 5/1 (i.e. 0.2 μ scanned in 5 min. and chart speed *1* inch per minute), $\tau = 1$ sec. (i.e. the record is time-constant limited).

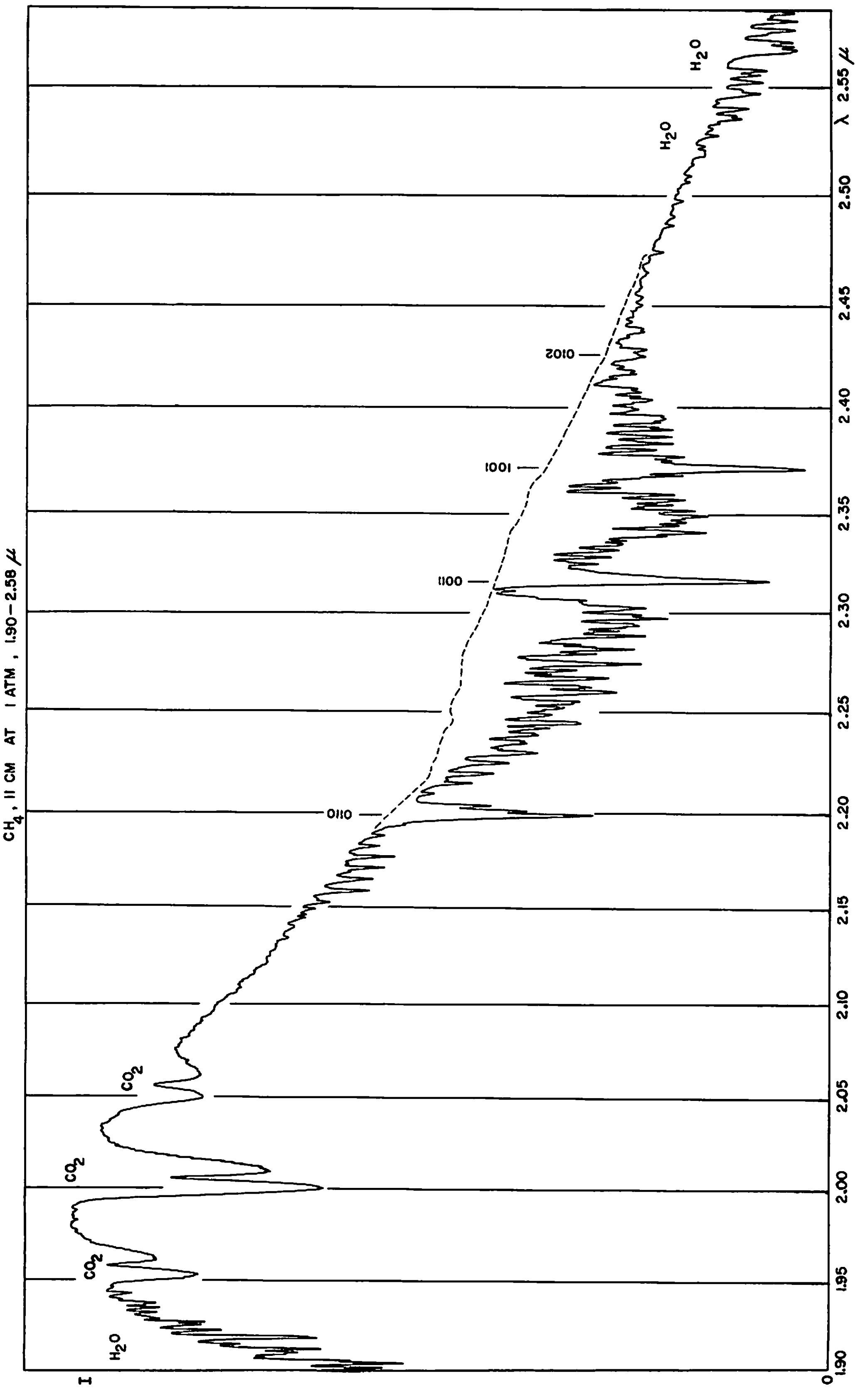

Fig. 2. CH_4, 11 cm at $p = 1$ atm, 1.90–2.58 μ, 1.6 μ grating, 2 μ filter, cell 0.1 mm, slit 0.18 mm, scan 5/1, $\tau = 1$ sec. Undisturbed continuum indicated by dashed line.

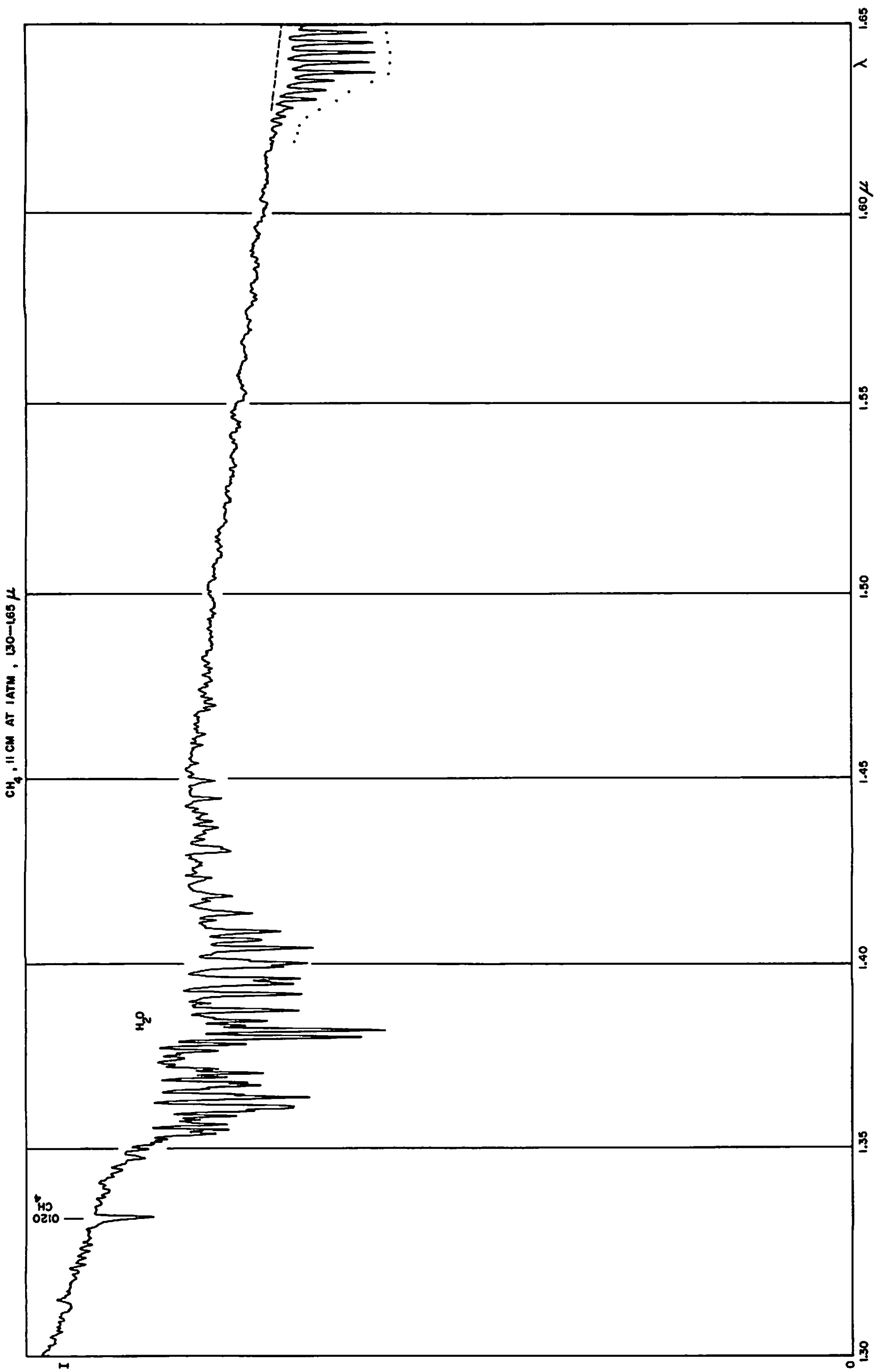

Fig. 3, Part 1. CH$_4$, 1.30–1.65 μ, as Fig. 1, but scan 12.5/1 (resolution increased over Fig. 1 because of longer scanning time).

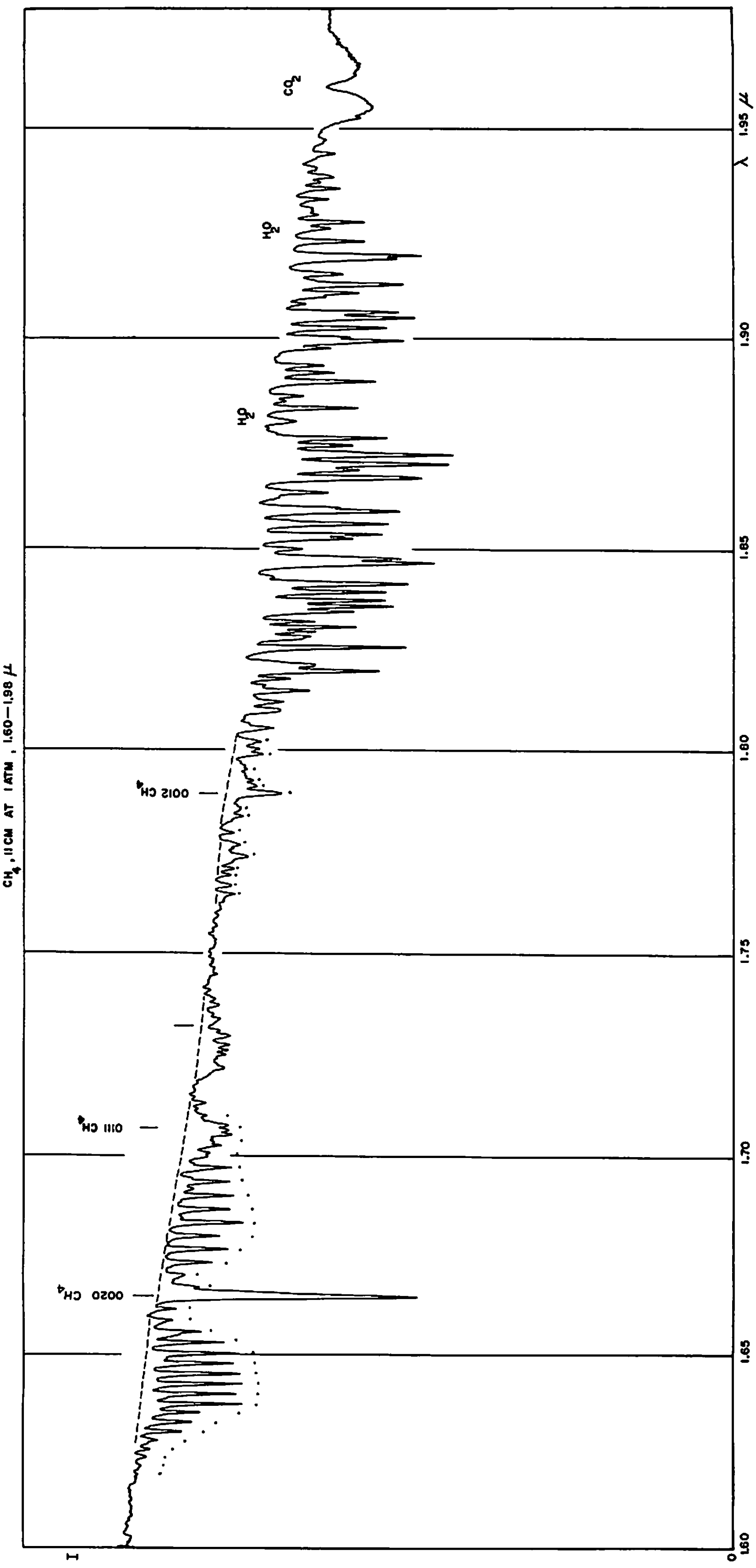

Fig. 3, Part 2. CH_4, 1.60–1.98 μ. *Dashed line*, undisturbed continuum. *Dots*, rotational lines.

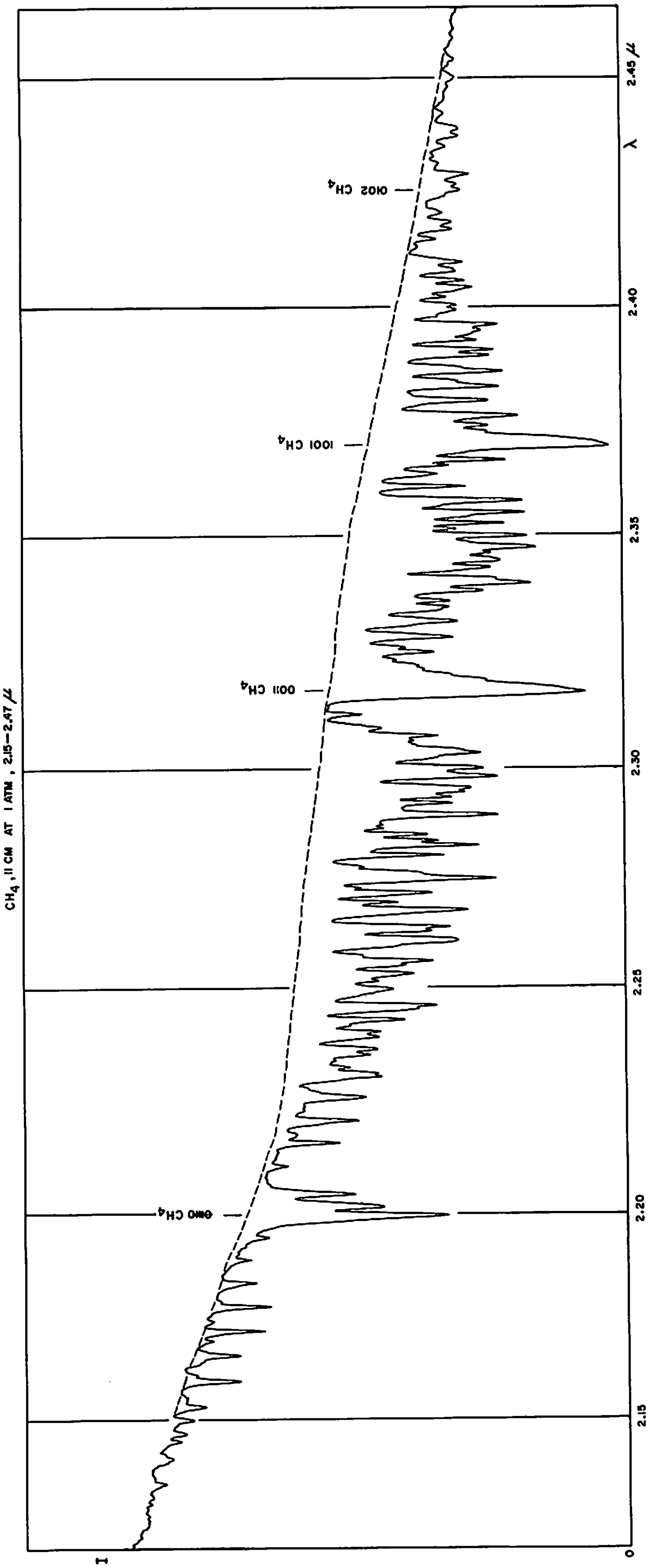

Fig. 4. CH_4, 11 cm at $p = 1$ atm, 2.12–2.46 μ and scan 12.5/1; cf. Fig. 2.

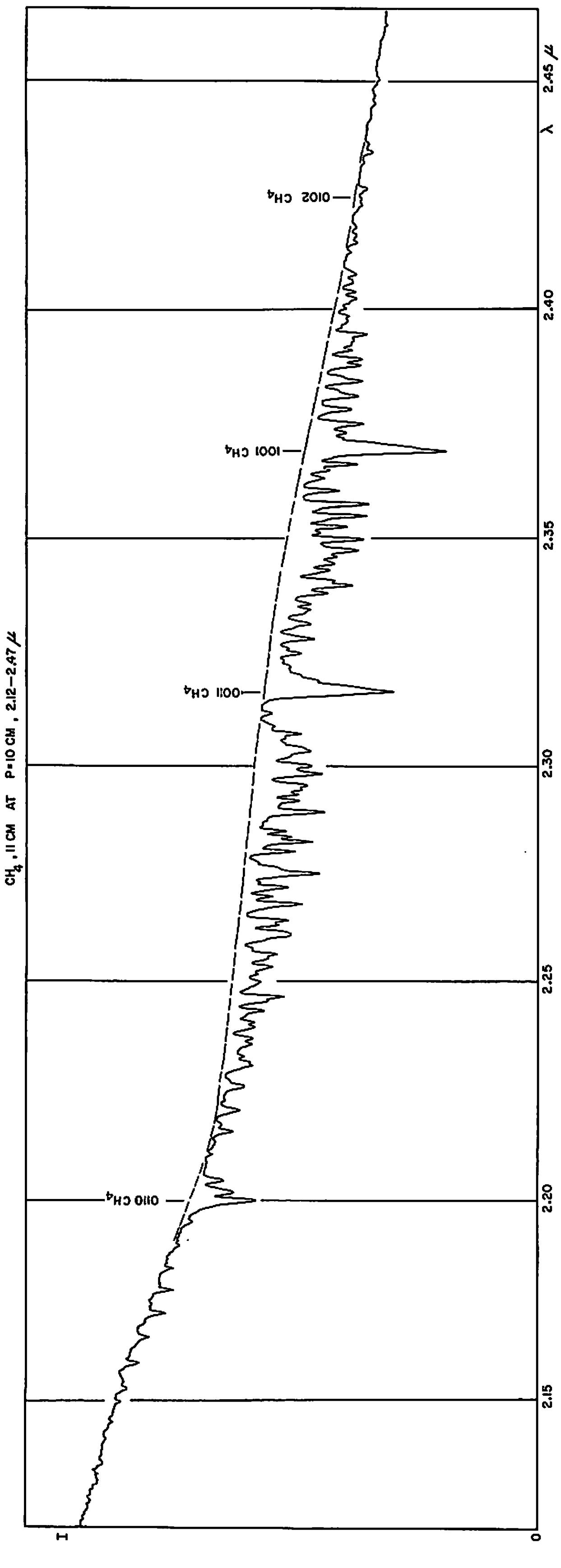

Fig. 5. CH_4, 11 cm at $p = 10$ cm, 2.12–2.47 μ, scan 12.5/1; cf. Fig. 4.

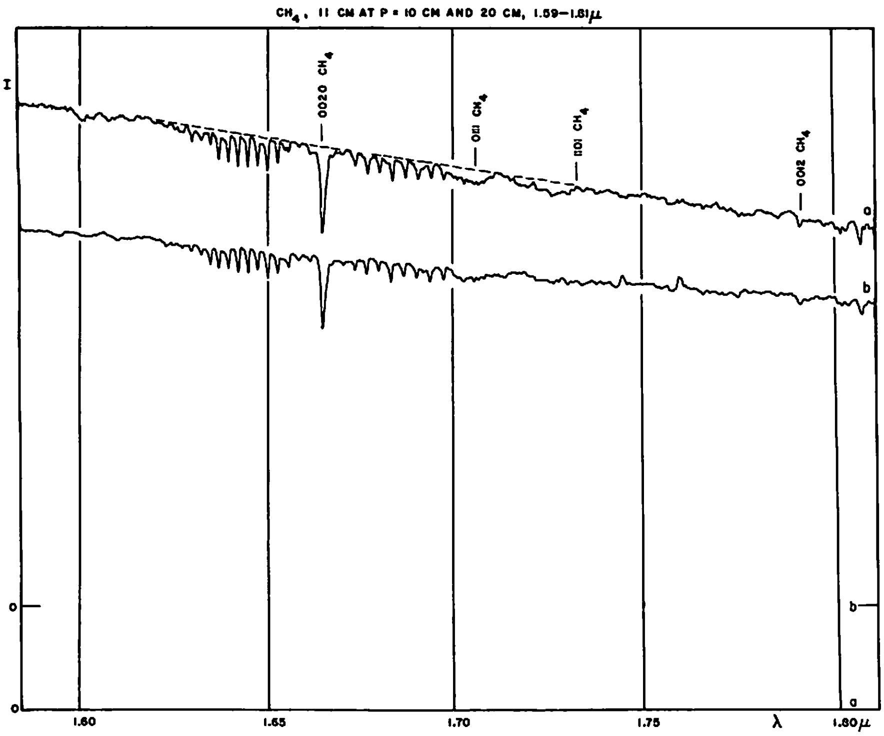

Fig. 6. CH_4, 1.59–1.81 μ; 11 cm at $p = 10$ cm (a), and 20 cm (b); scan 12.5/1; cf. Fig. 3. The zero levels are here in *reverse* order from the graphs, so that amplitude of curve a is 1.6 × larger than of curve b, more than compensating for intensity difference of band.

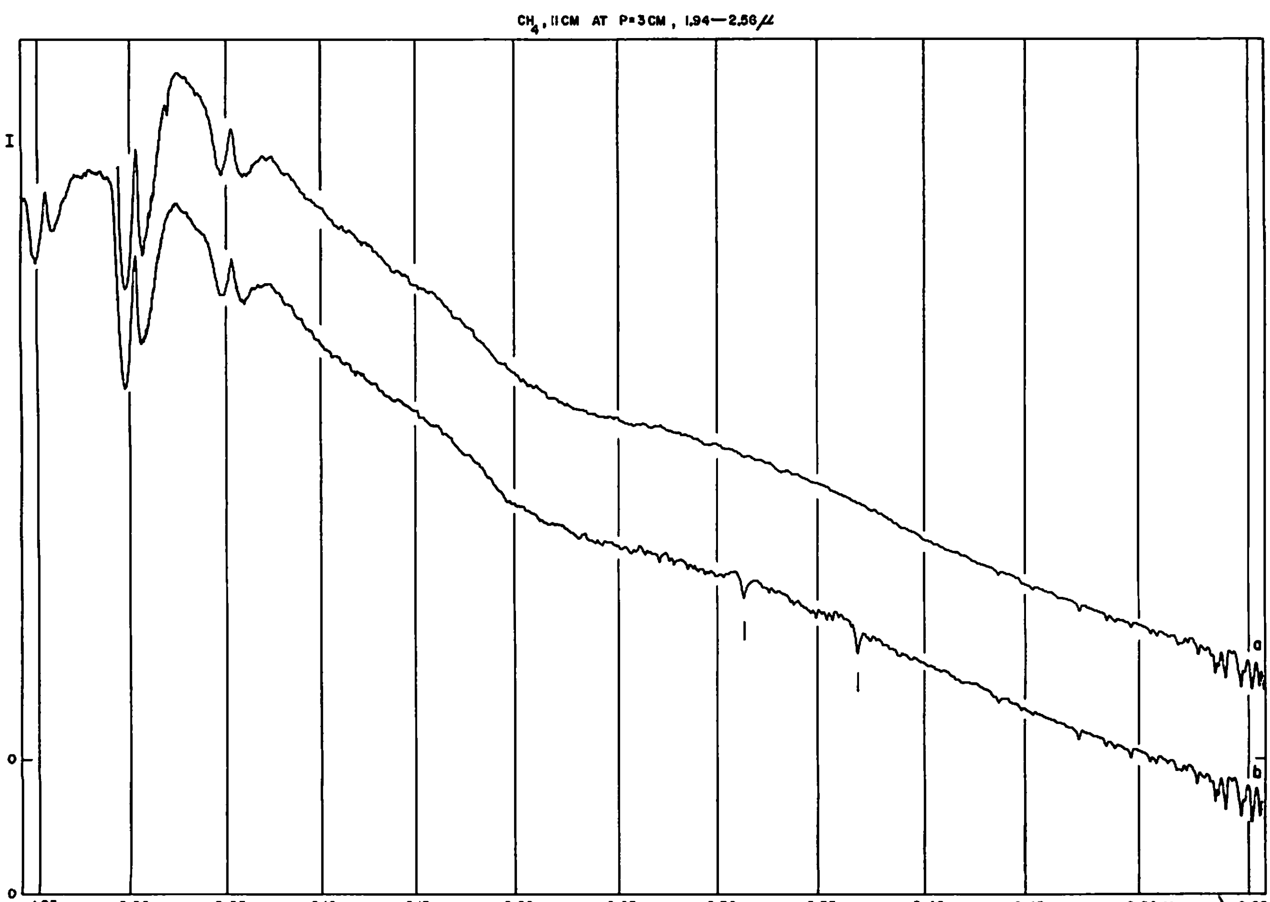

Fig. 7. CH_4, 11 cm at $p = 3$ cm (b) and blank run (a), 1.90–2.58 μ, 1.6 μ grating, 2 μ filter, cell 0.1 mm, slit 0.18 mm, scan 5/1, $\tau = 1$ sec.

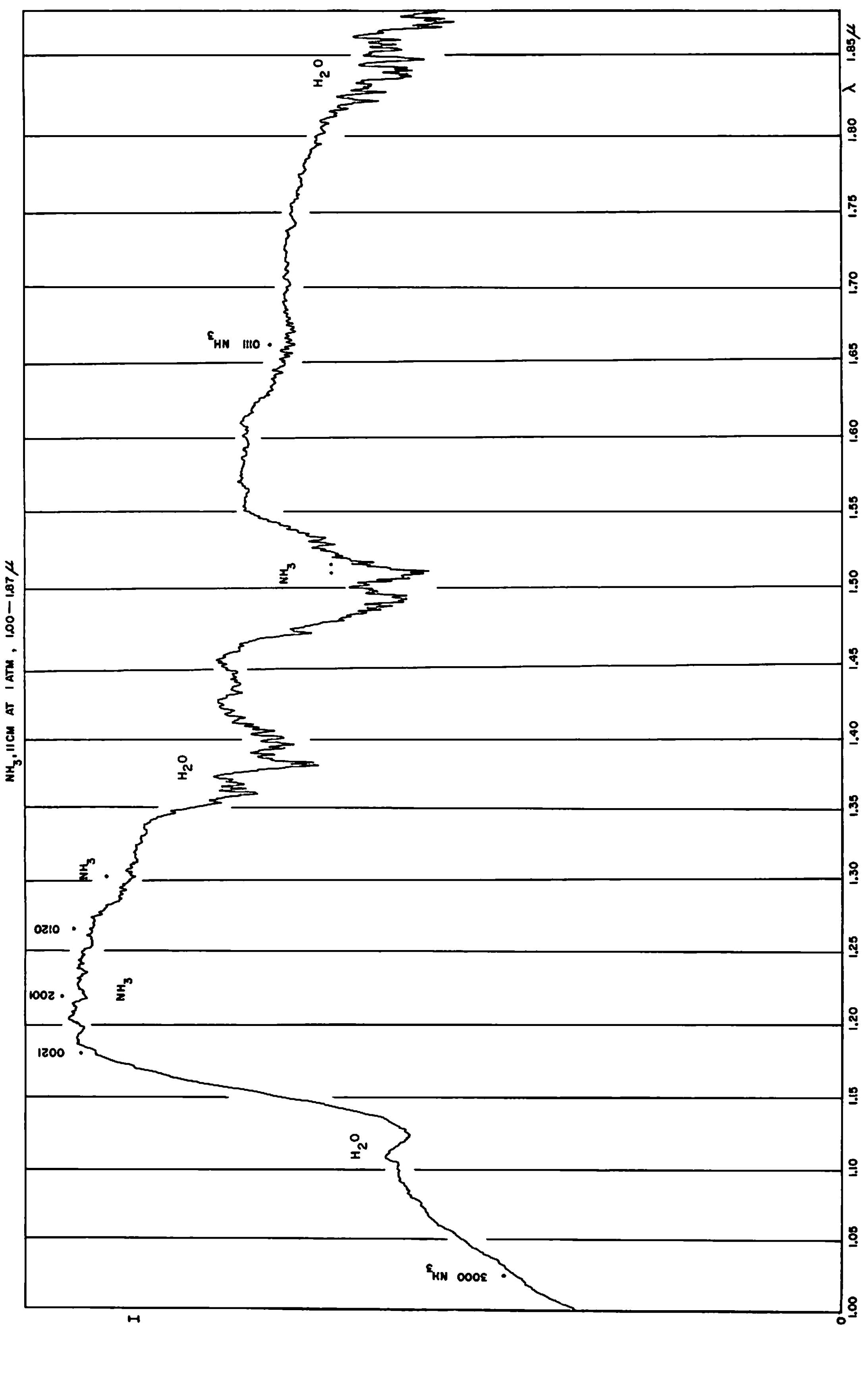

Fig. 8. NH_3, 11 cm at $p = 1$ atm, 1.00–1.87 μ, otherwise as Fig. 1. Dots signify weak NH_3 bands (G. Herzberg, *Infrared and Raman Spectra*, New York, Van Nostrand, 1945, p. 296).

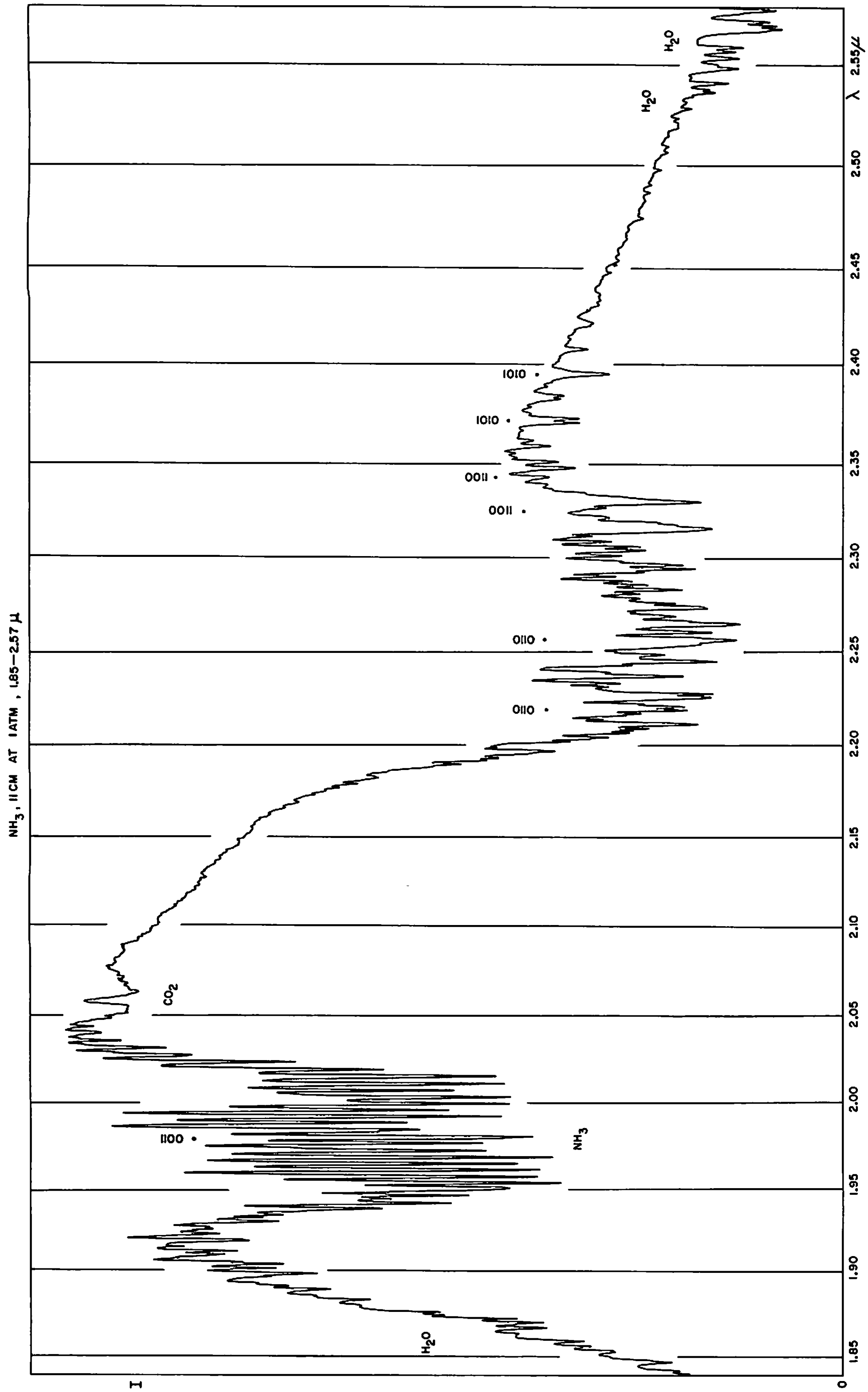

Fig. 9. NH_3. 11 cm at $p = 1$ atm, 1.85–2.57 μ, otherwise as Fig. 2.

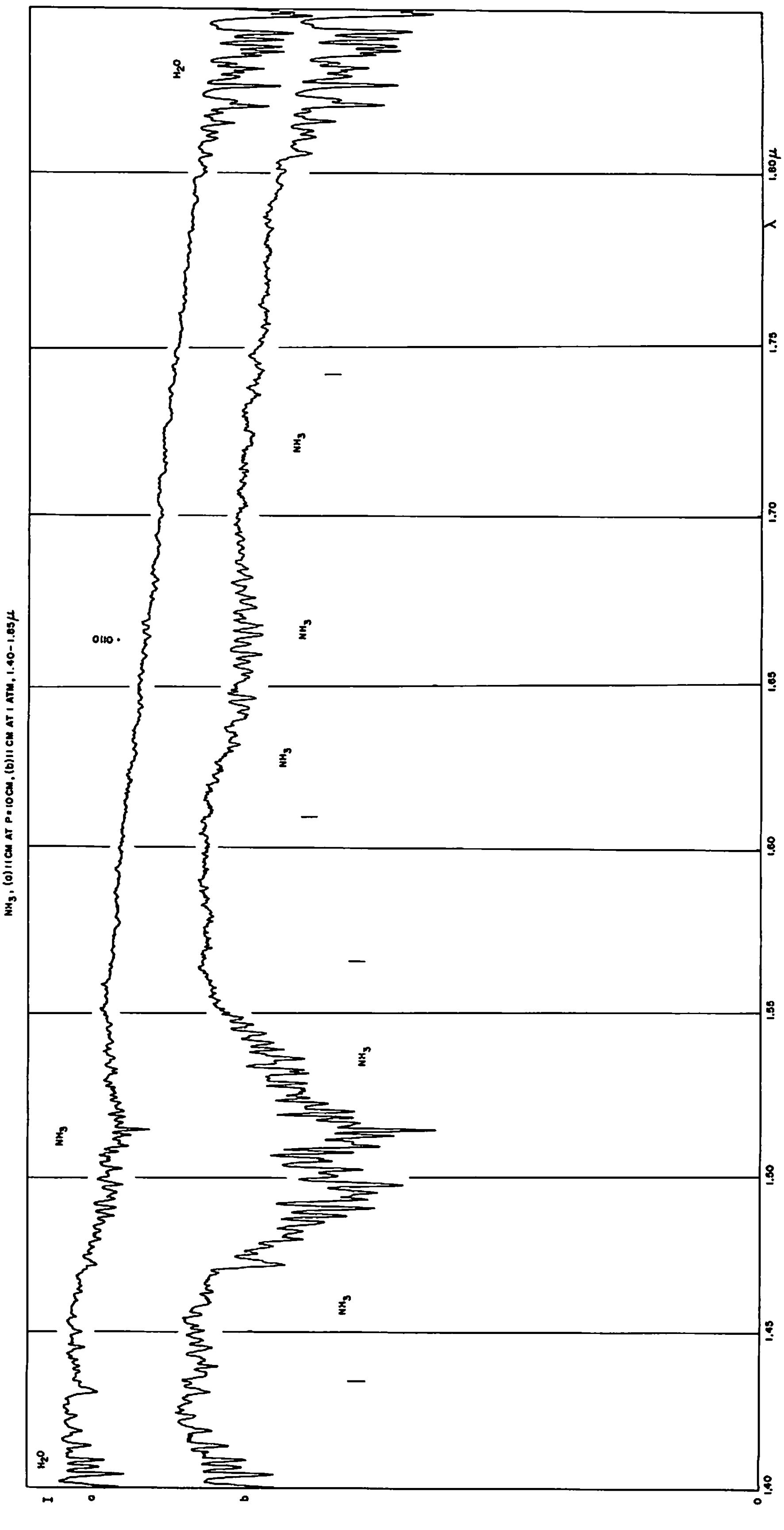

Fig. 10. NH_3, 11 cm at $p = 10$ cm and 1 atm, 1.40–1.85 μ, scan 12.5/1; cf. Fig. 8.

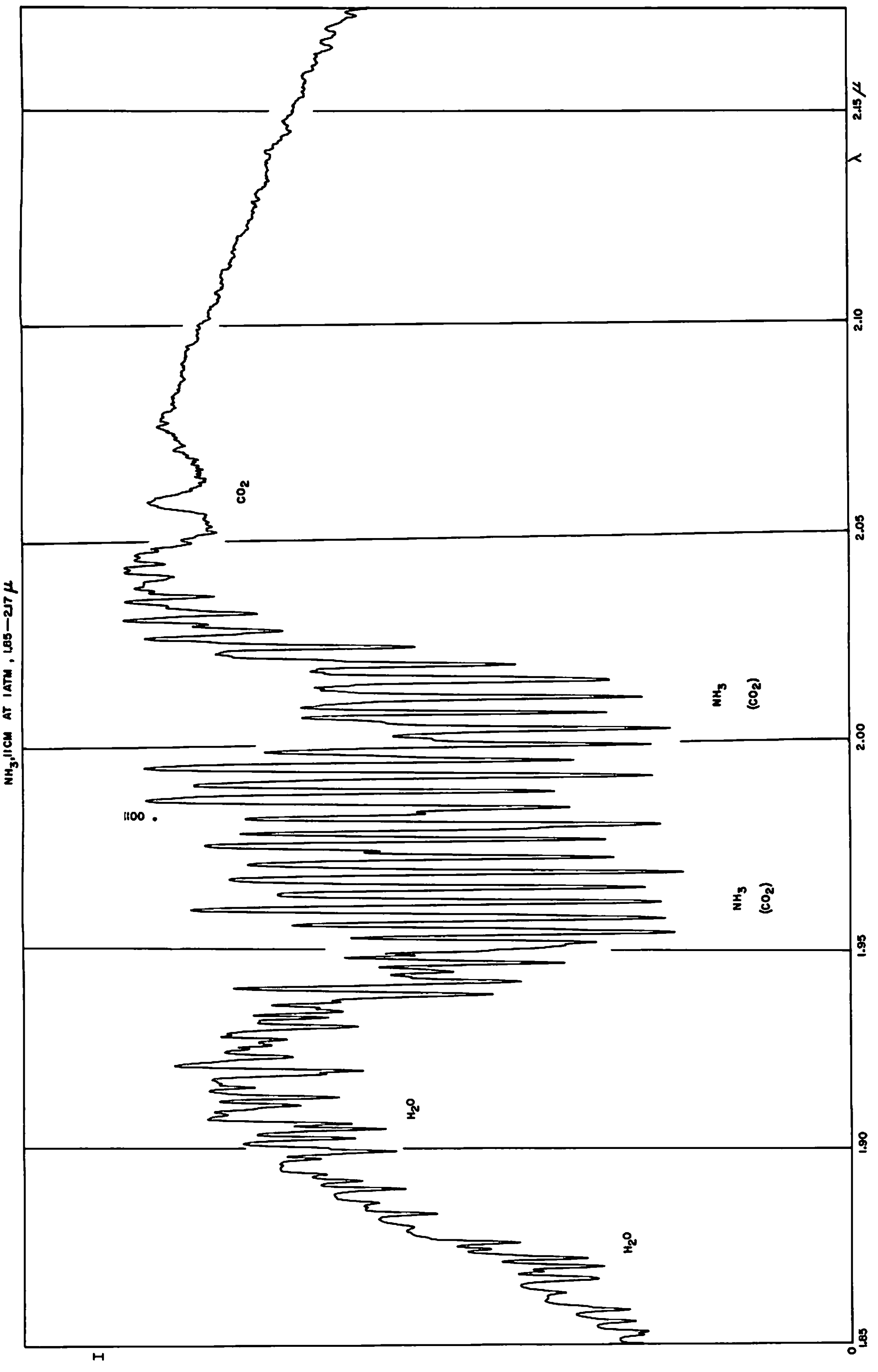

Fig. 11. NH_3, 11 cm at $p = 1$ atm, 1.85–2.17 μ, scan 12.5/1; cf. Figs. 7, 14.

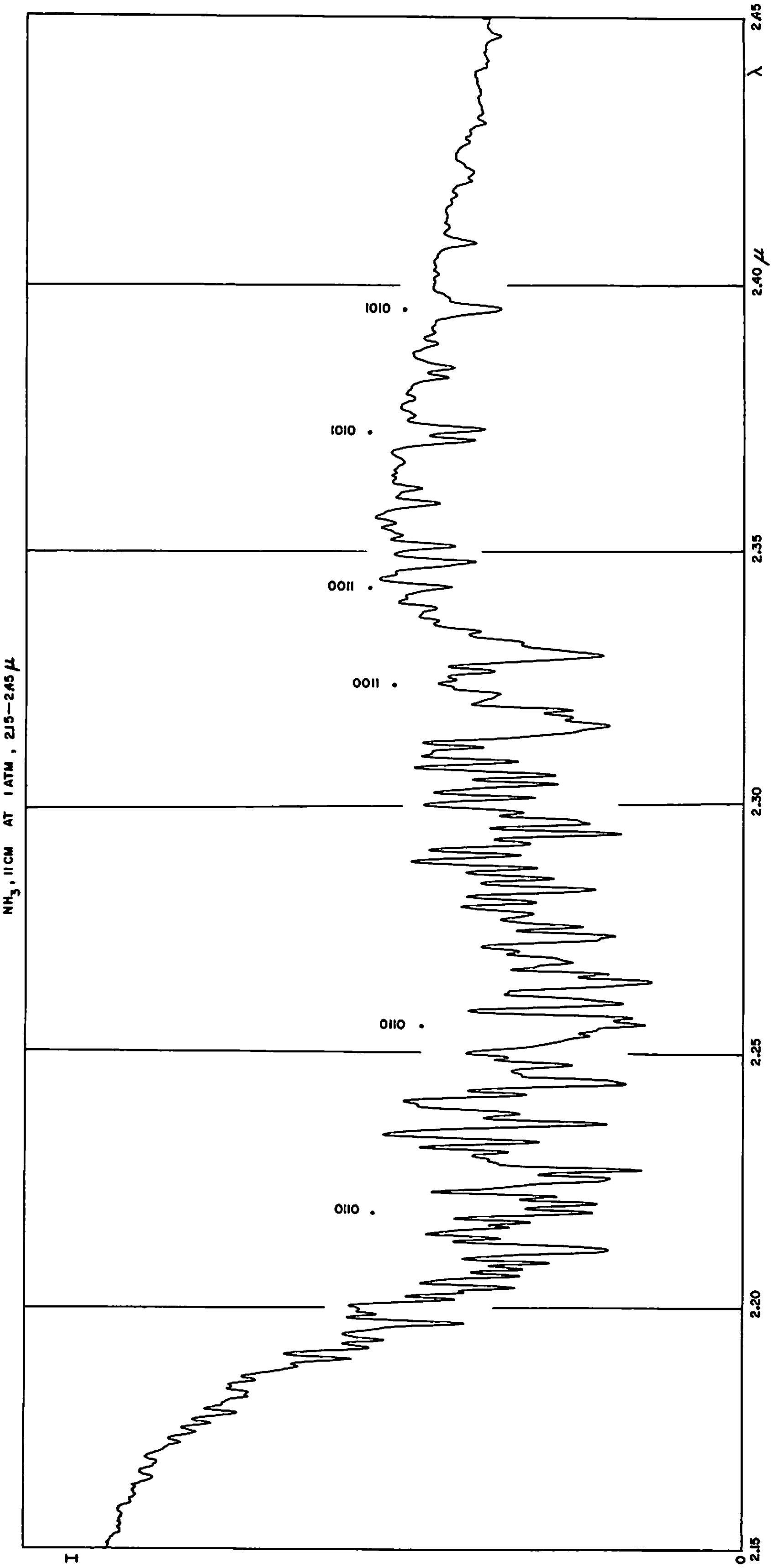

Fig. 12. NH_3, 11 cm at $p = 1$ atm, 2.15–2.45 μ, scan 12.5/1; cf. Figs. 7, 15.

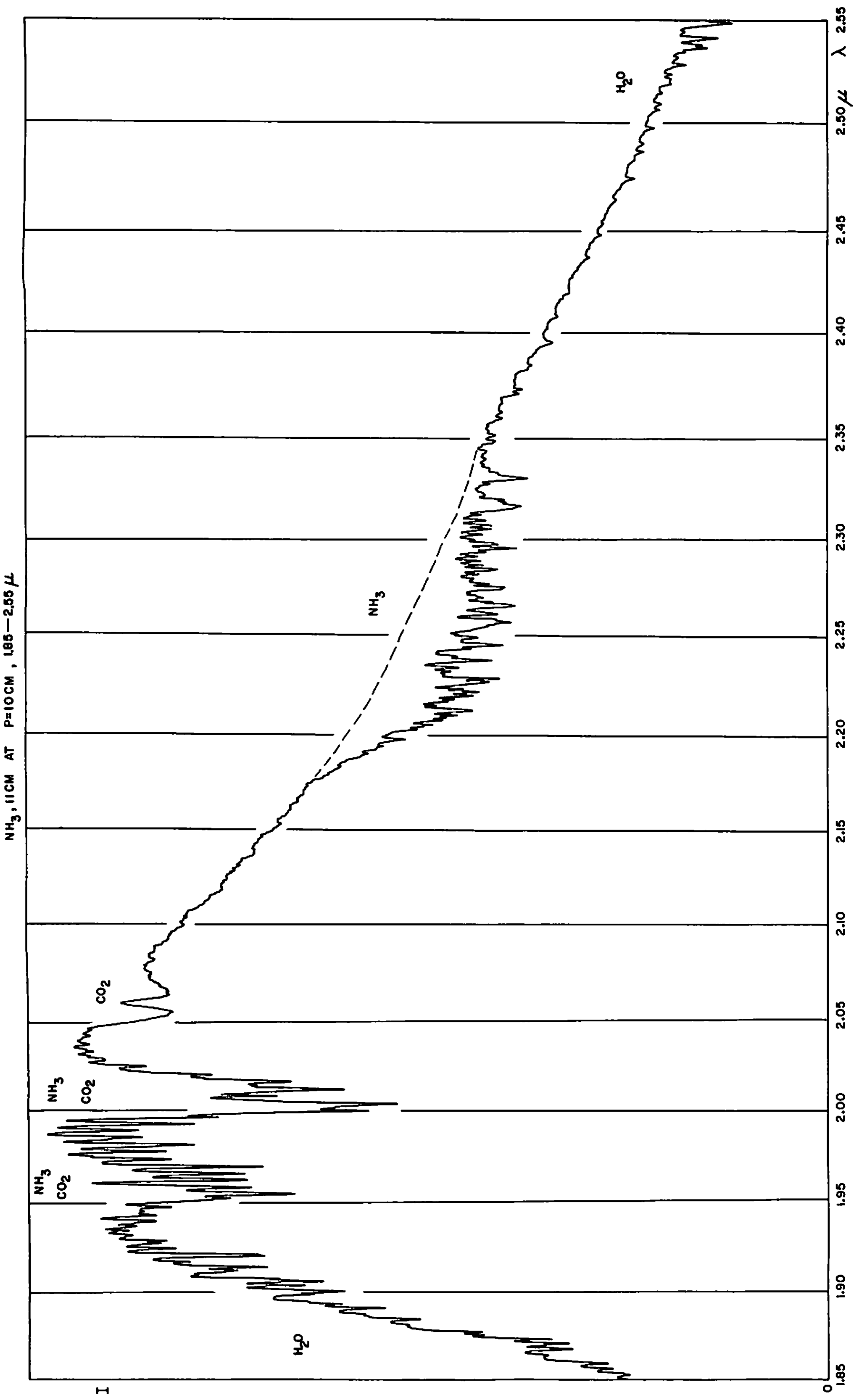

Fig. 13. NH_3, 11 cm at $p = 10$ cm, 1.85–2.55 μ, scan 5/1; cf. Fig. 7.

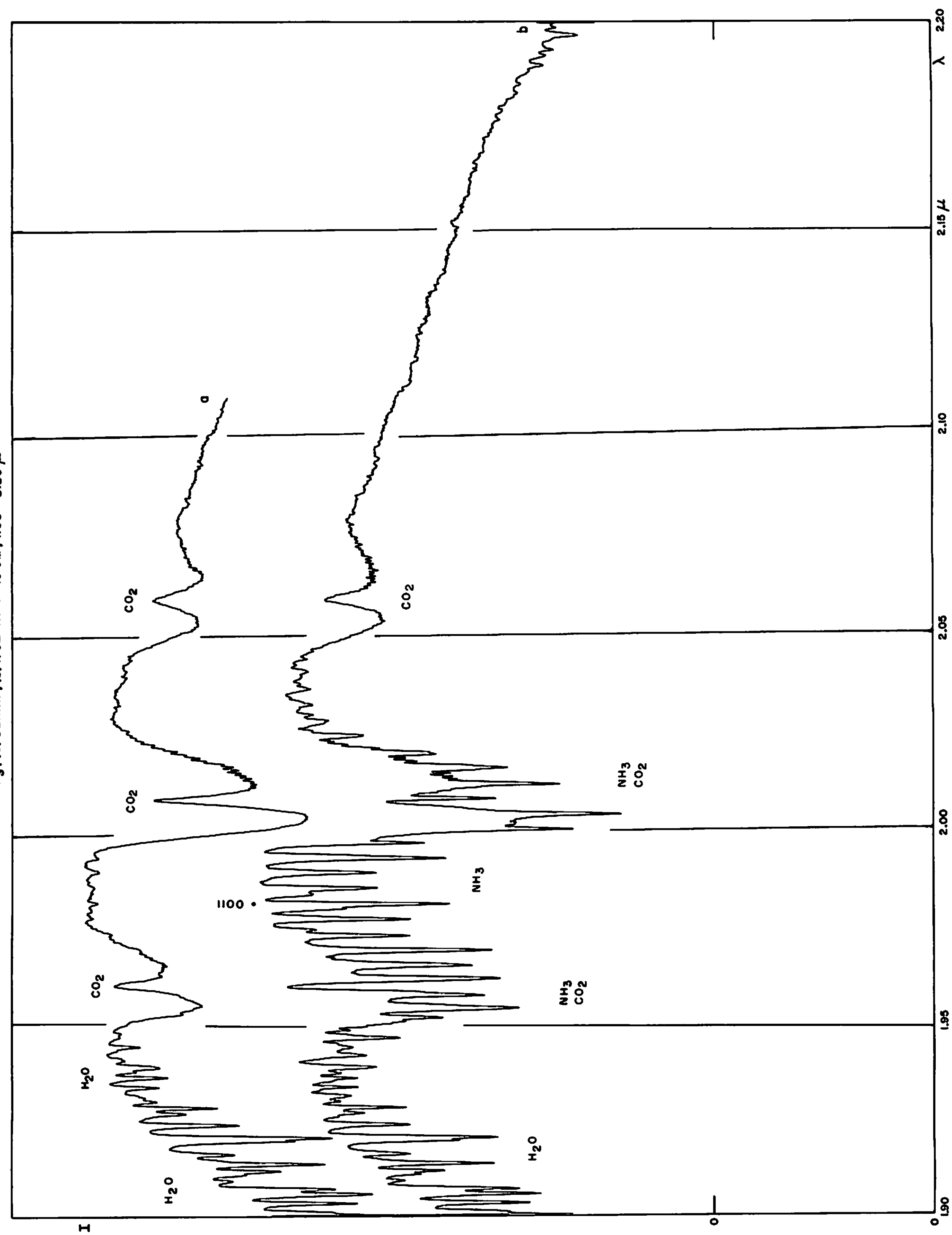

Fig. 14. Blank run and NH_3, 11 cm at $p = 10$ cm, 1.90–2.20 μ, scan 12.5/1; cf. Fig. 11.

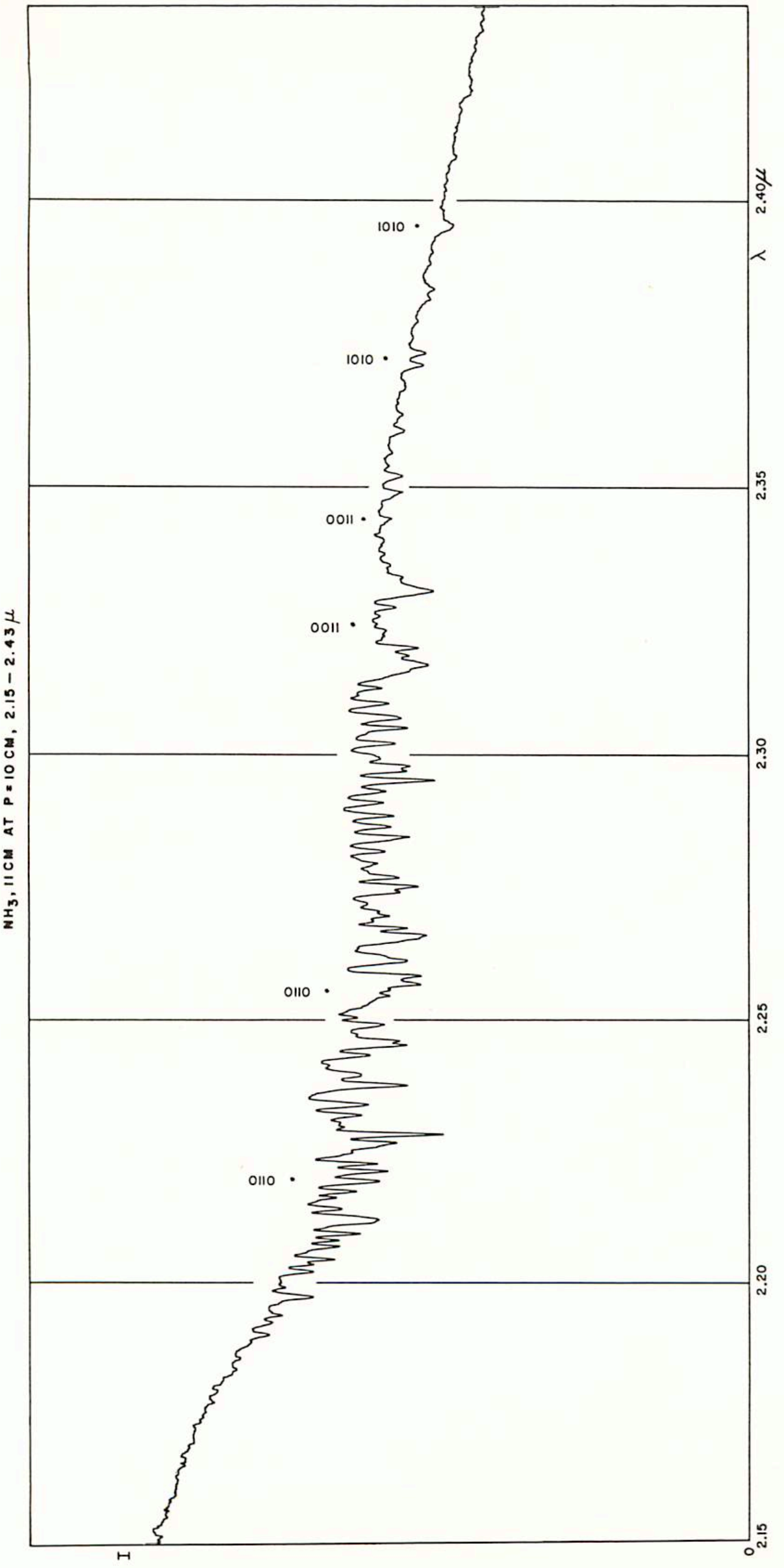

Fig. 15. NH_3, 11 cm at $p = 10$ cm, 2.15–2.43 μ, scan 12.5/1; cf. Figs. 12 and 13.

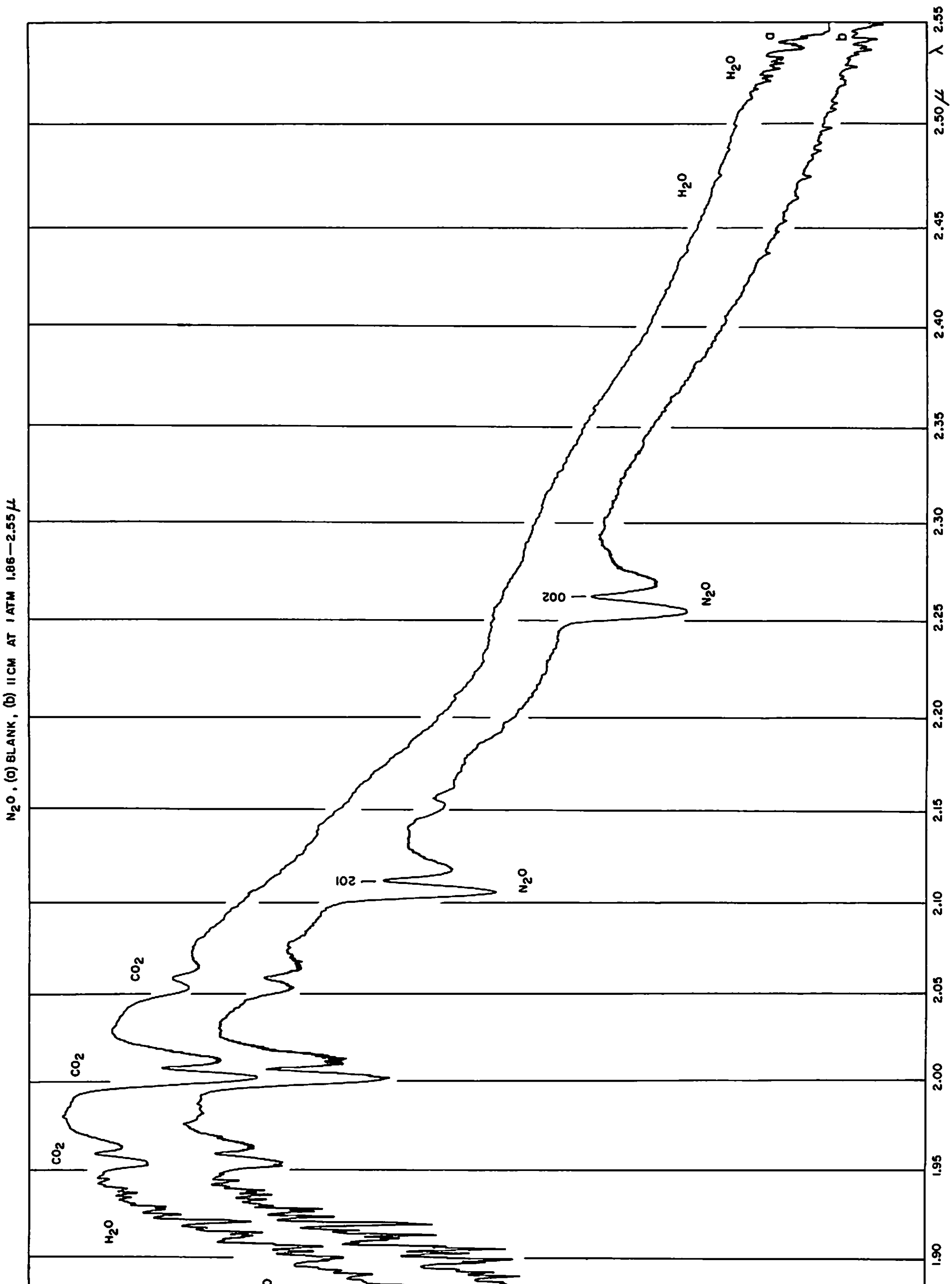

Fig. 16. Blank run and N_2O, 11 cm at $p = 1$ atm, 1.86–2.55 μ, scan 5/1. As Fig. 2.

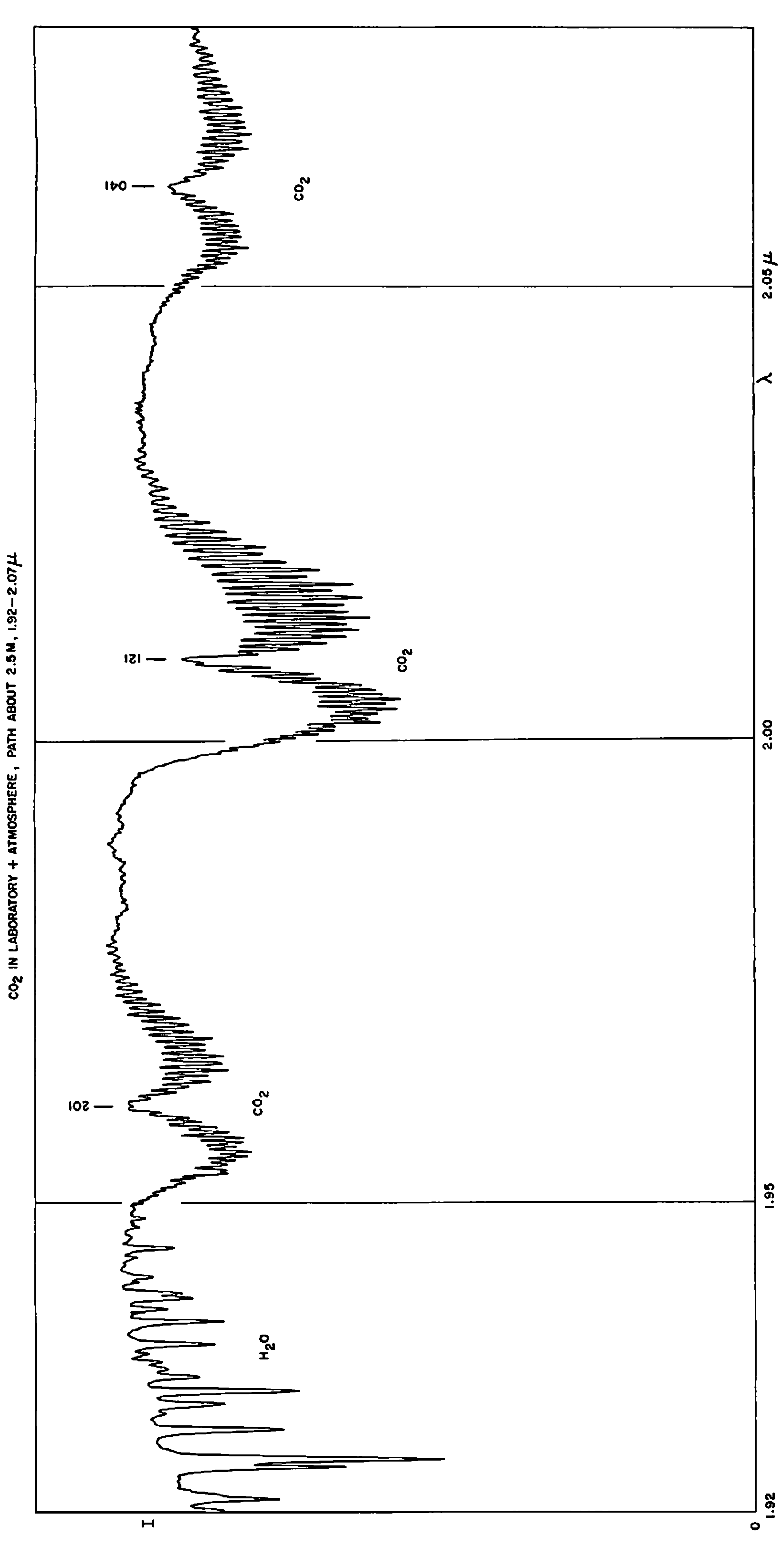

Fig. 17. CO_2 and H_2O, laboratory path of about 2.5 m, scan 25/1; for comparison with N_2O in Fig. 18.

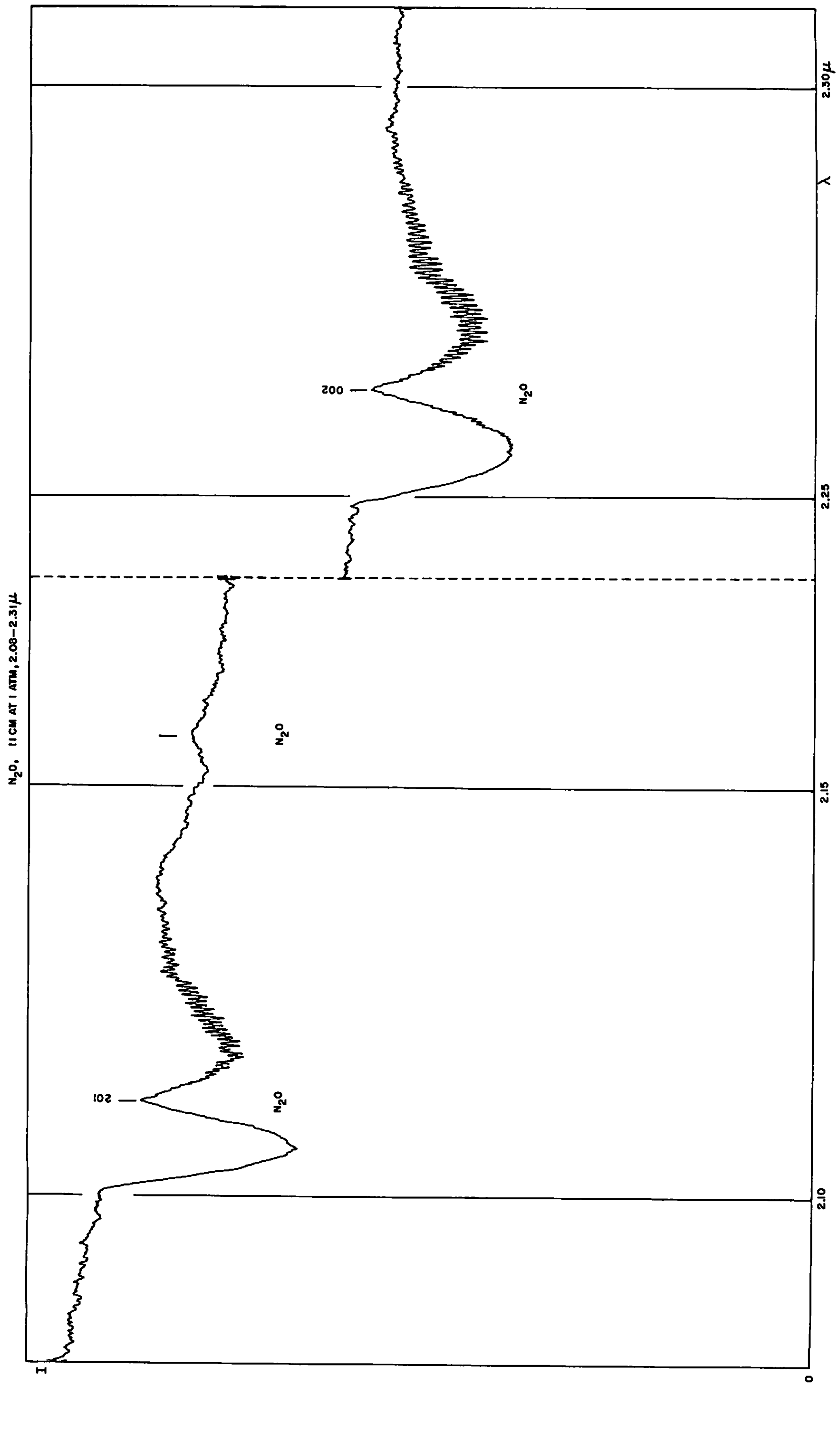

Fig. 18. N_2O, 11 cm at $p = 1$ atm, scan 25/1. Bands (201) and (002) compared to (201), (121), (041) of CO_2 in Fig. 17.

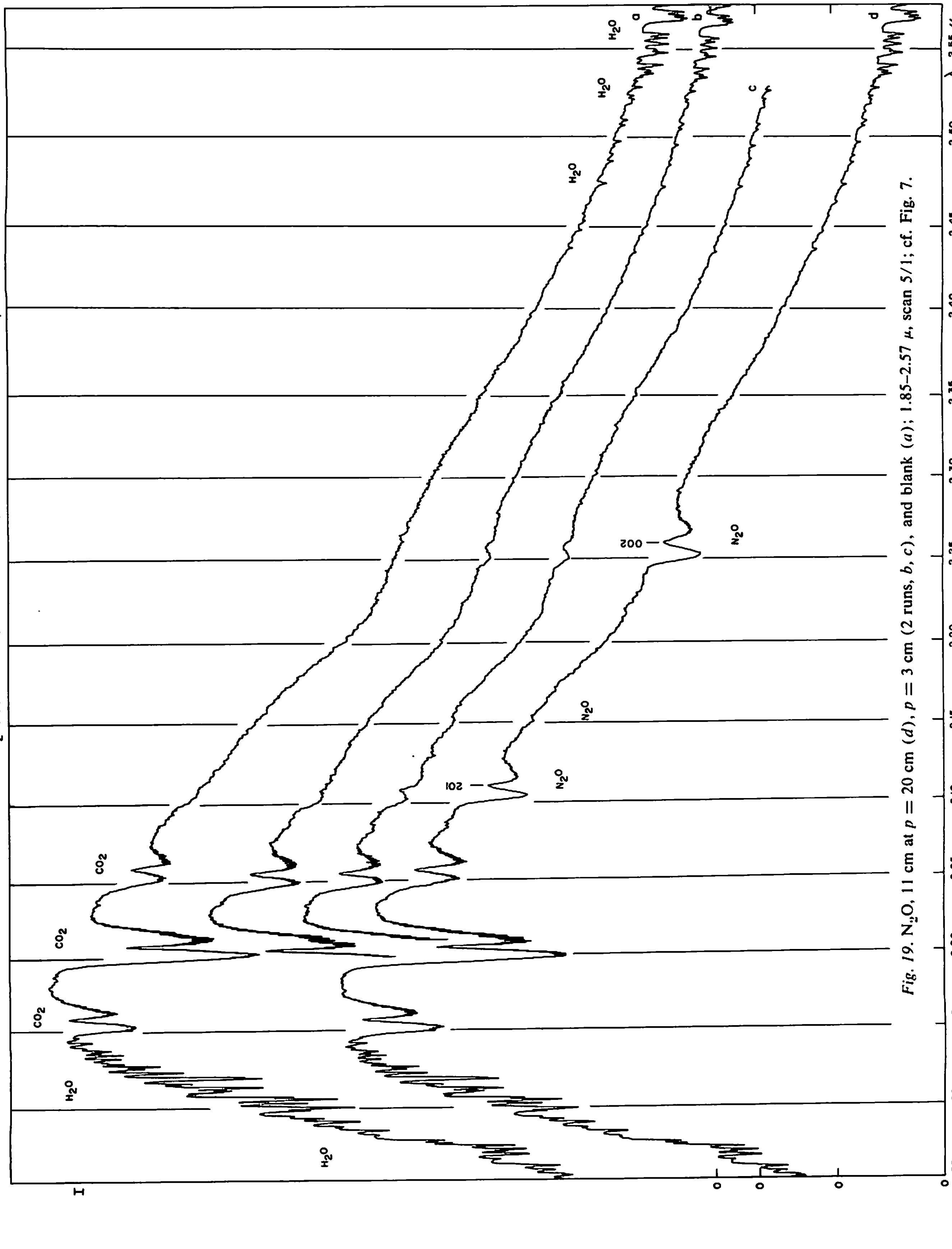

Fig. 19. N_2O, 11 cm at $p = 20$ cm (d), $p = 3$ cm (2 runs, b, c), and blank (a); 1.85–2.57 μ, scan 5/1; cf. Fig. 7.

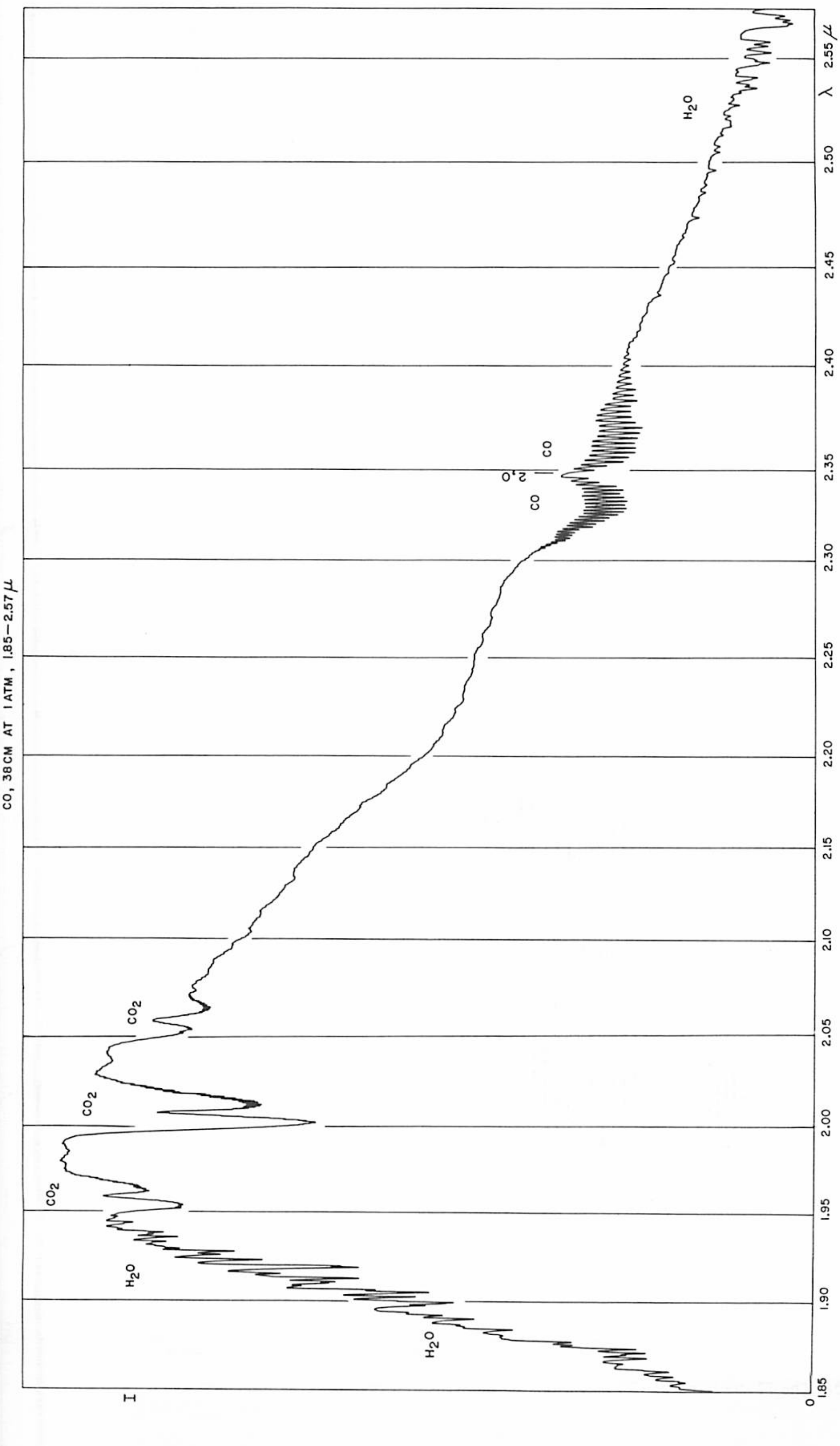

Fig. 20. CO, 38 cm at $p = 1$ atm, 1.85–2.57 μ, scan 5/1. The (2, 0) band is shown in different amounts and with more resolution in Fig. 21.

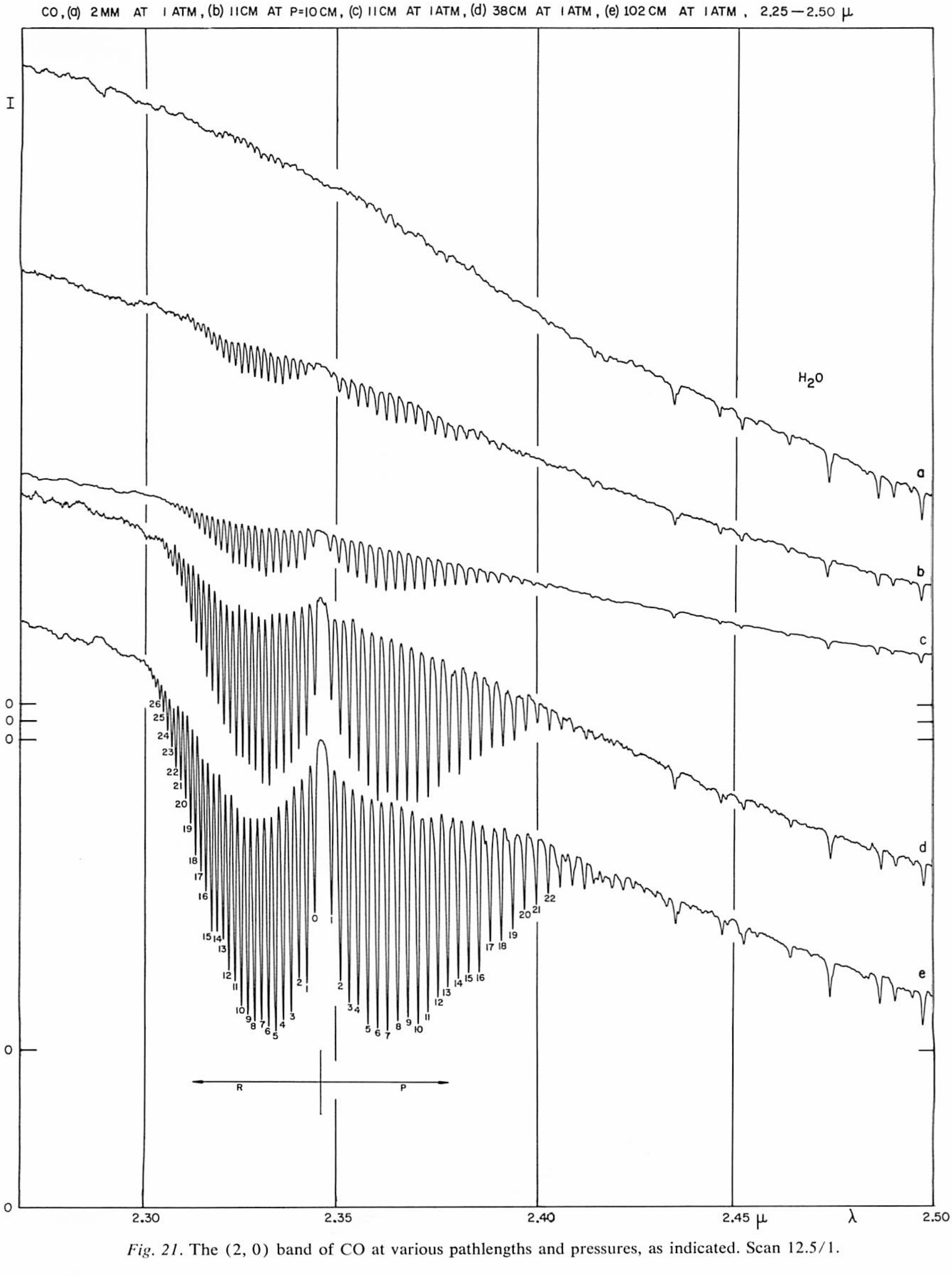

Fig. 21. The (2, 0) band of CO at various pathlengths and pressures, as indicated. Scan 12.5/1.

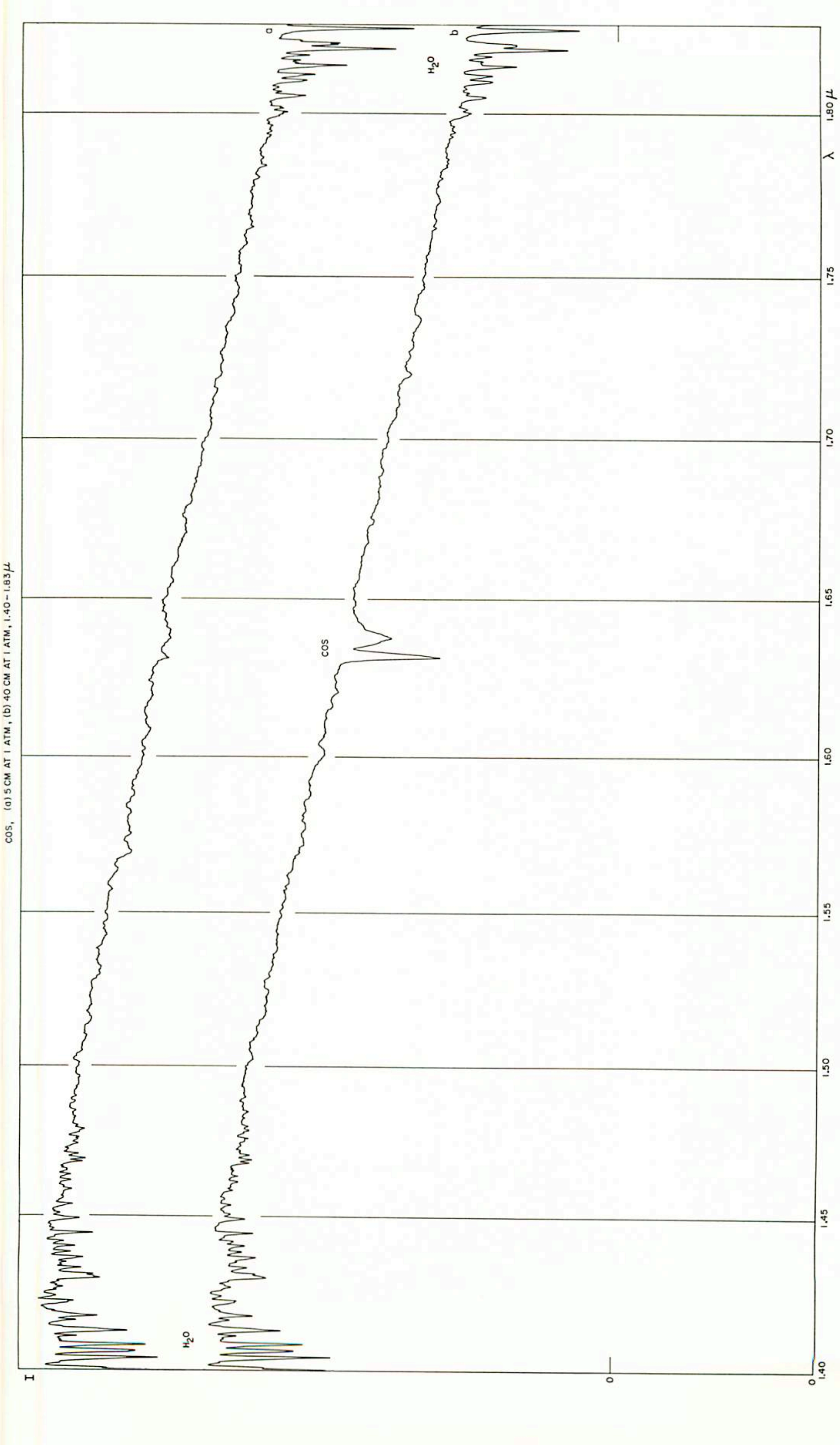

Fig. 22. COS, 5 and 40 cm at $p = 1$ atm, 1.40–1.82 μ, scan 12.5/1.

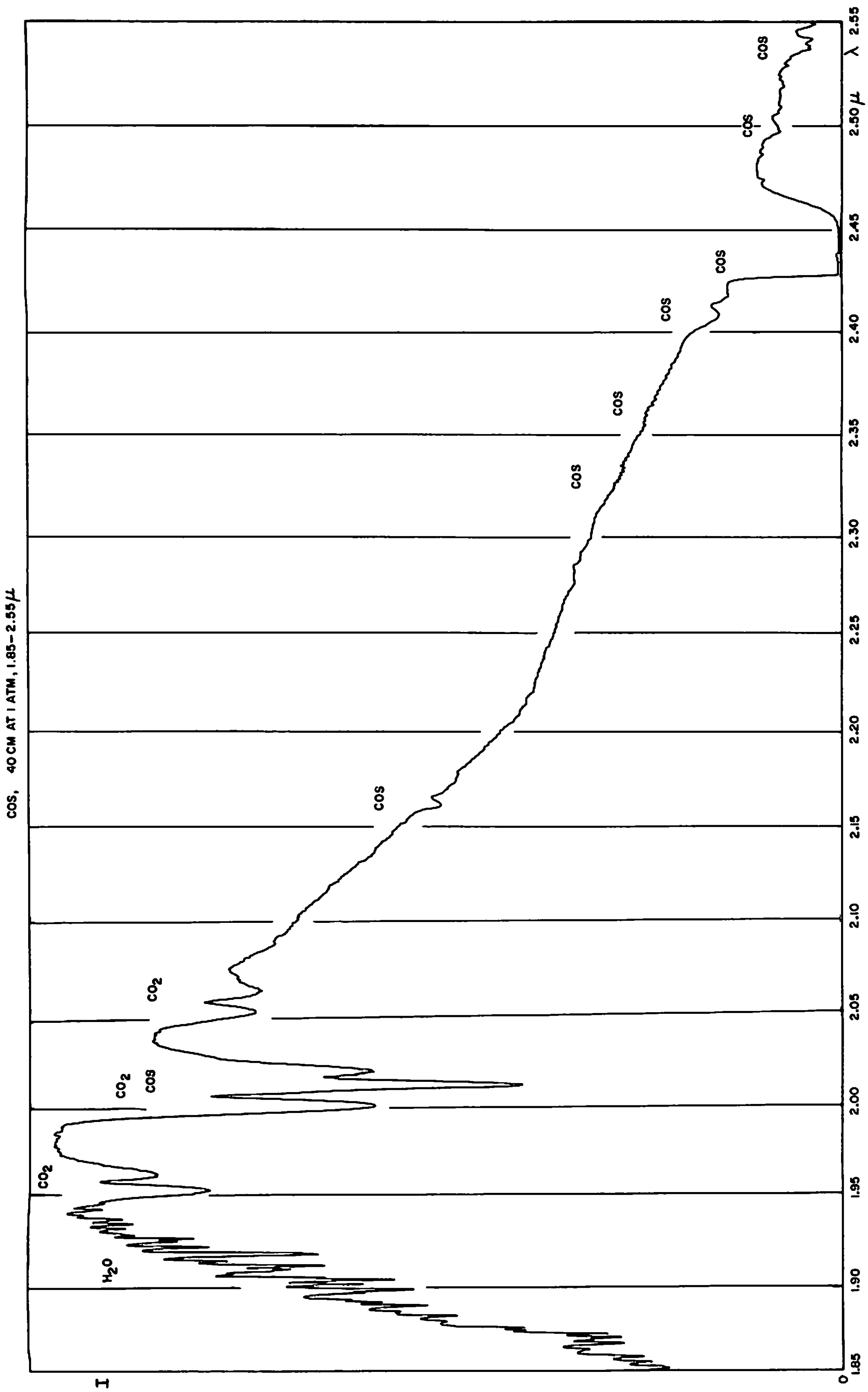

Fig. 23. COS, 40 cm at $p = 1$ atm, 1.85–2.55 μ, scan 5/1.

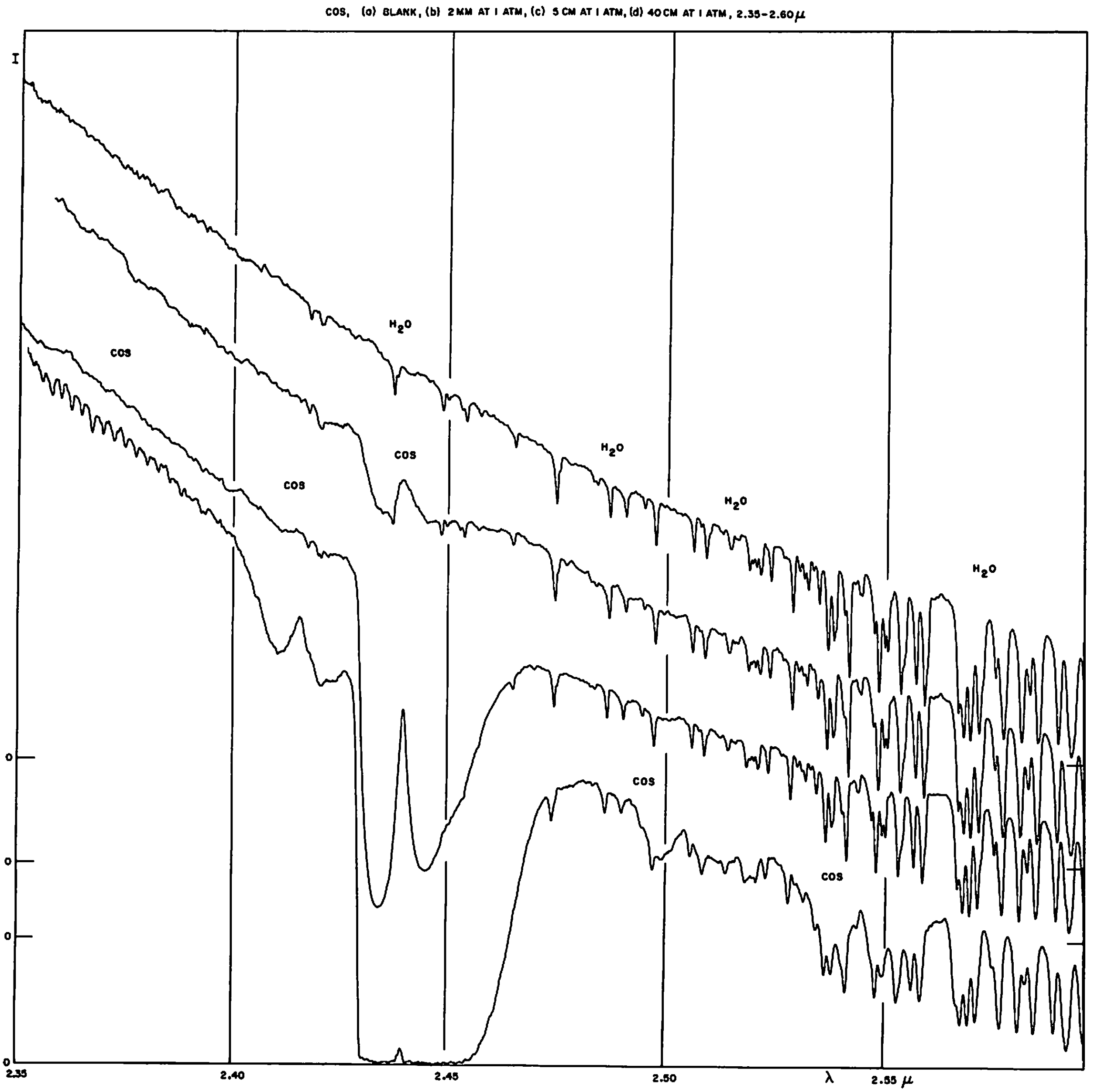

Fig. 24. COS in region 2.35–2.60 μ, with various pathlengths and gas pressures, as indicated. Scan 12.5/1.