NBS MONOGRAPH 24

A Spectrophotometric Atlas of the Spectrum of CH from 3000A to 5000A

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisons and sections on the inside of the back cover.

Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers. These papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($1.50), available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

UNITED STATES DEPARTMENT OF COMMERCE • Luther H. Hodges, *Secretary*
NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

A Spectrophotometric Atlas of the Spectrum of CH from 3000 A to 5000 A

Arnold M. Bass and H. P. Broida

National Bureau of Standards Monograph 24

Issued February 14, 1961

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. - Price 20 cents

A Spectrophotometric Atlas of the Spectrum of CH From 3000 A to 5000 A

Arnold M. Bass and H. P. Broida

The near ultraviolet and visible emission spectrum of CH was recorded and presented in the form of a spectrophotometric atlas. The spectrum was recorded photoelectrically from an acetylene-oxygen flame in the region 4900 to 3000 A by use of a high-resolution grating monochromator. Each of the lines in the CH spectrum is identified.

1. Introduction

In 1953 we published a spectrophotometric tlas of the $A^2\Sigma^+$—$X^2\Pi$ transition of OH,[1] with e expectation that other atlases would be preared as time and general interest dictated. At at time we recorded, also, the spectrum of CH the region from 3000 to 5000 A in order to preare a second atlas. However, the work had to e discontinued, and the preparation of the atlas as been completed only recently.

A number of valuable suggestions were received after the publication of the OH atlas and, where possible, these suggestions have been incorporated into the present atlas. We would, however, be interested in receiving any comments or suggestions which the users of this work think would be of value in the preparation of other atlases of this type.

2. Arrangement of the Atlas

The spectrum of CH in the visible and near ltraviolet regions is characterized by the three ectronic transitions: $A^2\Delta$—$X^2\Pi$, $B^2\Sigma^-$—$X^2\Pi$, and $^2\Sigma^+$—$X^2\Pi$. The notation, assignments, and avelengths used in this atlas are those given in e report by Moore and Broida.[2] As stated in at paper, the source of data for $A^2\Delta$—$X^2\Pi$,0; 1,1; 2,2) and $B^2\Sigma^-$—$X^2\Pi$ (0,0; 1,0; 1,1) is ero;[3] for $A^2\Delta$—$X^2\Pi$ (0,1; 1,2), Kiess and roida;[4] for $C^2\Sigma^+$—$X^2\Pi$ (0,0; 1,1), Heimer.[5]

The spectrum charts are arranged so that an erall view of the entire region from 3000 to 00 A is given in figures 1 and 2. The main atures are labeled, including the bands of C_2 hich occur in the flame source. However, the 1 and 1, 2 bands of $A^2\Delta$—$X^2\Pi$ are not included the overall scan. Following this, the spectrum presented on a larger scale in figures 3 to 18. e spectrum is subdivided into five spectral gions: 4940 to 4740 A ($A^2\Delta$—$X^2\Pi$, 0,1; 1,2) ures 3 and 4; 4420 to 4140 A ($A^2\Delta$—$X^2\Pi$, 0,0; ; 2,2) figures 5 to 10; 4130 to 3880 A ($B^2\Sigma^-$—Π, 0,0; 1,1) figures 11 to 14; 3720 to 3630 A $^2\Sigma^-$—$X^2\Pi$, 1,0) figure 15; and 3230 to 3070 A $^2\Sigma^+$—$X^2\Pi$, 0,0; 1,1), figures 16 to 18. In addition, the very closely spaced, intense, heads of the Q-branches of the $A^2\Delta$—$X^2\Pi$, 2,2 band and the $C^2\Sigma^+$—$X^2\Pi$, 0,0 band are shown in figures 7 and 17 in very slow scan to provide the maximum resolution of the rotational structure possible with the instrumentation used.

The rotation-vibration assignments of each of the lines in the spectrum, as described in the references mentioned above, are marked above each spectrum. The leading lines indicate the positions of the lines, but no attempt was made to indicate the relative intensities of the individual lines. On the charts containing the region from 3000 to 3500 A many lines of the $A^2\Sigma^+$—$X^2\Pi$ transition of OH appear, as these are readily excited in hydrocarbon flames. These lines are labeled as to P, Q, or R branch designation, but are not identified in detail. For specific identifications one should refer to the OH atlas.[1]

Each graph has an intensity scale which indicates the relative intensities of the lines as compared with the very intense line near 4303.9 A ($R_{1cd}1$, $R_{1dc}1$, $Q_{1c}12$, $Q_{1d}12$ of $A^2\Delta$—$X^2\Pi(0, 0)$) which was arbitrarily set at intensity 500. As mentioned in the OH atlas, the relative intensities of the various lines and bands are dependent on temperature and emissivity in the particular source used, and so it is necessary to use with care an atlas such as this to identify lines of the same spectrum produced in different sources.

. M. Bass and H. P. Broida, NBS Circ. 541 (1953).
. E. Moore and H. P. Broida, J. Research NBS **63A**, 19 (1959).
. Gero, Z. Physik. **118**, 27 (1941).
. H. Kiess and H. P. Broida, Astrophys. J. **123**, 166 (1956).
. Heimer, Z. Physik. **78**, 771 (1932).

3. Experimental Arrangement

The spectrum of CH was recorded by using a high-resolution grating monochromator,[6,7] with a grating having 1200 grooves/mm. The region from 4700 to 5000 A was recorded in the first order at a scan rate of 1 A per min. The remaining large scale charts were recorded in the second order at a scan rate of 0.5 A per min. The slow scans of figures 7 and 17 were made at 0.1 A per min. For the most part the resolution is sufficient to separate lines which are 0.1 A apart. The spectra were recorded on blank paper, and the figures are photographs of the original records.

The spectra were excited in an acetylene-oxygen flame burning on a water-cooled slot burner of dimensions 50 mm $\times$ 0.076 mm. Since the excitation of the different transitions in the CH molecule, relative to the other features ol served in the spectrum, depends strongly on tl characteristics of the source, it was not possib to keep the flame conditions constant in recordi the entire spectrum. Generally speaking, tl region between 4500 and 3600 A (that is part the $A^2\Delta$—$X^2\Pi$ transition, and the $B^2\Sigma^-$—X^2 transition) were obtained from a stoichiometr mixture of acetylene and oxygen. In order bring out the $C^2\Sigma^+$—$X^2\Pi$ system relative to tl overlapping OH lines it was necessary to use fuel-rich mixture (about 2.5 times stoichiometri The long wave end of the $A^2\Delta$—$X^2\Pi$ system (47 to 5000 A) is best excited, relative to the Swan bands in the same region, in very le mixtures (about 0.3 times stoichiometric).[4]

[6] This instrument was constructed by the Research Department of Leeds and Northrup Co., and loaned to the Heat Division of the National Bureau of Standards on a field-trial arrangement.

[7] W. G. Fastie, J. Opt. Soc. Am. 42, 641 (1952).

WASHINGTON, D.C., August 8, 1960.

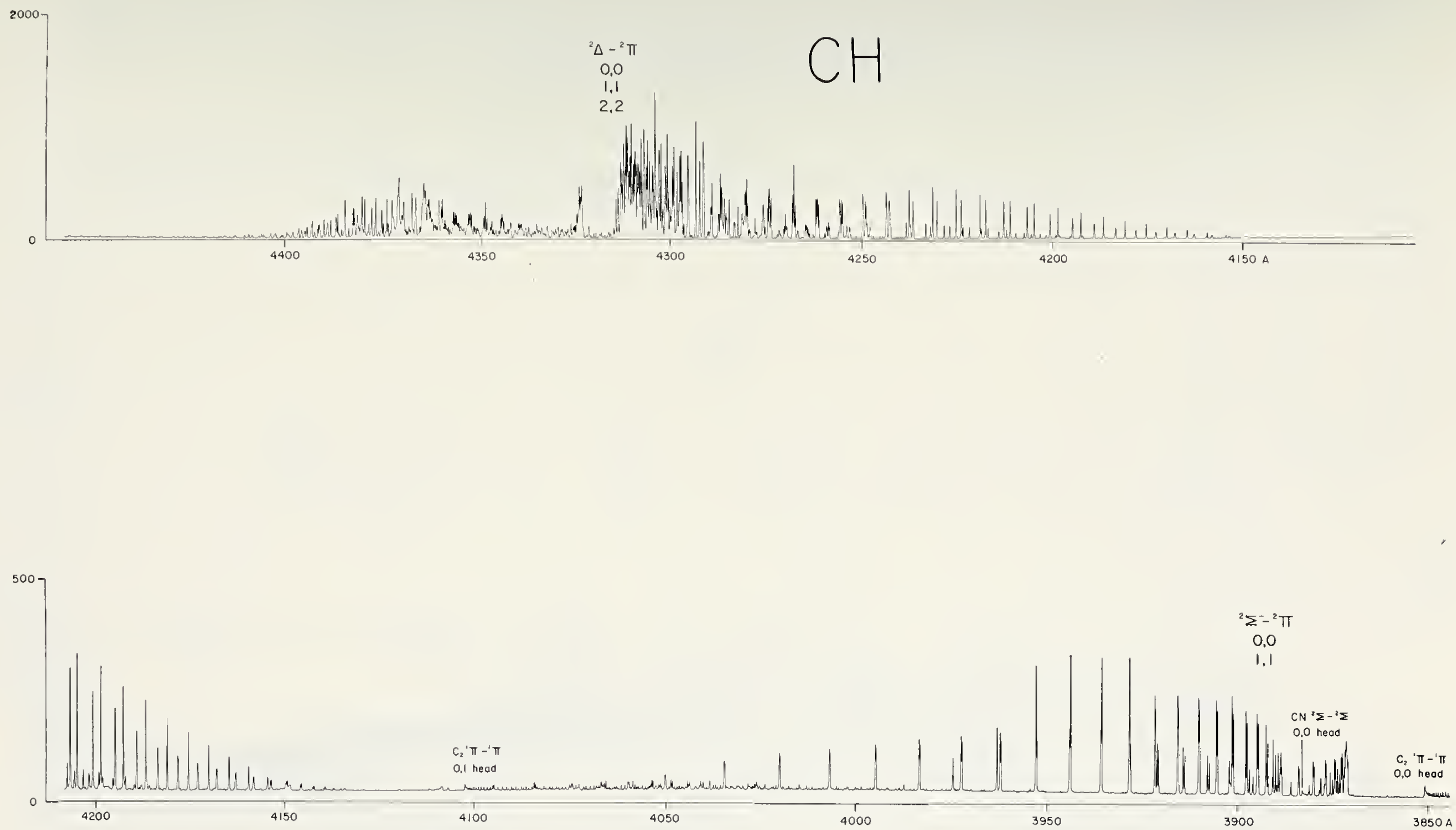

FIGURE 1. CH *spectrum—3850 to 5000 A.*

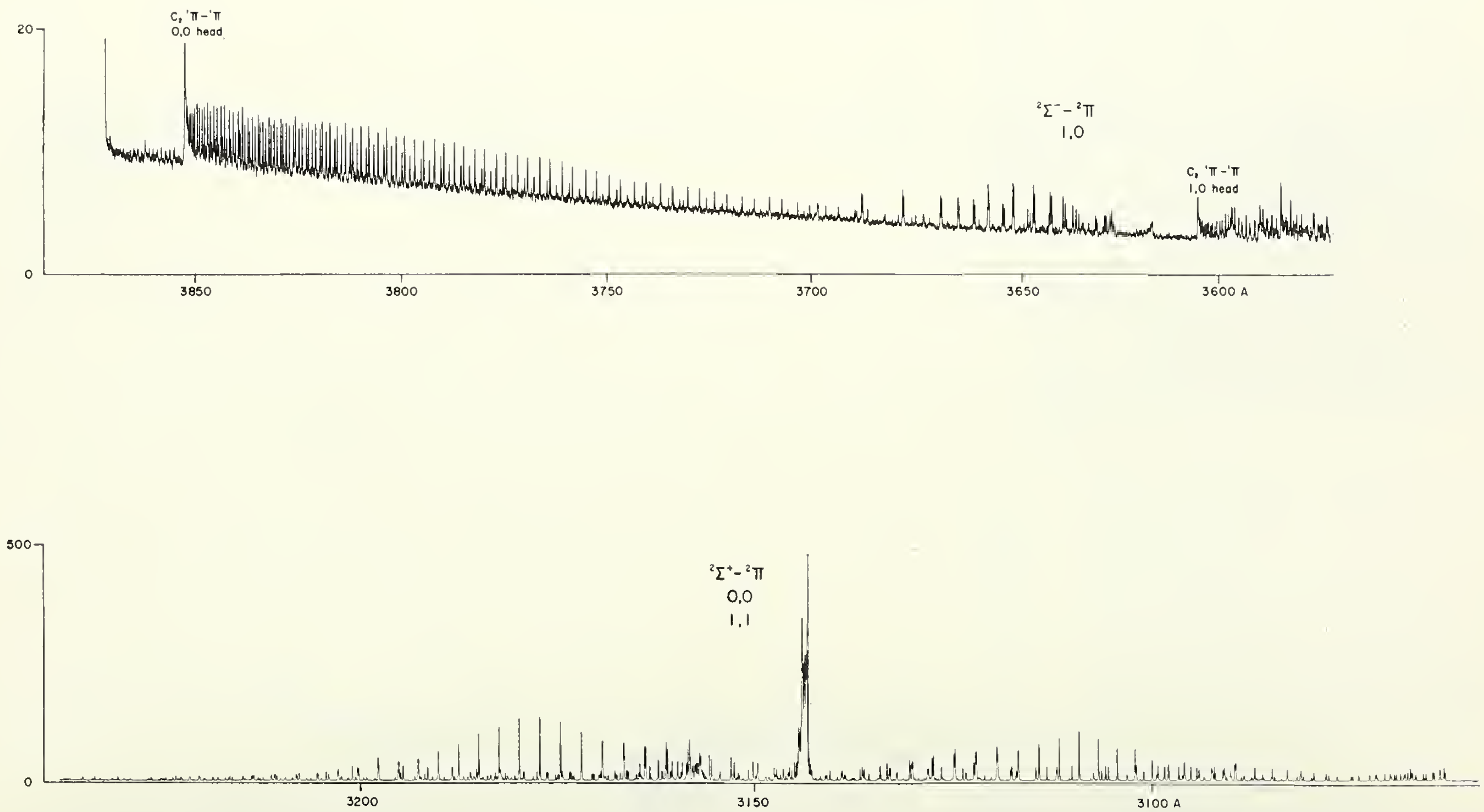

FIGURE 2. CH *spectrum—3000 to 3900 A.*

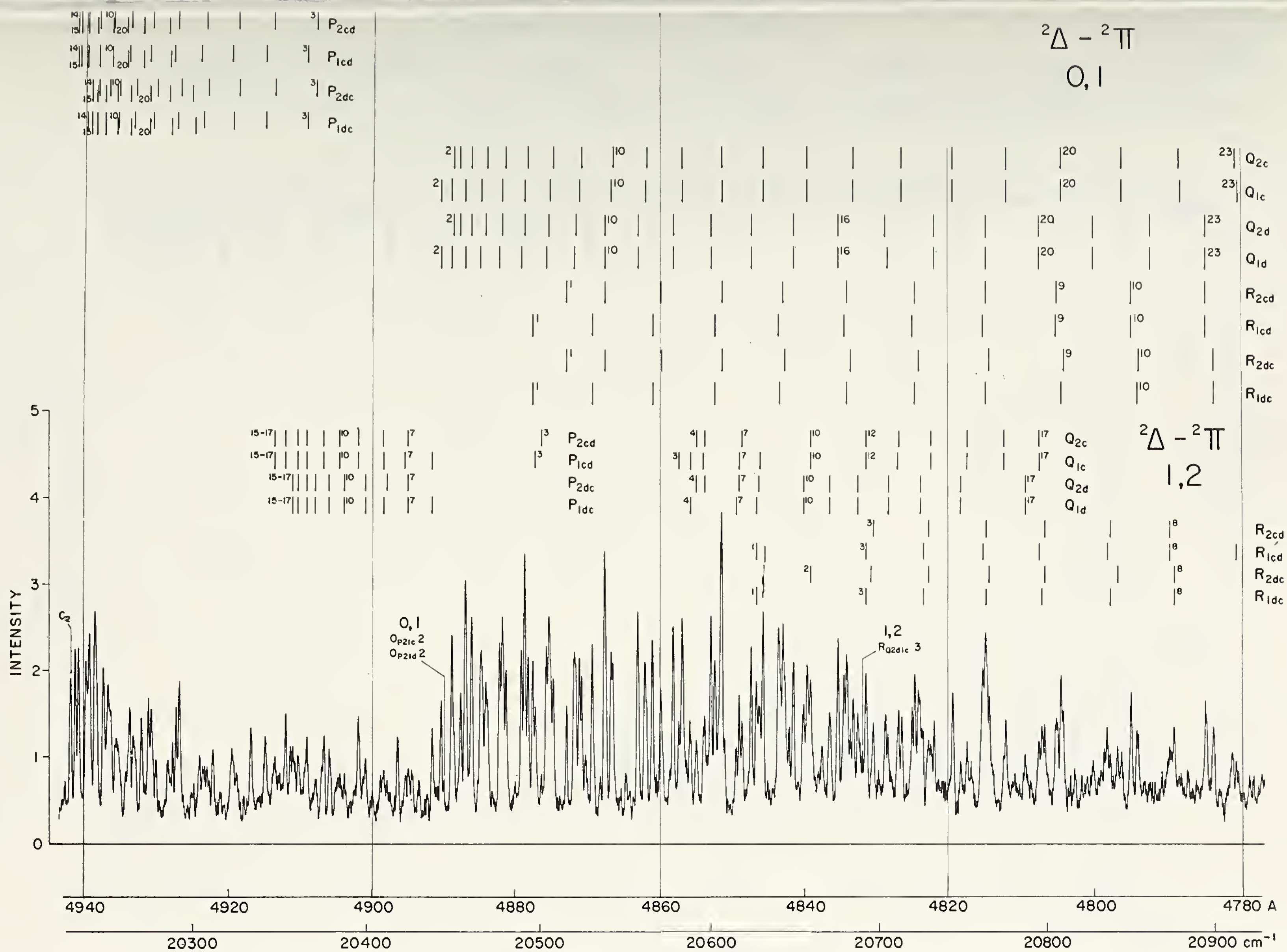

FIGURE 3. CH *spectrum—4700 to 4940 A.*

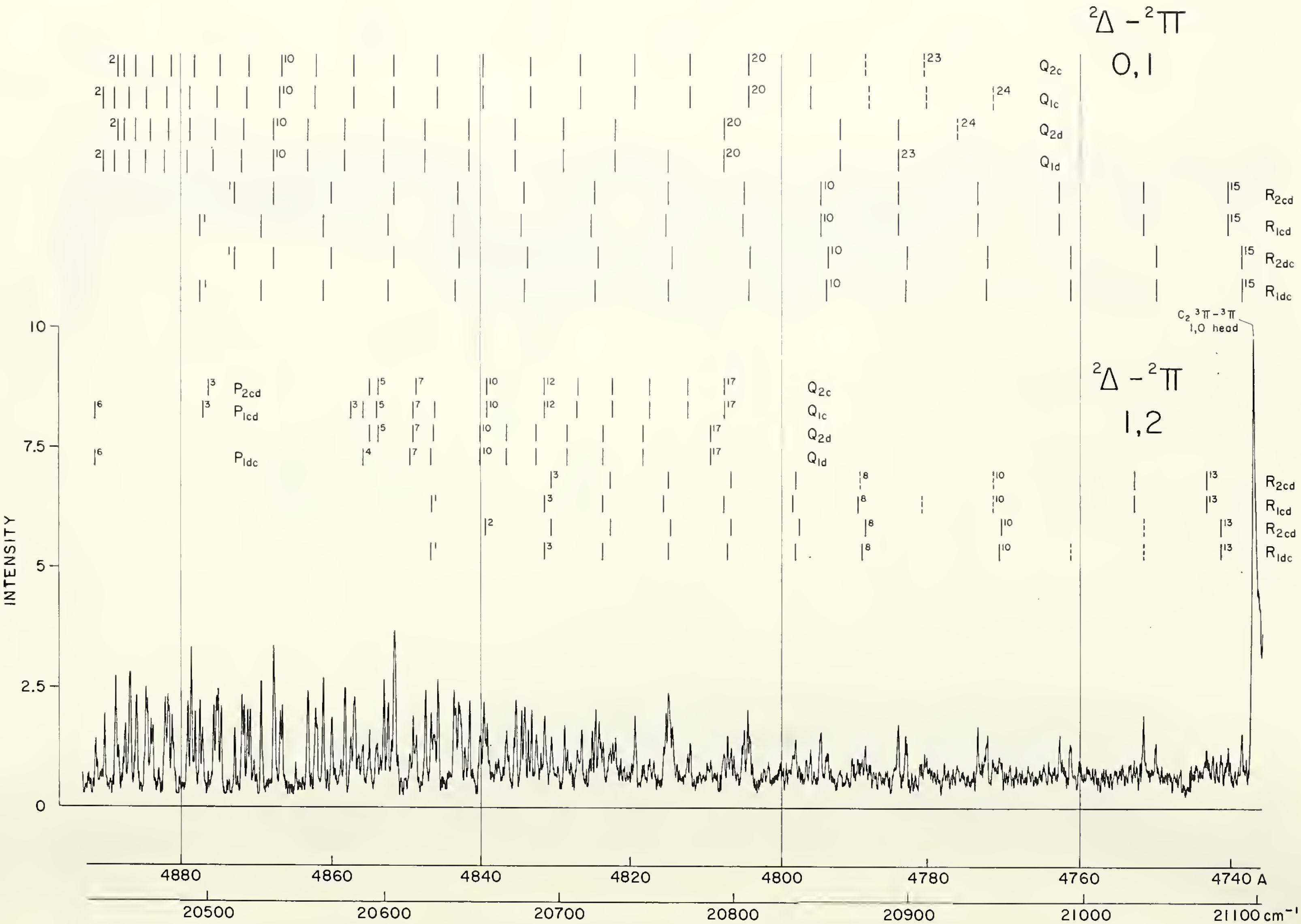

FIGURE 4. CH *spectrum—4740 to 4880 A.*

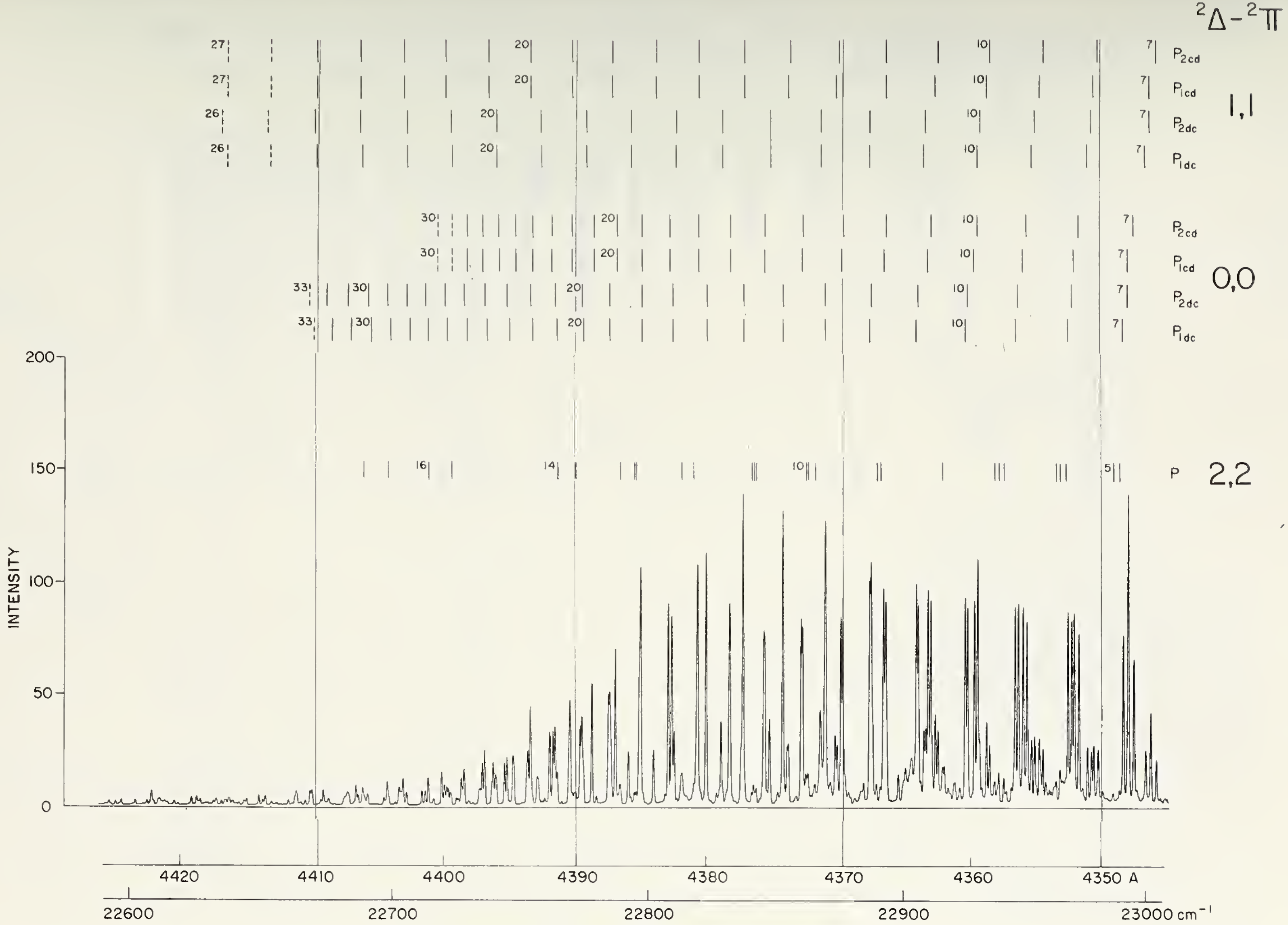

FIGURE 5. CH *spectrum—4350 to 4420 A.*

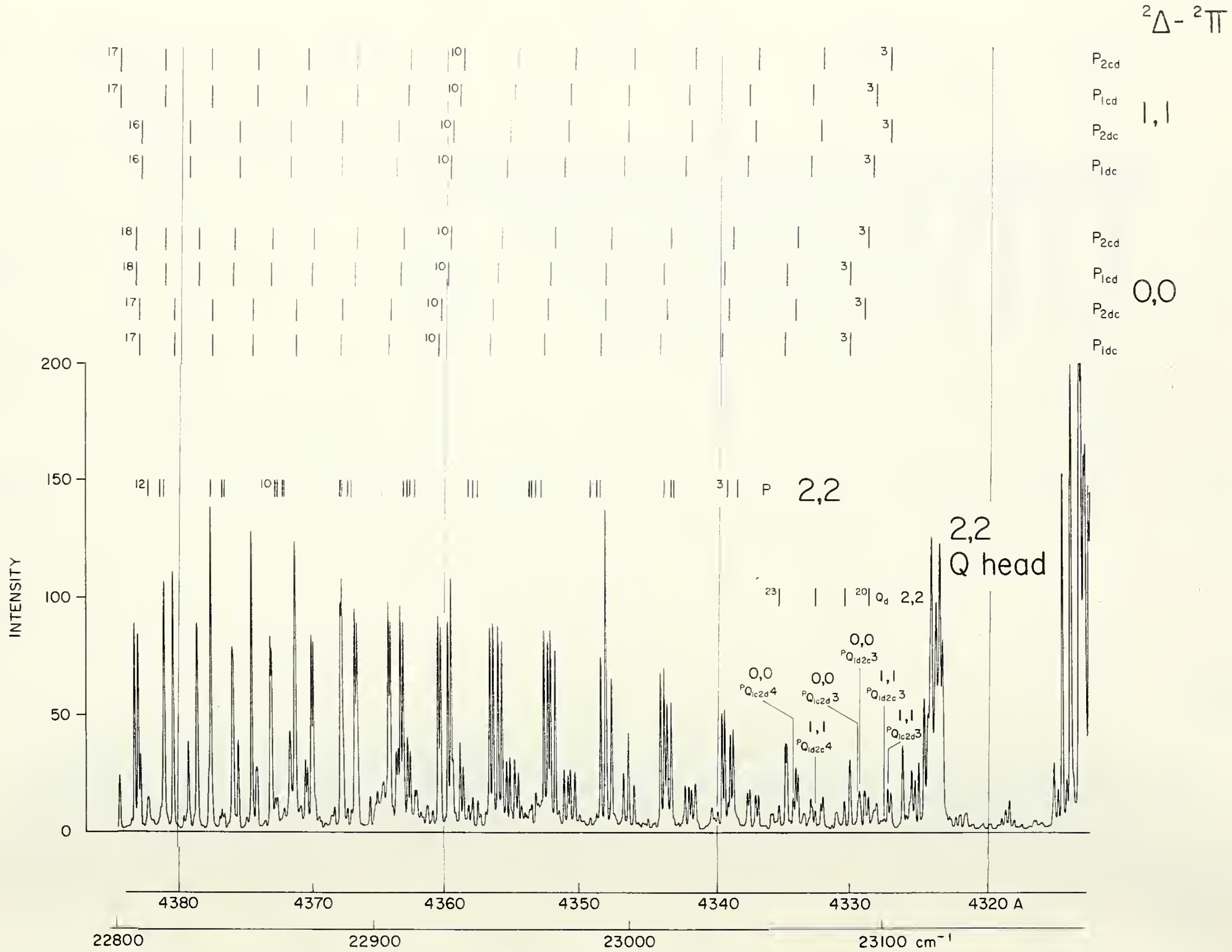

FIGURE 6. CH spectrum—*4320 to 4380 A.*

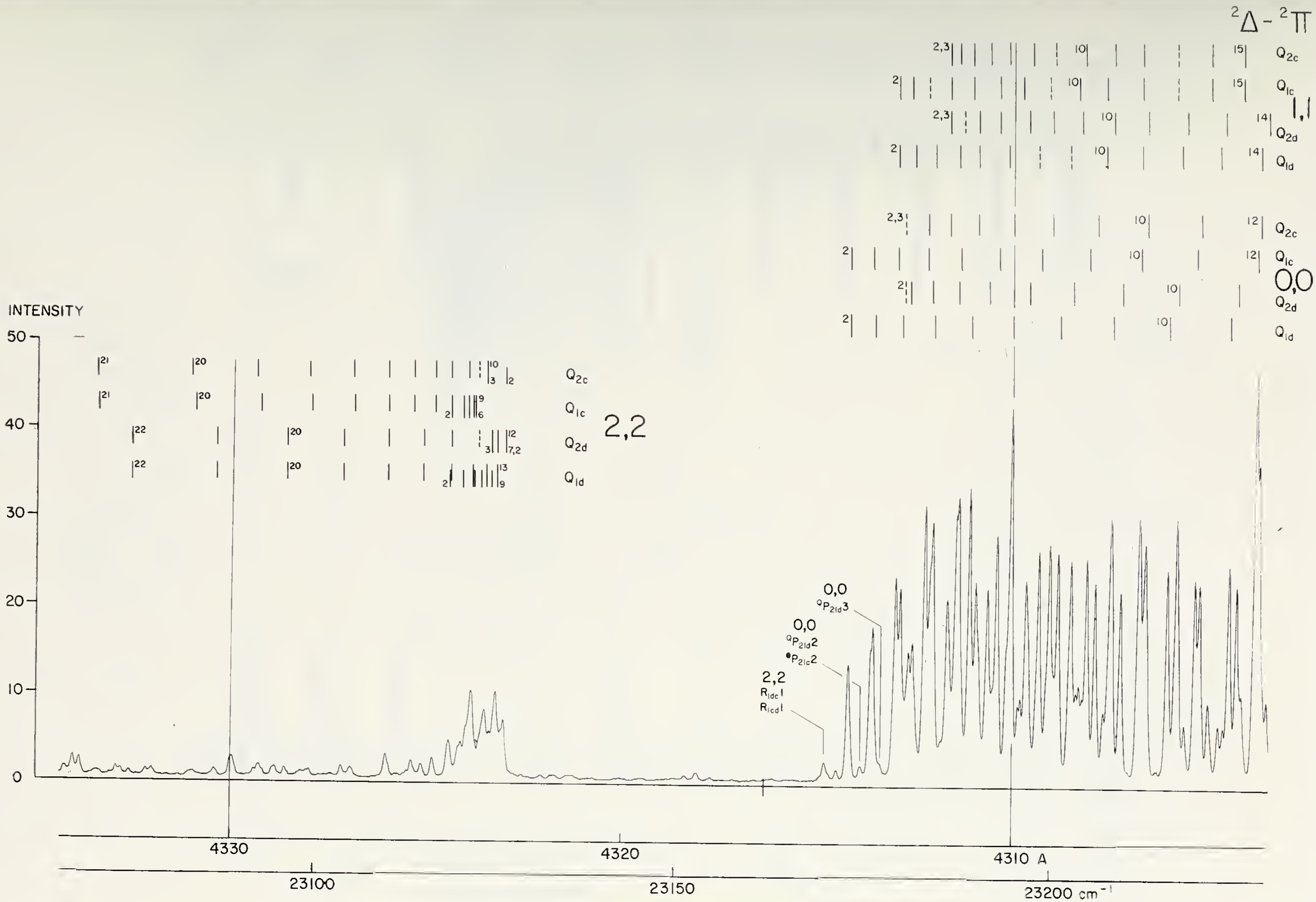

FIGURE 7. CH *spectrum—4310 to 4330 A.*

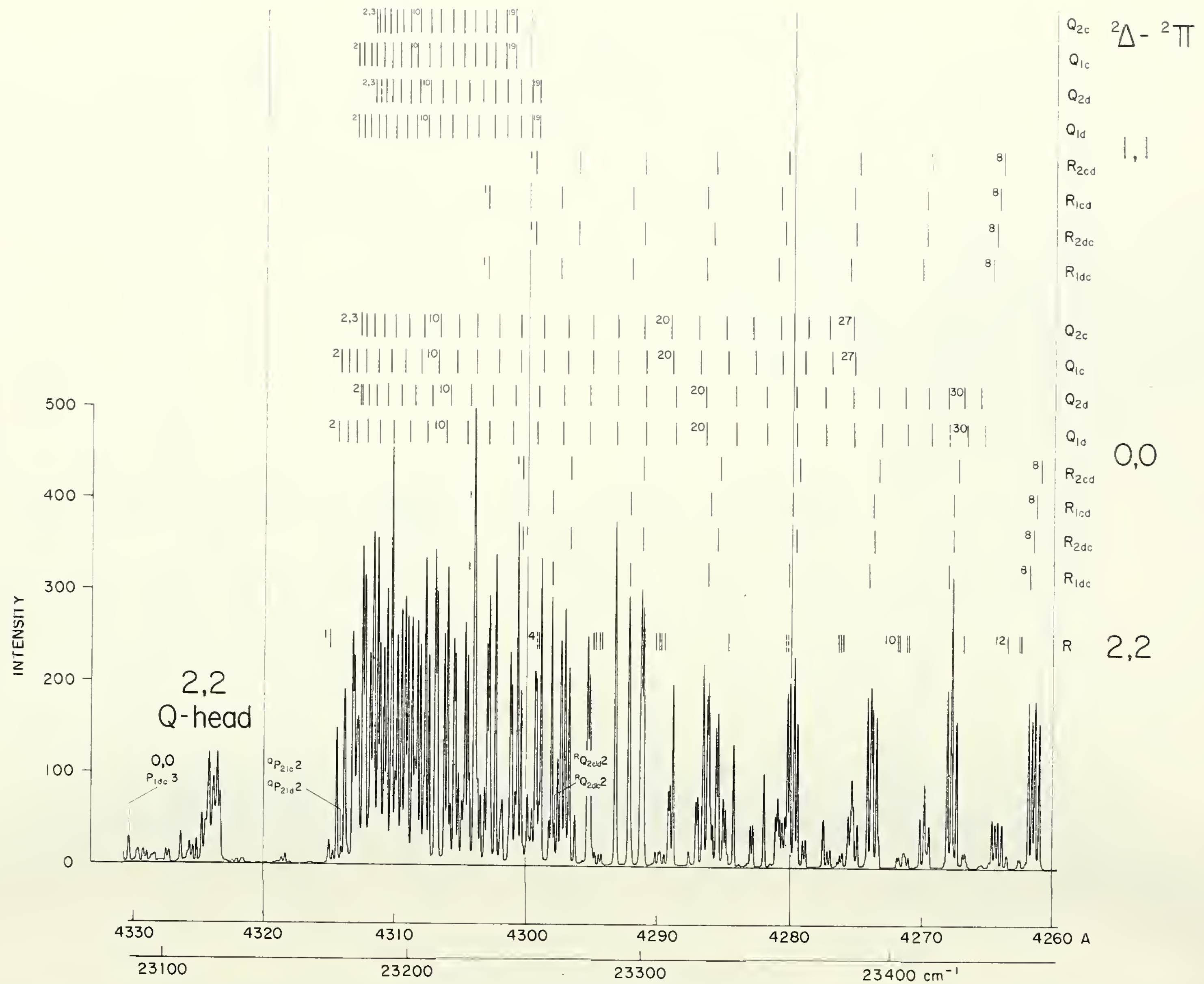

FIGURE 8. CH *spectrum—4260 to 4330 A.*

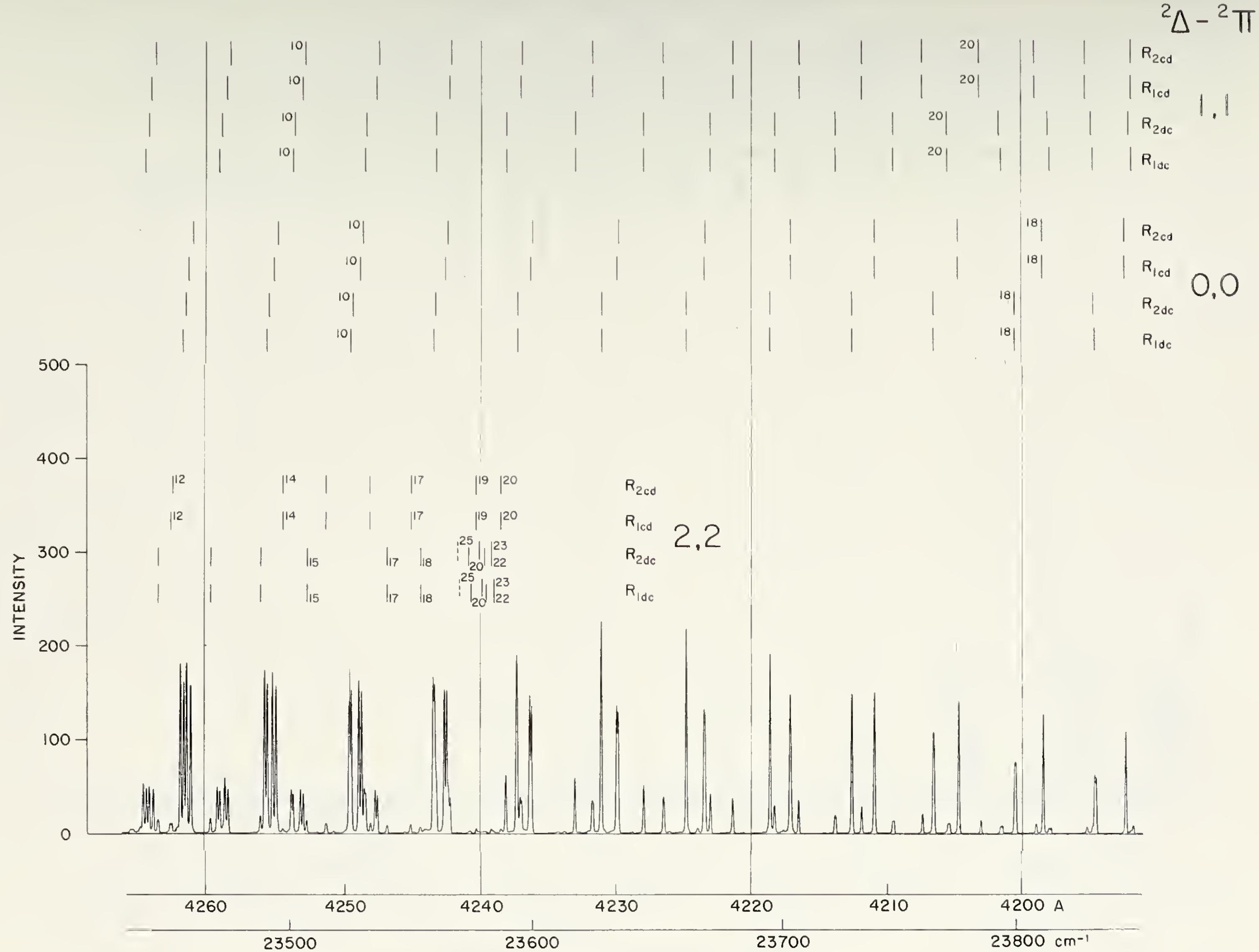

FIGURE 9. CH *spectrum—4200 to 4260 A.*

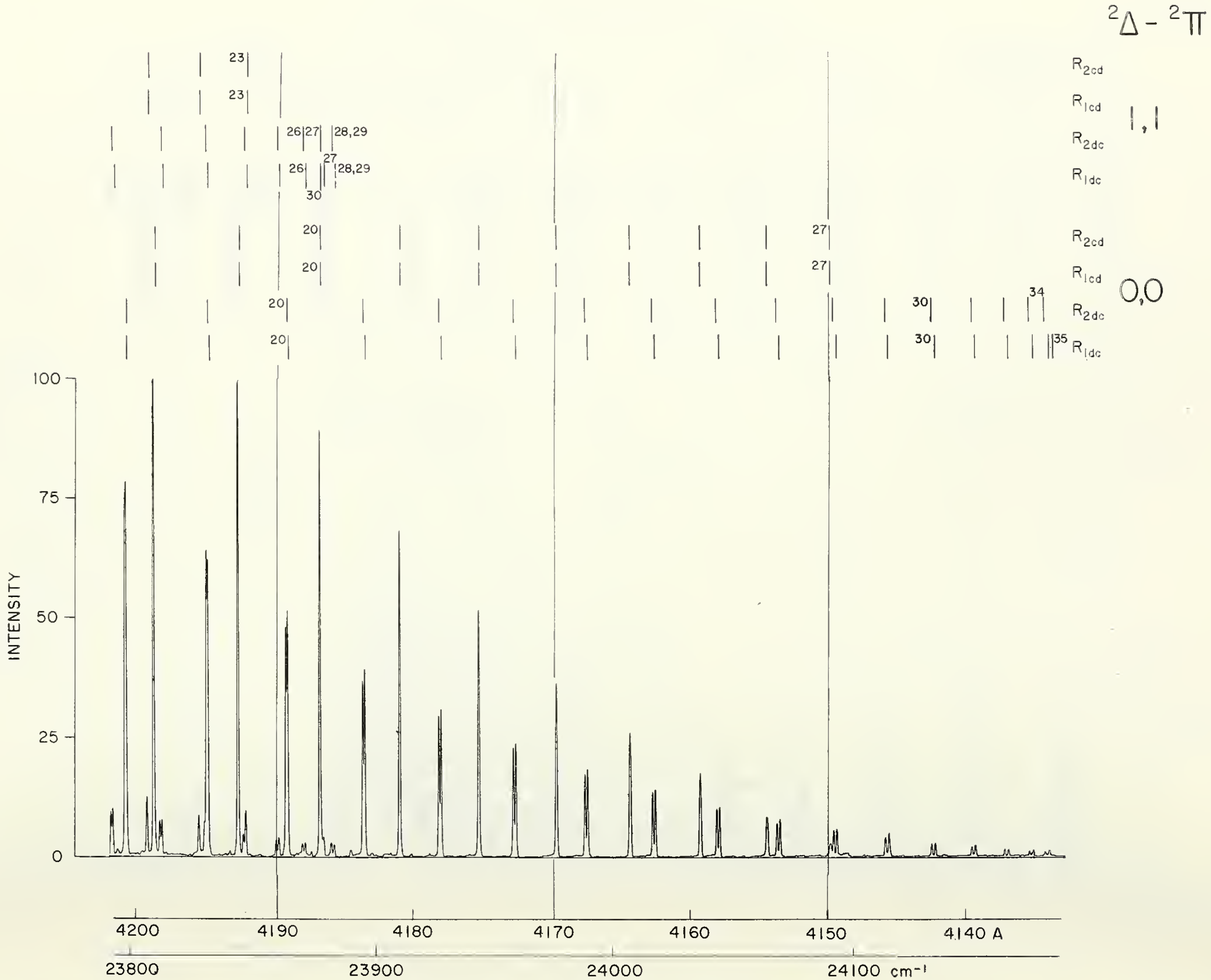

FIGURE 10. CH *spectrum—4140 to 4200 A.*

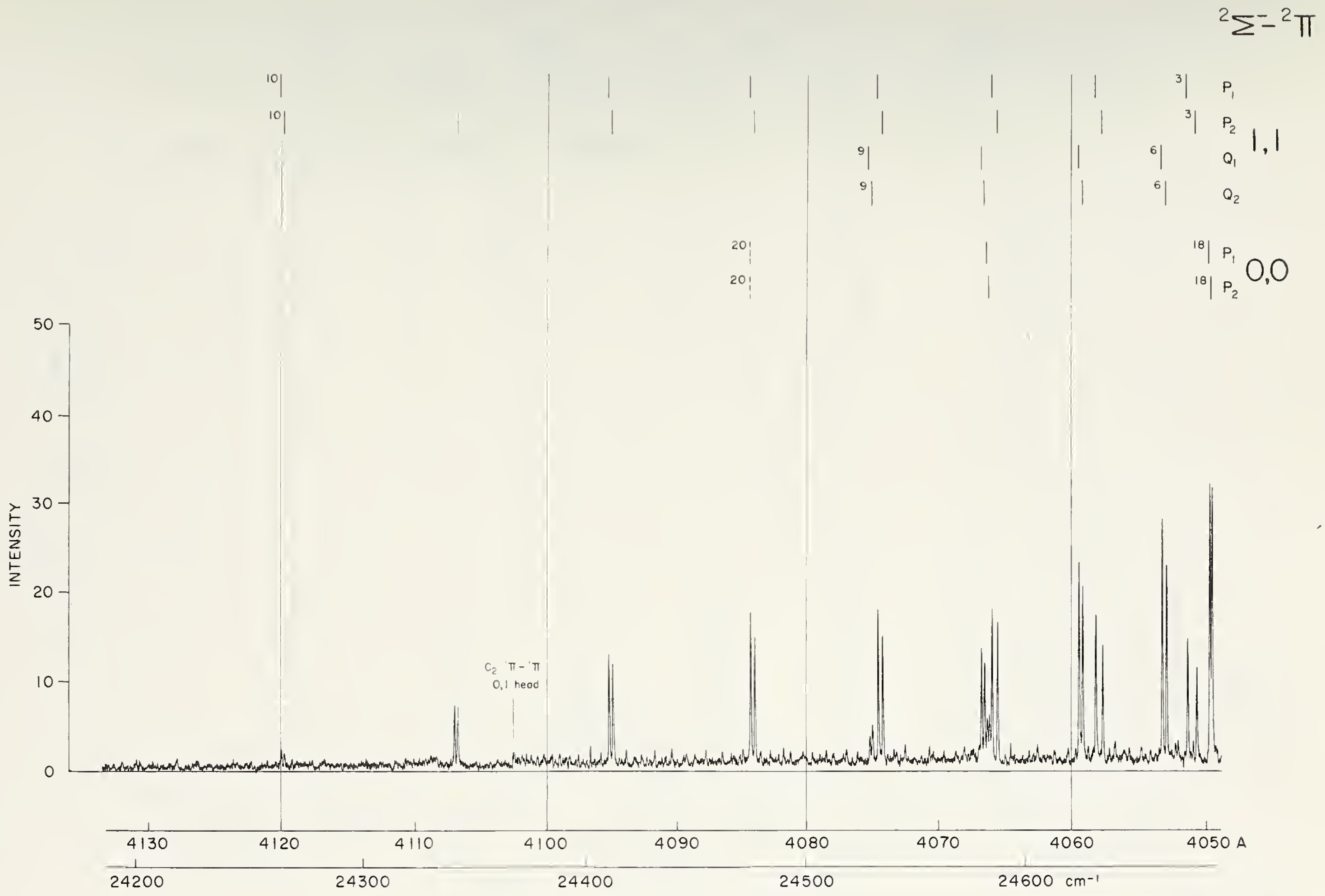

FIGURE 11. CH *spectrum—4050 to 4130 A.*

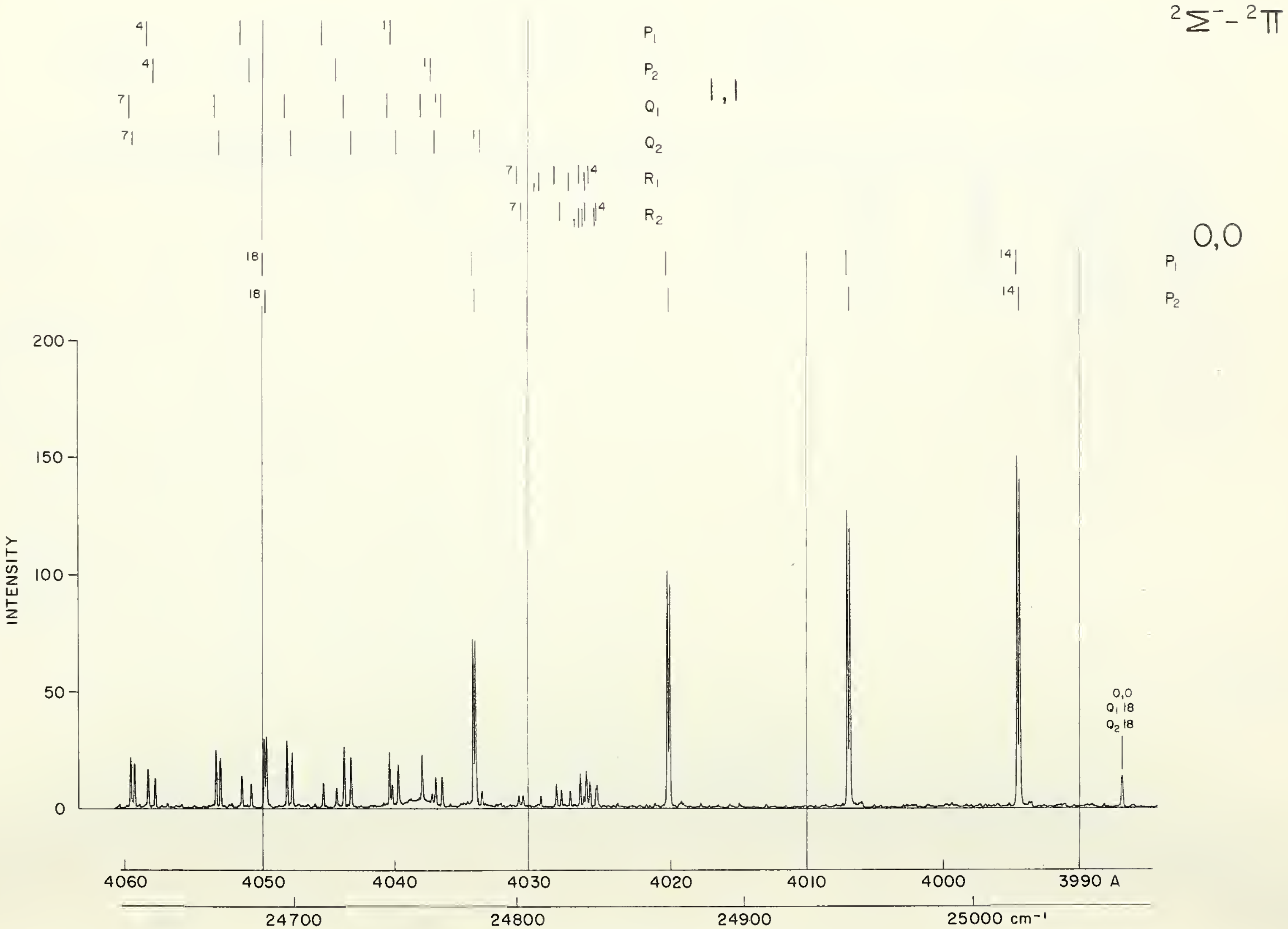

FIGURE 12. CH *spectrum—3990 to 4060 A.*

FIGURE 13. CH *spectrum—3930 to 4000 A.*

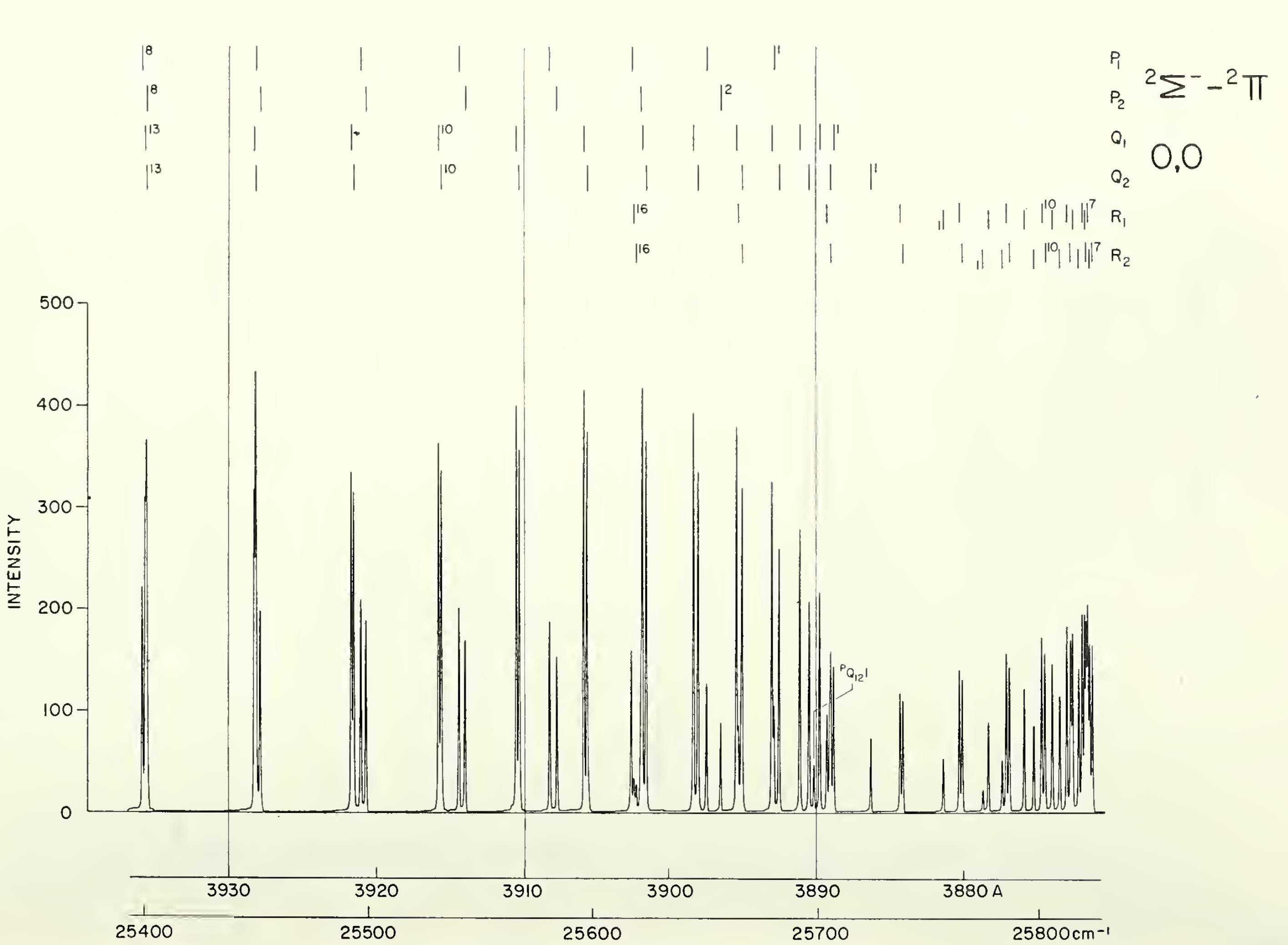

Figure 14. CH *spectrum—3880 to 3930 A.*

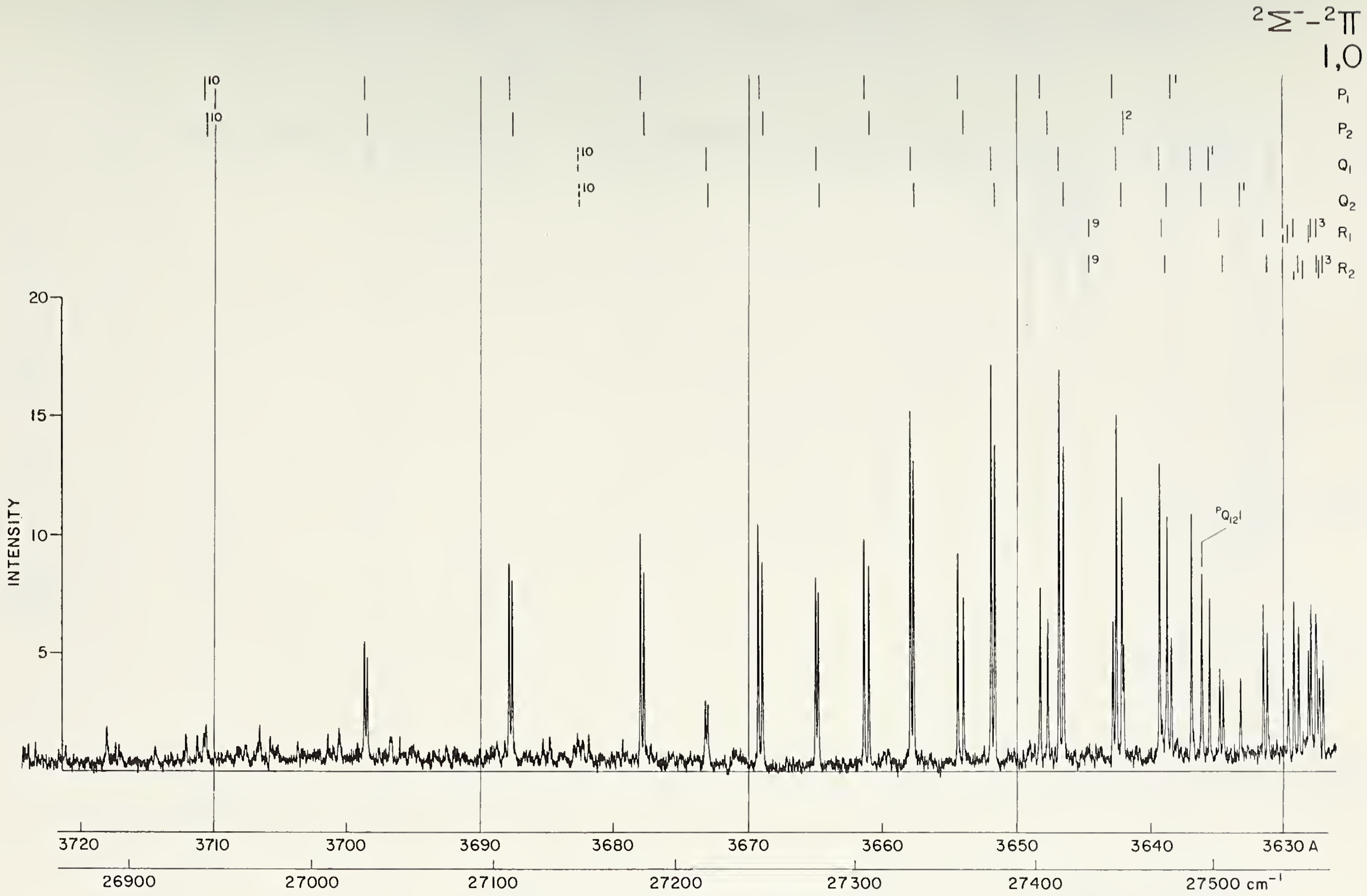

Figure 15. CH *spectrum—3630 to 3730 A.*

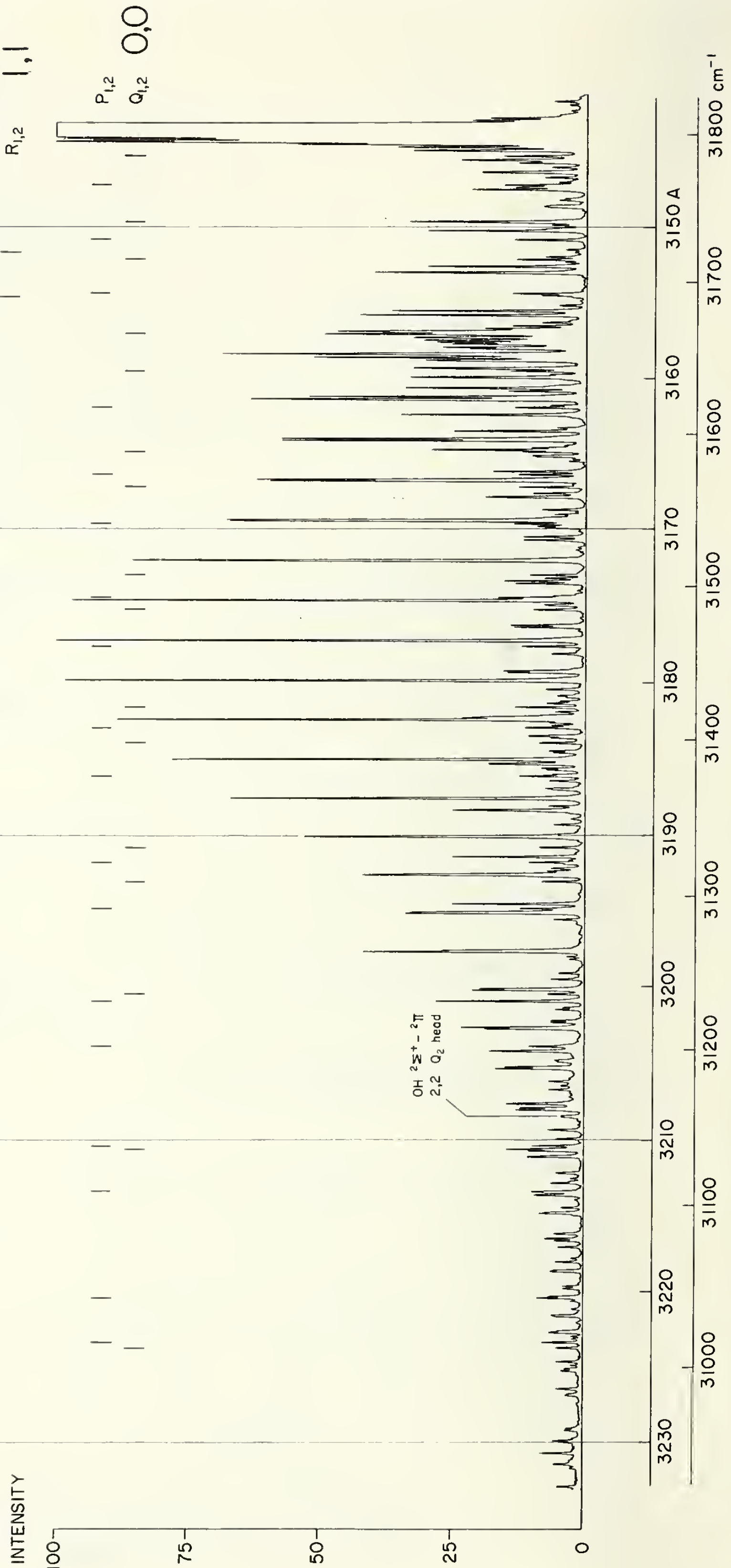

FIGURE 16. CH *spectrum—3150 to 3230 A.*

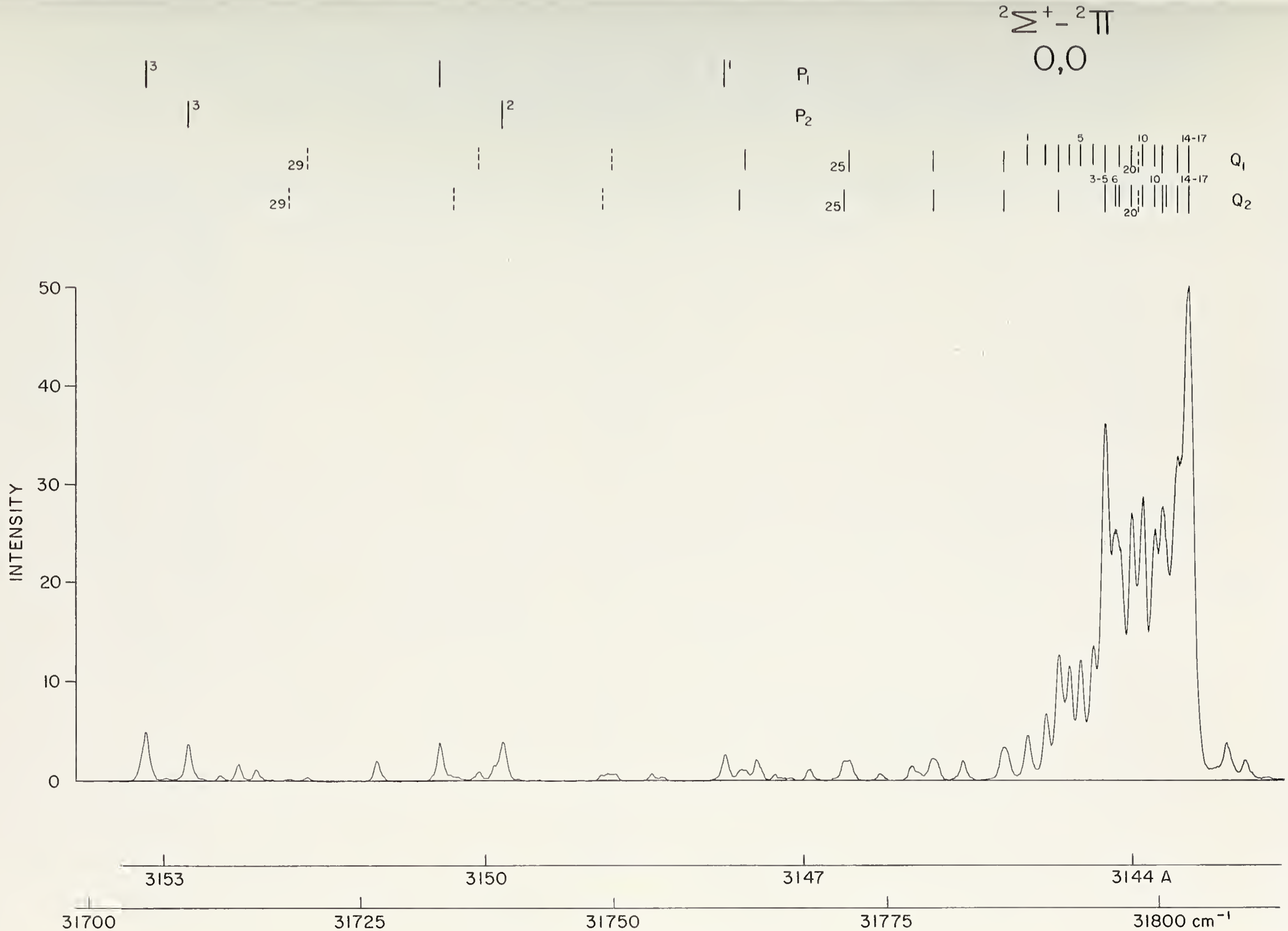

FIGURE 17. CH *spectrum—3144 to 3153 A.*

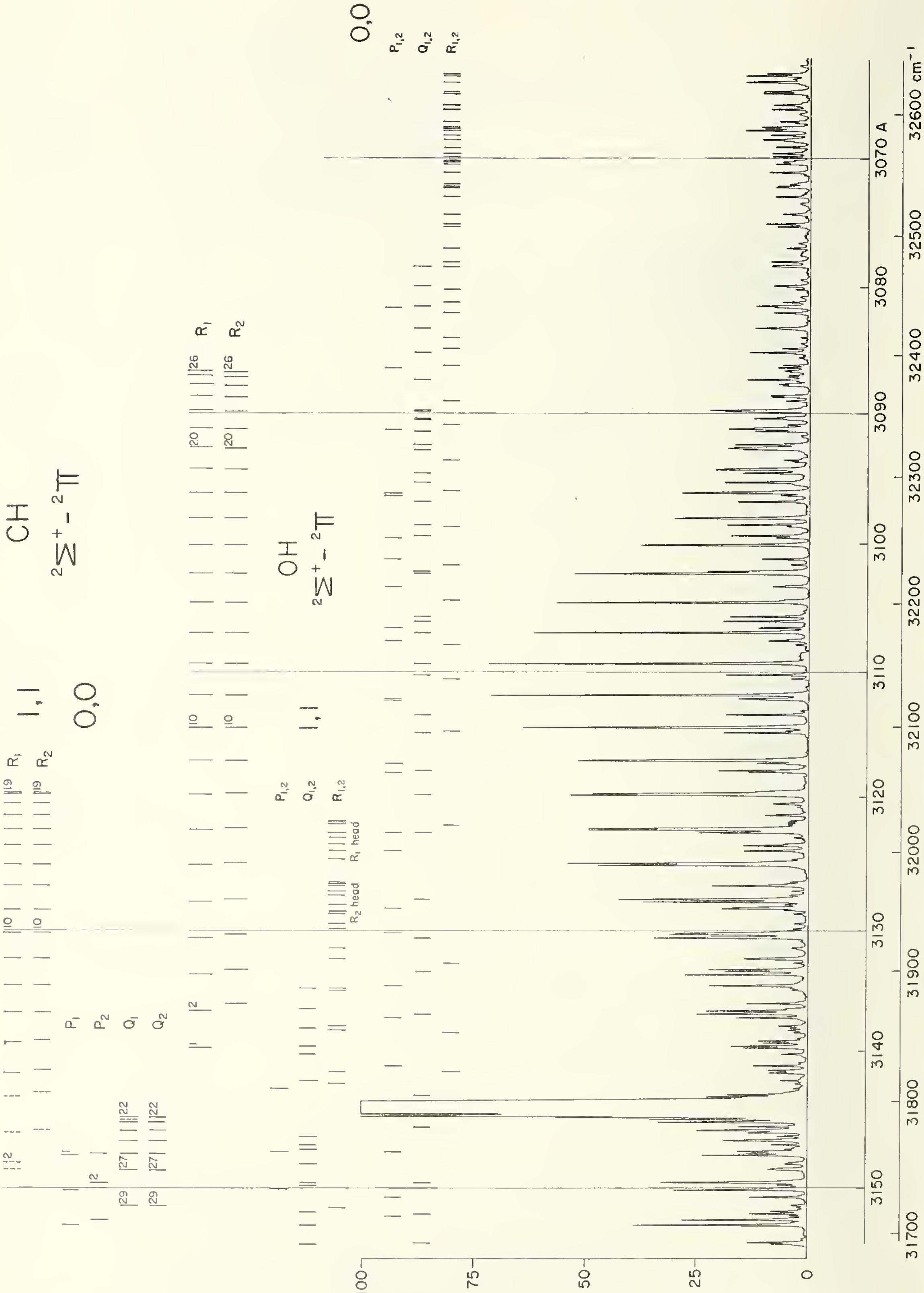

FIGURE 18. CH *spectrum—3070 to 3150 A.*

U.S. GOVERNMENT PRINTING OFFICE: 1961

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Rheology. Free Radicals Research. Equation of State. Statistical Physics.

Radiation Physics. X-Ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Chemistry I. Pure Substances. Spectrochemistry. Physical Chemistry. Analytical Chemistry. Inorganic Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics. Electrodeposition.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Applications Engineering.

Atomic Physics. Spectroscopy. Radiometry. Solid State Physics. Electron Physics. Atomic Physics.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Chemistry II. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Molecular Kinetics Mass Spectroscopy. Molecular Structure and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time Standards. Electronic Calibration Center. Millimeter-Wave Research. Microwave Circuit Standards.

Radio Systems. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Space Telecommunications.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.