Fermilab

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A SPECTROSCOPIC OIL DETECTOR

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The use of screw compressors for helium refrigeration necessitates the use of a sophisticated oil removal system to cleanup the high pressure helium. Should the separation system fail or lose efficiency, macroscopic amounts of oil will be transported to the refrigerator necessitating a warm-up and washing of the heat exchangers. To avoid this, an on-line process gas oil detector is a necessity. The oil concentration can range from 100 ppB to 10 ppm in the vapor phase, grams per hour in the mist phase and up to gallons per hour for major failure of the oil separators.

A Monocromator based N_2 detector previously described[1] was used as the basis for the oil detector. Initially helium gas was used to test the Monocromator-Photomultiplier system sensitivity to radiation from CH_4 or its by-products. Line radiation intensity at 4315°A was found to be linearly related to the methane concentration in the helium gas. This was the most prominent effect due to the methane to be found in the spectral region that was searched (3800°A - 5000°A). An enhancement of the background hydrogen spectrum also occurs

but is not uniquely due to hydrocarbons due to varying H_2 impurities in helium gas. A tentative identification of the 4315°A radiation as being due to a CH transition (4315°A) is most likely due to its ease of production during hydrocarbon decomposition[2]. It is also the most intense radiation due to a simple hydrocarbon likely to be found in the visible spectrum. CH is also favored because of the relative improbability of a recombination to form H_2 over dissociation to form CH. The linear response of the detector to methane concentrations (Fig. 1) was encouraging and an attempt to detect the same radiation from oil was made. Fig. 2 is a copy of the spectogram with the oil source in series. The cleanliness of the spectrum near 4315°A suggests the possibility of using an interference filter as a relatively cheap detector ($1K) versus the more costly monocromator system ($5K). Increasing the oil source temperature caused an increase in the signal due in part to the release of low vapor pressure constituents dissolved in the oil and to the increase in the vapor pressure of the oil itself. The signal due to the vapor phase is equivalent to about 1 ppm methane. The mist phase produced a signal about 100 times over the vapor signal. Since the oil is a 64 carbon atom chain, the ultimate vapor sensitivity is of order 100 PPb.

ARC SOURCE

The source of light for the detector is a moderate voltage discharge between stainless steel electrodes. Typical power supply voltages of 1500V provide good ignition and a 100 KΩ series resistance limits the current and maintains ~ 500V

across the arc. The arc possesses good stability if one exercises reasonable care in alignment. The electrodes are designed to be easily adjusted and removable from outside the cell and can withstand an operating pressure of 300 psig. The cell operates at low flows for test purposes but is capable of full flow operation. A high quality quartz glass window providing good transmission in the near ultraviolet completes the source.

Conclusion

The line radiation at 4315°A from the CH molecule has been shown to be sensitive to the methane concentration in helium gas and has been produced from oil vapor as well. Since the gains used have been relatively low, the signal-to-noise quite good (10 ÷ 1), and the presence of many carbon chains in the oil, the ultimate sensitivity may be in the 100 ppB region and thus the Monocromator system should be a viable oil vapor detector.

References

[1] R. Walker, Fermilab TM-742.

[2] Pearse and Gaydon, The Identification of Molecular Spectra.

NATIONAL ACCELERATOR LABORATORY
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE

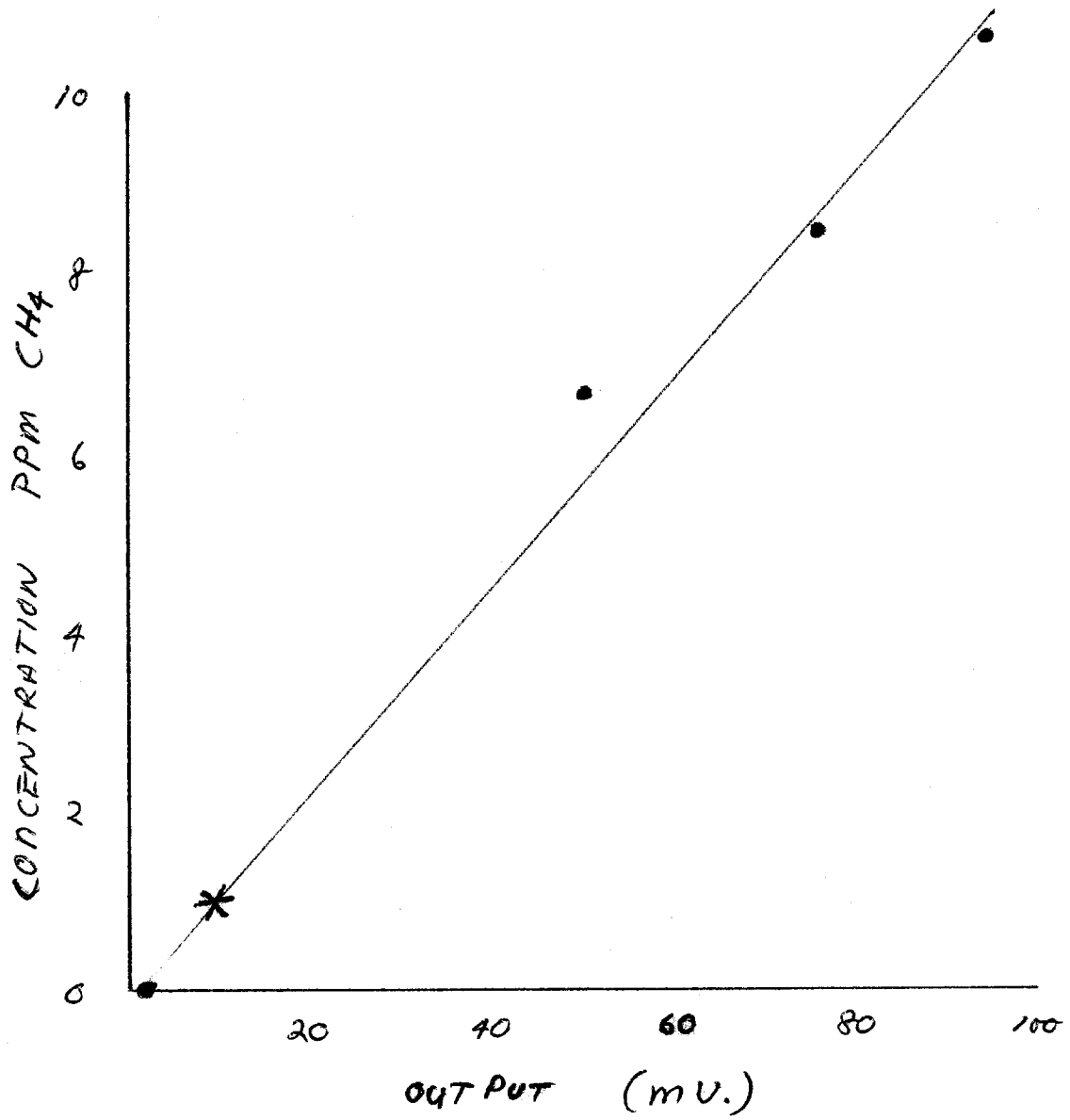
SUBJECT

NAME

DATE

REVISION DATE

INTENSITY OF 4315 Å RADIATION VS CONCENTRATION
(FIG 1)



* OIL SIGNAL @ 50 °C

● METHANE

SPECTROGRAM NEAR 4315 Å
(20 mv/cm)

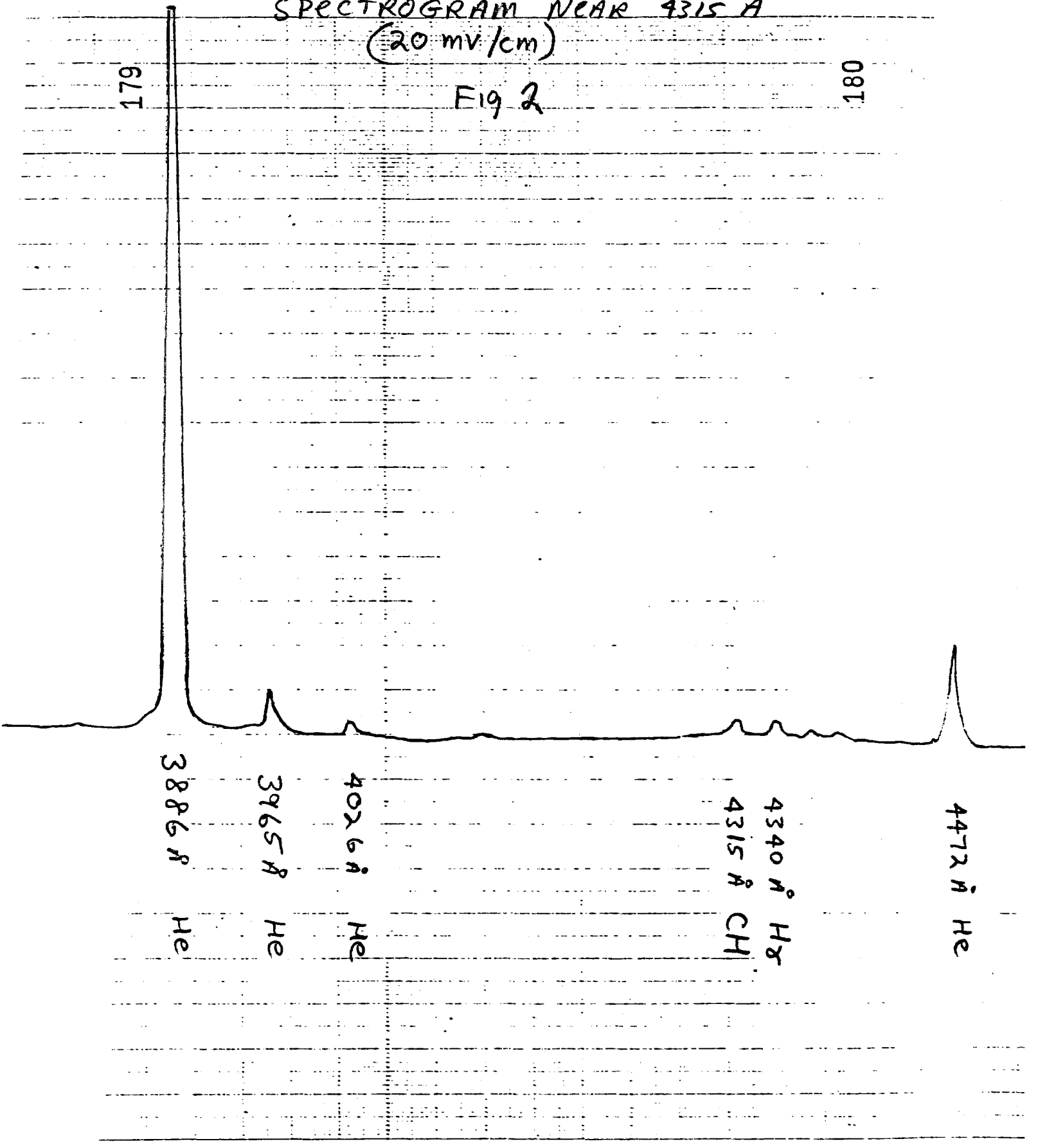



Fig 2