PROGRESS REPORT NO. 9

KINETICS OF OXIDATION AND QUENCHING OF COMBUSTIBLES IN EXHAUST SYSTEMS OF GASOLINE ENGINES

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PERIOD: NOVEMBER 1, 1969 to NOVEMBER 30, 1969

NOVEMBER 1969

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Coordinating Research Council
APRAC-Cape 8-68 Steering Committee

and is work performed by the:

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The University of Michigan
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LONG-RANGE OBJECTIVES

It is well-known that a significant amount of CO and unburned fuel may be consumed in the exhaust system of gasoline engines. Such combustion phenomena in exhaust reactors may be used to advantage to reduce the emission of these undesirable constituents. This process is the basis of exhaust air injection systems currently installed on some automobiles.

The overall objectives of this three-year research program are:

- To determine the chemical and physical processes which affect the emission characteristics of exhaust reactors installed on selected typical engines operating at various conditions on a dynamometer test stand.
- To identify the chemical species and significant chemical reactions present before, within, and after the reactor.
- To obtain information which will be helpful in predicting the design of the next generation of gasoline engine exhaust reactors.

PHASE I PROGRESS

Additional data were obtained on the effects of mixture ratio on emissions from the standard 350 CID V-8 engine. Two additional instruments were added, the Beckman NDIR NO analyzer and the subtractive column analyzer. Figures 1-4 show a set of data for the engine at 50% full load, 1200 rpm, MBT spark. All readings at each air-fuel ratio were recorded approximately at the same time. NO readings are not reported because a leak was found in the sampling system of the analyzer. The leak has been corrected. Tests shown were run with American Regular fuel.

Figure 1 shows the CO_2, CO, and O_2 emission from the engine. Figure 2 shows the hydrocarbon emission measured by both FID and NDIR analyzers. The ratios of the readings are plotted also. Figure 3 shows a class analysis using the subtractive column analyzer. Our analyzer, patterned after that of Sigsby, reports olefins and acetylene together and includes a fraction of the benzene in the paraffin reading. This fraction appears to be about 60% as indicated in last month's progress report.

A problem was found with the analyzer in that the columns became saturated quickly during engine tests. The missing and questionable data points on Figure 3 resulted from this problem. The problem appears to have resulted from a modification we made in the analyzer flow system. In our unit we monitor the back-flush with the FID. This gives us an indication of whether the nitrogen back-flush is effectively cleaning the columns. Unfortunately, this modification allowed exhaust gas to seep through the columns during the time that the analyzer was on standby and the FID was continuously monitoring the total hydrocarbons. A shut-off valve has been installed in the back-flush line to eliminate the problem.

Aldehydes, as formaldehyde, measured by the DNPH method are shown also on Figure 3. Minimum aldehyde emission was in the range of 11 to 13:1 air-fuel ratio. Aldehyde emissions doubled at 18.5:1. Some similarity exists between exhaust wye temperature change and aldehyde emission changes. Figure 4 shows the hydrocarbon class concentration as a percent of the total FID hydrocarbon reading. At present the level of confidence in these readings is low. Because reactivity depends primarily on the olefin concentrations, the data suggests that for lean mixtures, reactivity may actually increase even when total hydrocarbons decrease. More baseline data will be obtained with the subtractive column analyzer.

Progress continues toward developing a laser schlieren system for simultaneously measuring exhaust gas temperature and velocity. An optical test section has been built for a single cylinder engine. The NE-HE gas laser light tube needs replacing. The laser has been returned to Spectra-Physics for this repair.

A design nears completion for a two tank single cylinder exhaust reactor system. This system is designed to obtain basic kinetic data similar to that of Richard Schwing, GM Research. Next, this exhaust reactor system will be fabricated.

PHASE II PROGRESS

The first generation model is being programmed on the IBM-360 computer.

PHASE III PROGRESS

Work continues to separate the lighter hydrocarbons using the Perkin-Elmer 800 gas chromatograph.

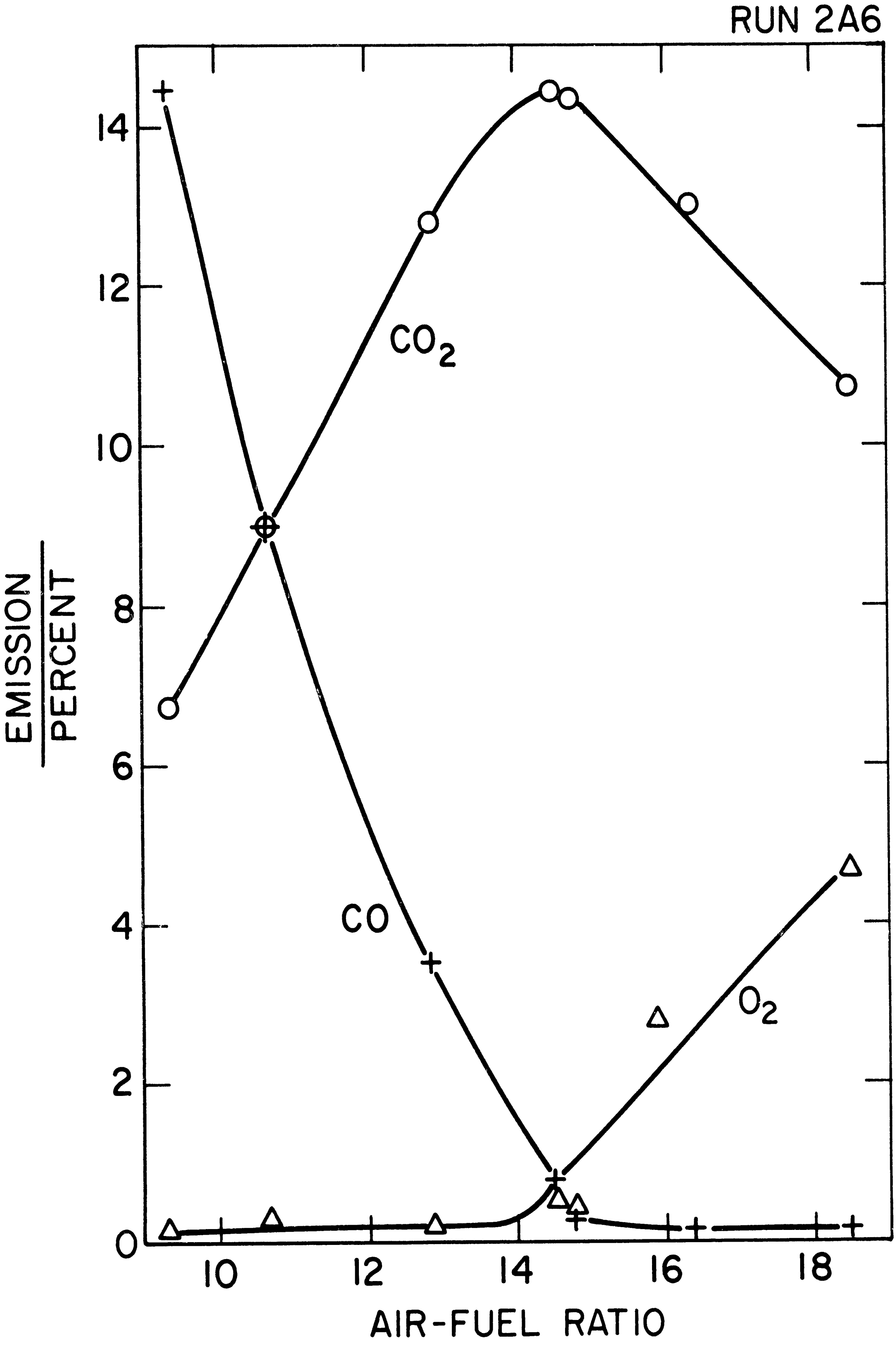


Figure 1. CO_2, CO, and O_2 emission versus air-fuel ratio. 350 CID, V-8, 1200 rpm, 50% load, MBT spark, regular gasoline.

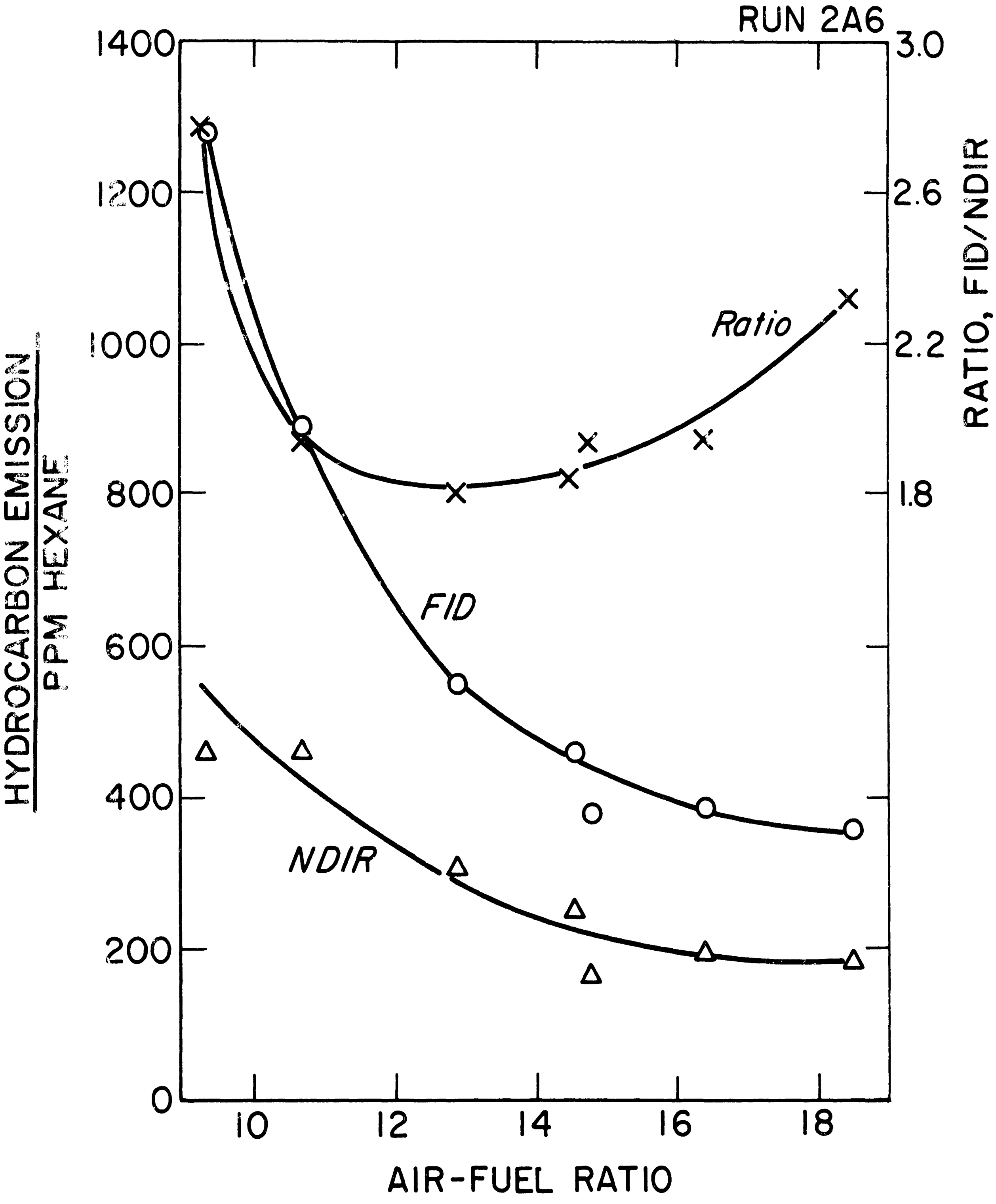


Figure 2. Hydrocarbon emission versus air-fuel ratio. 350 CID, V-8, 1200 rpm, 50% load, MBT spark, regular gasoline.

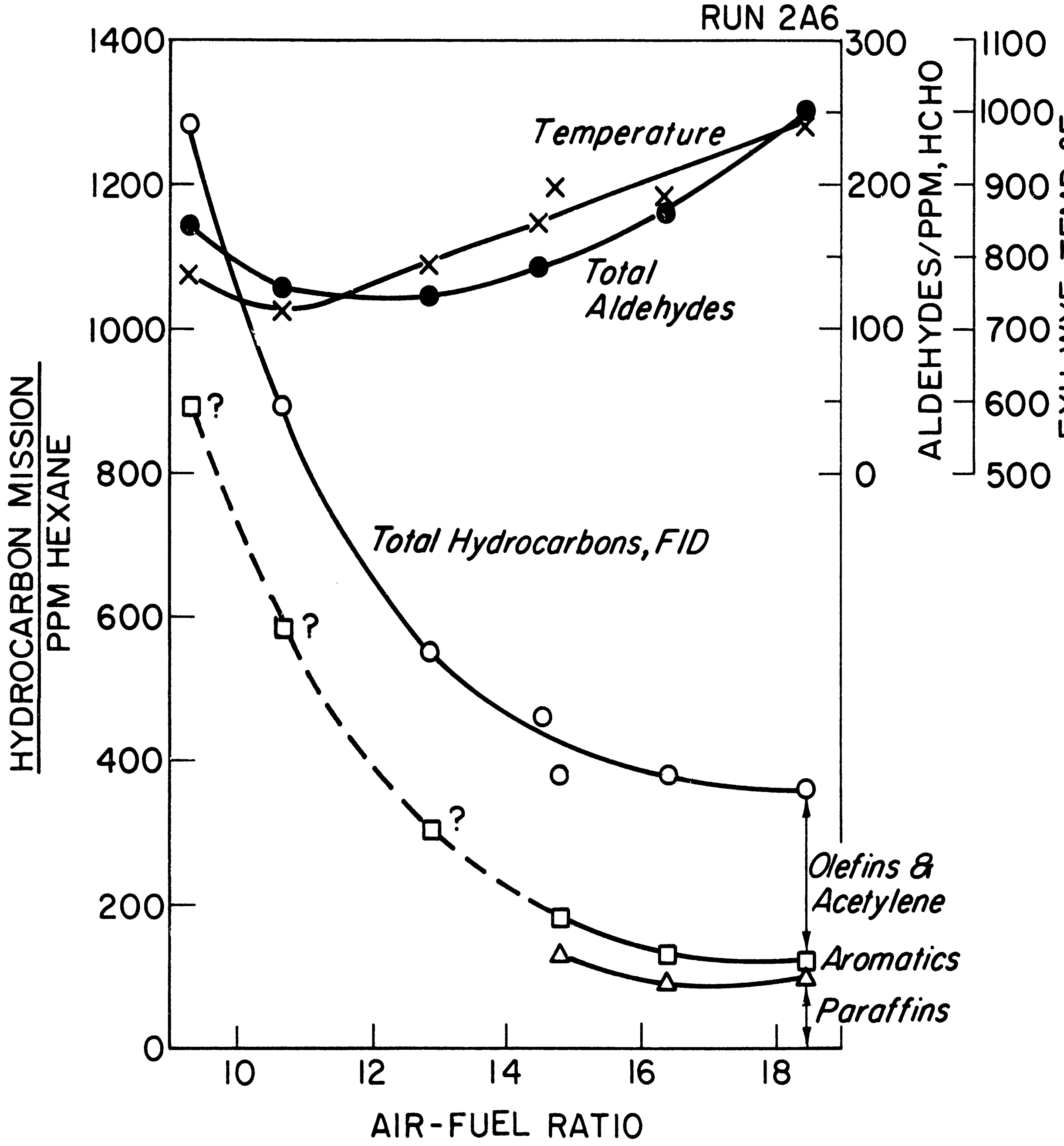


Figure 3. Hydrocarbon emission by classes and exhaust Wye temperature as a function of air-fuel ratio. Class analysis by subtractive column. DNPH aldehydes are indicated also. 350 CID, V-8, 1200 rpm, 50% load, MBT spark, regular gasoline. Question marks indicate questionable data.

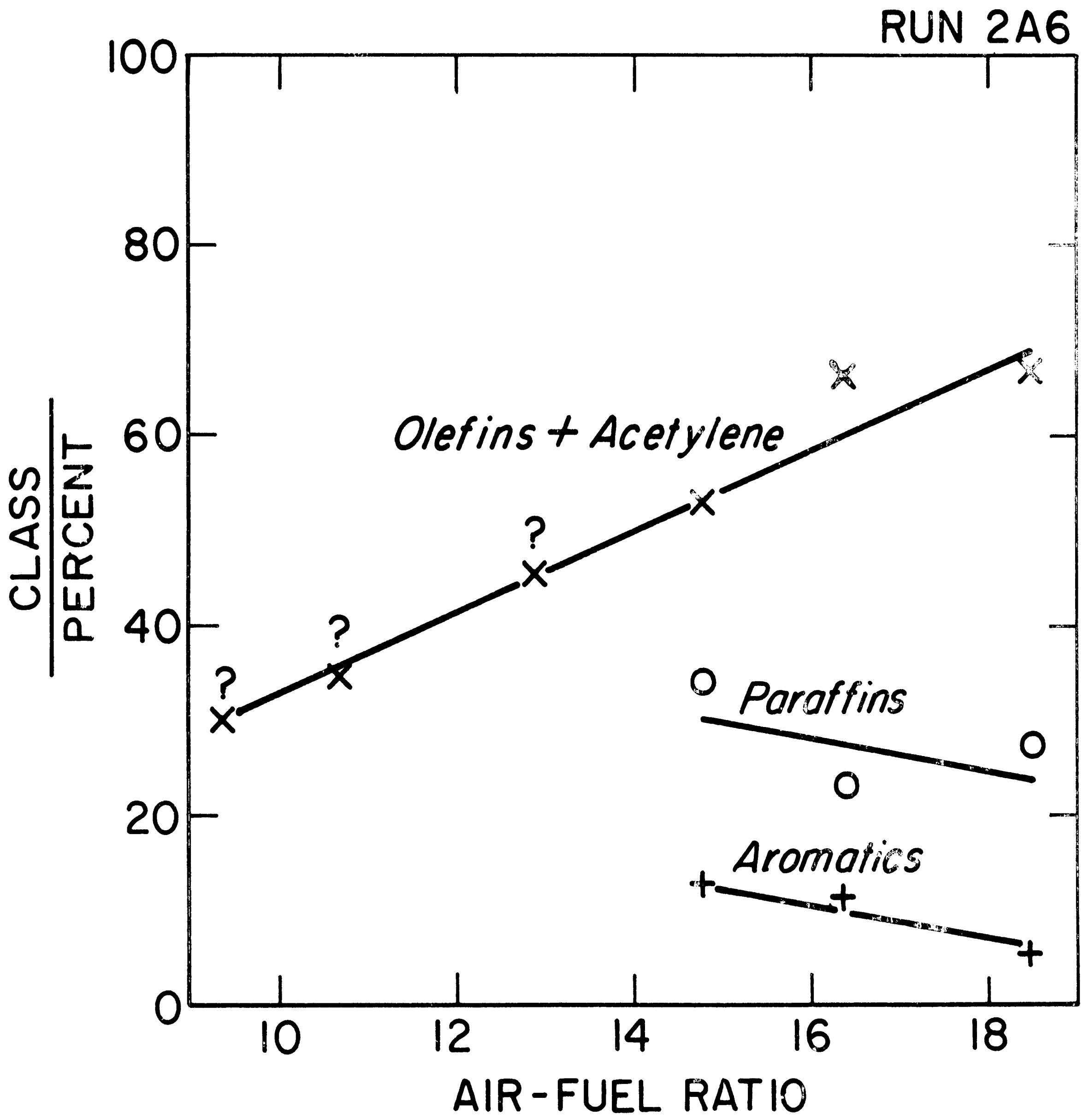
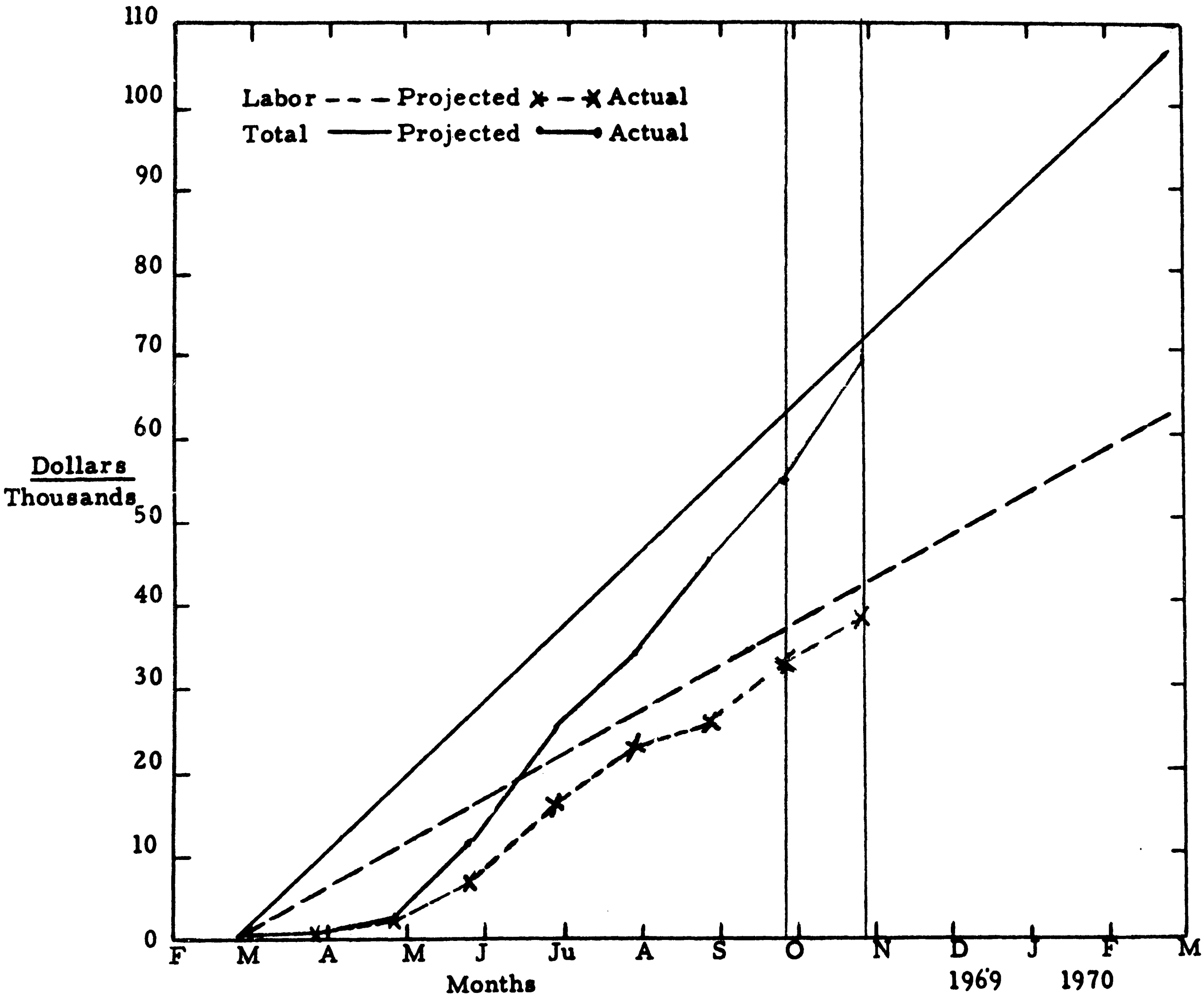


Figure 4. Hydrocarbon classes, percent, as a function of air-fuel ratio. Question marks indicate questionable data.

CRC CAPE 8-68 PROGRAM

OVERALL FINANCIAL SUMMARY

Program Total: February 24, 1969 - February 23, 1970		$106,455
Cumulative Expenditures through October 24, 1969		68,909
	Balance	$ 37,546



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