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FINAL REPORT
ON
FREON INJECTION TECHNIQUES
FOR
SATURN SYSTEMS LEAK CHECK

Contract NAS8-11910
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Prepared For:
National Aeronautics And Space Administration
George C. Marshall Space Flight Center
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INTRODUCTION

Astro-Space Laboratories has developed, under NASA contract NAS8-11910, a device for pressurizing tanks with a mixture of Freon-22 and air for leak detection purposes.

The Freon Injection System is designed to fill tanks with a mixture containing 1% Freon -22. This will allow leaks of 10^{-5} cc/min to be reliably detected with commercial halocarbon leak detectors.

The system is designed to pressurize tanks of up to 50,000 cubic feet, and to operate at pressures up to 2400 psig.

The system fills the tank to be tested with an automatically regulated constant percentage mixture of Freon-22 and air.

Since the Freon-22 and air are mixed as the tank is filled, a uniform mixture is achieved throughout the tank volume. These characteristics make it possible to make consistant and repeatable leak detection tests.

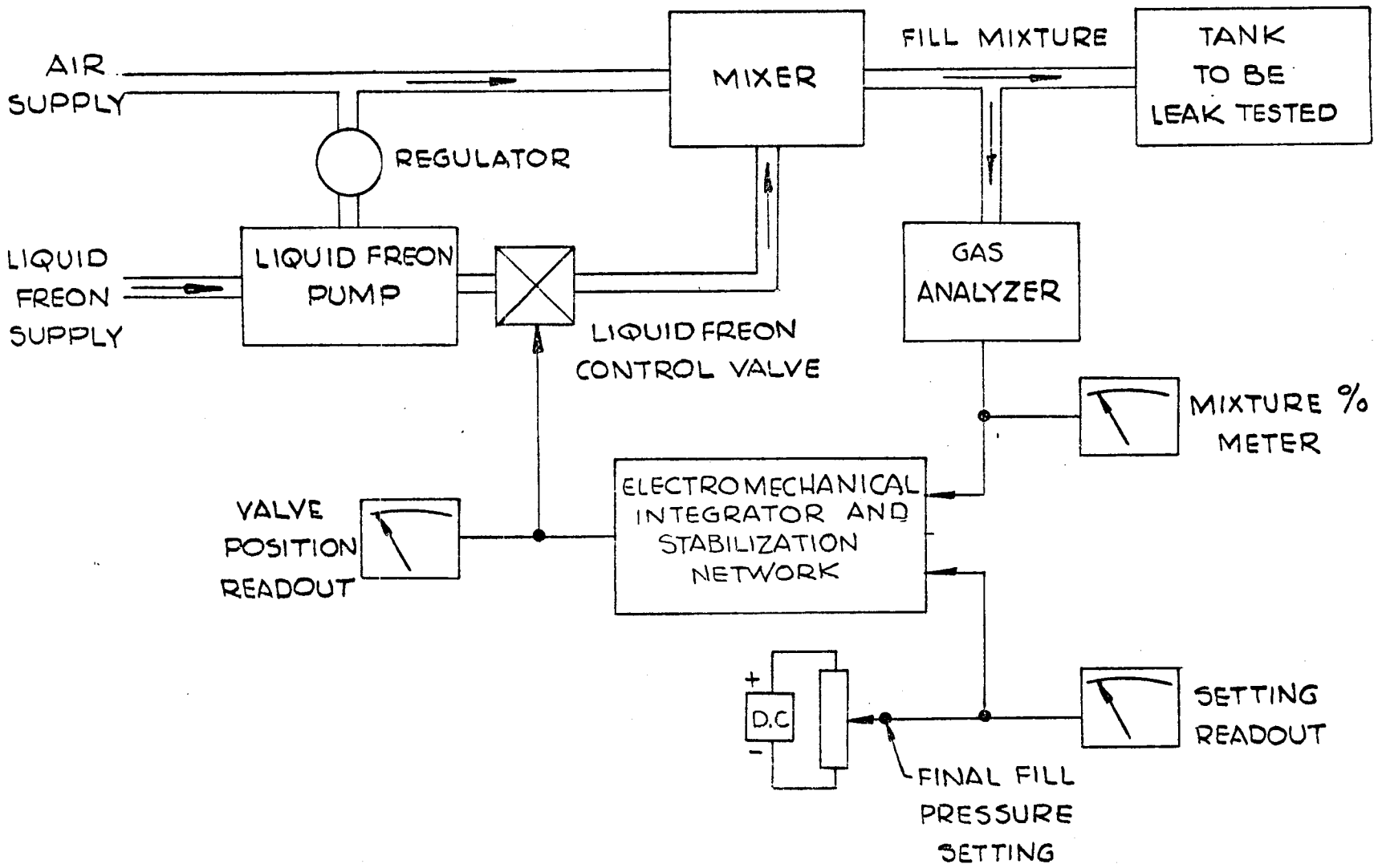
PRINCIPLE OF OPERATION

The operation of the system may be understood from the functional block diagram. (See Figure 1.)

Air from the high pressure supply flows through the mixer assembly and out to the tank under test. Liquid Freon-22 enters the liquid Freon pump which increases its pressure to approximately 2400 psig. This pump is an air-actuated hydraulic booster type pump. The high pressure Freon-22 is metered into the mixer by an electropneumatically operated proportional valve. In the mixer, the liquid Freon-22 is sprayed into the air stream where it evaporates and mixes with the filling air.

Downstream from the mixer a small portion of the air - Freon-22 mixture is bled off and analyzed by means of an infrared detection system. The output of the gas analyzer is used to control the liquid Freon control valve to maintain the desired mixture ratio. This control is accomplished by an electromechanical integrator and stabilization network.

The tank to be tested is filled with a constant ratio mixture. The ratio is determined by the final desired mixture (1% Freon) and the final tank pressure.



FUNCTIONAL BLOCK DIAGRAM
FREON INJECTION SYSTEM
FIG. 1

$$M_f = \frac{P+14.7}{P} M_P$$

where:

M_f = fill mixture
M_P = desired mixture at final pressure
P = final pressure in psig

The fill mixture ratio is set by setting in the final fill pressure desired. The system is calibrated to produce the proper fill mixture to produce a final tank mixture of 1% Freon-22. This is the only setting required for system operation.

LEAK PARAMETER STUDY

In order to determine the system parameters, certain definitions were made:

a. Sensitivity of leak detection equipment.

b. Minimum leak that is to be detectable.

The industry standard for halogen leak detectors has been developed by General Electric Co. The G.E. Type H-2 gun probe and associated control unit is presently being used in the NASA Quality Lab and throughout industry. The unit is very sensitive, rugged and easily portable. The G.E. detector appears to be reliable for detecting a leak corresponding to 10^{-7} cc/min. of pure Freon-22 or Freon-12 halocarbon gas.

The minimum permissable leak had to be determined. Studies indicated that the minimum detectable leak at test pressure utilizing the soap water or liquid leak detection equipment was equivalent to 1.28×10^{-4} cc/min while the smallest leak recommended for tanks containing liquids was equivalent to 10^{-4} cc/min. dry air, at the operating pressure. Therefore, the minimum system leak was selected to be 10^{-5} cc/min. at that pressure. With a 1% mixture of Freon in the tank, a 10^{-5} cc/min leak would be equivalent to a 10^{-7} cc/min leak of pure Freon to the detector.

The use of this relatively low percentage of Freon is not only justified by the sensitivity of the detection system and leak requirement as shown above, but also from the economy of system design and the avoidance of air contamination. Additionally the cooling effects of evaporating Freon makes it very difficult

to fill large containers with ratio mixtures of over a few percent. Using a low percentage of Freon tracers also eliminates the possibility of exceeding the vapor pressure of the tracer, causing condensation of the tracer at high test pressures.

FINAL TEST AND DESIGN CHANGES

During the final test at NASA Quality Laboratory several changes were made in the system. These changes were as follows:

a. The freon sample line was found to be too long and too large. The line and controls were relocated and made smaller.

b. It was determined that it was necessary to start the Freon pump and pressurize the Freon Injector system itself before using it to pressurize another system. A switch was added to perform this function.

c. It was found desirable to have a switch to remove the system from the operate mode without shutting down the complete system. This switch was added to the system.

All of these changes were incorporated in the final drawings which were delivered to NASA in December 1966. These drawings have been checked by NASA and approved.

All documentation and equipment has been delivered to NASA Quality Laboratories.