INTERIM ENGINEERING REPORT
ON DEVELOPMENT OF
INFRARED DETECTORS

W33-038-ac-15293 IR-16

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PART I

A. Purpose

The following pages contain a report on activities carried out for Contract W33-038-ac-15293 during the period 15 April 1949 to 15 June 1949.

B. General Factual Data

1. Ultrasonic Detector

The work of the past period on the ultrasonic method of detecting infrared radiation has been mainly concerned with the design and construction of a double receiver system to minimize the effects of noise at the receiver input due to the driver. A double receiver has been constructed and preliminary tests are now in progress.

In preparation for these tests the receiver crystal of the double-crystal interferometer has been replaced with a pair of matched crystals whose total area is one square inch. Adjustment of the crystals in the holder is now being carried out in order to obtain equal output voltages and a good ratio of driver-to-receiver voltage.

Construction of the electronic setup for the crystal paralleling instrument has been started. A diagram is included in this report.

2. Molecular Detector

By way of initiating work on the infrared properties of multimolecular films, a Harkins type film tray has been constructed. This tray in conjunction with a modified pulp balance will serve as a device for the measurement of film pressures which are essential in any investigation of multimolecular films formed on liquid substrates.

Very little further work has been done on the determination of lifetimes for spontaneous emission from excited vibrational states of molecules in the gaseous phase. An amplifier is needed for use in conjunction with the Baird bolometer as a detector of the radiation. Request for permission to purchase an amplifier which is especially suited to this purpose has been submitted to Wright Field.

C. Detailed Factual Data

1. Ultrasonic Detector

a. Double Receiver

In accordance with the attempt to improve the sensitivity of the ultrasonic detector, construction work was completed on the double receiver designed to cut down noise in the system.

Tests run from a modulated r.f. signal source indicate that the double receivers cut down the modulation level by a factor of eight over the output of a single receiver.

Tests run with both receivers connected to the same output crystal of an interferometer, to study the effect on the noise in the detector system, show that the overall noise can be kept down to 3-5 mv.

At the present time, the detector interferometer and the receivers are being set up to test the complete scheme involving the use of the split receiver crystals.

A schematic diagram of the receiver is given in Fig. 1.

b. Split Receiver Crystal

A set of split crystals has been received and set up in the double-crystal interferometer. The initial work is concerned with adjusting this system so that a reasonably balanced voltage output is obtained from the two crystals. Some study has been made with the two crystals feeding into the double-receiver system but as yet no radiation measurements have been attempted.

The mounting technique used for both the driver crystal and the two receiving crystals is the one most readily set up. It utilizes a cork layer as a support for the quartz plate and a steel spring wire member on the ground face to push the plate against the cork.

It is hoped that this setup will be ready for radiation measurements within the next few weeks.

c. Lithium Sulfate Crystals

As an aid in the study of coupling mechanisms between infrared radiation and supersonically excited gas fields we have obtained some lithium sulfate crystals which have a much broader resonant characteristic than a quartz plate for the same frequency. The advantage of such a characteristic is that for higher shutter speeds the sensitivity of the detection scheme will be greater for the crystal with the broader characteristic. These crystals are 1/2 in. square and thus have only 1/4 the area of the crystals used at present. Work with these crystals will be started as rapidly as possible.

2. Molecular Detector

Some apparatus has been constructed and set up to initiate work on the study of molecular emission lifetimes for molecules orientated in the multimolecular layer films. This apparatus at present consists of a Harkins[1] type film tray and balance for the measurement of film pressures. The setup is depicted in Fig. 2.

Basically the film tray provides a large horizontal trough which contains a substrate material in liquid form. On this substrate

1. Surface Chemistry, American Association of Advanced Science, No. 21, 1943.

is placed a material which will spread to the thickness of a single molecule. A movable barrier is provided in the tray to compress the film. A vertically suspended thin metal or glass sheet is immersed in the liquid. By means of a balance attached to the sheet the vertical force exerted by the film on the sheet can be determined. This pressure is of the greatest importance in film work since a knowledge of its value and the area of the film between the movable barrier and the side walls yield the very significant film pressure-area curves.[2]

3. Instrumentation

a. Paralleled Crystals

In the last report mention was made of an instrument which would find use in the paralleling of crystals. This instrument is not new in principle, however its application to crystal interferometer work is new.

A study of the literature indicated that many circuits are available for measuring small mechanical movements by use of a capacitive probe. Incorporating one of these circuits[3] capable of detecting movements to a millionth of an inch into a piece of apparatus with a level probe arm which can fit between the crystals of an interferometer yields a device which can be used to parallel crystals within a millionth of an inch. The circuit diagram used is included in the report as Fig. 3. The apparatus is at present under construction.

Fundamentally the method invloves the detection of minute changes of capacity between a surface and a movable condenser plate. A schematic diagram is shown in Fig. 4. The capacitance of plate 1 with the face of crystal B is made constant over the entire face of B by adjustment of a mechanism attached to arm D. Plate 1 is of course always close to B, of the order of a few thousandths of an inch. End-effect changes are practically eliminated by keeping plate 1 somewhat away from the edges of B. Crystal A by means of its mechanism is so adjusted that movement of arm D over the face of A keeps the capacitance of plate 2 with respect of A constant. This results in both crystals A and B having a high degree of accuracy in their parallelism.

b. Gas Purifying System

In line with the molecular vibrational studies being carried out, a piece of apparatus for purifying gases has been designed (see Fig. 5) and is under construction. This will permit more accurate investigations of the lifetimes of molecular states in gases and in particular in the ammonia gas which is being used in the ultrasonic detector.

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2. Boyd and Harkins, Industrial and Engineering Chemistry, Vol. 14, No. 6, 1942, p. 496-502.
3. Frommer, Joseph C., Detecting Small Mechanical Movements, Electronics, July, 1943 p. 104.

PART II

PROGRAM FOR THE NEXT INTERVAL

1. Carry out noise suppression tests on ultrasonic infrared detector using the double receiver system in conjunction with the split receiver crystals of the acoustical interferometer.

2. Complete the crystal paralleling instrument for use with the interferometers.

3. Start the measurement of lifetimes for spontaneous emission from vibrational states of molecules in gas phase if the amplifier is received during this period.

4. Set up the Harkins apparatus for measurement of film pressures on liquid substrates.

APPENDIX A

Illustrations

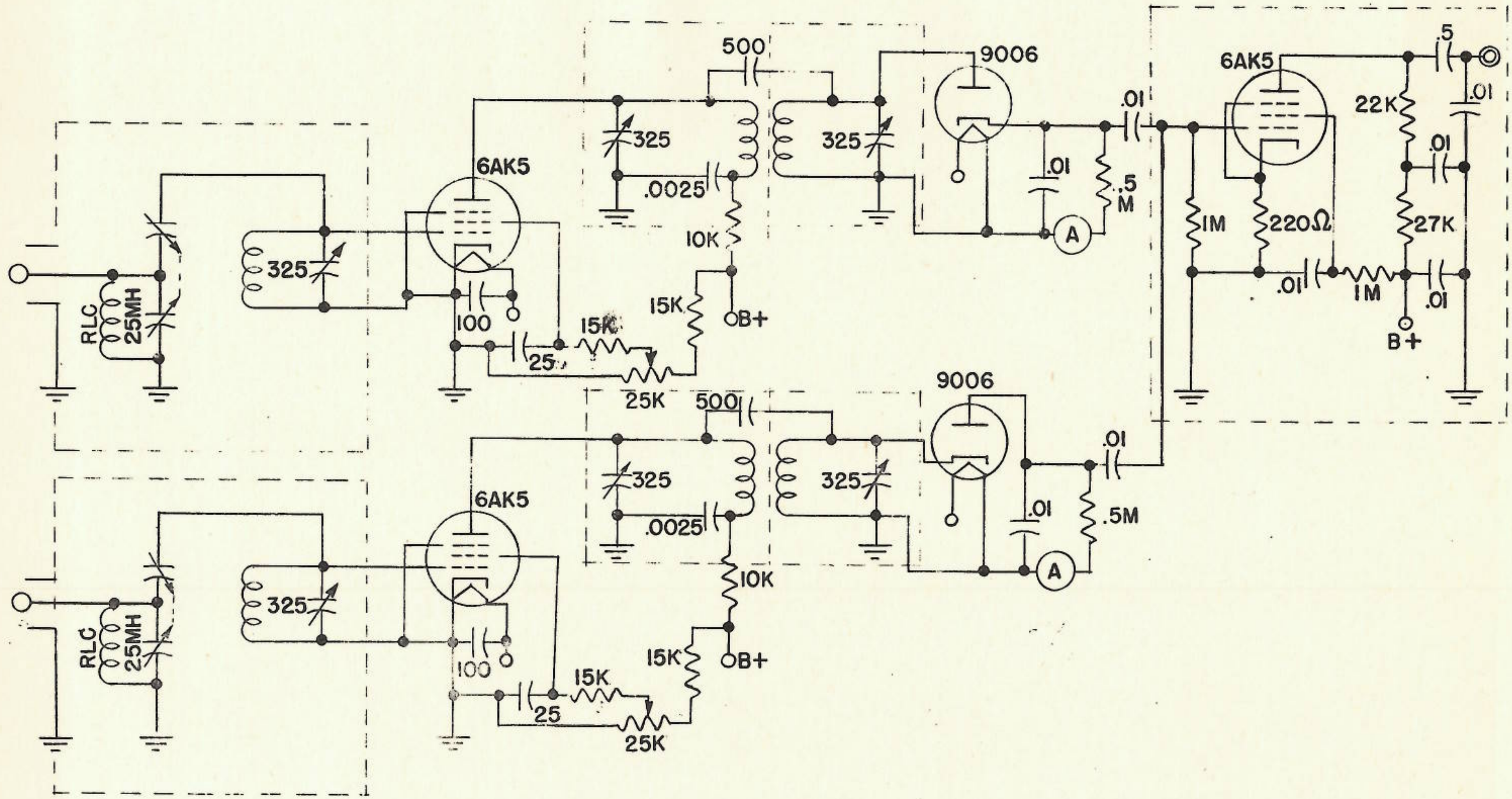

Figure 1
Double-Channel Receiver

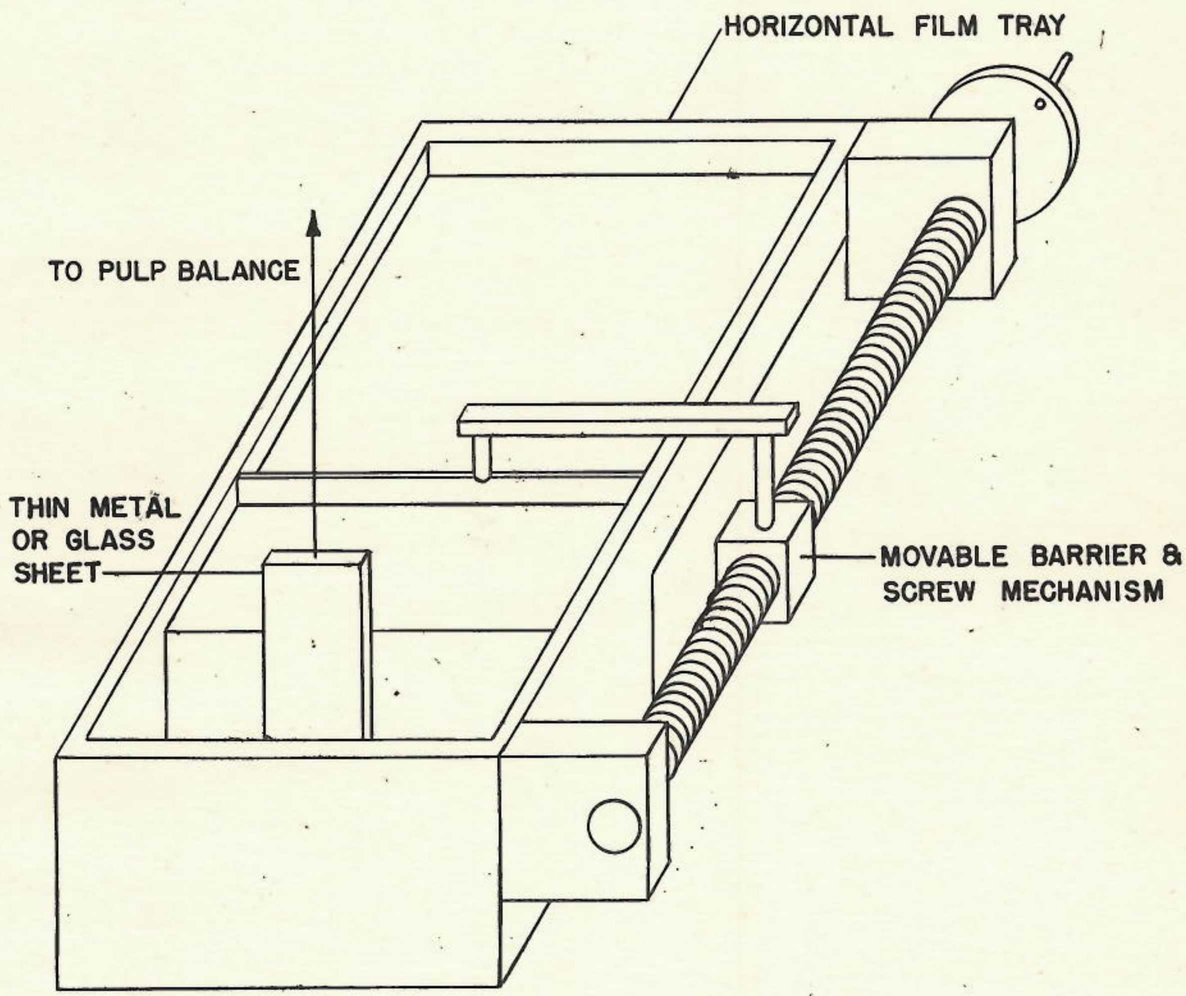

Figure 2
Harkins Film Tray

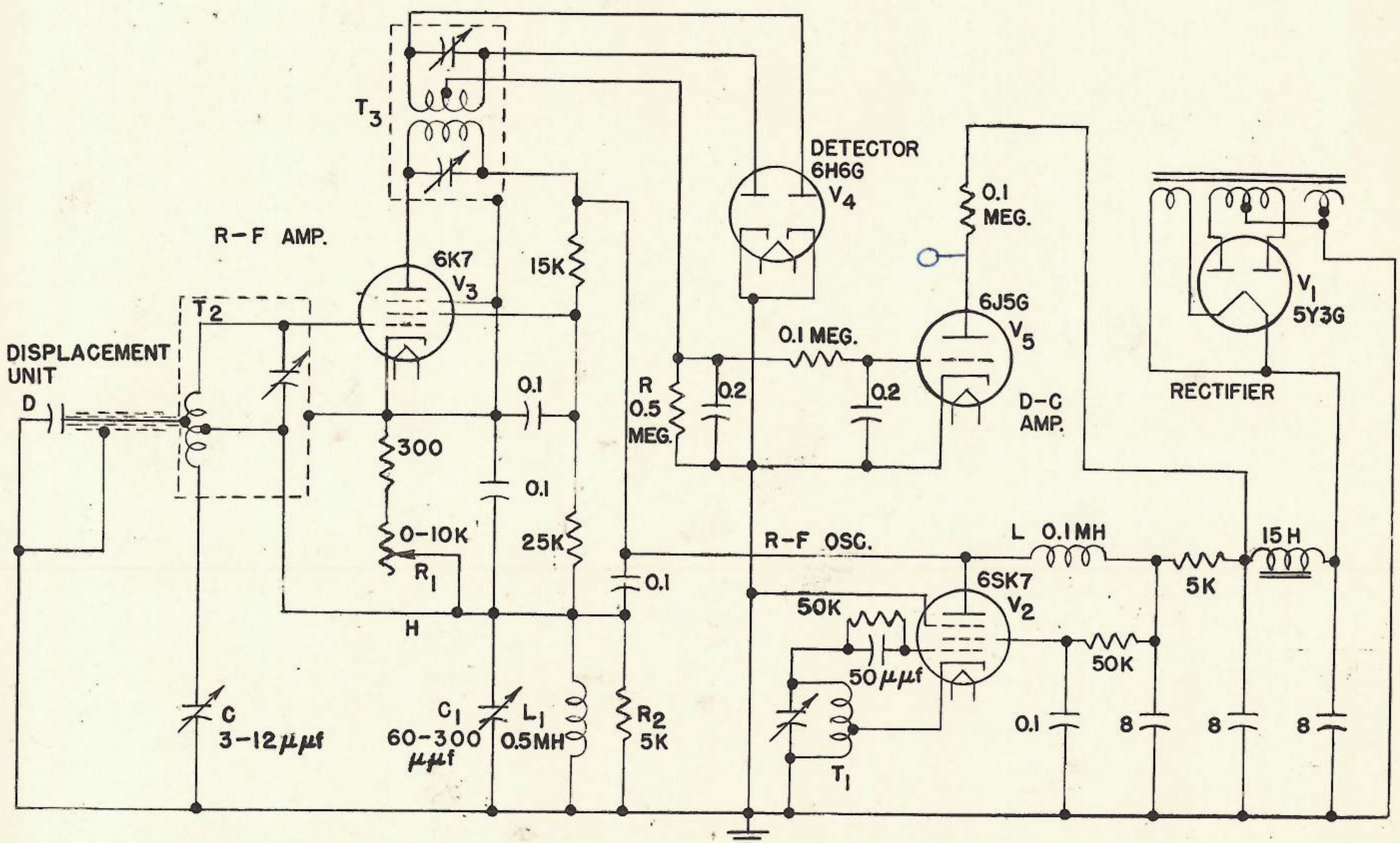

Figure 3
Diagram of Circuit Used to Parallel Crystals

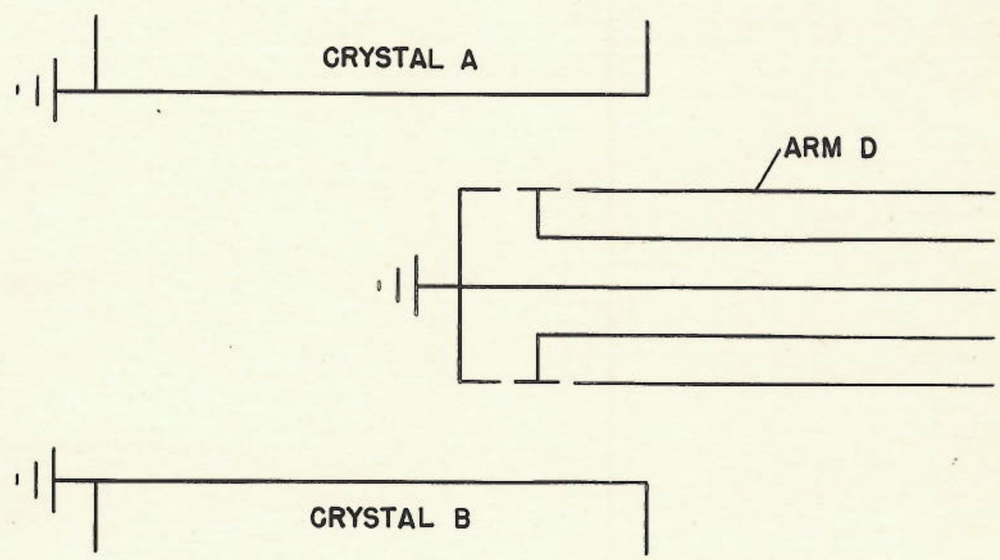

Figure 4
Schematic Diagram of Crystal Paralleling Device

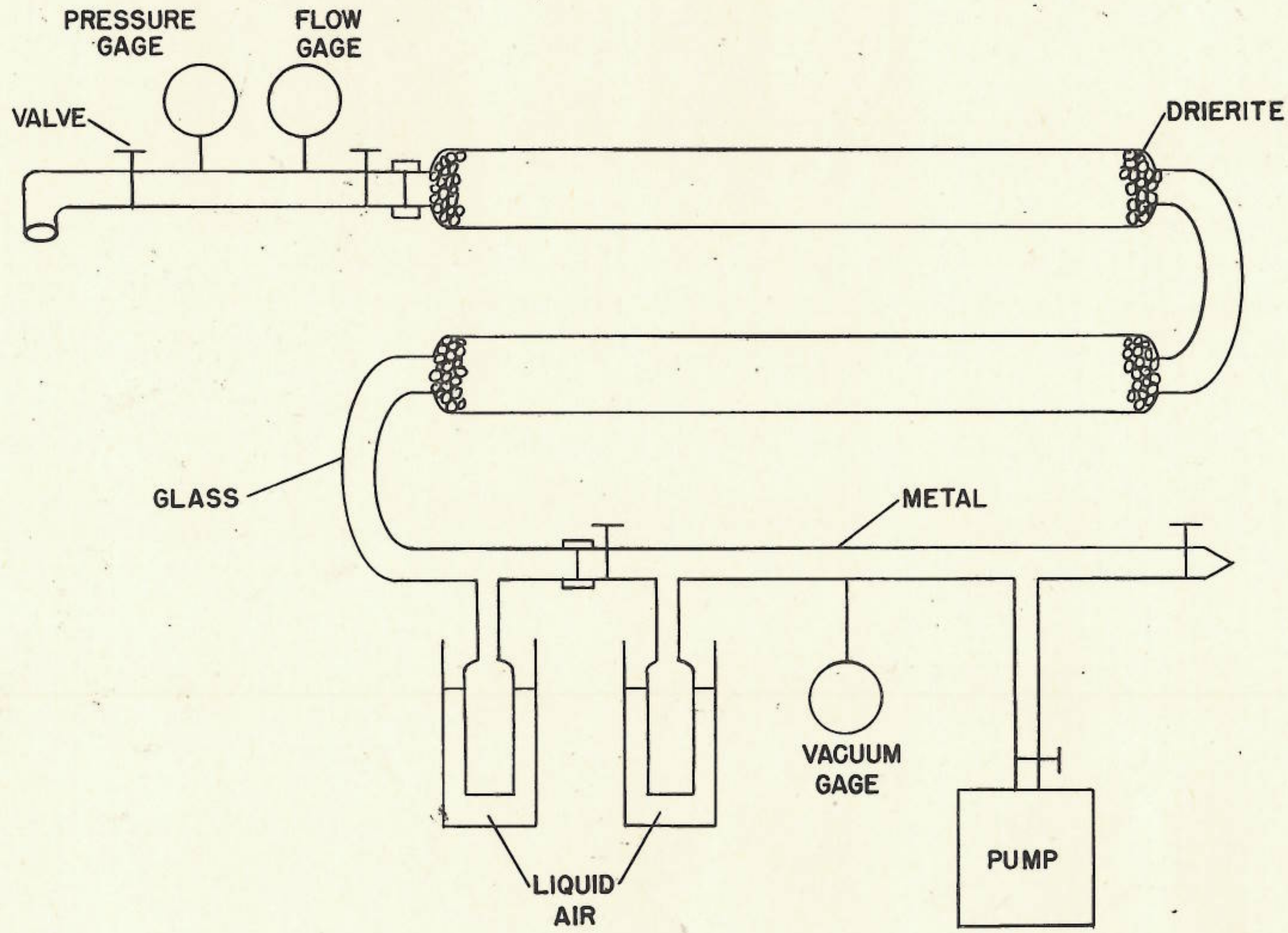

Figure 5
Gas Purifying System