

**ORIGINAL**Decision No. 52401

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

In the Matter of the Investigation )  
 on the Commission's own motion into )  
 the methods and practices of gas ) Case No. 4720  
 corporations in determining and )  
 recording the heating value of gas. )

(A list of appearances and witnesses  
 is included herein as Appendix A)

O P I N I O N

The above-entitled investigation was instituted by the Commission on April 25, 1944, for the purpose of obtaining information on methods and practices of gas corporations in determining and recording the heating value of gas. The Commission at that time also contemplated a possible revision of General Order No. 58-A in order to establish uniform standards and practices in connection with testing equipment and facilities, making of tests, and calorimetry practices.

Public Hearing

After due notice to all of the gas corporations in the state and other interested parties, three days of public hearing were held upon this investigation. The first day was October 23, 1944, before Commissioner Ira H. Rowell, and thereafter a long period ensued while a committee composed of representatives of the utilities, gas industry, cities, associations, educational institutions, the Commission staff and others studied this matter. The work of the committee was summarized in a report, dated February, 1952, entitled: "Results of Heating Value Tests of Fuel Gases Performed with Water-Flow and Recording Calorimeters".

Thereafter this committee drafted standard procedures for the installation, operation, maintenance and testing of recording and water-flow calorimeters. The Commission staff used this work as a background and in lieu of revising General Order No. 58-A, prepared a proposed general order which was presented at the second and third days of hearing on November 2, 1955, in San Francisco and on November 9, 1955, in Los Angeles before Examiner M. W. Edwards. The matter was submitted for Commission decision at the close of the hearing on November 9, 1955.

#### Staff's Proposal

The staff's proposed general order is set forth in Exhibit No. 4 entitled: "Standards of Calorimetry for Gaseous Fuels". Copies of the proposed general order were sent to the various interested parties by letter dated September 2, 1955. Several suggestions for changes were received from the interested parties. These were consolidated and by Exhibit No. 5 the staff placed certain recommended revisions into the record.

As the record now stands, the staff proposes that the rules shall apply to any person, firm or corporation now or hereafter engaged as a public utility in the business of furnishing manufactured gas, natural gas, hydrocarbon gas or a mixture of fuel gases. Deviation from the methods specified will be permitted where hardship results on the basis of a full and complete justification. After proposing certain definitions of terms, the staff recommends that tests by means of a recording gas calorimeter be performed by means of the standard method set forth in the proposed general order and that tests by means of a water-flow calorimeter be conducted in accordance with ASTM Designation: D900-48, adopted in 1948 by the American Society for Testing Materials, entitled "Standard Method of Test for Calorific Value of Gaseous Fuels by the Water-Flow Calorimeter".

The staff's proposed "Standard Method for Operating Recording Gas Calorimeters for Determining the Heating Value of Fuel Gases" is segregated into the following main topics:

- a. Location, Housing and Installation,
- b. General Care, Operation and Testing,
- c. Sensitivity Test,
- d. Restoration of Sensitivity,
- e. Restoration of Accuracy,
- f. Preparation of Theoretical Scale Reading of Reference Hydrogen Tank Gas and for Certification of Natural Gas,
- g. Determination of Theoretical Scale Reading for Reference Hydrogen Tank Gas,
- h. Certification of Natural Gas.

In addition to the detailed description in the body of the proposed order, the staff included five charts in Exhibit No. 4 showing schematic arrangement for connections, installation report form, weekly test record form, sample chart, and burner unit detail. The staff did not intend that the proposed order replace any of the calorimetry provisions of General Order No. 58-A, but rather that it be supplemental thereto.

#### Objections to Staff's Proposed General Order

While the utility representatives in general were in favor of the proposed order, objections were made to some of the many provisions. Several representatives objected to the proposed revision of Section 4.b.(4) to read: "Each recording calorimeter installation shall be provided with suitable air conditioning facilities such that the ambient room temperature can be maintained reasonably uniform and that the temperature of the tank water will be maintained within a range of 60 to 80 degrees Fahrenheit at all times. These air conditioning facilities must be capable of maintaining the room temperature within a range of 5 degrees Fahrenheit during each 24-hour period". This provision would require that the utilities install air conditioning equipment and they questioned that the possible small gain in accuracy warranted such installation.

A witness for the Southern Counties Gas Company of California objected to the staff's proposal to adopt the ASTM Designation: D900-48, as the only method for testing water-flow calorimeters. He asked that methods propounded by the National Bureau of Standards and by the Pacific Coast Gas Association be specified as alternate methods.

A protest was entered on behalf of two small gas companies where straight propane gas is served, that this order might require them to install and operate calorimeters. It was pointed out in this regard that General Order No. 58-A is controlling and in those cases where a company is not now required to maintain and operate a calorimeter under that general order it would not be required to do so under the proposed general order.

#### Discussion

When this investigation was originated the Commission had in mind the possibility of revising General Order No. 58-A. The staff considered this problem and in view of the importance of the subject matter and the extensive coverage it felt was necessary, recommended a separate general order for the subject. While in general the Commission agrees with the staff's recommendation, there is some question as to form of the proposed general order. Many sections contain procedures applicable only to one type of recording calorimeter, that is, the so-called "Thomas Calorimeter" manufactured by Cutler-Hammer, Inc.

The Commission's view on this subject is that in so far as practicable the general orders should be general in their applicability and not be limited to one make or type of equipment. The staff points to the hardship provision as the means for new makes to be considered. So long as new equipment is proven to meet the required accuracy standards, after adequate tests have been made by the manufacturer and by the utilities, we see no reason why such equipment should not be considered for use.

One method of providing for this situation is to place in the general order those provisions which are generally applicable to all types of calorimeters, and place the special provisions relating to particular makes in the appendices of the general order. Then, if and when new developments occur in the field of calorimetry, it will be necessary only to prepare additional appendices to the general order as the standard for such new equipment.

#### Conclusions

The Commission concludes that the subject of calorimetry is of sufficient importance to warrant a separate general order, but will revise the form of the proposed general order.

Objection has been made to the requirement that air conditioning equipment be installed in the calorimetry room in order to maintain the tank water temperature in the range of 60 to 80 degrees Fahrenheit, in view of the weekly tests and calibrations required. In considering the testimony in regard to tank water temperature control, it appears to the Commission that such control would be warranted at calorimeter locations as of the effective date of this order where tank water temperatures are outside of the 60 to 80 degrees Fahrenheit limit for a substantial period of time. Accordingly, the general order will provide for a requirement to maintain the tank water temperatures in the range of 60 to 80 degrees Fahrenheit at those calorimeter stations as of the effective date of this order where past experience indicates that tank water temperatures outside of that range are experienced for more than 15 days of the year. In connection with the installation of calorimeters at new calorimeter stations or the relocation of existing calorimeters subsequent to the effective date of this order, suitable air conditioning equipment shall be installed at such calorimeter installations where tank water temperatures will exceed 80 degrees

Fahrenheit at any time. Calorimeters should be installed in suitable rooms with proper building insulation and heating means to prevent the tank water temperature from falling below 60 degrees Fahrenheit at any time.

The request that alternative methods of test of water-flow calorimeters be adopted appears unnecessary. It is the Commission's desire to adopt the latest method and prescribe only one method of procedure. In those cases where hardship is alleged to result from changing to the ASTM procedure and existing methods give reasonably good accuracy, deviations can be considered upon request of and a showing by the utility.

O R D E R

An investigation into the methods and practices of gas corporations in determining and recording the heating value of gas having been conducted on the Commission's own motion, hearings having been held, the matter having been submitted and the Commission being of the opinion that the rules governing calorimetry prescribed in the attached General Order No. 58-B are reasonable and should be adopted; therefore,

IT IS HEREBY ORDERED that said General Order No. 58-B attached hereto be and it is hereby adopted. Said General Order No. 58-B shall be supplementary to the requirements of General Order

No. 58-A, and shall not relieve any gas corporation from complying with the provisions of General Order No. 58-A.

The effective date of this order shall be twenty days after the date hereof.

Dated at San Francisco, California, this 28<sup>th</sup> day of December, 1955.

[Signature]  
President

[Signature]

[Signature]

[Signature]

Commissioners

Commissioner [Redacted], being necessarily absent, did not participate in the disposition of this proceeding.

APPENDIX A

List of Appearances

Interested Parties: Pacific Gas and Electric Company, by R. W. DuVal, Frank Wills, Phillip Beckman, Morris Richford, Rudolph Jenny; F. T. Searls and John Carroll Morrissey; Coast Counties Gas and Electric Company, by Charles Grunsky; California Farm Bureau Federation, by J. J. Deuel, Joseph O. Joynt and Russell L. Perry; Southern Counties Gas Company of California, by Frederick Dutton and N. K. Senatoroff; City and County of San Francisco, by Dion R. Holm and Paul Beck; San Diego Gas & Electric Company, by H. M. Barnes; City of Alameda, by H. Albert George; C. B. Gentry Company, by W. D. McKay; Cutler-Hammer, Inc., by J. M. Cook; 12th Naval District, Public Works Department, by Oliver O. Rands; Municipal Gas Department, City of Long Beach, by Virgil L. Sadler; Department of Public Utilities and Transportation of the City of Los Angeles, by P. A. Erickson and M. Kroman; 11th Naval District, Public Works Office, Department of Navy, by Clarence Alliman; Pacific Lighting Gas Supply Company, by James Randolph Elliott.

Protestants: Southern California Gas Company, by Guy Corfield and J. S. Powell; Cloverdale Gas Company and Russian River Gas Company, by N. E. Waltenspiel.

For the Commission Staff: Roy A. Wehe, Lloyd E. Cooper, M. J. Kimball and J. E. Spelce.

LIST OF WITNESSES

M. A. Richford and Rudolph Jenny for Pacific Gas and Electric Company; N. K. Senatoroff for Southern Counties Gas Company of California; J. E. Spelce for the Commission staff.



PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

GENERAL ORDER NO. 58-B

STANDARDS OF CALORIMETRY FOR GASEOUS FUELS

Approved December 8, 1955 Effective January 17, 1956

IT IS HEREBY ORDERED that the following rules be adopted, effective January 17, 1956 to govern all gas corporations as defined in the Public Utilities Code,<sup>1</sup> in the determination of heating values of fuel gases. This order is supplemental to General Order No. 58-A, which requires utilities to provide and maintain calorimeter testing stations, and shall not relieve any gas corporation from complying with the provisions of General Order No. 58-A.

The order herein comprises the following sections and appendix:

1. Applicability of Rules
  2. Deviations from Rules
  3. Definitions of Terms
  4. Types of Calorimeters
  5. Standards for Recording Calorimeters
  6. Standards for Water-Flow Calorimeters
  7. Minimum Requirements
- Appendix 1, Standard Method for Installing, Operating, Testing and Maintaining Recording Calorimeters Manufactured by Cutler-Hammer, Inc.

1. Applicability of Rules

- a. The following rules shall apply to any person, firm or corporation now or hereafter engaged as a public utility in the business of furnishing manufactured gas, natural gas, hydrocarbon gas, or a mixture of fuel gases for domestic, commercial, industrial or other purposes within the State of California where the gas service rendered is subject to the jurisdiction of the Public Utilities Commission of the State of California.

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<sup>1</sup> "Gas corporation" includes every corporation or person owning, controlling, operating, or managing any gas plant for compensation within this State, except where gas is made or produced on and distributed by the maker or producer through private property alone solely for his own use or the use of his tenants and not for sale to others. Gas corporations are also herein referred to as "utilities" or "gas utilities".

- b. When a change is desired in the type of calorimeter to be used at a given calorimeter station a request shall be made to the Commission by the utility, briefly stating the authorization sought, the type of calorimeter presently being used at the calorimeter station, the type of calorimeter desired to be used at the station in the future, and the major reason for making the change.

2. Deviations from Rules

In no case shall any public utility deviate from the methods herein set forth except with special written authorization from the Commission. If hardship results from the application of any rule herein prescribed because of special conditions, application may be made to the Commission for authorization to deviate therefrom. Such request for deviation authority shall set forth a complete justification of the proposed procedure.

3. Definitions of Terms

a. Fuel Gas

Any combustible gas or vapor, or combustible mixture of gaseous constituents, used to produce heat by burning.

b. Fuel Gas Calorimeter

An apparatus for determining the calorific (heating) values of fuel gases.

(1) Recording Calorimeter

An automatic device that continuously makes a written record of the heating value of a fuel gas or mixture of fuel gases on a chart.

(2) Water-Flow Calorimeter

A laboratory device for measuring the total and/or net heating value of a fuel gas or mixture of fuel gases in which the heat evolved by the complete combustion of a measured quantity of gas burning at a uniform rate is absorbed by a quantity of water also flowing at a uniform rate. The weight and increase in temperature of the water flowing during the interval that the measured quantity of gas is being burned furnish the primary data necessary for calculating the heating value of the gas.

c. Calorimeter Station

The location at which a calorimeter is maintained for the purpose of determining the heating value of a fuel gas.

d. Standard Temperature

60° F., based on the international temperature scale.

e. Standard Pressure

The absolute pressure of a column of pure mercury 30 inches in height at 32° F. and under standard gravity (32.174 ft./sec.<sup>2</sup>) or (980.665 cm/sec.<sup>2</sup>)

f. Standard Cubic Foot of Gas

The quantity of gas which, when saturated with water vapor and at a temperature of 60° F. and under a pressure of 30 inches in height of mercury at 32° F. (density 13.5951 grams/cc and acceleration of gravity 980.665 cm/sec.<sup>2</sup>) occupies one cubic foot.

g. Dry Cubic Foot of Gas

The quantity of gas which, when free of water vapor at standard temperature and under standard pressure will fill a space of one cubic foot. The total heating value of one dry cubic foot of gas is equal to the product of the total calorific value per standard cubic foot and the constant 1.0177.

h. British Thermal Unit (Btu)

The quantity of heat that must be added to one avoirdupois pound of pure water to raise its temperature from 58.5° F. 59.5° F. under standard pressure.

i. Total Calorific Value

The number of British thermal units evolved by the complete combustion, at constant pressure, of one standard cubic foot of gas with air, the temperature of the gas, air and products of combustion being 60° F. and all of the water formed by the combustion reaction being condensed to the liquid state.

j. Net Calorific Value

The number of British thermal units evolved by the complete combustion, at constant pressure, of one standard cubic foot of gas with air, the temperature of the gas, air and products of combustion being 60° F. and all of the water formed by the combustion reaction remaining in the vapor state. The net calorific value of a gas is its total calorific value minus the latent heat of vaporization at standard temperature of the water formed by the combustion reaction. Latent heat of vaporization of water at 60° F. = 1057.8 Btu per lb. or 50.37 Btu per standard cubic foot.

k. Theoretical Air

The volume of air that contains the quantity of oxygen, in addition to that in the gas itself, consumed in the complete combustion of a given quantity of gas.

l. Excess Air

The quantity of air passing through the combustion space in excess of theoretical air.

m. Combustion Air

The air passing into the combustion space of the calorimeter (theoretical air plus excess air).

n. Products of Combustion

All substances resulting from the burning of gas with its theoretical air, including the inert constituents of the gas and the theoretical air, but excluding excess air.

o. Flue Gases

The products of combustion remaining in the gaseous state, together with the excess air.

p. Certified Natural Gas

A sample of natural gas of certified heating value. The sample must be of constant composition and heating value and contain no condensibles that will effect a change in its heating value with any temperature-pressure conditions to which the gas may be subjected.

q. Standard Hydrogen Gas

Hydrogen gas generated by the reaction of water on hydrone, an alloy of sodium and lead. (Purity approximates 99.94 per cent hydrogen.)

r. Reference Hydrogen Tank Gas

Hydrogen gas of commercial quality and purity stored in a tank or cylinder at high pressure, the heating value (theoretical scale reading) of which has been determined with standard hydrogen gas.

s. Reference Natural Gas

Natural gas of constant composition and heating value, the heating value of which has been accurately determined by use of certified natural gas or standard hydrogen gas. Such gas shall contain no condensibles that will effect a change in its heating value with any temperature-pressure change to which the gas may be subjected.

t. Condensate

The water that is condensed to the liquid state within the body of the calorimeter.

4. Types of Calorimeters

It is the intent of the Commission that this general order be applicable to all types of calorimeters; however, at the present time there are only two types of calorimeters in use of which the Commission approves. These are the recording and water-flow types. Each type is being manufactured only by a limited number of manufacturers. In the case of the recording calorimeter there is only one principal manufacturer, Cutler-Hammer, Inc., and in the case of the water-flow type there are only a few manufacturers. Under these circumstances standards are provided or specified that treat specifically with the equipment produced by these manufacturers.

5. Standards for Recording Calorimeters

The standard methods for installing and operating recording gas calorimeters for determining the heating value (calorific value) of fuel gases applicable to the utilities using the Cutler-Hammer type of equipment are set forth in Appendix 1, attached to and made a part of this order.

6. Standards for Water-Flow Calorimeters

- a. The "Standard Method of Test for Calorific Value of Gaseous Fuels by the Water-Flow Calorimeter", published by the American Society of Testing Materials, ASTM designation: D900-48, adopted 1948, is hereby prescribed as the approved method of the Commission for operating water-flow calorimeters by the gas utilities in the State of California.
- b. The humidity correction procedure and the humidity control procedure of the "Standard Method of Test for Calorific Value of Gaseous Fuels by the Water-Flow Calorimeter", are the approved standard procedures of the standard method and shall be adhered to in detail as each is described in publication ASTM Designation: D900-48, Adopted 1948.
- c. Where a water-flow calorimeter is employed for making a heating value determination of a fuel gas no less than one set of duplicate heating value tests shall be made of that gas for each determination performed. The difference between the two heating value test results obtained shall not exceed 10 Btu per standard cubic foot. If a difference of 10 Btu per standard cubic foot is exceeded, additional heating value tests shall be run until two test results are obtained of a lesser difference than 10 Btu per standard cubic foot. The average of the first two test results having a lesser difference than 10 Btu per standard cubic foot shall be the accepted heating value test result for that determination.

7. Minimum Requirements

The requirements contained herein should be considered as minimum and any utility may adopt additional rules and practices provided they are not inconsistent with the provisions of this order.

Approved and dated at San Francisco, California,  
this 28<sup>th</sup> day of December, 1955.

PUBLIC UTILITIES COMMISSION  
OF THE STATE OF CALIFORNIA

By

  
R. J. PAJALICH, Secretary.

## APPENDIX 1

Standard method for installing, operating, testing and maintaining recording calorimeters manufactured by Cutler-Hammer, Inc.

## A. Location, Housing and Installation

## (1) General Location

Calorimeters shall be located in a place where the possibility of contamination of the combustion air by heat producing constituents is negligible. Where contamination of the air in the room occurs, uncontaminated air shall be delivered to the calorimeter or calorimeter room at room pressure. The building or room for housing a recording calorimeter shall be constructed of such material and in such a manner as to eliminate the possibility of drafts and wide or rapid changes in temperature. The calorimeter room or enclosure shall not be used for any purpose that may cause contamination of the atmosphere or interfere with the proper maintenance and operation of the calorimeter or calorimeters.<sup>1</sup>

## (2) Housing

The minimum clearance shall be 18 inches from the back and the sides of the tank unit and the hinged side and back of the recorder unit, and 36 inches from the front of both units. The minimum floor area suitable for one recording calorimeter and auxiliary equipment shall be approximately 10 by 7 feet. Additional units may be installed in the calorimeter room provided the foregoing specified clearances are maintained. The tank and recorder unit or units may be installed in separate rooms but should not be separated by more than 100 feet. The room in which the calorimeter tank or recorder unit is located shall have a foundation reasonably free from vibration and floor shock and shall be capable of withstanding without deflection the weight of the tank unit and recorder unit, together with normal traffic and operations.

## (3) Installation

## (a) Wiring

The calorimeter wiring to be installed shall be in accordance with the manufacturer's applicable instructions and applicable national and local codes.

## (b) Gas Connections

A suitable piping system for conveying line and calibrating gases to each recording calorimeter that will

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<sup>1</sup> One tenth of 1 per cent gas by volume in the combustion air supplied to a calorimeter will cause the calorimeter to read approximately 1 per cent too high. Such a concentration of natural gas normally will not have a detectible odor:

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enable the shifting from one gas to another, without extinguishing the burner flame and prevent the contamination of one gas supply with another, shall be provided at each recording calorimeter station. One quarter-inch needle valves and iron pipe size (I.P.S.) piping are recommended. Such a system is outlined in Figure A attached. In making the connections to the gas supply, the small orifice in the end of the nipple connected to the  $\frac{1}{4}$ -inch union shall not be damaged or removed. A suitable pressure regulator shall be used with each calorimeter to provide proper pressure of the gas at the calorimeter when line pressures exist up to 30 inches of water. For line pressures above 30 inches of water, an additional or substitute pressure regulator must be used. The gas sampling or supply pipe to each recording calorimeter installed after the effective date of this order shall follow a direct route and be of the smallest practical internal diameter possible to enable the amount of gas required to properly operate the calorimeter to reach the instrument. Reduce to an absolute minimum the length of "dead" sample line connected at any time to the pipeline through which gas is conveyed to the calorimeter. For all hydrogen tests eliminate the passage of hydrogen through lines and regulators which have been in contact with other fuel gas.

## (c) Gas Condition

The gas supplied to the calorimeter shall be practically free from hydrogen sulphide and other impurities which may interfere with its operation.<sup>2</sup>

## (d) Installation of Tank and Recorder Units

Install the tank and recorder units and place them in readiness to operate as directed by the manufacturer's applicable book of instructions.

## (e) Installation Report

1. Each gas utility shall file with the Commission at the time of the installation of each recording calorimeter, or as soon thereafter as practical, a complete installation report setting forth all items of information contained in Figure B together with such other data or facts as may be pertinent to a suitable record of the equipment and facilities comprising a recording calorimeter station.

<sup>2</sup> Hydrogen sulphide concentrations in the order of 0.25 grains per 100 cubic feet may cause difficulty with the operation of a recording calorimeter. It is recommended that the hydrogen sulphide concentration of the gas supplied to a calorimeter be kept below a trace which approximates 0.25 grains per 100 cubic feet.

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2. To the "Installation Report" for each calorimeter shall be attached a "Ground Plan of the Recording Calorimeter Station", setting forth the outline of the building, the location of the calorimeter or calorimeters within the building, the size, length gas pressure and general route of the gas sample pipe from the supply main to each calorimeter and the relative location of all secondary equipment necessary for the operation of the recording calorimeter.

B. General Care, Operation, Maintenance and Testing

The provisions of this section shall apply to the practices to be followed by gas utilities for operating, maintaining and testing recording calorimeters.

(1) Calorimeter Station Records

Each gas utility shall keep a chronological record of weekly tests performed on each recording calorimeter for a period of not less than two years. In the record shall be entered the dates and results of operation to restore sensitivity and accuracy, including results of air-gas ratio tests, baffle tube changes, gas meter level adjustments, renewals of parts and other pertinent operations not otherwise specified in this order but included in the manufacturer's applicable book of instructions. This record shall be of a form shown in Figure C.

(2) Gases Used for Testing

The calorimeters must be tested at periodic intervals on a gas of known heating value as defined in items p. through s. of Section 3. of General Order No. 58-B.

(3) Placing Calorimeter in Operation

Following the installation of a recording calorimeter as prescribed in Section A.(3), it shall be run for a breaking-in period of not less than 24 hours and shall then be checked and adjusted for sensitivity and over-all accuracy in accordance with the following "Weekly Routine Tests", starting with Section B.(5)(b) "As Found" test.

The 24-hour breaking-in run shall be made with the gas meter operating with air-gas ratio gears as specified in the manufacturer's applicable book of instructions and the heat absorbing air meter operating at normal speed. This run shall be made under normal ambient room temperature conditions.

(4) Temperature Control Facilities

Suitable air conditioning facilities shall be provided at those calorimeter stations existing as of the effective date of General Order No. 58-B where tank water temperature



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has exceeded 80° Fahrenheit during more than 15 days of the year. Suitable air conditioning equipment shall be installed at new calorimeter stations or in connection with the relocation of existing calorimeter stations subsequent to the effective date of this order where tank water temperatures will exceed 80° Fahrenheit at any time. Suitable provisions shall be made at all calorimeter stations to insure a minimum tank water temperature of 60° Fahrenheit at any time.

## (5) Weekly Routine Tests

The following routine weekly operating accuracy tests shall be performed on each calorimeter.

## (a) Selection of Test Days

One day of each week shall be selected for the performance of an "As Found" accuracy test, mechanical tests, adjustments, and an "As Left" accuracy test of each recording calorimeter, and thereafter the specified accuracy tests, adjustments and maintenance work shall be performed on the same day of each week in so far as practicable.

## (b) "As Found" Test

Operate the calorimeter using reference (or certified) natural gas before cleaning parts or making any adjustments to either the tank unit or the recorder mechanism. Make the change from line gas to the reference natural gas so as to have a continuous chart reading by avoiding extinguishment of the calorimeter burner.

After the recorder pen has assumed its new position and has drawn a line at constant value for at least 20 minutes, make an over-all sensitivity test as described in Section C. Record the Upper and Lower Sensitivity readings on the face of the chart using a stamp, the print of which is illustrated by Figure D attached hereto. Calculate the mean of the two sensitivity readings and record the result as the average chart reading. Complete the "As Found" record showing the Btu of the reference natural gas and the correction to chart readings.

## (c) "As Left" Test

If the "As Found" correction to the chart readings is 1 per cent or less of the heating value of the reference natural gas and the sensitivity difference is 2 Btu or less, no adjustment need be made and the instrument may be returned to service in which event fill in the "As Left" column of the form stamped on the recorder chart. The sensitivity difference of 2 Btu applies to a recording calorimeter of the split-scale type having a 900 to 1,200 Btu range. For uniform scale instruments the sensitivity difference shall not exceed 0.5 per cent of full scale reading.

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## (6) Maintenance and Recalibration Procedure

If the sensitivity or the correction to the chart reading is not within the limits specified in Section B.(5)(c), follow the instructions set forth in Sections D. and E. to the extent necessary. If the sensitivity and accuracy have been restored, enter the final results in the "As Left" column of the weekly test record.

If the accuracy still is not within the prescribed limits, perform to the extent necessary the operations prescribed in Section F.

## (7) Reading Charts and Applying Corrections

The average heating value shall be determined from the chart for hourly periods and shall correspond to an imaginary line at the center of the inked line on the chart record.

When the chart record varies to such an extent that it is evident that an exact average heating value for an hourly period cannot be determined by one observation covering the chart record, the average for the hour shall be the average of four readings each covering a 15-minute chart interval. The corrections to compensate for the total error in the chart record, determined in Section B. and recorded as "Correction to Chart Readings as Left", shall be applied to all subsequent chart readings until the correction has been again determined.

## C. Sensitivity Test

The sensitivity test of the recording mechanism shall be made by one of the following methods with the instrument operating on a gas of constant heating value.

## (1) Rheostat Method

Open the recorder door so as not to cause a deflection of the galvanometer. Rotate the rheostat from the operating setting in a counter-clockwise direction to cause the recorder pen to move toward scale zero approximately 10 Btu. Then reset the rheostat to the operating setting. Close the recorder door. Observe and record the chart reading when it shows no further increase.

Again open the recorder door and rotate the rheostat from the operating setting in a clockwise direction to cause the recorder pen to move toward the upper end of the scale approximately 10 Btu. Then reset the rheostat to the operating setting. Close the recorder door. Observe and record the chart reading when it shows no further decrease. The numerical difference between the two readings is the sensitivity of the recorder.

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## (2) Alternate Method

Open the recorder door, slowly lower and unlatch the chart assembly. Then pull forward on the latch to swing the assembly out exposing the slide wire. Grasp the metal shaft extension from the slide wire and rotate in a clockwise direction so that the scale indicator has moved toward scale zero approximately 10 Btu. Latch the chart assembly and carefully close the recorder door. When there is no further increase, observe and record the chart reading.

Repeat the procedure, except rotate the slide wire in a counter-clockwise direction so that the scale indicator moves toward the upper end of the scale approximately 10 Btu. When there is no further decrease, observe and record the chart reading. The numerical difference between the two readings is the sensitivity of the recorder.

## D. Restoration of Sensitivity

If the sensitivity difference of a recording calorimeter of the split-scale type is more than 2 Btu or the sensitivity difference of a recording calorimeter having a uniform scale is greater than 0.5 per cent of the full scale reading of the instrument, take the following procedures to restore the sensitivity of the calorimeter to acceptable limits.

- (1) Check all electrical connections of the recorder for corroded or loose contacts.
- (2) Check the clearance between the galvanometer pointer and the upper and lower clamping bar.
- (3) Note the play between the slide wire and the pen tip to make certain that it is not excessive.
- (4) Check the voltage on the bridge circuit using a voltmeter with a resistance of at least 1,000 ohms per volt. With the bridge circuit closed, the normal potential difference should be approximately 1.5 volts. The voltage on the bridge circuit should always be kept between 1.45 and 1.75 volts. A low voltage on the bridge circuit could cause poor sensitivity of the recorder.

If restoration of the sensitivity of the recorder cannot be accomplished by the methods listed above, follow the directions for removing other causes of a lack of sensitivity of the recorder to be found in the manufacturer's applicable book of instructions for operating and maintaining the calorimeter.

- (5) Check galvanometer suspension wires for proper size.

Split scale instruments	2½ mill red tips
Uniform scale instruments	3 mill green tips

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## E. Restoration of Accuracy

- (1) Stop the tank unit drive motor and the recorder unit drive motor.
- (2) Remove the exit thermometer from the top of the return flow tube and clean the thermometer and/or burner jacket, if necessary.
- (3) Remove the burner jacket assembly, including the fluted tube, burner cap, inlet tube, and combustion tube and clean all accessible parts.
- (4) Remove any excess water in the seal pot and in the base of the burner casting.
- (5) Remove the air-meter connector (inlet thermometer housing). Clean the thermometer and connector passages and replace the air-meter connector.
- (6) Remove the gas mixture connector assembly and the primary and secondary air orifice caps. Clean the orifice with a soft wood probe and replace the parts.
- (7) Replace the parts removed in item (3) above, making sure that the top of the inlet tube is centered in the combustion tube and the combustion tube is centered in the fluted tube.
- (8) Replace the exit thermometer.
- (9) Start the tank unit drive motor.
- (10) Check the operation of the water pump. The pump bucket in the lowest position should just touch the bottom of the water reservoir. At the top of the stroke, the bucket should be empty.
- (11) Clean the water overflow weir. Use of a clean soft pencil eraser is recommended.
- (12) Examine the water level in the water tank and make sure that the water is flowing over the overflow weir.
- (13) Remove any oil that has accumulated on the surface of the tank unit mechanism, being very careful that no oil reaches the surface of the water. This is important because the accumulation of oil on the surface of the water will affect the efficiency of the overflow weir and the accuracy of measurement by the metering units.
- (14) Close the lid of the tank unit and start the recorder unit drive motor.
- (15) Check, and if necessary, adjust the "in place" mechanical balance of the galvanometer by placing the toggle switch located adjacent to the balancing rheostat in the "off" position and, with the recorder motor running, close the recorder door. When the galvanometer is in proper balance

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## (2) Mechanical Balance

With the calorimeter supplied with a natural gas of constant heating value, and having drawn a straight line for at least 20 minutes, perform the following operations in the order given: Check and adjust the "in place" mechanical balance of the galvanometer by placing the toggle switch located adjacent to the cold balancing rheostat in the "off" position and, with the recorder motor running, close the recorder door. When the galvanometer is in proper balance, the pen should draw a straight line on the chart. If the pen does not draw a straight line on the chart, adjust the knurled adjusting nut at the top and to the left of the galvanometer support until a constant chart reading is obtained for at least five minutes. Be sure to close the door of the recorder after each adjustment to prevent air drafts from causing a false deflection of the galvanometer pointer.

## (3) Sensitivity Tests

Make a sensitivity test of the recording mechanism, in accordance with Section C.

## (4) Restoration of Sensitivity

If the sensitivity of the recording mechanism as determined at the conclusion of the operation specified in Section F.(3) above is outside the limits prescribed in the first paragraph of Section D., perform the operations prescribed in Section D.

## (5) Accuracy Tests and Adjustments

At the conclusion of the tests and adjustments specified in item (4) above, the calorimeter may be changed from operation on constant heating value gas to line gas after which the operations of items (1) through (16) specified in Section E. shall be performed.

## (6) Preliminary Preparation for Hydrogen Test

- (a) Stop the recorder unit motor and then stop the tank unit motor.
- (b) Change the calorimeter from operation on natural gas to operation on hydrogen gas generated from hydrone and arrange the supply piping to the instrument to convey gas to the orifice nipple through rubber tubing fitted with a screw clamp as indicated in Figure A.
- (c) Verify that the gas inlet orifice is a No. 70 drill size.

## (7) Hydrogen Test

- (a) Supply hydrogen generated from hydrone to the calorimeter.
- (b) Remove the bleeder burner and burn the excess hydrogen from the bleeder port.

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- (c) Control the flow of hydrogen from the generator with the screw clamp to give a flame above the bleeder burner  $3/8$  to  $1/2$  inch in height.
- (d) Allow the instrument to operate until the pen has drawn a straight line for at least 30 minutes. Perform the sensitivity test as outlined in Section C. and observe and record the scale reading for each direction of approach. The average of these two readings will be the Btu scale reading for the hydrogen gas tested.

## (8) Theoretical Scale Readings for Standard Hydrogen Gas

The calorimeter scale reading to use when testing a calorimeter for accuracy by burning hydrogen generated from hydrone with the specified hydrogen test gears shall be the applicable value taken from the table on Theoretical Scale Readings on Standard Hydrogen Gas shown following or from the manufacturer's applicable book of instructions for the specific calorimeter under test.

## THEORETICAL SCALE READINGS ON STANDARD HYDROGEN GAS\*\*

Calorimeter	Hydrogen Test Gears			
Range Btu/Cu.Ft.	20A-40B	24A-36B	27A-33B	28A-32B
150	80.0	106.5	130.7	139.8
200	106.5	142.0	174.3	186.4
300	159.8	213.1	261.5	279.7
450	239.8	319.6	392.2	419.4
500	266.3	355.1	435.8	466.1
600*	319.6	426.1	523.0	559.3
700*	372.8	497.2	610.2	652.5
900*	479.6	639.2	784.5	838.9
1000*	532.6	710.2	871.6	932.2
1200*	639.2	852.2	1046.0	1119.0
1500	799.0	1066.0	1308.0	1398.0
1800	959.0	1278.0	1570.0	1678.0
2100	1118.0	1492.0	1831.0	1958.0
2400	1278.0	1704.0	2092.0	2237.0
3000	1598.0	2131.0	2615.0	2797.0

NOTE: \* For calorimeters which are to be used on butane-air mixtures, the tabulated values should be multiplied by 1.001.

\*\* The tabulation is for instruments calibrated to give results in Btu per standard cubic foot. (30" Hg-60° F. sat.) Test values for instruments designed to give results on a dry basis at standard conditions of pressure and temperature may be calculated by multiplying the above stated values by the factor 1.0177.

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- (9) Use of the split scale recording calorimeter for determining the theoretical scale reading of reference hydrogen tank gas and for certifying natural gas.

The determination of the theoretical scale reading of reference hydrogen tank gas and the certification of natural gas shall be performed on a split-scale recording calorimeter.

- (10) Required Operating Accuracy Using Hydrogen

If the scale reading from the recording calorimeter, as determined at the conclusion of the operations specified in Section F.(8), does not differ by more than 0.5 per cent from the "Theoretical Scale Readings for Standard Hydrogen Gas", the calorimeter shall be considered to be in correct operating adjustment, requiring corrections to its scale readings of 0.5 per cent or less.

- (11) Requirements for Changing Length of Baffle Tube

If the scale reading from the recording calorimeter, as determined at the conclusion of Section F.(8) differs by more than 0.5 per cent from the "Theoretical Scale Readings for Standard Hydrogen Gas", items (1) through (8) of Section F. shall be repeated in a further attempt to obtain the required accuracy. If there is continued failure to obtain the required accuracy and it is evident that the error is a result of incorrect heat exchange, rather than incorrect air-gas ratio adjustment or defective parts, change the length of Dimension "A", as shown in Figure E to correct the error.

G. Determination of Theoretical Scale Reading for Reference Hydrogen Tank Gas

Relatively pure hydrogen is available in cylinders and can be used for certification purposes.

Tank hydrogen is to be designated as "Reference Hydrogen Tank Gas" only if its heating value is equal to or is less than that of standard hydrogen gas by not more than  $\frac{1}{2}$  of 1 per cent.

Immediately after a recording calorimeter has been checked and adjusted as specified in Section F. and its operating accuracy is in agreement with that specified in Section F.(10), it may be used to determine the theoretical scale reading for reference hydrogen tank gas. The theoretical scale reading can be determined by use of the following equation:

$$\left( \frac{\text{Btu scale reading for Hydrogen Tank Gas}}{\text{Btu scale reading for Standard Hydrogen Gas}} \right) \times \left( \frac{\text{Theoretical scale reading for Standard Hydrogen Gas}}{\text{Theoretical scale reading for Reference Hydrogen Tank Gas}} \right) = \left( \frac{\text{Theoretical scale reading for Reference Hydrogen Tank Gas}}{\text{Theoretical scale reading for Standard Hydrogen Gas}} \right)$$

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After the pen has drawn a straight line for at least 30 minutes, perform the sensitivity test as outlined in Section C. and observe and record the scale reading for each direction of approach. The average of these two readings will be the Btu scale reading for the hydrogen gas tested.

## H. Certification of Natural Gas

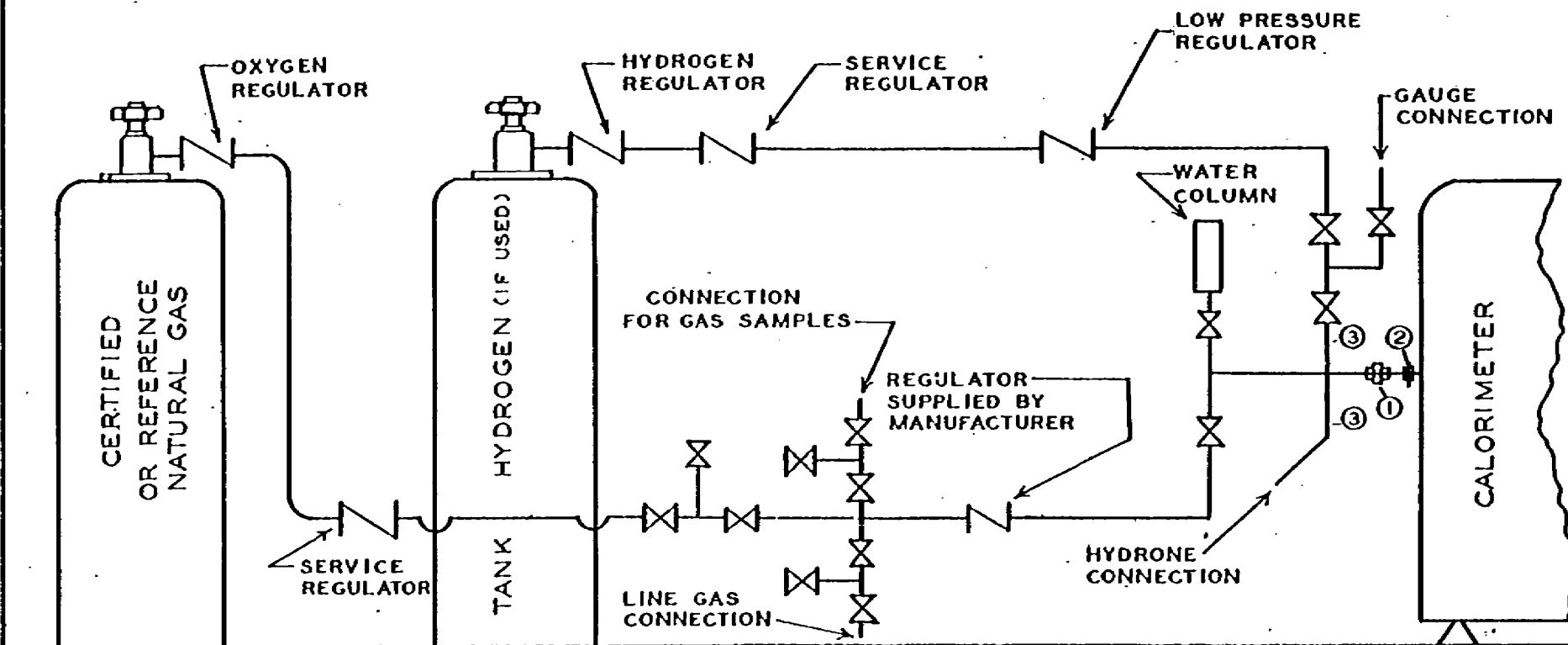
- (1) Immediately after a recording calorimeter has been checked and adjusted as specified in Section F. and its operating accuracy is in agreement with that specified in Section F.(10) it may be used to determine the heating value of a suitable sample of natural gas for certification purposes. Allow the instrument to operate on the natural gas to be tested for certification until the pen has drawn a straight line for at least 30 minutes. Perform the sensitivity test as outlined in Section C. and observe and record the scale reading for each direction of approach. The average of these two readings will be the Btu scale reading for the natural gas tested.
- (2) In order that adequate information concerning each cylinder of "Certified Natural Gas" be available at all times, the following information shall be entered on a form or in a log book provided for the purpose and also on a label or tag securely attached to each cylinder in which the gas is stored:
  - (a) Serial number of the cylinder.
  - (b) Name used to identify gas.
  - (c) Date of tests to determine heating value for certification.
  - (d) Identification number of recording calorimeter used for the certification test.
  - (e) Heating value of the gas contained in the cylinder.
  - (f) Pressure in cylinder after filling.
  - (g) Source of gas contained in cylinder.
  - (h) Date cylinder was filled.

## I. Maintenance of Records re Certification of Natural Gas and Determination of the Theoretical Scale Reading for Reference Hydrogen Tank Gas

- (1) Substantiating records of all the tests performed by a gas utility in the preparation of a recording calorimeter for certification of a natural gas and for the determination of the theoretical scale reading of reference hydrogen tank gas shall be maintained for a period of two years after those gases were last employed for the testing of recording calorimeters of any gas utility.



## SCHEMATIC ARRANGEMENT FOR CONNECTING FUEL GASES TO A RECORDING CALORIMETER



1. INSTALL UNION FOR ACCESS TO INSPECT AND CLEAN ORIFICE.
2. NO. 70 DRILL SIZE ORIFICE.
3. USE RUBBER TUBING AND SCREW CLAMP ON HYDROGEN TESTS. SET FLOW OF HYDROGEN TO GIVE BLEEDER FLAME  $3/8$ " TO  $1/2$ " HIGH.

FIGURE A  
-13-

RECORDING CALORIMETER INSTALLATION REPORT

COMPANY NO. \_\_\_\_\_

GAS UTILITY \_\_\_\_\_ DATE \_\_\_\_\_

LOCATION OF CALORIMETER \_\_\_\_\_ DIVISION OR DISTRICT \_\_\_\_\_

CITY \_\_\_\_\_ STATION OR PLANT (NAME) \_\_\_\_\_

KIND OF GAS TESTED \_\_\_\_\_

SERIAL NUMBER, TANK UNIT \_\_\_\_\_, RECORDER UNIT \_\_\_\_\_

TYPE OF SCALE - UNIFORM OR SPLIT \_\_\_\_\_ SCALE RANGE \_\_\_\_\_

DATE INSTALLED \_\_\_\_\_

BASIS OF MEASUREMENT - (60°F.-30" OF Hg.) DRY \_\_\_\_\_ OR SATURATED \_\_\_\_\_

MEANS OF AIR CONDITIONING, IF ANY \_\_\_\_\_

PUBLICATION NO. OF MANUFACTURER'S APPLICABLE BOOK OF INSTRUCTIONS \_\_\_\_\_

FIGURE 8





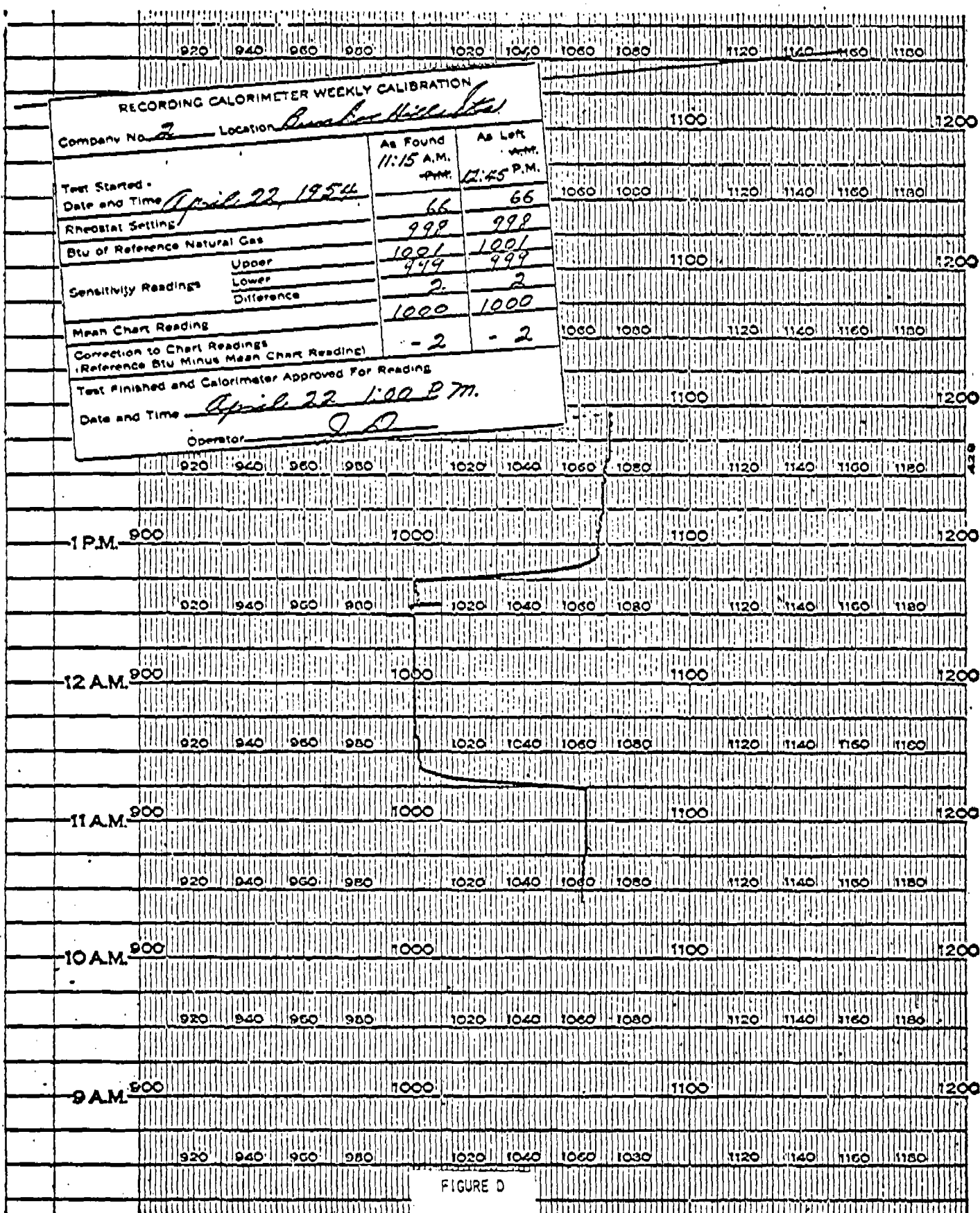


FIGURE D

# BURNER UNIT DETAIL

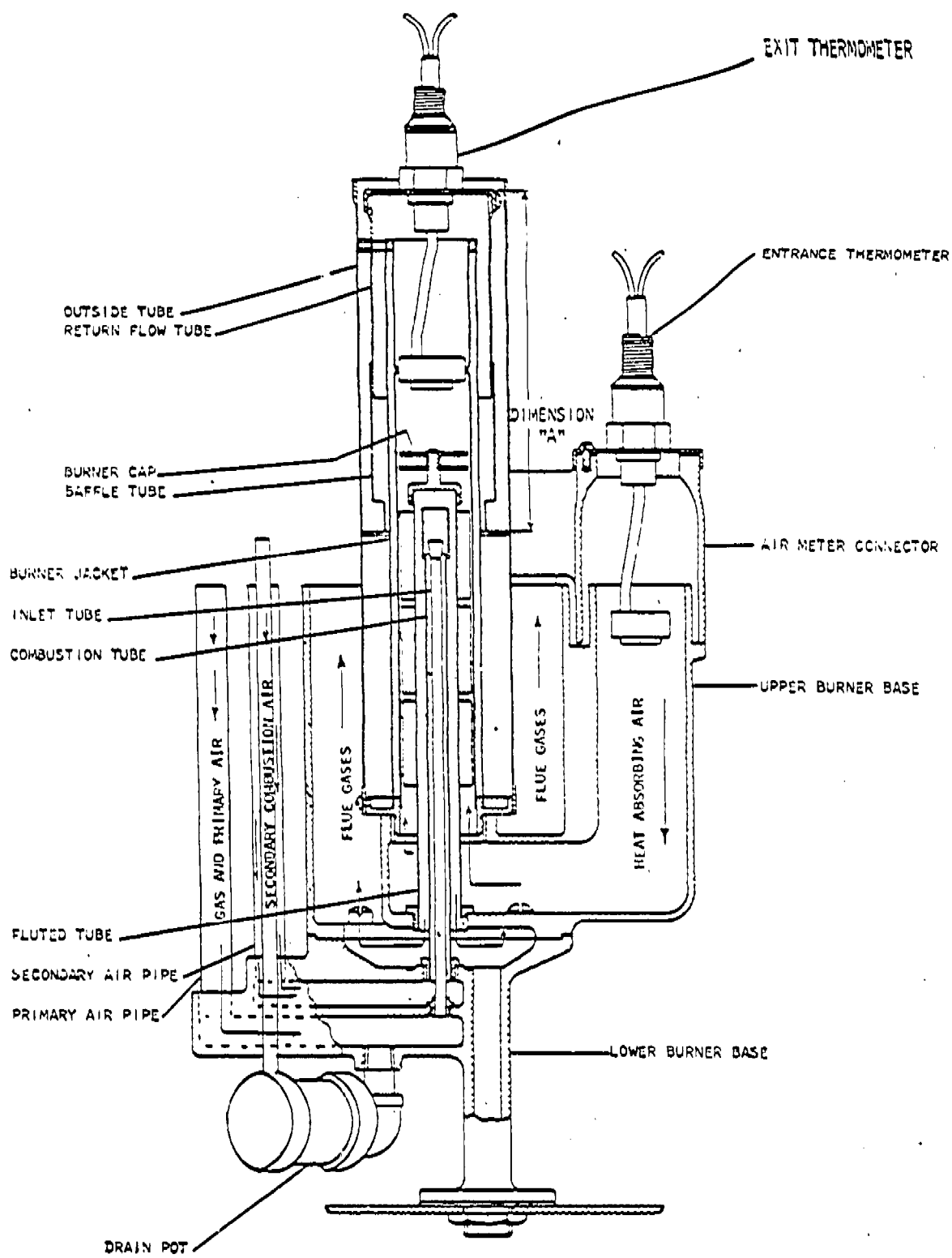


FIGURE E