



A method for testing a domestic gas-fired warm furnace
by Gordon Conrad

A Thesis Submitted to the Graduate Committee in partial fulfillment of the requirements for the Degree of Master of Science in Mechanical Engineering
Montana State University
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Abstract:

Within the last six years, gas fired furnaces, either of the gas designed or conversion type, have been installed in a large number of homes in Montana. These are of all types, steam, hot water, and warm air. Each of these three types of systems would require a different method of testing. It was decided to confine this investigation to a single type for the present, and the warm air system was the one selected.

Due to the relatively short time that gas has been used, to any great extent, for domestic heating purposes in other than the immediate vicinity of a natural gas supply, there has been very little work done on the determination of the efficiency of domestic gas fired furnaces. A test code for gas designed furnaces, established by the American Gas Association specifies minimum requirements which must be fulfilled in order that the appliance may be approved by the Association. A code has also been established for the installation of conversion burners, but no testing code for the conversion burners has been established.

The conversion burner has been developed to a point where it has made a definite place for itself in the field of domestic heating and, consequently, a method of testing must include the conversion burner as well as the gas designed type of furnace.

Since natural gas has gained such wide distribution and is continually gaining in popularity as a house heating fuel, it was felt that an investigation into the efficiencies obtained with this fuel would be a service to users, and to those contemplating the use of gas as a fuel for house heating purposes.

It was with this service in Mind that the project of devising a method for testing was started.

It is hoped that the testing may be carried on over a period of years so that some reliable data can be accumulated on a number of different types of warm air furnaces, and that the testing may be extended to steam and hot water heating systems.

PURPOSE OF INVESTIGATION The purpose of the investigation is to develop a method for testing domestic gas fired warm air furnaces. The method has been devised so that it would be equally well suited to the testing of either gas designed or conversion types of furnaces and, consequently, establish a means of comparison between them on the basis of their efficiencies.

BASIC PREMISES It is generally conceded that the more nearly test conditions approach actual operating conditions the more acceptable are the results of the test. This is the first premise on which the method is based. The method has been held to this requirement as rigorously as possible. The laboratory has been in a residence and the apparatus a conversion installation put in by the distributors of the gas, without their knowledge of the fact that it would be used for testing purposes. A few slight modifications of the installation have been made to facilitate the use of testing instruments, but the installation remains essentially as it was placed by the installation men in the employ of the distributors.

The second premise of the method is that all heat is utilised except that which goes up the stack. Radiation in the basement of a home cannot be considered as a loss unless it is excessive. The radiation from the furnace and leaders is generally not greater than is required to maintain a proper temperature in the basement to prevent cold floors. A dry warm basement is essential to proper heating of the house. A properly installed warm air heating system will not give radiation from the furnace and leaders in excess of what is required for maintenance of proper temperature in the basement.

A METHOD FOR TESTING A DOMESTIC GAS-FIRED
WARM AIR FURNACE

by

GORDON CONRAD

A THESIS

Submitted to the Graduate Committee in
partial fulfillment of the requirements
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INTRODUCTION

Within the last six years, gas fired furnaces, either of the gas designed or conversion type, have been installed in a large number of homes in Montana. These are of all types, steam, hot water, and warm air. Each of these three types of systems would require a different method of testing. It was decided to confine this investigation to a single type for the present, and the warm air system was the one selected.

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BASIC PREMISES

It is generally conceded that the more nearly test conditions approach actual operating conditions the more acceptable are the results of the test. This is the first premise on which the method is based. The method has been held to this requirement as rigorously as possible. The laboratory has been in a residence and the apparatus a conversion installation put in by the distributors of the gas, without their knowledge of the fact that it would be used for testing purposes. A few slight modifications of the installation have been made to facilitate the use of testing instruments, but the installation remains essentially as it was placed by the installation men in the employ of the distributors.

The second premise of the method is that all heat is utilized except that which goes up the stack. Radiation in the basement of a home cannot be considered as a loss unless it is excessive. The radiation from the furnace and leaders is generally not greater than is required to maintain a proper temperature in the basement to prevent cold floors. A dry warm basement is essential to proper heating of the house. A properly installed warm air heating system will not give radiation from the furnace and leaders in excess of what is required for maintenance of proper temperature in the basement.

DISCUSSION OF TEST METHODS

The principle material available on testing methods for domestic furnaces is as follows:

1. Investigation of Warm Air Furnaces and Heating Systems at the University of Illinois. ^{6,7,8,9,10,11}
2. Tests of Gas Home-Heating Equipment at Purdue University. ¹⁷
3. American Gas Association Approval Requirements for Central Heating Appliances. ¹

The most extensive tests on warm air furnaces have been carried on at the University of Illinois. These tests have been devised for, and made with coal fired furnaces.

In collaboration with the National Warm Air Heating Association, the University of Illinois has carried on a research program over a period of about twelve years on the investigation of all phases of warm air heating. There have been six bulletins, each of considerable length, issued on the

work which has been done.

The methods of testing are very complete, and a great deal of data on the performance and operation of warm air furnaces has been obtained. Briefly, the method used is to measure the heat input by weighing the fuel, and to determine the stack losses by means of Orsat apparatus. The furnace output is measured at each register face by means of anemometer traverses and temperature measurements with thermocouples and thermometers. The efficiency is based on the measurement of input to the furnace and the output as measured at the register faces. It would be entirely unnecessary to duplicate work which has already been so well done. If it should become desirable to extend the scope of these tests at some later date, many of the methods and devices used at Illinois could be adopted to a good advantage.

In May 1931 a bulletin entitled "Test of Gas Home-Heating Equipment"¹⁷ was issued by Purdue University. This bulletin covers the method of testing and results of tests made on domestic steam boilers fired with gas. Research was carried on over a period of two years, tests being made on a number of different types of conversion burners in several makes of boilers. Tests were also made on a gas designed boiler.

The method of testing as devised at Purdue, used the principle of testing intermittent operation of the boiler. Previous to these tests, no testing with intermittent operation had been done. Since these tests were made, a code, drawn up by an A.S.H.V.E. committee, for testing oil burning devices included a provision for intermittent tests.²⁰

The A.G.A. Approval Requirements for Central Heating Appliances are specified as requirements which "represent minimum standards for safe

operation, satisfactory performance, substantial and durable construction." A method of testing gas designed warm air furnaces is specified in the code. The method, however, is only applicable where the furnace can be set up in a laboratory where certain apparatus is available for the test. While the method with certain modifications could be used in testing conversion furnaces, the method was devised for determining the minimum performance requirements in order to obtain the approval of the A.G.A. Laboratories, which is primarily for the testing of gas burning devices submitted by the manufacturers.

The principle on which this method is devised is the second basic premise. The method is, briefly stated, to measure the gas input and the air supplied for combustion; to measure the loss to the stack, and by taking the difference of these two quantities the heat output utilized in heating the house can be found. By knowing the input, the output and the losses, the efficiency of the furnace can be determined.

The principle of testing on intermittent operation is used in this method. The furnace is allowed to operate normally with thermostatic control and no specific period of operation is required. Testing is done during the "off" periods, as well as during the "on" periods so that the entire loss through the furnace is measured. Entirely normal operation of the furnace is thus obtained and adherence to the first basic premise is strictly maintained.

TESTING PLANT AND APPARATUS

Figure 1 gives a diagrammatic layout of the testing plant and Figures 2 and 3 are photographs of the setup made.

The furnace, part 11, is a warm air furnace of steel construction, installed for burning coal. For burning gas, the grates have been removed, and the burner placed at about the position occupied by the grates. The ash pit door was removed for installing the burner and the entire opening, with the exception of a small secondary air opening near the floor, was bricked up and sealed with high temperature cement.

The burner is of the bunsen type. The burner head, is a ring which fits the fire pot, over which is placed radiants to throw the heat against the walls of the fire pot.

The gas input to the furnace is measured by a standard volumetric, dry type of meter, part 1, Figure 2, which has a maximum capacity of 150 cubic feet per hour. The meter was new when it was installed. A ten foot prover is available at the gas warehouse of the Montana Power Company, where the calibration of the meter can be checked as frequently as desired.

A tee is placed in the gas line just ahead of the meter, arranged as shown in the diagram, in which is placed a thermometer, part 10, Figure 2, to obtain the temperature of the gas as it is metered. It is necessary that the thermometer be inserted a sufficient distance so that the bulb is in the gas stream. Another connection to the same tee is provided to which is attached a water manometer, part 7, Figure 2, for obtaining the gas pressure as metered.

A specially constructed box of galvanized iron, part 4, Figure 2, and Figure 4, is used to cover the mixer and the secondary air inlet. In the box between the mixer and secondary air inlet is placed a damper for the re-

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DIAGRAM OF APPARATUS USED FOR TESTS

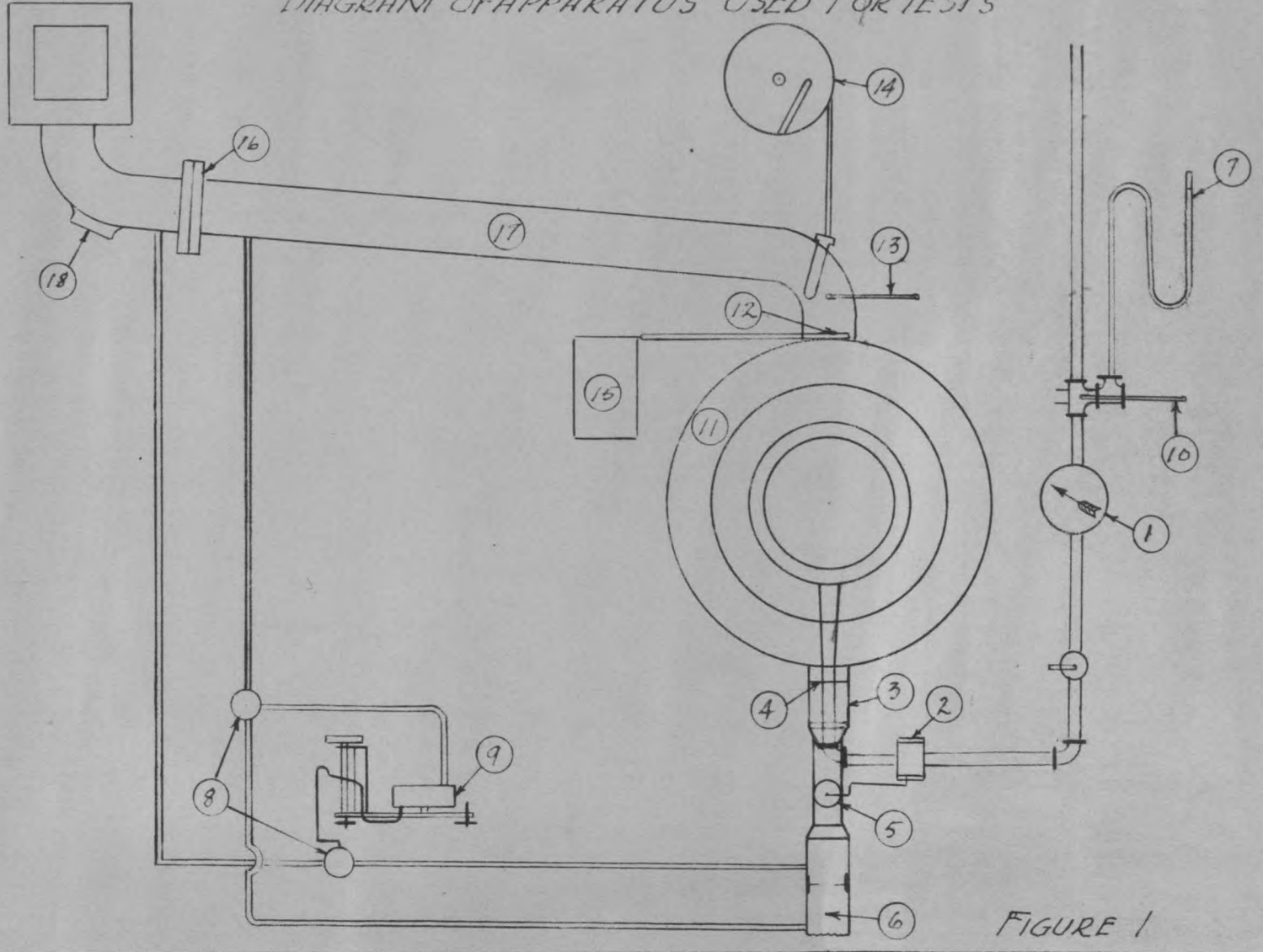


FIGURE 1

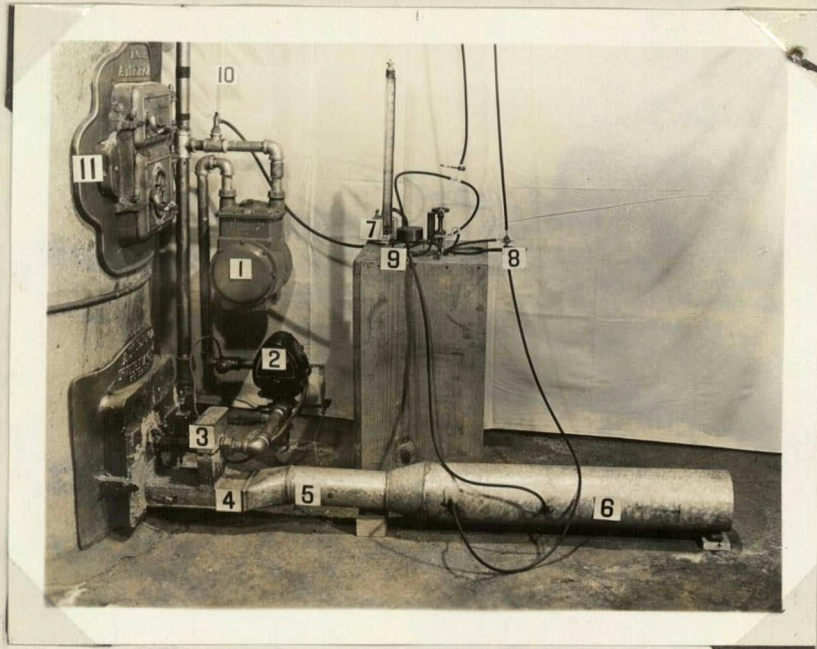


Fig. 2

Arrangement of Apparatus at Front of Furnace

1. Gas Meter
2. Thermostatically Controlled Electric Valve
3. Primary Air and Gas Mixer
4. Air Control Box
5. Total Air Damper
6. Inlet Air Metering Pipe
7. Gas Pressure Manometer
8. Three Way Cock
9. Micromanometer
10. Fuel Gas Thermometer
11. Furnace.

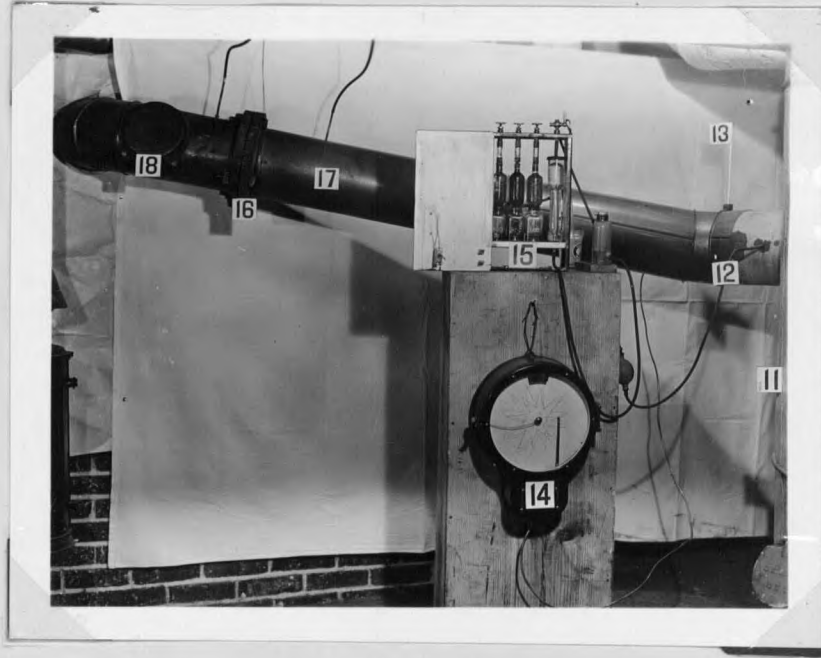


Fig. 3

Arrangement of Apparatus at Rear of Furnace.

11. Furnace
12. Flue Gas Sampling Tube
13. Flue Gas Thermometer
14. Flue Gas Recording Thermometer
15. Orsat Apparatus
16. Chimney Flue Orifice Flanges
17. Chimney Flue Pipe
18. Check Damper Opening (Capped)

