

***** T H E S I S *****

" THE DESIGN OF A GAS SUPERHEATER "

PRESENTED

FOR

THE DEGREE OF BACHELOR OF SCIENCE OF
MECHANICAL AND ELECTRICAL ENGINEERING.

Under the direction of Professor

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University of Tennessee

June 1, 1920.

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***** THE DESIGN OF A GAS SUPERHEATER *****

The first superheater was probably built by Dr. Denys Papin, a Frenchman, in 1705. It was used on a crude steam engine of that day which was, in fact, a non-condensing, single action steam pump with the steam and pump cylinders in one. " A curious feature of this engine was a heater placed in the diaphragm. This was a mass of metal for keeping the steam dry or preventing condensation during expansion." This device might be called the first superheater.

The practical application of superheat to steam in the Engineering World is a practice of recent origin and is in some respects still in its infancy. Superheat was first used about forty or fifty years ago and the means of superheating then was very similar to that now in use. It has been in use long enough however to remove all doubt as to the increased economy obtained thereby. The principal advantages of superheating may be summed up under three heads:

1. At high temperatures steam behaves like a gas and is, therefore, in a far more stable condition than in the saturated form.
2. A moderate amount of superheat produces a large increase in volume, the pressure remaining constant, and diminishes the weight of steam for a given amount of work.
3. Superheated steam has a much lower thermal conductivity than saturated steam, and therefore, less heat is absorbed per unit of time by the cylinder walls of a steam engine.

It is not however the writer's purpose to show the value of superheating steam, for this has, beyond a doubt, been proven by the many experiments made by as many steam engineers throughout the world, and by the practical use to which it is put to-day by so large a number of steam power plants.

Superheaters are manufactured by practically all boiler builders, the characteristics of the boiler being embodied to a large extent in the design of the superheater. There are in general two types of superheaters on the market, namely: the independently fired, and that located in the boiler setting. The first type is almost obsolete. In the latter arrangement the superheater may be located in the furnace at the end of the heating surface or at some intermediate point. Since the absorption of heat depends chiefly on the temperature difference between the gases and the steam and the extent of the heating surface, the required amount of superheat may be obtained from a small amount of heating surface in the first pass, or a larger extent in the rear passes, or a proportionate amount in the intermediate passes.

The requirements of a successful superheater are:

1. Security of operation, or a minimum danger from overheating.
2. Economical use of heat applied.
3. Provision for free expansion.
4. Disposition so that it may be cut out without interfering with the operation of the plant.
5. Provision for keeping the tubes free from soot and scale.

As ordinarily installed the indirectly fired superheater is subject to the fluctuating temperatures of the furnace so that forcing the boiler has a similar effect on the superheater.

The present type of superheater is built of cold drawn seamless steel tubes bent in a U-shape and expanded into two wrought steel manifolds. The tubes are inclosed in heavy cast-iron rings shrunk onto them. The heater must be equipped with a safety valve and a means of flooding when the boilers are being brought into operation. All of these characteristics make this type of superheater costly to build, while the life of one is only from eighteen to thirty months. The cast-iron rings make the apparatus extremely hard to keep clean and the coefficient of heat transfer through such a thickness of iron and steel is very small thus reducing the efficiency.

The object of this experiment is two-fold:

1. To devise a means of burning gas or oil directly in contact with the steam thus securing one hundred percent efficiency in heating and,
2. To prove that a heater of this type is more economical than the one above described.

The equipment available for conducting these experiments is:

A twenty horsepower return tubular boiler.

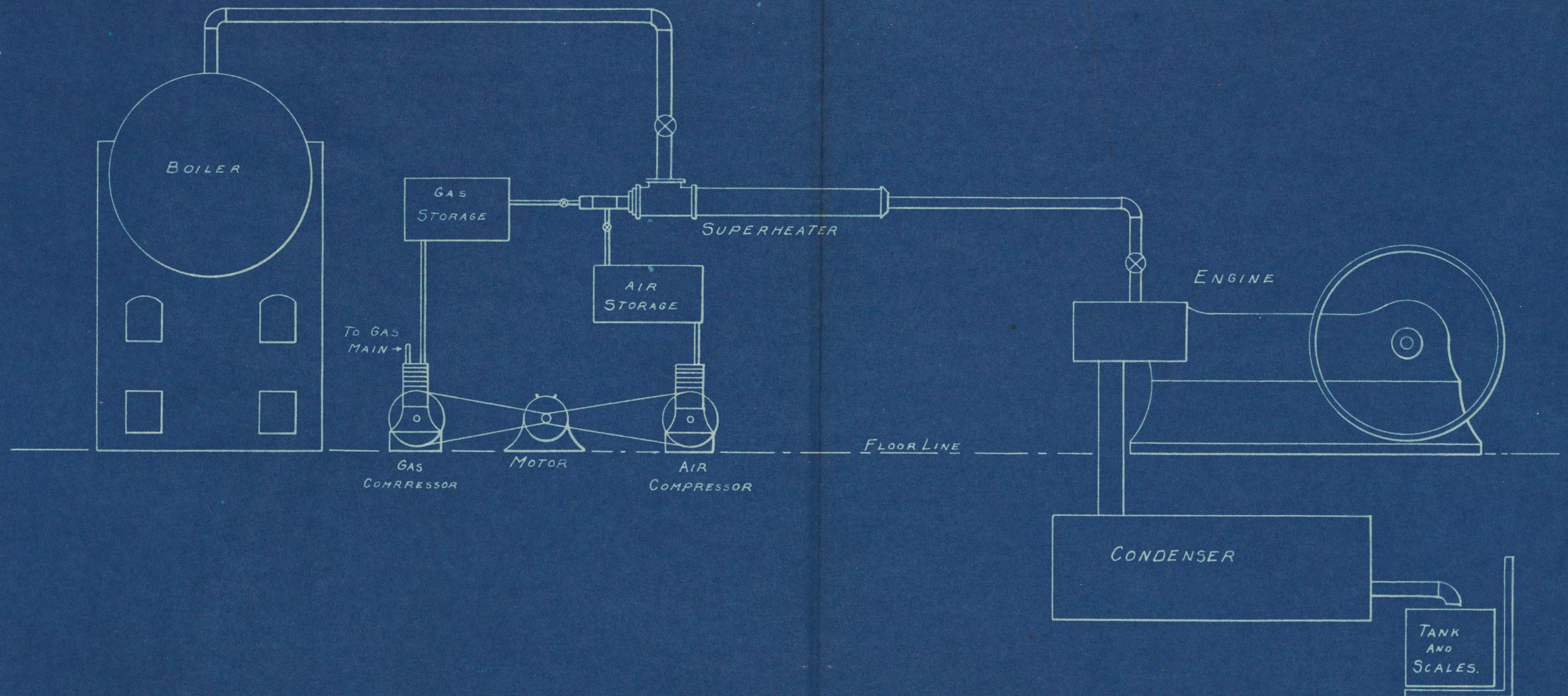
A twenty-five horsepower Corliss engine connected to a surface condenser.

Air pumps for compressing the gas and air necessary for combustion.

Drawing No. 1. is a layout of the equipment as installed. Steam is supplied to the superheater from the boiler and passes from this directly to the engine. The engine is equipped with a prony brake for varying the load and consequently the amount of steam consumed. The condenser is arranged with two pairs of scales and two tanks for measuring continuously the amount of steam condensed. A throttling calorimeter is inserted in the steam main just before it enters the superheater for the purpose of determining the quality of the steam as it enters the heater and a thermometer is inserted at the outlet for determining the temperature of the steam as it leaves the superheater. One compressor is used for compressing the necessary air for combustion and the other the inlet of which is directly connected to the gas main is used for compressing the fuel. In the case of the oil burner this compressor is used for compressing the air to force the oil through the burner or is cut out entirely and one compressor used for both purposes.

Drawing No.2. shows the superheater in section. It consists of an outer casing made of 5" steel pipe onto one end of which is screwed a flange and reducers. The other end is reduced and connected direct to the engine. In the bushing at the head end is screwed a two inch pipe which extends not quite the full length of the outer casing. Into the outer end of this bushing is screwed another bushing and into this the burner, the tip of which extends about 12" into the inner pipe in order that the flame will be located where it will be surrounded with live steam. A spark plug is screwed into the inner pipe as shown for igniting the fuel.

Drawing No.3. is a detail of a gas burner designed and built



LAYOUT OF APPARATUS.

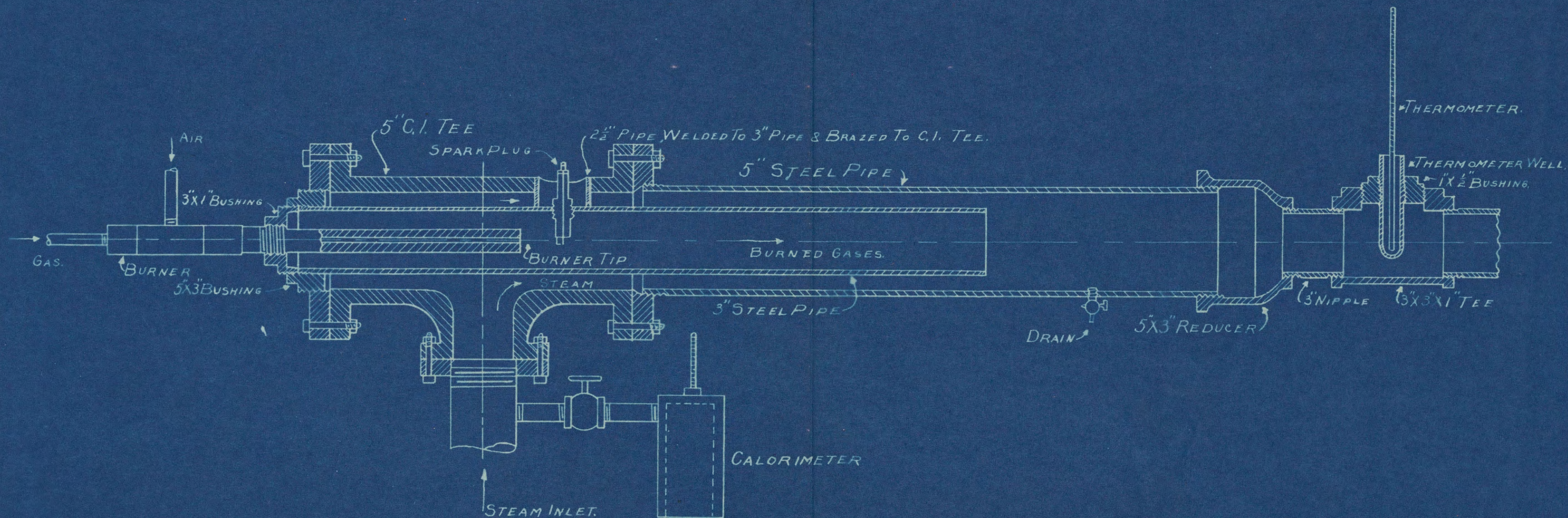
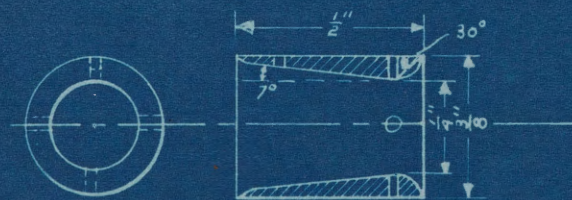
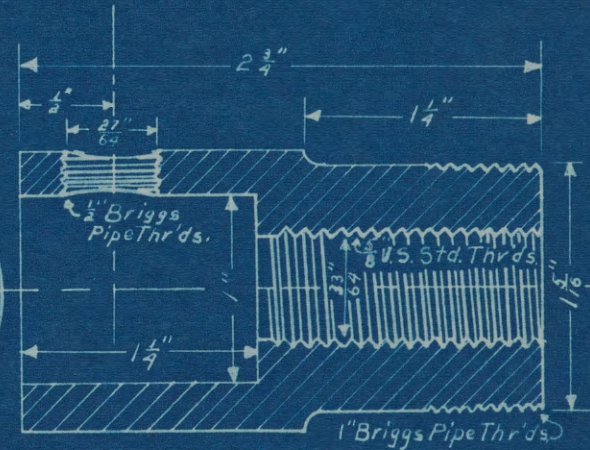
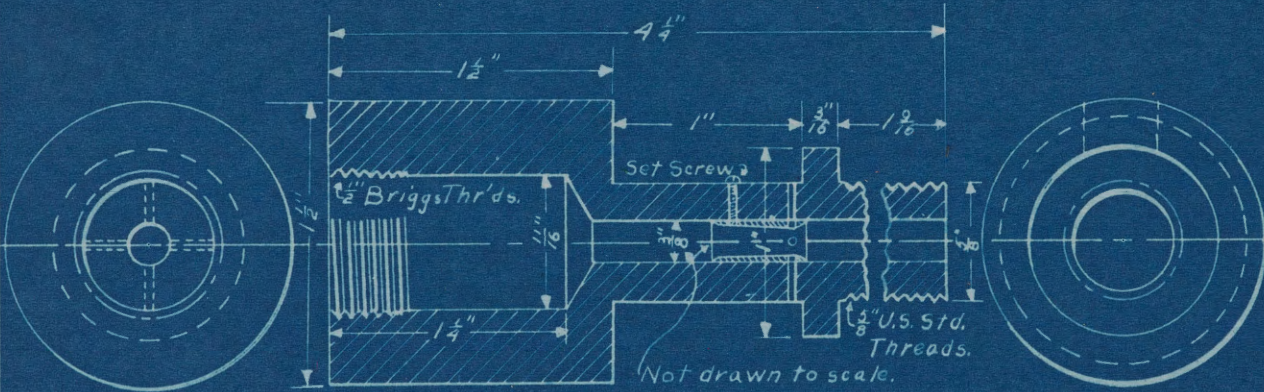
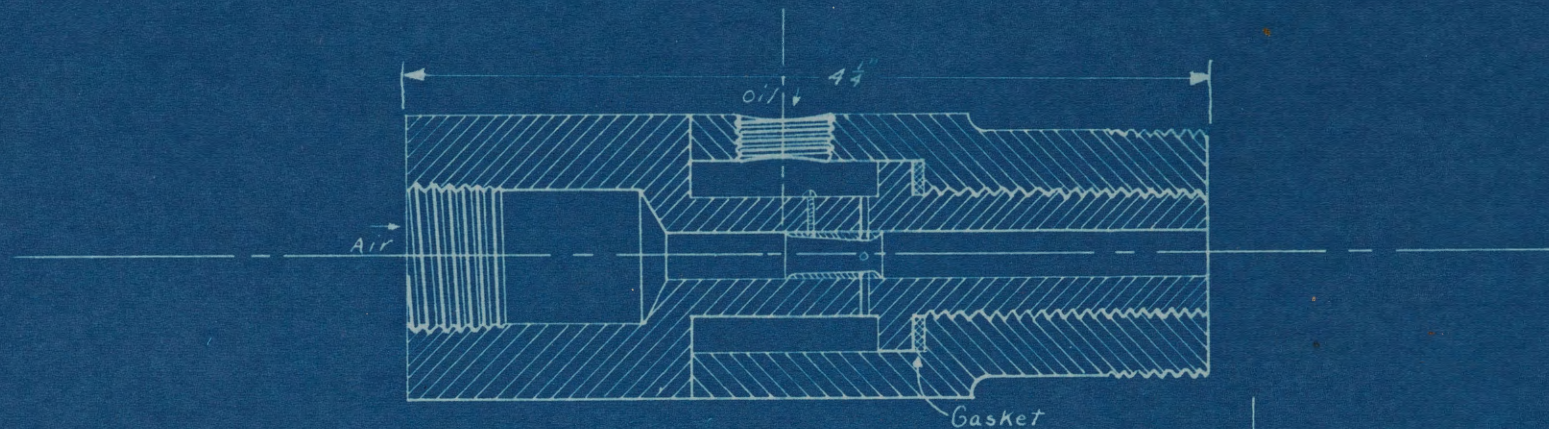


DIAGRAM OF SUPERHEATER.

in the University machine shop. Detail No.1 is a section of the gas nozzle, No.2 is a section of the air chamber, No.3 the burner tip and No.4 the mixing cone. The fuel gas is fed through the nozzle and the air through the air chamber and mixing cone. The two are mixed and pass through a wire gauze to prevent back-firing, thence through the burner tip and burned in contact with the steam. The gas and air supply are controlled by valves connected in the feed pipes outside the burner. A pointer is attached to each of the valves and the handle wheels are graduated so that the gas and air supply may be regulated for complete combustion. These graduations were made by removing the spark plug and adjusting the gas and air supply for complete combustion at different rates of fuel consumption. This may be checked by adjusting the supply so that the maximum temperature of the outgoing steam is obtained.

Drawing No.4 is a detail of an oil burner designed at the University but was never built because of lack of time. Detail No.1 is the air chamber, No.2 the oil chamber and No.3 a Venturi tube. Referring to the assembled drawing on the same sheet, the air is fed through the inner chamber and the Venturi tube. The oil enters the outer chamber and is fed through small nozzles in the Venturi tube at right angles to the direction of flow of the air. The purpose of the Venturi tube is to increase the velocity of the air at the point where the oil comes in contact with it and then to allow it to expand slightly thus aiding the atomization. It also causes a swirling of the atomized fuel fuel producing a better mixture.

DESIGN OF GAS BURNER.



Venturi Tube
Scale - Double size.

DESIGN OF FUEL OIL BURNER.
Machine Steel. Scale - Full Size.