3. Instead of spreading the fresh charge of coal over the grate it may be heaped up on the dead plate just inside the door. As soon as it has become coked by heat from the rest of the furnace, it is spread over the fire and a fresh charge of coal is placed on the dead plate, and so on. This method was proved very effective, and is obviously very satisfactory when considering the combustion of the hydro-carbons, for, as in the case of the chain-grate stoker, they may be led over the whole length of the furnace, but for all that the method is obviously not without objections. An objection peculiar to this particular method is that the ash and clinker will tend to collect at the back of the furnace where they are most difficult to get at, and their removal will necessitate the fire door being open for a considerable length of time. An obvious improvement would be to have a door in the side of the boiler setting and towards the back of the grate, but this is not always feasible.

With hand-firing condition (2) requires special attention in that when fresh coal is placed in the furnace a plentiful admission of air above the grate is required, whereas, as the fresh charge becomes coked, the supply of air admitted in this way should be considerably reduced. This necessity may be more or less complied with by simple, direct manipulation of the fire door damper, or the damper may be actuated automatically by means of some mechanical contrivance. In ordinary practice, apart from manipulation, the fire-door damper provision is very seldom adequate with regard to its capacity. According to Mr. Booth, under ordinary circumstances, the available area of above grate air opening should not be less than four square inches per square foot of grate area. When the damper is operated mechanically the operation of opening and closing the fire door automatically opens the damper to any pre-arranged extent and at the same time a mechanical device is set in motion which will close the damper any desired amount at the conclusion of any pre-arranged interval of time.

The use of steam jets in connection with furnaces appears to be a practice that has long since been abandoned by experts, although it has from time to time been brought forward as being accompanied by various substantial advantages. Such claims have now been practically abandoned, and with one exception they will receive no further mention in this paper. The one way in which a steam jet may benefit a furnace depends on its action as an air aspirator. If properly designed and situated the steam jet will draw in a supply of air and this air will be caused to mingle rapidly and effectively with the gases rising from the fire. This action, however, when brought about by means of a steam jet, is accompanied by considerable loss in other directions. If the furnace needs such assistance

it may doubtless be obtained much more economically and efficiently by employing a separate blower, by means of which jets of pure air may be made to play on the top of the fire.

At this point a few more words may be said on the subject of air regulation in the case of a variable load. Suppose that the load falls off; it is clear that the rate of combustion must be at once reduced, and that means that the total air supply must be reduced. This reduction, however, cannot be brought about satisfactorily by mere manipulation of the main damper, and this point needs emphasising. The reason for this statement is most evident in the case of hand-firing, for, in that case, it will clearly be necessary to admit almost the same quantity of air above the grate, at the moment of charging, whether the load be high or low; and to do this, it will be desirable to maintain a constant draught pull at the back of the grate, and that means that the main damper opening must not be reduced. Accordingly, in the case of hand-firing, the change in air supply that should accompany a change in load should be effected almost entirely by means of an ash-pit damper, and thus the use of such a damper is again emphasised. Where stoking is performed mechanically the above remarks will not, in most cases, apply with the same force, but at the same time this statement is by no means to be taken as acting against the use of auxiliary dampers in conjunction with mechanical stoking.

Having dealt with the subjects of stoking and air admission and regulation, we have now to consider the design of the combustion chamber. As a guide in the design of this part of the furnace there is little to be said beyond what is summed up in the following statement:—The design of combustion chamber should be such that the hydro-carbons do not come into direct contact with any portion of the heating surfaces of the boiler until their combustion is complete. The furnace designs commonly met with in practice are simply detestable in this respect, although a fire-brick arch or some form of refractory lining is often practically all that is required to effect a very substantial improvement in combustion conditions. Figures 3 to 8 illustrate forms of more or less improved furnace which may be applied to well known types of boiler, and they should serve as a further indication of the goal to be aimed at by the furnace designer. It may be claimed in some instances that such designs will result in a reduction of the heating surface of the boiler. This may be true to a certain extent, but the heating surface lost in this way will be a very small proportion of the whole, and, apart from the very considerable gain that may be expected in other directions, it is not improbable that the greater cleanness of the remainder of the heating surface will more than make up for any such

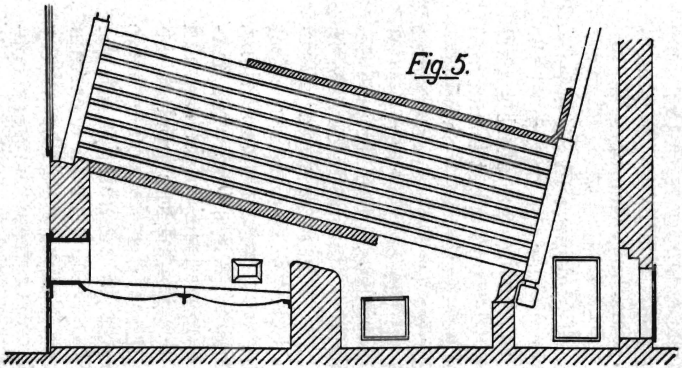

Fig. 5.

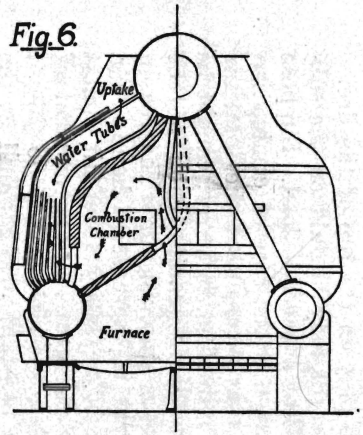


Fig. 6.

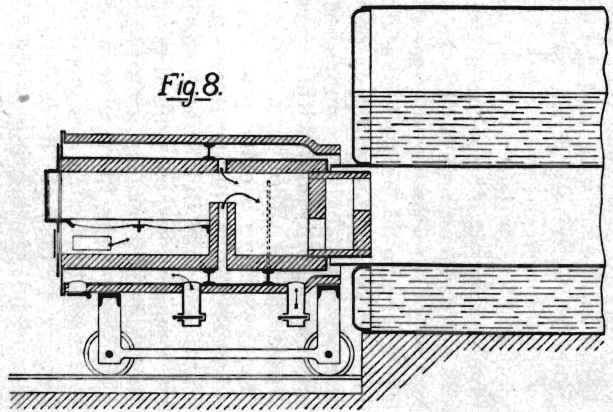

Fig. 8.

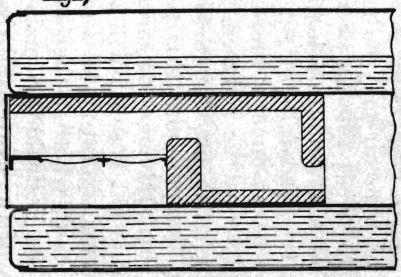

Fig. 7.

loss. The life of a good well-built fire-brick arch, a matter which is of financial importance, may be stated to be about one year.

Figure 7 illustrates a type of furnace with refractory lining that may be employed in the case of a Lancashire type boiler. A prominent fault of this type of boiler is that the cross tubes are often placed far too near to the back end of the furnace. In this position they provide a very material obstacle to complete combustion, and it is probable that they soon become coated so thickly with soot that their value as heating surface is reduced to practically nil.

Figure 8 illustrates a type of external furnace which may also be used in connection with Lancashire or Cornish type boilers. The loss in grate area that may result from the use of a rather thick internal lining may thus be obviated, and the heating surface of the boiler may be allowed to retain its full original value; but, on the other hand, extra radiation losses will occur which, however, may be somewhat reduced by using an air jacket as shown. It will be noticed that the admixture of the air and gases is assisted by means of baffles.

An under-fired boiler is undoubtedly better suited to economic combustion than an internal fired boiler, for, in the case of the former type, there is no difficulty in regard to space for a properly constructed furnace.

The one remaining diagram, namely, Figure 9, is put forward with the idea of rendering the paper perhaps a little more complete. The figure represents a suggested form of furnace in the design of which an attempt has been made to comply as far as possible with the conditions essential to economic combustion of bituminous coal. A mechanically operated step grate, with the inherent advantages already mentioned, is indicated in the figure. The above-grate air supply will enter to some extent along with the coal, but it is mainly controlled by dampers as indicated at A. These dampers open into a chamber where the air should become well heated before it passses through the opening B, and thence down to the furnace, being directed as far down as possible on to the surface of the fire by means of the plate C. The below-grate air supply is controlled by means of the damper E. The removal of ashes is effected with the aid of a sort of lock, and thus, during that proceeding, the admission of undesired air may be avoided. The grate with its attendant gear may be supported on wheels, as shown, so that the furnace may be completely laid open for inspection and repairs when necessary. The design of combustion chamber indicated should need no special comment after what has already been said.

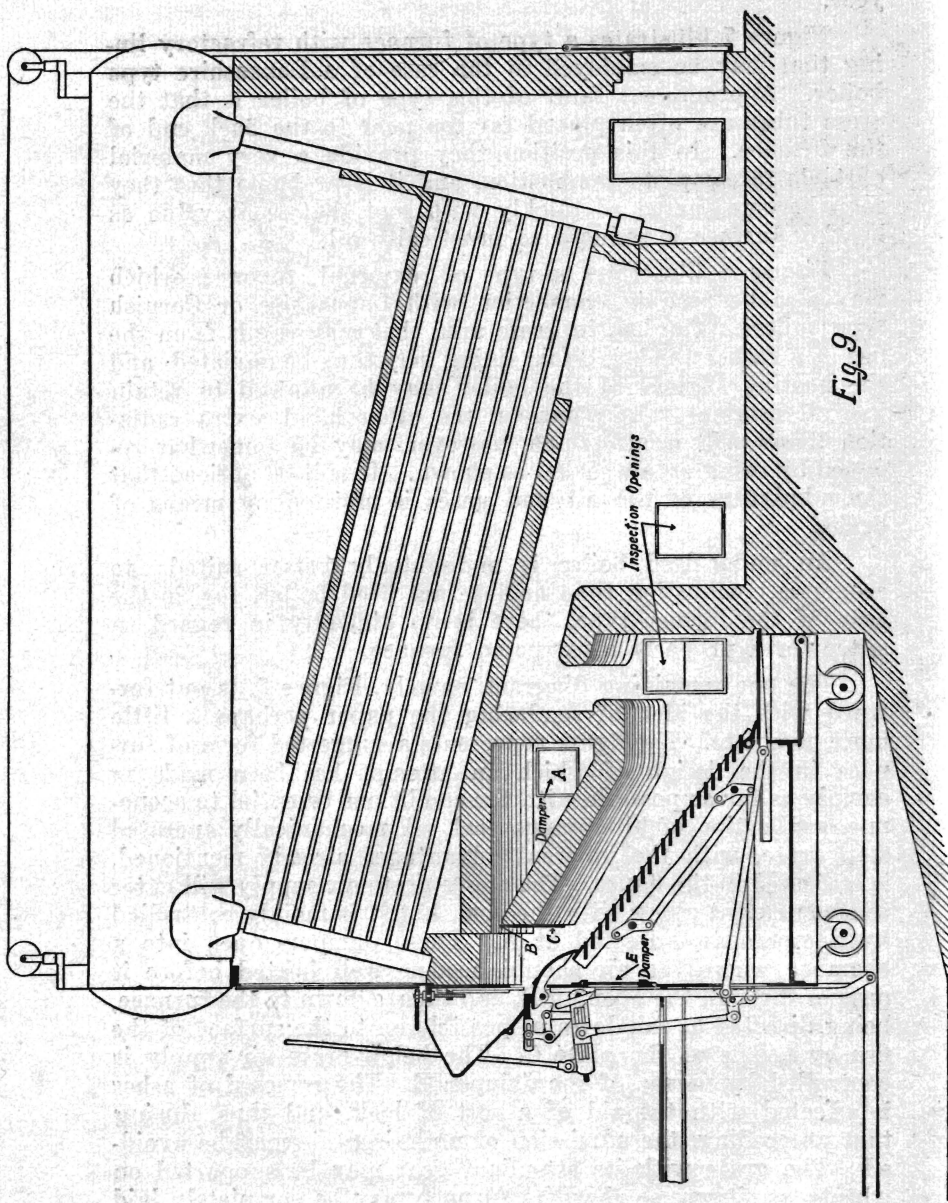


Fig. 9.

The figure is, in the main, diagrammatic, and there is no claim to minute attention to detail, but it is hoped that it is sufficiently detailed to satisfactorily indicate a suggesed possible embodiment of principles put forward in this paper, and as such, it may perhaps serve as a not altogether unsatisfactory conclusion.

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*EDITOR'S NOTE.—This paper was awarded the Society's Prize for the best paper submitted by an Undergraduate Member.*