ly reduced. The exhaust steam from the turbine will also be conveyed to, and utilized in heating the feed water during the time when the waste steam from the other sources is not available for this purpose.

When mechanically forced draft is employed, there is no reason why the products of combustion should not be cooled down almost to the temperature of the water in the boiler, providing that it is possible to introduce into the boiler sufficient heating surface to accomplish this result. As in hand firing, combustion is dependent on an induced current of air through the grate air spaces to provide sufficient oxygen to ignite with the carbon, and as in the present universal type of boiler, the flame is immediately conveyed to the small tubes, which, through their lack of volume will destroy combustion, a large amount of carbon monoxide will be produced, that, for the reason of its being the product of imperfect combustion, will produce 2⅓ less heat units than if the carbon had been properly supplied with air properly consumed.

The efficiency of the mechanical forced draft will readily assert itself as a means to provide for perfect combustion, and some of its advantageous features are as follows: The absolute command of the draft controlled by power for the generation of whatever amount of steam the conditions may require; positive and instantaneous in action; the steam pressure can be maintained more constant through more automatic control of the draft; efficiency which is greatly in advance of induced draft; the supply of air can be readily adjusted to effect efficient combustion of fuel of inferior and different qualities at different rates of combustion; independent of climate and weather, and no liability to be affected by atmospheric conditions; control of the rate of travel and hot products of combustion, insuring the highest possible combustion; less air required for dilution, resulting in a higher temperature of the fire, more rapid conduction of heat through the heating surface, and better economy of heat; possibility to increase the evaporative power of the boiler without injury or loss of economy through reducing the evaporative effect of the fuel; possibility to use low grades of fuel; adaptability to meet sudden demands upon the boiler; prevention of smoke with soft coal or screenings, and low cost for maintenance; also under certain severe conditions of weather, when with a normal proportion of boiler it would be impossible to maintain the desired steam pressure with natural draft, normal power may be insured with forced draft.

MECHANICAL AUTOMATIC STOKING.

The ideal arrangement for mechanical stoking for locomotive service consists of a steam cylinder and ram connected with a hopper for holding the gravity conveyed fuel outside of the furnace proper, and a retort, or fuel magazine, inside of the furnace into which the green coal can be underfed by means of the ram. Tuyere blocks for the admission of air by means of forced draft to be placed on either side of the fuel magazine, this retort to contain at its lowest point where the fire never reaches, an auxiliary ram, or pusher, by means of which an even distribution of the fuel may be obtained. By means of this ram, the coal can be forced underneath the fire, each charge of fuel raising the preceding charge upward, until it reaches the fire, which point it does not reach until it has been thoroughly coked, and when in this coked state, it is forced still further upward into the fire.

The action of the ram in pushing the coal ahead and upward provides the same action as the rocking of the grates in hand firing, and this will tend to keep the bed of the fire broken, and prevent the formation of any large amount of solid clinker. The gases being liberated under the fire and at that point mixed with the air, they must necessarily pass through the fire and be consumed, thus giving the benefit of all the combustible matter in the coal. The air is forced at a pressure of about two ounces per square inch from the tuyere blocks under the burning fuel by means of the mechanical forced draft from the blower operated by the turbine engines, automatically controlled. The coal being in the hopper and the ram plunger at its forward stroke, when more coal is needed the ram plunger is shifted by moving the lever either by hand or automatically; the coal then falls in front of the plunger, and upon the return movement it is forced into the retort, this movement being repeated until sufficient coal is in the retort.

The automatic movement of the stoker rams to be controlled by motion to be taken from an eccentric located on the rear driver wheel axle.

As the speed of the locomotive will, to a considerable extent, govern the proportion of the steam that will be used per hour, the corresponding movement to be derived from the eccentric motion referred to will fairly well regulate the automatic supply of the required amount of fuel to the stokers, and what irregularity may occur can readily be adjusted by the firemen, who will have entire control over both the automatic and independent action of the stoker feeds.

The air at a low pressure being admitted into the air chamber and through the tuyere blocks over the top of the green fuel in the retort, but under and through the burning fuel, the result is that the heat from the burning fuel over the retort slowly liberates the gas from the green fuel in the retort, and this gas being thoroughly mixed with the incoming air before it is passed to the burning fuel above, results in a bright incandescent fire, free from smoke, and the complete combustion of all the heat producing elements in the fuel. The retort being air tight from below and the fuel being in a compact mass in the retort, the air will find its way in the direction of the least resistance, which is upward; consequently combustion takes place only above the air slots, and the tuyeres of the retorts are always cool and not subject to the action of the fire. The incoming fuel from the retort forces the resulting ash and clinker over the top of the tuyere blocks on to the dead plates, whence it may be removed at any time and dumped through the drop grates into the ash pan at the rear, without in the least interfering with the fires over the retorts, and which will result in a high even temperature being maintained in the furnace at all times.

In brief, some of the advantages of mechanical automatic underfeed stoking in connection with locomotive boilers are as follows:

Adaptability to the combustion of the cheapest grades of fuel, economy of labor in firing, economy and increased effectiveness in combustion even with forced firing under proper management, constancy and regularity of the fuel supply and complete control over the admission of fuel into the furnace at all times.

There being but little necessity for the opening of the furnace doors, which must occur through hand firing, the chilling effect on the furnace plates will be lessened.

Facility for cleaning the fires, one portion of which can be done at a time and without reducing the burning of the fuel in the individual stokers.

By underfeeding the fuel, the green coal is continually introduced below the fire line, and in rising is brought to the coking stage, at which time the gases are liberated, pass upward and are consumed to the last degree, producing, as nearly as possible, complete combustion.

This method of stoking, besides providing a more uniform fire and consequent unvarying pressure, dispenses, by complete combustion, with the smoke nuisance, and there is no waste of solid fuel by loss through grate bars, or by being carried through the flues, tubes and smokebox, and ejected into the atmosphere.

There is no liability of holes in the fire and consequent cold air coming in contact with the gases passing to the heated sheets, producing severe stresses in the boiler and failures to steam.

An inferior grade of fuel, such as screenings and run-of-mine, can be burned to advantage, and at the same time steam coal can be used up to any size which would not be too large for economical hand firing.

The fuel magazines, or stokers, are practically self-cleaning, as on account of the upward and forward movement of the new fuel, the ash and clinker is forced upward and upon the dead plates, from where it can be readily removed as necessary, ample provision for this being made by the two furnace door openings and the drop grates at the rear, and where the incoming draft at this time will not have any detrimental effects on the furnace sheets.

The underfeed stokers also dispense with the use of rocking grates and rigging, which are liable to become out of order on account of burning out through neglect or mismanagement, and which usually result in a severe failure of the entire locomotive, expensive delays to train movements and renewals of parts to make repairs.

When fires must be drawn from the furnace, the amount of unconsumed fuel accumulated on the rocking grates, and which is wasted, will be overcome, and the stokers will facilitate and economize largely in the banking, renewal and starting of fires.

Mechanical stoking will also overcome the large losses in fuel on account of the irregular and wasteful methods of hand firing practised by different firemen, which are bound to occur under almost the same conditions.

It will show up not only economical results in the use of fuel, but, at the same time, the labor of the fireman will be considerably reduced through its requiring less effort and skill on his part to feed and operate than by hand firing. While the cost of fuel should receive every consideration, it is also necessary that economizing devices be inaugurated which will not only reduce the amount of fuel burned, but also the labor required of the average fireman to keep up the maximum pressure of steam with the engine operating at its full capacity under the methods and construction as applied to the present type of locomotives.

So much skilled labor not being required to operate the stokers, the fireman's time can be more given to assist the engineer in looking out for signals and attending to other duties not so severe, and which are more essential and productive of good results than the continual shovelling of coal. While constant attention is necessary in mechanical firing in order to regulate the rate of feed to the rate of evaporation, the total amount of labor is far less than required in hand firing.

Resuming the subject of the benefits to be derived from a combination of mechanical forced draft and mechanical and automatic underfeed stoking as applied to locomotive service, and compared with hand firing: The temperature of the furnace gases will be increased probably 1,000° by the more perfect combustion and as intense draft is one of the most important factors in the utilization of cheap fuels, the value of mechanical draft and stoking asserts itself. With fuels of moderate smoking qualities, mechanical draft in its simplest application can furnish an adequate amount of air under pressure sufficient to cause it to pass readily through the mechanically fed fuel, which will meet all the requirements of smoke preventives, even when all the air is admitted below the fire. The air required for a given weight of fuel may be reduced to the minimum, which will promote an economy in fuel in consequence of a better