Unnecessary Smoke.—It is folly to advocate the stopping of all smoke, necessary and unnecessary, and it is none the less foolish to demand a statutory right, in even special heat treatment processes, to make 80 per cent. more smoke than is absolutely necessary for the processes, for to do so is a waste of valuable fuel, and a public health nuisance in addition.

CHAPTER VII.

SMOKE PREVENTERS AND FUEL SAVERS.

Since uneven or careless stoking lies at the root of the smoke evil, many attempts have been made to eliminate the human element and to secure even and equal stoking by mechanical means.

Several types of apparatus have been evolved and meet with varying degrees of success, but it is necessary that those operating the machines should understand thoroughly the principles upon which they work in order to secure the best results.

For this purpose an account is given in the following pages of some of these machines, and it will be seen that the adoption of one or other is likely to enable a steam user to effect considerable economy in his fuel bill, and at the same time avoid giving offence by the emission of smoke.

"Bennis" Patent Machine Stoker, fitted with Patent Pneumatic Gear and Self-cleaning Compressed Air Furnace.—This stoker receives small fuel or slack by hand or mechanical means, into a hopper of about 3 cwts. capacity. There are two hoppers to each Lancashire boiler. Under each hopper is a cast-iron feeding-box, in the interior of which is a simple pusher plate with an adjustable reciprocating motion. The fuel falls in front of the pusher plate, and is pushed over a ledge formed by the bottom of the feeding box.

The weight of fuel so pushed over is regulated by means of an adjustable cam on the driving shaft, so that the rate of feed can be seen by noting the position of the cam. The simple motion of turning a hand nut, whilst the machine is running, enables the coal feed to be graduated from nothing to a ton or more per hour.

The fuel falls on to a flat place called the shovel box, and is projected into the fire at intervals by an angular

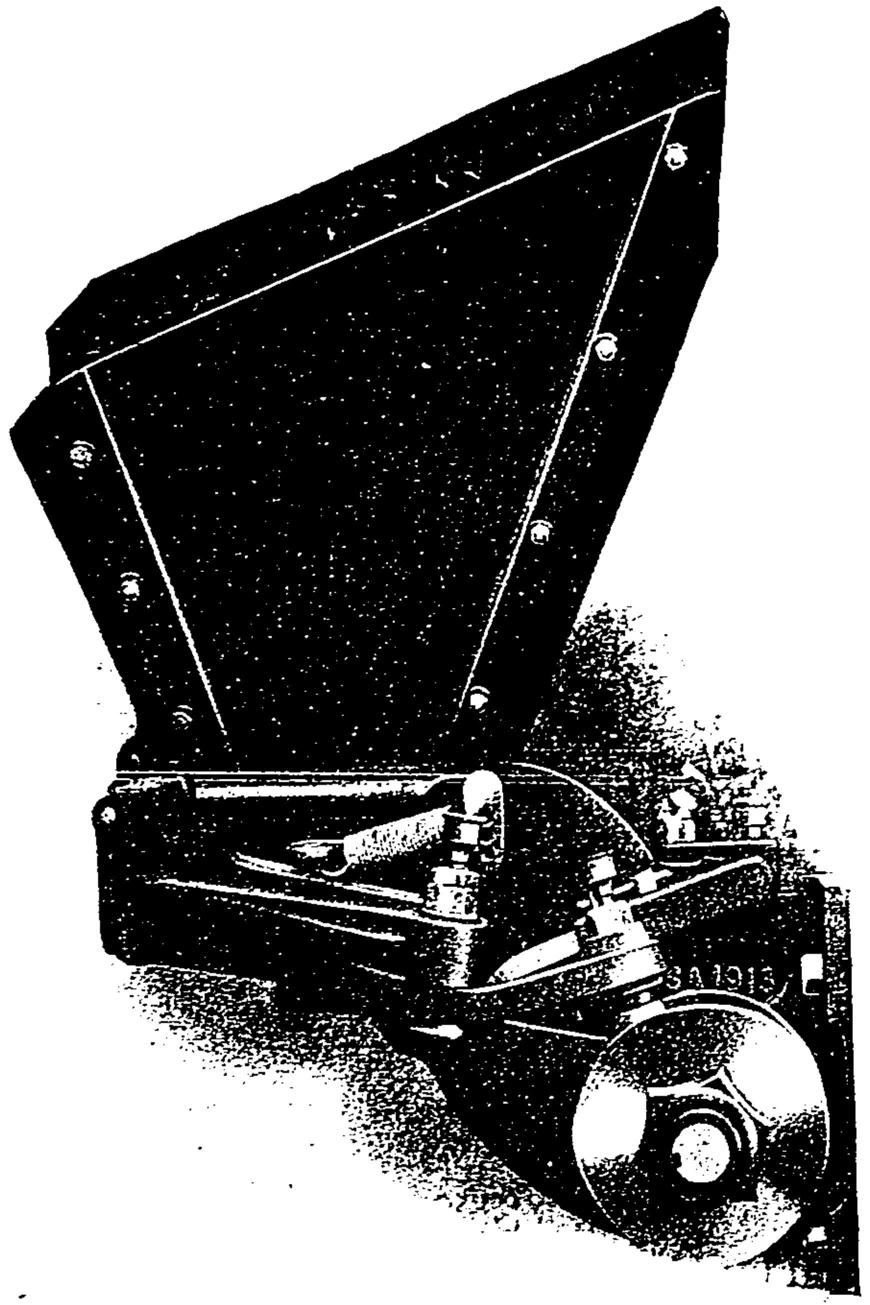

Fig. 8.—Side view showing Feed Cam, Regulating Nut and Feed Lever.

shovel, being by this means effectually scattered over the entire width of the grate.

The shovel is actuated by patent pneumatic gear which consists of a long coiled spring enclosed in a cylinder and pressing on a piston, the use of the spring being to propel the shovel forward. Any remaining momentum is taken up by an air cushion, thus avoiding all shock

or jar on the boiler front, and ensuring noiseless operation. The rotating tappet that draws back the shovel has four varying lifts. The effect of this is to scatter the fuel on the fire in four divisions, each about 18 ins. long, so that in a 6-ft. furnace the fuel is thrown on only a quarter of the fire at once—an essential point for securing smoke-

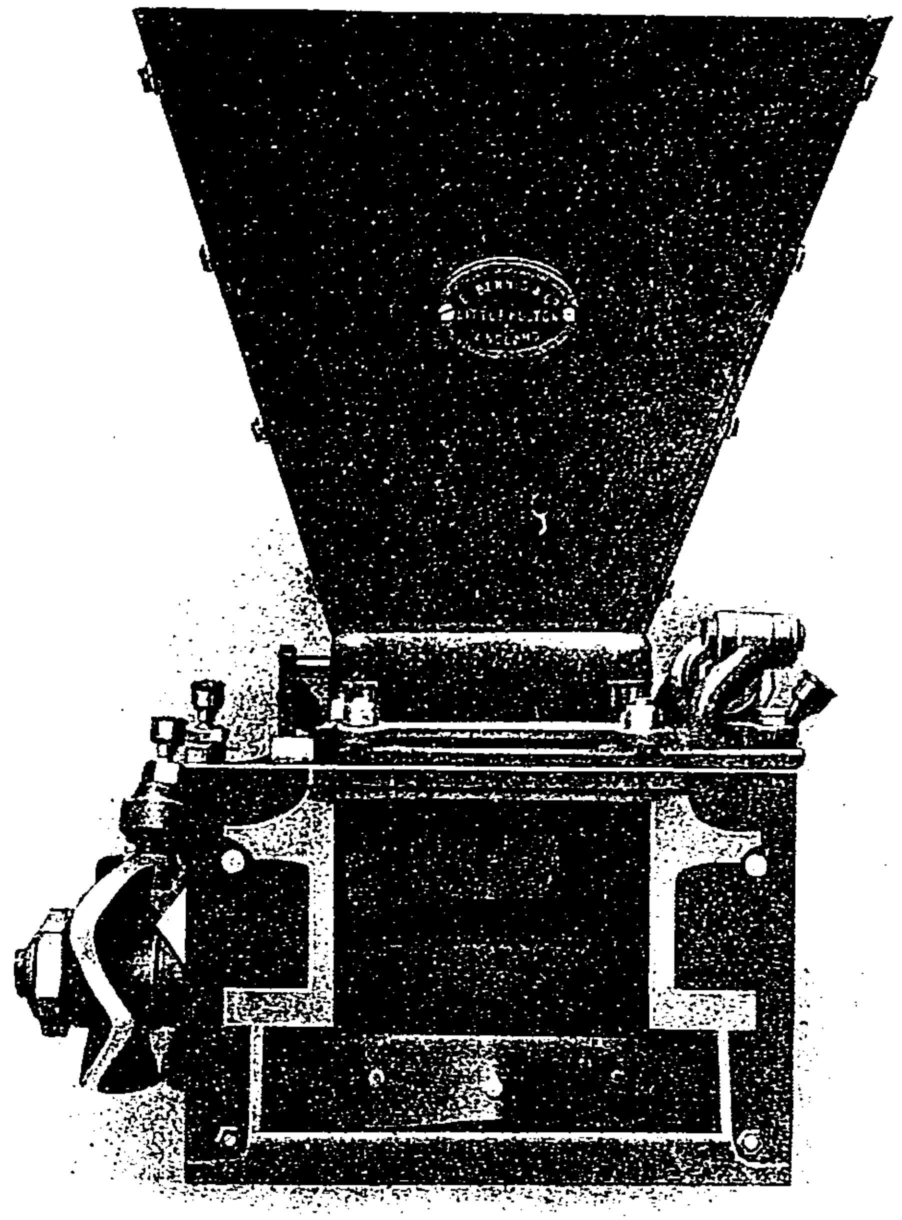

Fig. 9.—Back view of Throwing Box, showing Feed Plate and Shovel.

lessness. Each portion of the fire thus has time to become incandescent between the charges.

The shovel arm is attached to a steel rocking shaft, which rests in three replaceable outside bearings right away from the heat. The ends of the steel shaft are turned to a sliding fit. The shaft is made with two projecting arms of channel section, one down each side of the box, which form the seatings that carry the shovel arm. The shovel arm, of rectangular section, is made from the finest open-hearth acid steel, and is bent round and carried up both sides of the box, the upper ends being fitted into the projecting arms of the shovel shaft,

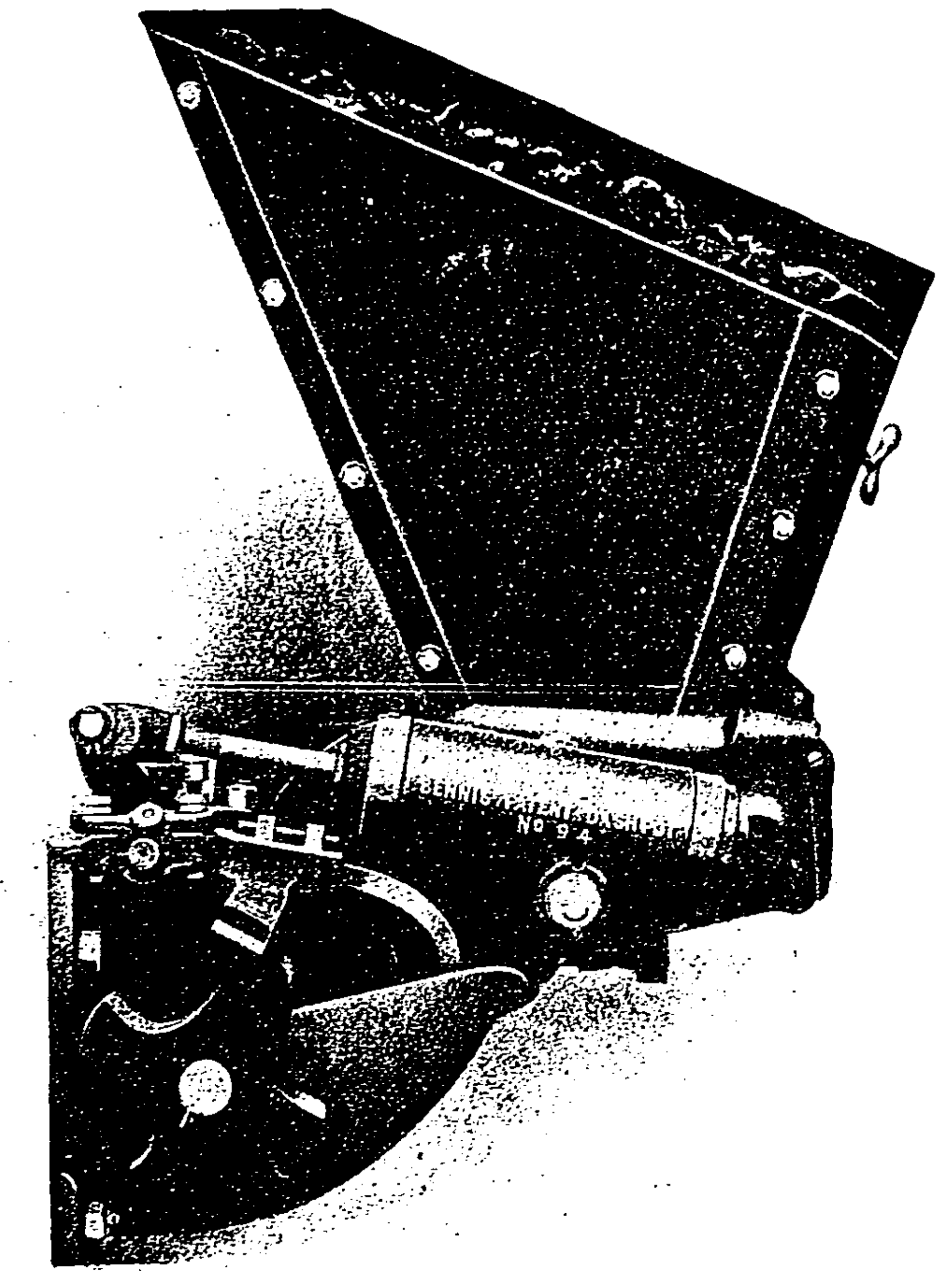

Fig. 10.—Side view of Throwing Box, showing Pneumatic Cylinder, Variable Throwing Cam, Shovel Arm Connection and Renewable Tripper.

where they are securely fastened by special screws and locking pins.

The shovel arm and the rocking shaft form practically a rigid rectangle with one side bent into the shape of the pointed nose of the throwing shovel, to which the latter is rivetted.

The shovel arm shaft bearings are retained in position by means of studs and lock nuts. The tappet which works the shovel arm is of such a shape that it carries the shovel back out of the way of the feed. The shovel arm and shovel can be easily detached from the shaft without necessitating the removal of the latter from its bearings.

The tripper is a separate piece of hardened steel rivetted to an extension on one of the projecting arms

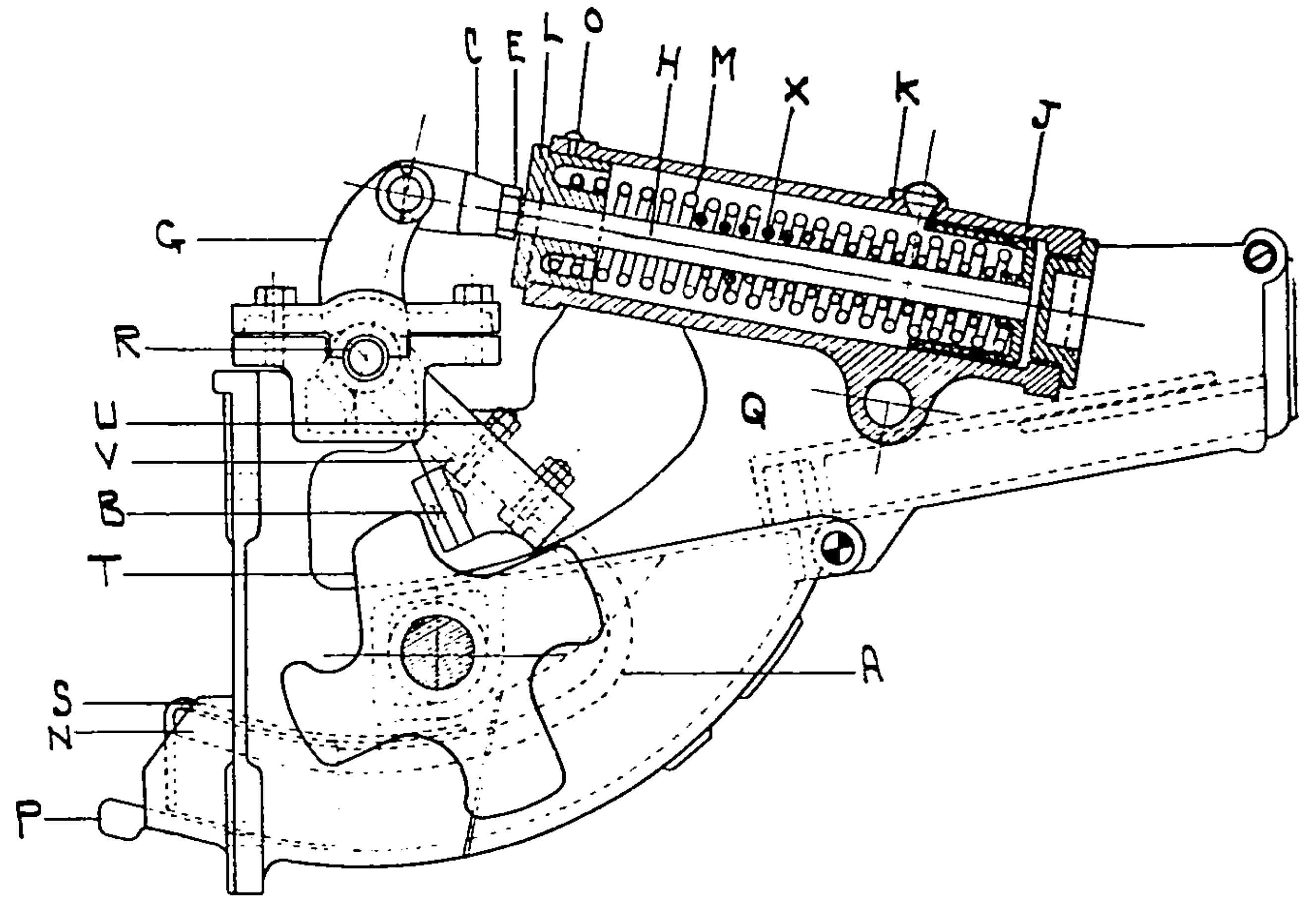

Fig. 11.—Illustrating Method of Throw.

of the rocking shaft in such a manner that it can be easily replaced in case of wear.

The method of adjusting the throw is explained below. and the various parts referred to are clearly shown in the accompanying illustration.

The shovel arm consists of an arm " A " with a pointed shovel " S." This is attached by means of special screws " U " and split pin " V " to a lever arm " G " integral with its rocking shaft " R." The lever arm " G " is provided with a tripper " B " faced with a renewable hardened steel piece.

The arm "G" terminates at its upper end in a joint working in a crosshead "C," this crosshead joining up to piston-rod "H," working a piston "J." The piston works in a pneumatic cylinder "K," provided with an adjusting nut "L." A spring "M" pressing between the piston "J" and the end of the adjusting nut "L" provides the motive power for propelling the shovel "S" forward, scattering the coal over the furnace. The tappet "T" has four varying lifts. If the coal is dropped too near the furnace door, the spring pressure must be slightly increased by screwing up the adjusting tension nut "L." To do this, first loosen the set screw "O," screw up the adjusting tension nut "L" half a revolution, and then re-screw the set screw. A half-turn on the spring makes quite an appreciable difference in the throw. Should the coal be thrown too far, the reverse operation is, of course, necessary.

The shovel arms are set in the following manner: First let the tappet cam "T" engage with the tripper "B," release the shovel arm, and then pull the piston rod "H" by taking hold of the crosshead "C" right back until the piston "J" is up against the dead end of the cylinder "K."

At this point the nose "M" of the shovel "S" should be flush with the lip "P" of the throwing box "Q." If this is not so it must be adjusted by lengthening or shortening the piston-rod "H" into the crosshead by its lock nut "E." As, however, these are set correctly before being sent out from the works and are tested under actual load, throwing coal, they should not need any adjusting, though it is desirable to verify the adjustment when fitting a new shovel.

The spring should be adjusted half-turn by half-turn until there is evidence of a little fuel being carried over the back end, at which point take off half a turn and the setting should then be correct.

The stoker is fitted with the "Bennis" patent self-

cleaning compressed air furnace, which constitutes so important a part of the "Bennis" method of machine firing.

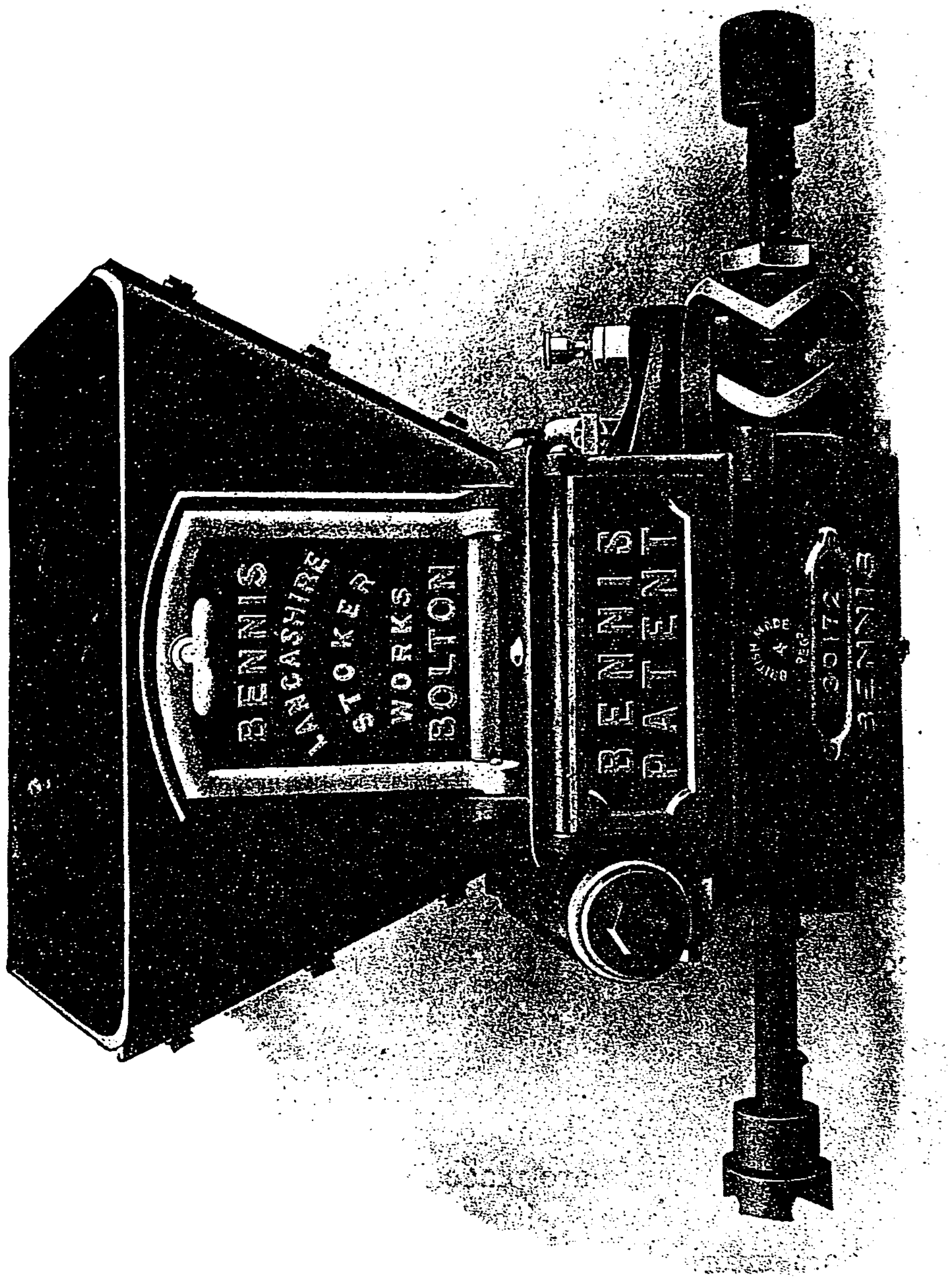

Fig. 12.—Front view of Throwing Box, showing Pneumatic Cylinder, Throwing Cam and Feed motion.

A consideration of the following points will make clear the aim and attainments of this furnace.

When using low-class or waste fuels that generally contain a large proportion of clinker and ash, the air spaces in the fire bars or ordinary furnaces soon become more or less covered, or stopped up, and the fire suffers in consequence.

It is manifestly impossible to adjust the supply of air

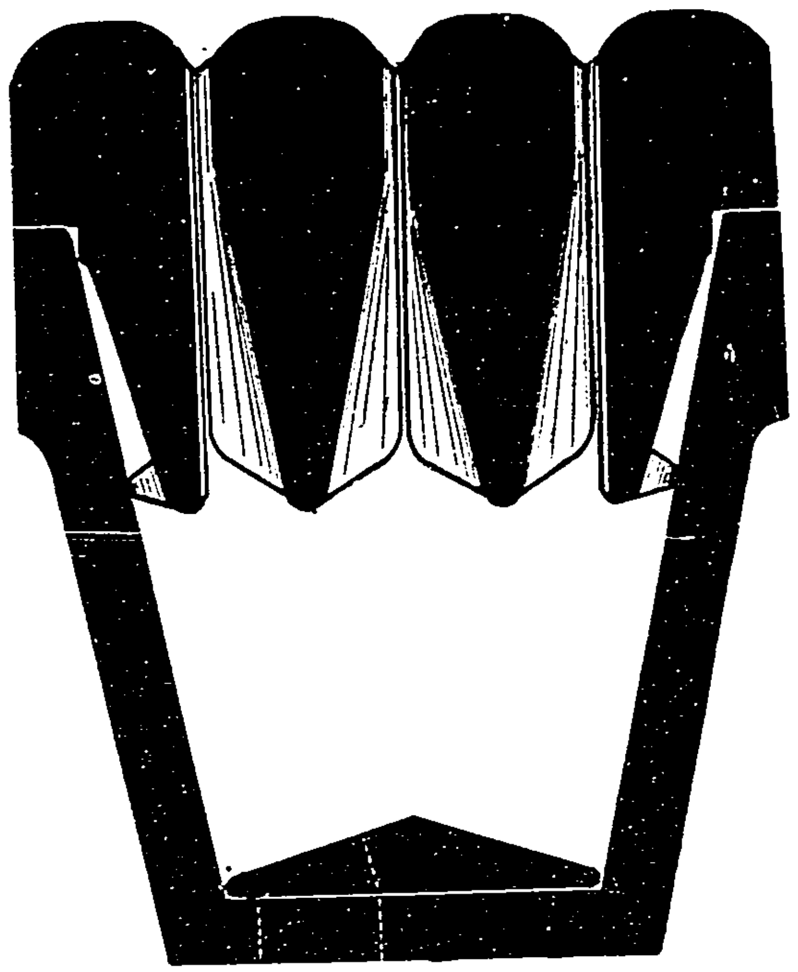

Fig. 13.—Section through Tubular Trough Bar showing Round-topped Grids and Automatic Ash Cleaning Slide.

to consume the fuel perfectly, unless the clinker and ash are continuously removed from the fire. This is automatically accomplished in the "Bennis" Patent Self-cleaning Compressed Air Furnace, which consists of tubular fire troughs of the length of the grate.

The tubular troughs are placed close together, and are protected from contact with the fire by being covered with short interlocking grate bars or grids about 2 ft. in length, and these grids are rounded on the tops, thus

presenting less sticking surface for the clinker, and ensuring the air space being always clear. Projections are arranged at the sides of each grid to ensure a regular and even air space.

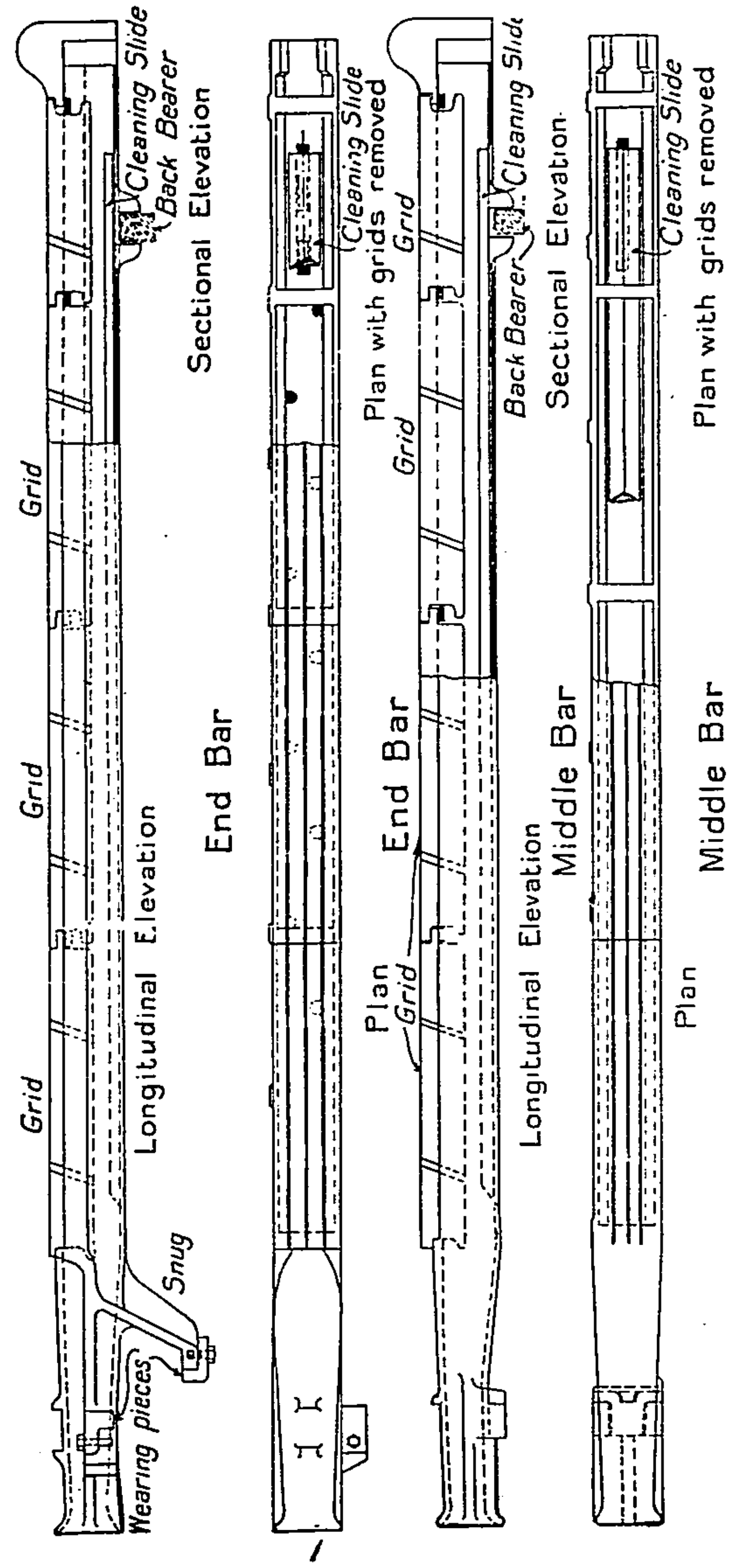

Fig. 14.—"Bennis" Patent Compressed Air Bars.

Air is forced through the grids by means of fine pin jets of highly superheated steam, which blow the air into the tubular trough at a comparatively high pressure. These jets can be instantly regulated to supply the requisite air for combustion to suit the varying demands for steam from the boilers.

The tubular troughs all move into the fire together for a distance of about 2 ins., and are withdrawn individually by means of 4-in. wide cams on a transverse shaft. These cams are made the full width of the troughs the result being that there is scarcely any wear upon them. The motion of the trough bars is so arranged that each bar on its outward travel moves between two other bars which are, for the time being, stationary. This arrangement ensures the right amount of travel to the fuel. So powerful is the self-cleaning action of this furnace, that in travelling from the front of the fire to the back, the coal ascends an incline of more than 3 ins. The ash or clinker is slowly carried by this reciprocating action to the back ends of the bars, is dropped over into a closed chamber, gives up its heat to the boiler and is withdrawn when required.

The air spaces between the grids are always free and open, and each tubular trough has its own supply of air, fed by a minute steam jet, so that the draught is evenly distributed over the whole grate surface, and the boiler continues to do its work even while the operation of cleaning out the clinker from the chamber proceeds. The fire is thus always clean and ready should sudden calls for steam be made upon it. By turning the blowers full on, the rate of combustion can be enormously increased. The grids are constructed with extremely fine air spaces, so that breeze or dust fuel can be burned with advantage.

Any wear of the cams upon the compressed air trough bars is taken up by adjustable, replaceable, highly-chilled, cast-iron wedge-wearing pieces which dovetail into sockets prepared for them, thus rendering the moving furnace trough bars practically everlasting.

The wearing parts can be adjusted or replaced, and the small interlocking bars, subject to the action of the

fire, may also be replaced when worn out. The back end of each trough bar is protected by a solid replaceable block and thus the fire never reaches the troughs.

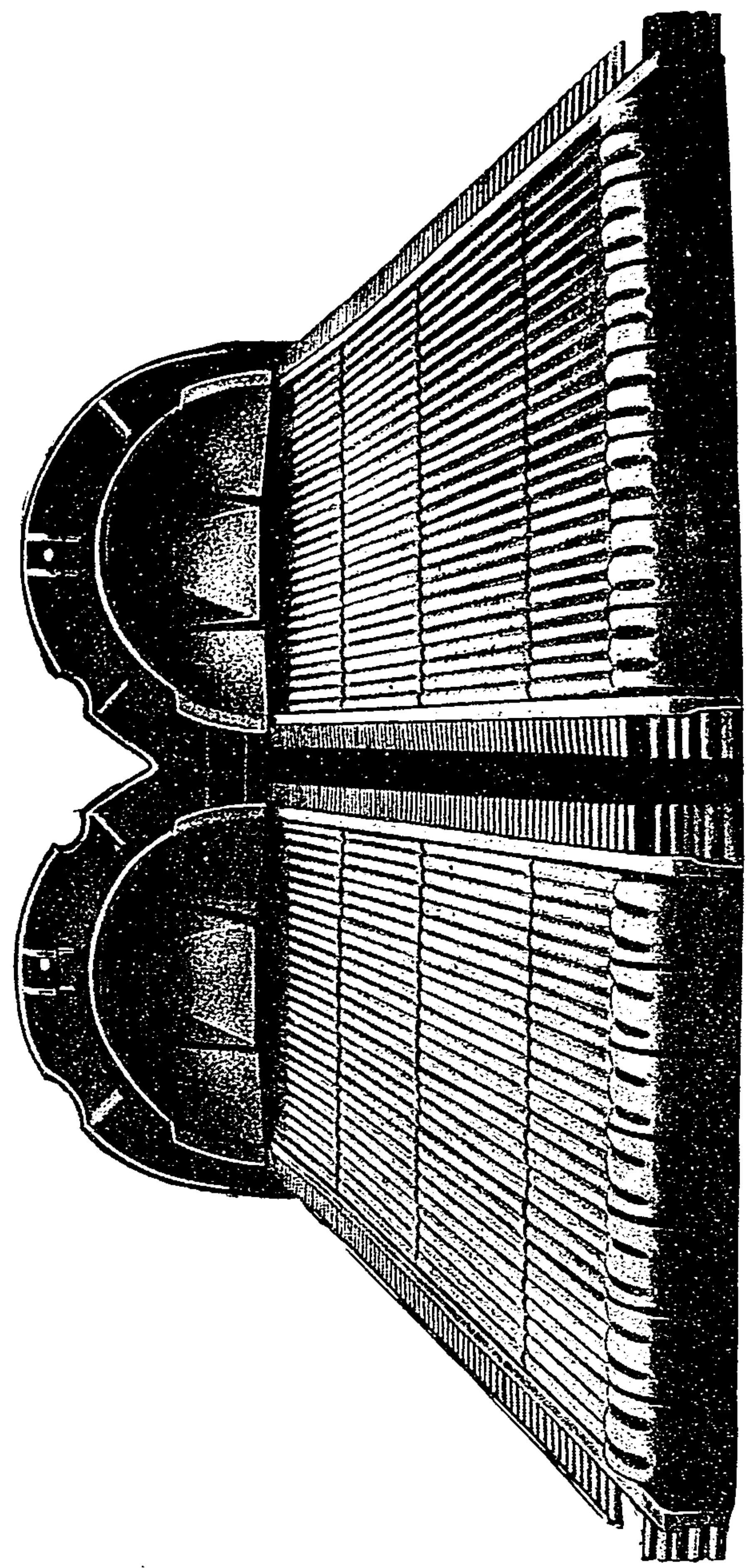

Fig. 15.—Back view of Compressed Air Furnace.

The trough bars are fitted with automatic ash-cleaning slides which effectively remove any small particles of ash that may fall between the grate bars into the troughs. These slides are so arranged that any such accumulation is removed with the minimum loss of air-pressure in the trough bars.

The illustration, p. 77, shows the "Bennis" compressed air furnace applied to a Lancashire boiler seen from the inside. The grids, back blocks, and toothed side-bars are clearly visible. The side bars are made with extended teeth, which can be chipped to suit any irregularities or corrugations in the flues.

The inside protection plates used for protecting the rivets and mouths of the furnaces from the intense heat of the furnace are shown.

The power required to drive a set of sprinkler stokers and compressed air furnaces fitted to a Lancashire boiler is about ½ B.H.P.

TESTS OF BENNIS MACHINE STOKER.

A Large Hosiery Mill in the Midlands.—Report on boiler tests made at a Midland Hosiery Manufactory. The boiler was a Lancashire 8′ × 30′, and the test was comparative between the "Bennis" Sprinkler Stoker with Self-cleaning Compressed Air Furnace and hand-firing. These tests show the adaptability of the "Bennis" Stokers for satisfactorily burning a mixture of coal and coke breeze.

The Stirling Chain Grate Stoker.—The stoker consists of a suitable framework, a travelling grate, fuel hopper, and the necessary driving mechanism.

The stoker is entirely self-contained, and no part of it is attached in anyway to the boiler framework or the brick setting; the entire machine rests upon four wheels which are supported by suitable rails which extend a sufficient distance into the stokehole to enable the stoker to be drawn completely from under the boiler.

		System of Firing.	
		Hand.	Bennis Sprinkler Stoker and Compressed Air Furnace.
Duration of test,	hours	9	9
Temperature of feed water,			
Entering economisers,	°F.	67	69
Leaving economisers,	°F.	180	192
Steam pressure by gauge,	lbs. per sq. in.	86·4	101·1
Factor of equivalent evaporation as from and at 212° F.,	—	1·1872	1·1876
Class of fuel,	—	Slack	½ slack, ½ coke breeze.
Price of fuel,	per ton	18/6	11/-
Fuel burnt per hour,	lbs.	1,503	1,367
Fuel burnt per sq. ft. grate surface per hour,	lbs.	39·6	33·3
Water evaporated per hour,	lbs.	7,295	8,316
Water evaporated per lb. of fuel,	lbs.	4·85	6·08
Equivalent evaporation per hour,	**lbs.**	**8,660**	**9,878**
Equivalent evaporation per sq. ft. heating surface per hour,	lbs.	8·68	9·9
Equivalent evaporation per lb. of fuel,	lbs.	5·76	7·22
Coast of fuel to evaporate 10,000 lbs. of water as from and at 212° F.,	pence	172	81·64
Comparison of Results.			
Extra water evaporated as from and at 212° F. per hour,	—	—	**14·0**
Extra water evaporated as from and at 212° F. per lb. of fuel,	—	—	**25·3**
Reduction in fuel costs per 10,000 lbs. evaporated,	—	—	**52·5**

The framework is made of cast iron and so designed that any part of it can be easily renewed. A shaft is fitted in the front of the frame equipped with sprocket wheels and a similar shaft at the back is supplied with a

THE STIRLING CHAIN GRATE STOKER.

Fig. 16.—View of Boiler House of London County Council Power Station at Greenwich containing twenty-four Stirling Boilers.

drum keyed to it. The grate is an endless chain composed of links of narrow width and relatively greater depth. This travels over the above mentioned sprocket wheel and drum and is driven by the former.

To provide for wear and expansion of the grate, the distance between the centres of the idler shaft and sprocket shaft can be adjusted. The coal is fed on to the grate through the hopper and the amount of coal is regulated by the depth of the guillotine door, which is provided at the back of the stoker hopper. The stoker is driven through a gear box giving a range of speeds so that the rate of travel of the grate can be altered to suit conditions. The motion is transmitted from the gear box to the sprocket shaft by means of a worm and worm wheel. A thrust washer is provided in the gear box so that if the grate seizes for any reason, slip will occur, so preventing breakage.

The chain grate stoker has been designed to give smokeless combustion and if proper attention is given to the working of the stoker and the speed of grate, and the thickness of fire regulated so as to suit the particular coal that is being burnt. This object can be obtained without the admission of excess air. Smokeless combustion is brought about by the green coal being fed in at the front of the boiler and under the coking arch. This coking arch being in an incandescent state, ensures that all the volatile matter in the fuel is driven off and consumed before the end of the coking arch is reached, thereafter it is only the fixed carbon which remains to be burnt. This means that complete combustion is effected before the hot gases touch any portion of the heating surface of the boiler.

The chain grate stoker was primarily designed for burning coal, but it is also suitable for lignites, and when fitted with forced draught will burn Welsh coal or coke.

Fig. 16 shows a view of a battery of Stirling boilers, each boiler has a heating surface of 3,650 square feet, and will evaporate 15,000 lbs. of water per hour. Each boiler is fitted with chain-grate stokers, giving 60 square feet grate area, and a super-heater capable of imparting 150° F. of super-heat to the steam.

TEST OF STIRLING WATER TUBE BOILER.

Fitted with Chain Grate Stoker.

At Messrs. Vickers, Ltd., River Don Works, Sheffield.

Description of Boilers, Cons. 1671 and 1704 "S,"	T33/18 Nos. 15 and 16 Boilers.
Date of Test,	14th June, 1918.
Duration of Test,	6 hours.
Heating Surface of Boiler,	each 8,282 sq. ft.
Grate Area,	each 168 sq. ft.
Ratio of Grate Area to Heating Surface,	1 to 49.
Form of Furnace,	Chain Grate,
Heating Surface of Superheater,	each 168 sq. ft.
Average Boiler Pressure by Gauge,	157 lbs.
,, Temperature of Steam at above pressure,	386·87° Fah.
,, ,, of Superheated Steam,	550° Fah.
,, Amount of Superheat,	163·13° Fah.
,, Temperature of Feed Water entering heater or economiser,	90° Fah.
,, ,, of Feed Water entering Boiler,	204° Fah.
,, ,, of Furnace,	..° Fah.
,, ,, of Flue Gases leaving Boiler,	575° Fah.
,, ,, of Flue Gases leaving Air Heater,	..° Fah.
,, ,, of Air entering Air Heater,	..° Fah.
,, ,, of Hot Air entering Furnace,	..° Fah.
,, ,, of boiler house,	70° Fah.
Fuel,	Clay Cross Beans.
Calorific value of dry coal,	12,850 B.Th.U.
,, ,, of coal as fired,	12,020 B.Th.U.
Total coal as fired (2 Boilers),	49,350 lbs.
,, dry coal consumed,	46,389 lbs.
Percentage of moisture in coal,	6 per cent.
Total ash and clinker,	6,415 lbs.
Percentage of ash and clinker,	13 per cent.
Total combustible consumed,	39,974 lbs.
Coal as fired per hour (2 Boilers),	8,225 lbs.
,, ,, ,, per sq. ft. of grate surface,	24·46 lbs.
Dry Coal consumed per hour,	7,731·5 lbs.
Dry Coal consumed per hour per sq. ft. of grate surface,	23·01 lbs.
Draught at Boiler damper,	·7 to ·8 inch.
Pressure under grate,	.. inches.
Total weight of feed water to boiler (actual) (2 Boilers),	386,995 lbs.
Equivalent total water evaporated from and at 212° F.,	493,419 lbs.
Factor of evaporation,	1·275.
Water evaporated per hour (actual) (2 Boilers),	64,499 lbs.
Equivalent evaporation per hour from and at 212° F.,	82,236 lbs.
Equivalent evaporation per hour from and at 212° F. per sq. ft. of heating surface,	4·9 lbs.
Water evaporated under actual condition per lb. of coal as fired,	7·84 lbs.
Equivalent evaporation from and at 212° F. per lb. of coal as fired,	9·99 lbs.
Water evaporated under actual conditions per lb. of dry coal,	8·34 lbs.
Equivalent evaporation from and at 212° F., per lb. of dry coal,	10·63 lbs.
CO_2 on flue gases,	11 per cent.
CO in flue gases,	.. per cent.
O in flue gases,	.. per cent.
Efficiency of Boilers and Economisers,	80·3 per cent.

REMARKS.—Boiler and Economiser contract 1671 started up November, 1917, but cleaned out first week in May, 1918. Boiler and Economiser Contract 1704 started up first week of April, 1918. Both combined plants in continual service until date of this test.

Underfeed Stoker.—Fig. 17 illustrates the Underfeed Stoker. The coal is fed into the hopper and is pushed through into the trough—D—(Fig. 18) by the Archimedean screw or worm which is shown below the stoker in Fig. 17. The coal thus pushed along the trough eventually overflows the sides and works down the grate bars to the point G (Fig. 18), at which place it gradually burns out.

Forced draught is an integral part of the equipment, the air is admitted by piping to a point from whence it is

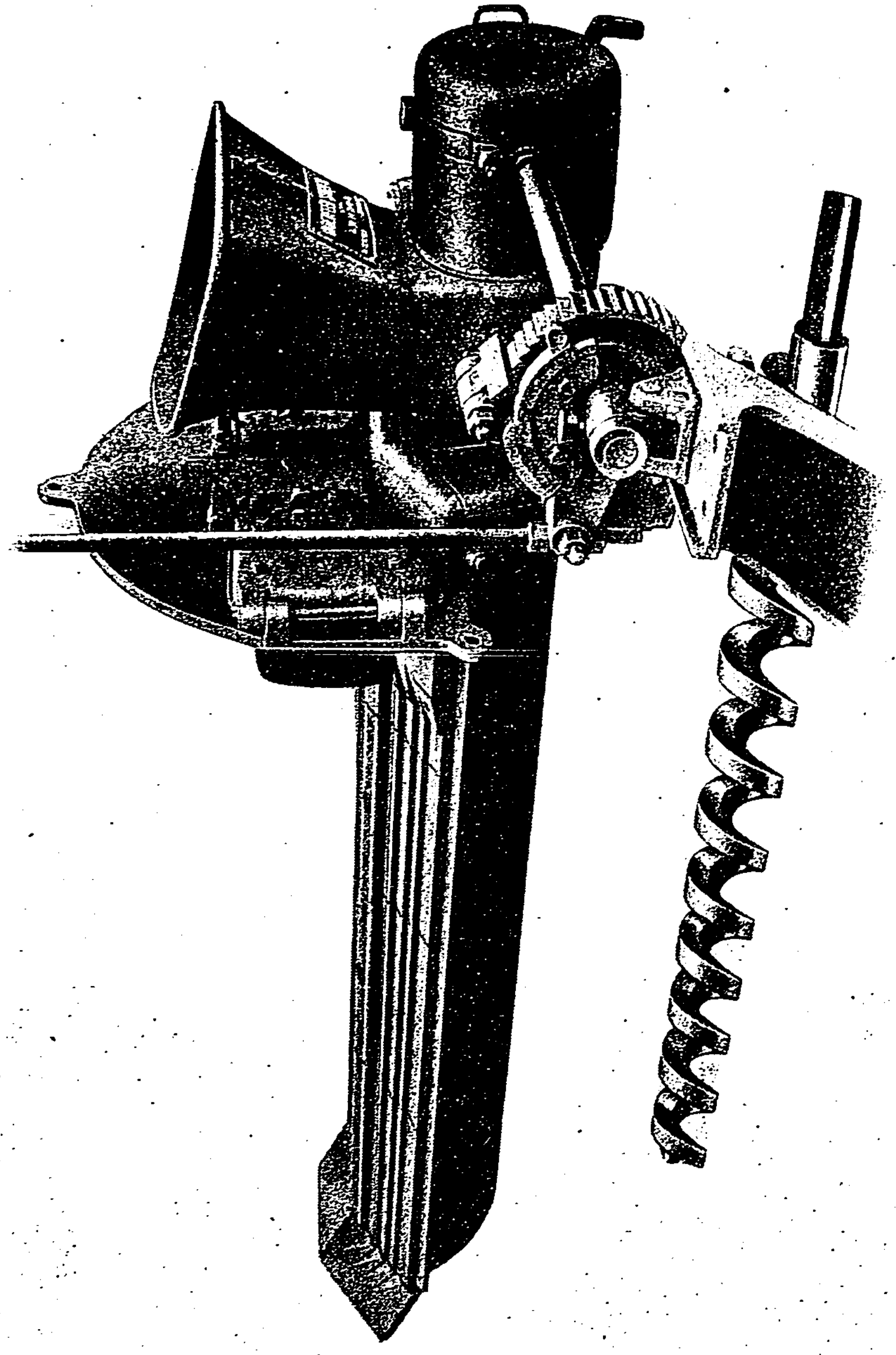

Fig. 17.—The Underfeed Company's Stoker.

conducted to the wind box—C—(Fig. 18). The air then passes through the slots shown at F in Fig. 18, and so

into the coal bed; there is a damper to control the amount of air required.

It will thus be seen that because the green coal is fed up underneath the glowing coal and coked, the hydrocarbon gases pass through the bed and are consumed, in contradistinction to the ordinary way of throwing green coal on top of the glowing coal, when a large portion of the gases pass unconsumed up the chimney. The method

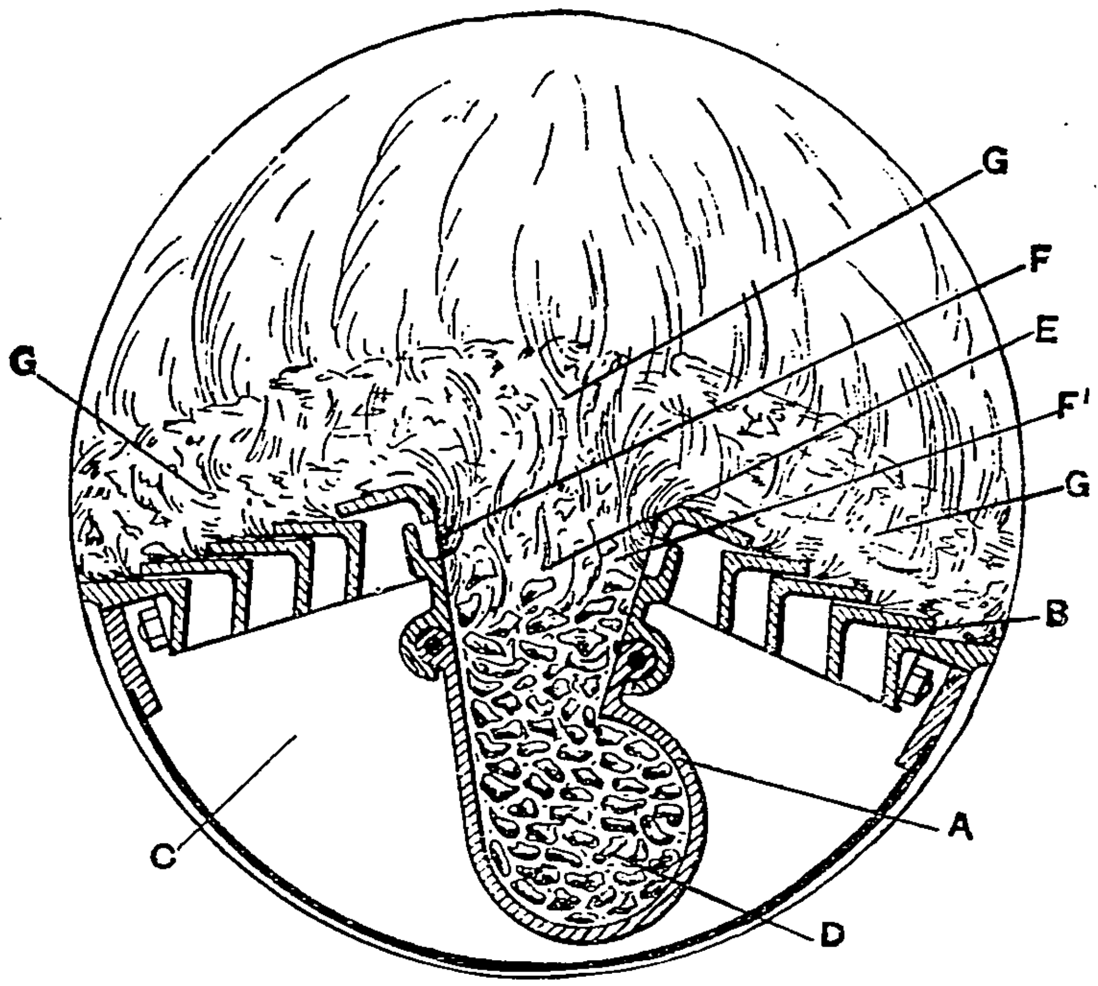

Fig. 18.—Cross-Section of the Underfeed Stoker in the Flue of a Lancashire Boiler.

by which the stoking is effected in the former case ensures that there is smokeless combustion, and that without the use of steam jets—which as everyone knows are so wasteful, often using 3 per cent. to 12 per cent. of the total steam generated.

The hopper (Fig. 17) can either be filled by hand or by mechanical means and it may be swung to either side for inspection purposes, though in actual practice it is seldom moved.

The stoker is actuated by the bevel wheel on the end of the Archimedean screw, in mesh with a bevel wheel on the driving shaft; this latter is operated by a vertical shaft through a ratchet and pawl motion, the vertical shaft being operated from an overhead line shaft through

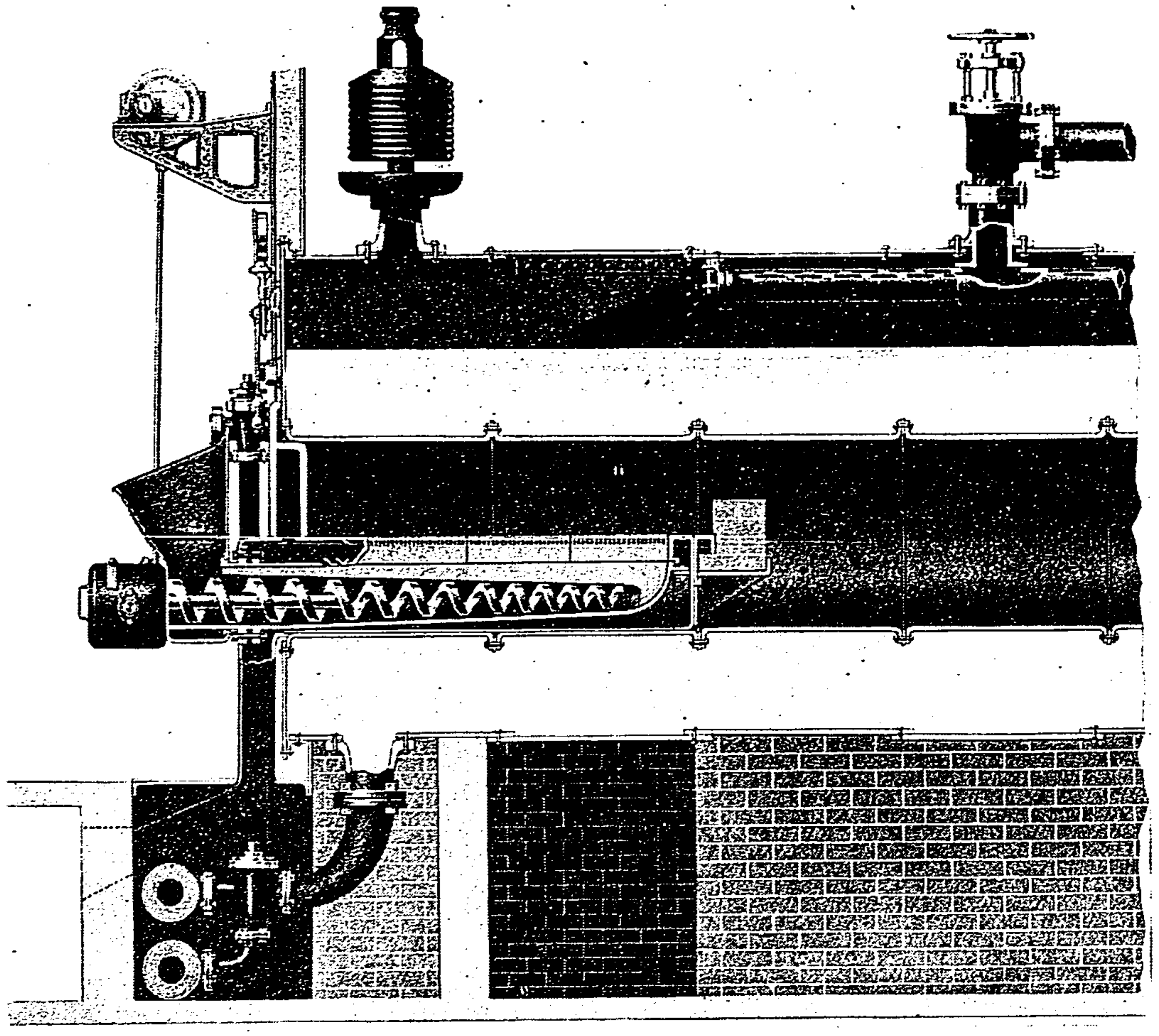

Fig. 19.—Longitudinal Section of the Underfeed Stoker in the Flue of a Lancashire Boiler.

an eccentric. This line shaft may, of course, be driven from a small motor or a low pressure steam engine.

The above-mentioned line shaft also is connected by a belt to a fan which supplies the forced draught already mentioned.

A notable feature in regard to this stoker is that there are only three moving parts—the Archimedean screw and the two bevel wheels—as opposed to the many moving parts in a great many stokers of other makes; and there are no moving parts in the fire. This means that the upkeep expenses are reduced to the absolute minimum.

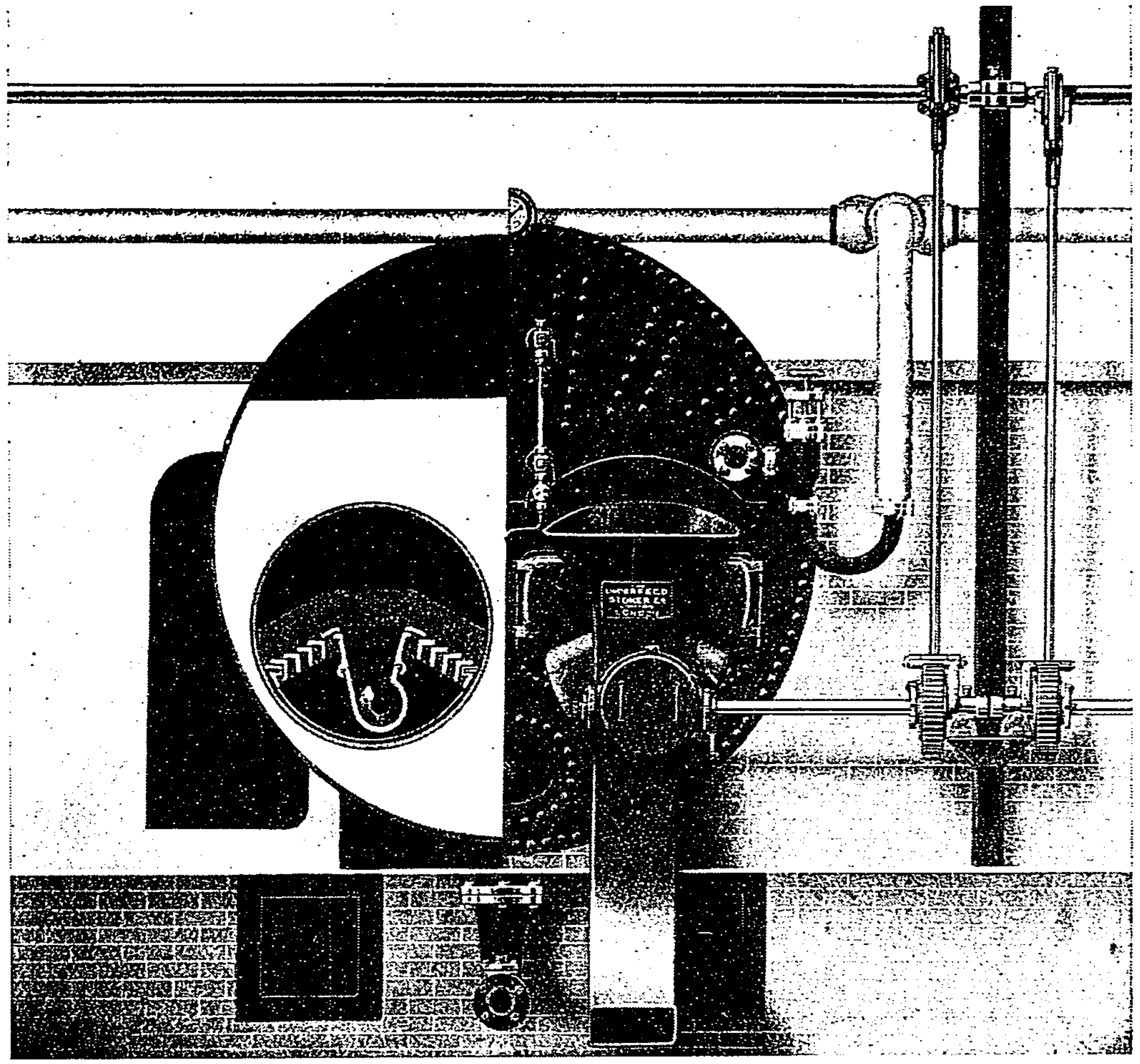

Fig. 20.—Underfeed Stoker applied to a Lancashire Boiler, one half in Section.

There are five different rates of feed so that the variation in output is very wide.

Provision is made with this stoker for a possible break-down to the motor or low pressure steam engine; that is to say that the stoker can be operated in exactly the same way as a hand-fired grate. In other words, the coal is thrown in through the doors as with an ordinary hand-fired furnace, by a shovel; two grates are opened

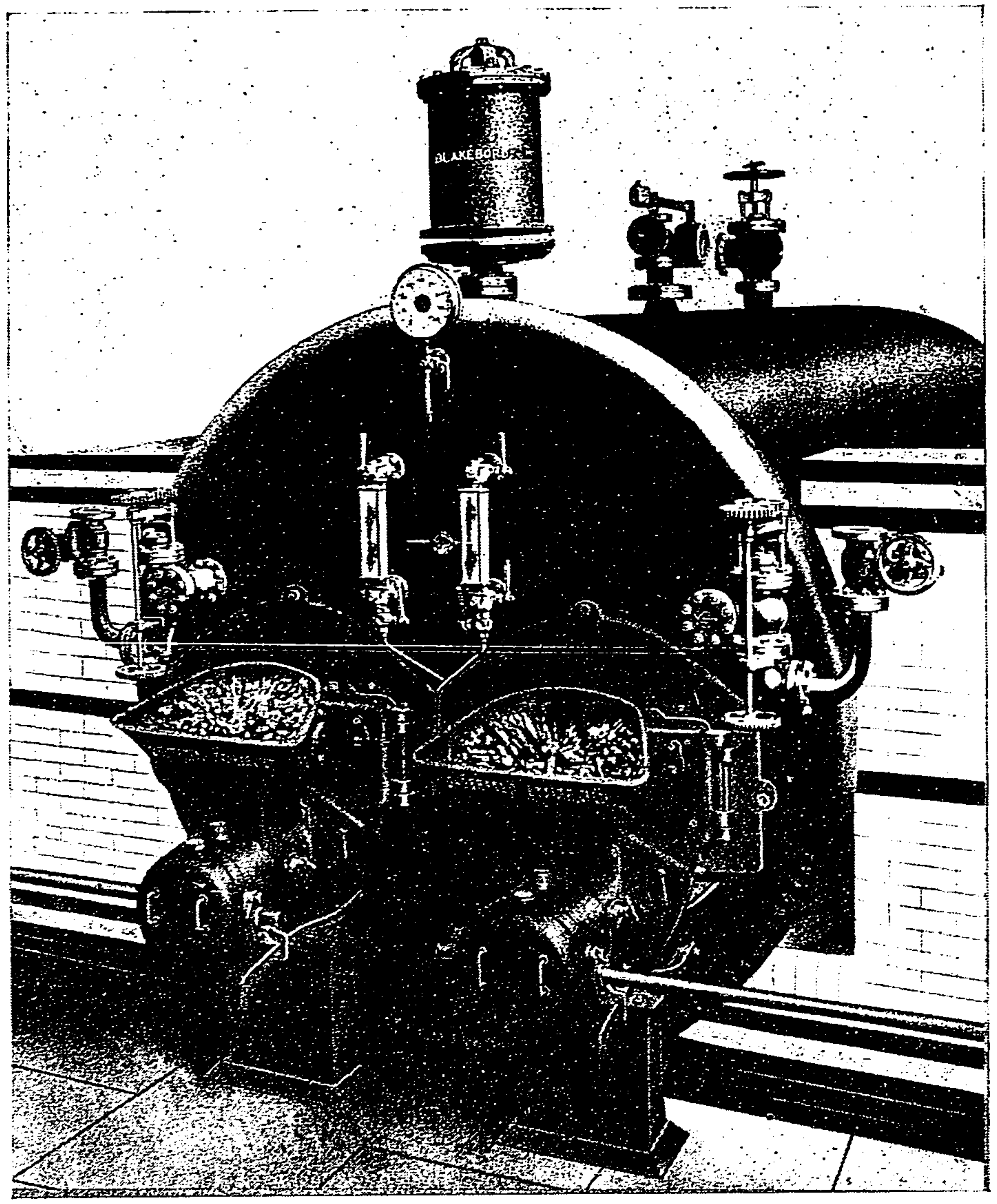

Fig. 21.—Front View of Lancashire Boiler with Underfeed Stoker.

at the bottom of the stoker front and below the grate level to give the necesssary natural draught. It will be noted that the hopper is necked in order to facilitate the throwing of coal on to the grate.

Fig. 19 shows the longitudinal section; the air piping shown in the illustration is varied according to circumstances. The stoker is fixed to the boiler by three studs in the front plate and can very easily be withdrawn for Insurance inspection purposes. Figs. 20 and 21 are front views.

Fig. 22 illustrates the latest " A " type of stoker.

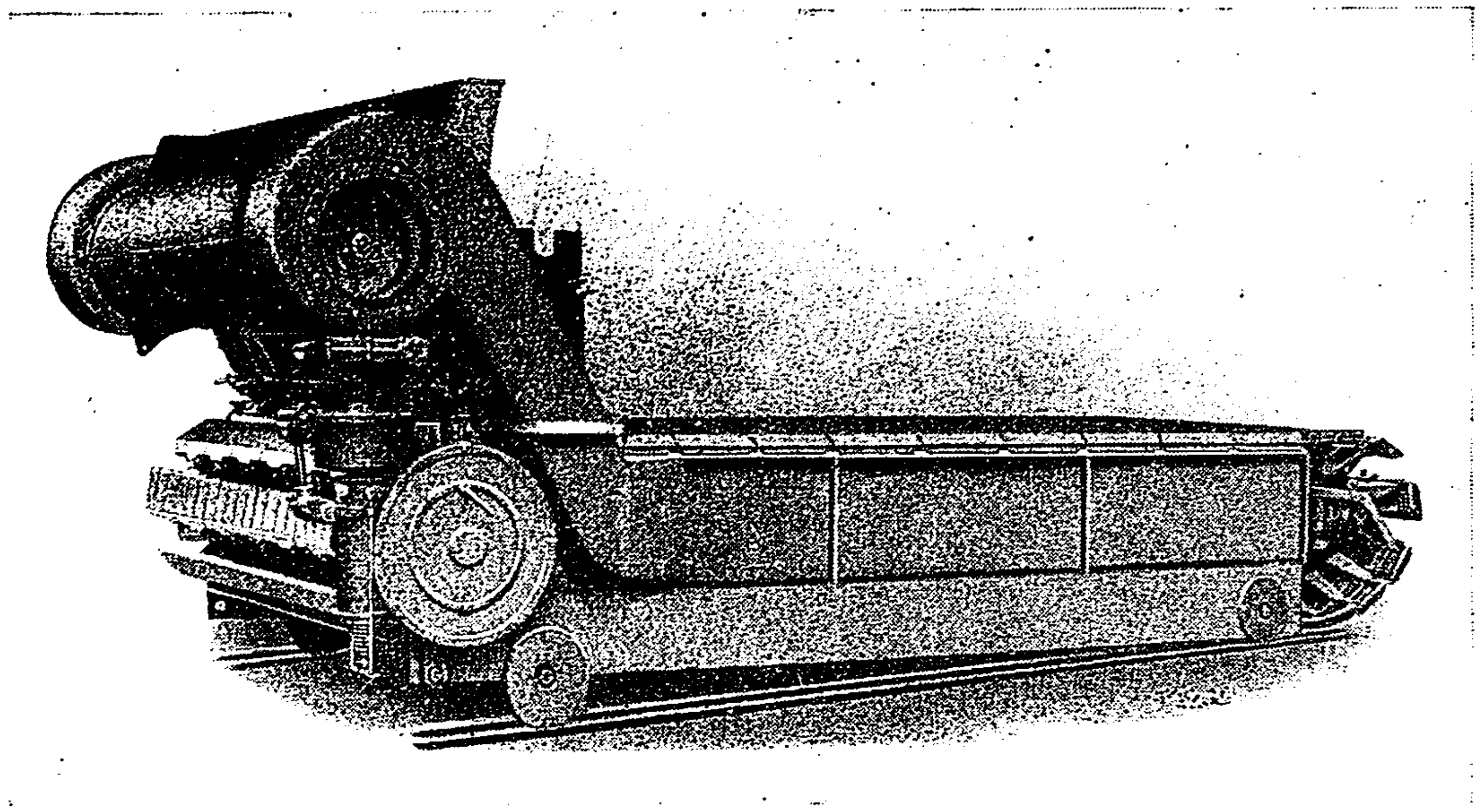

Fig. 22.—Underfeed Stoker, Type A.

Concisely, the advantages of installing such a mechanical stoker in a Lancashire or Cornish Boiler are these :—

1. A much lower grade of fuel can be used than is possible with the best hand-firing and natural draught, or alternatively a lesser quantity of the same grade of fuel as is used with hand-firing. It is not at all uncommon to find that the saving made by these stokers is equal to an annual investment of 60 per cent. to 80 per cent. on the original outlay.

2. Absolutely smokeless combustion results; this can only be appreciated by seeing plants in actual operation.

3. Having Forced Draught and five different rates of feed the stoker caters for a fluctuating load to an extent

impossible with hand-firing, and it is for this reason that this particular stoker is used so much in the Paper Trade and in other lines of business where a great variation in load is required.

The following are the tabulated results of a Test made, by Messrs. The Beck Estates Co., Ltd., on 2 Lancashire Boilers fitted with Underfeed Stokers, and using Hickleton slack as fuel.

Date of Test, . . .		13-5-25
Method of firing, . .		Stoker.
Class of Stoker, . .		"B" 5
Class of Economiser, .		Greens-160 tube
Duration of Trial, .	hrs.	10
Dimensions.		
Grate surface per boiler, . . .	sq. ft.	42
Heating surface of Economiser, . .	sq. ft.	1,600
Pressure.		
Steam gauge, . .	lbs.	142
Draught gauge chimney, . .	in water	¾″
Pitot gauge air supply boxes W.G	in water	⅜″ to ¼″
Absolute steam pressure, . . .	lbs.	156·7
Air pressure in duct over fire, . . .		⅛″
Temperature.		
Gases leaving boiler,	°F.	605·5
Gases leaving Economiser, . . .	°F.	293·75
Feed water entering Economiser, . .	°F.	49
Feed water entering Boiler, . . .	°F.	210
Steam, ...	°F.	698·6
Superheat, . .	degrees.	336·6
Fuel.		
Total fuel consumed,	lbs.	11,872
Total refuse, . .	lbs.	665
Total refuse, dry analysis, . .	per ct.	5·6

Fuel Per Hour.		
Fuel as fired per hour, ...	lbs.	1,187
Fuel as fired per sq. ft. of grate, . .	lbs.	28
Flue Gas.		
CO_2 in gases leaving Boiler, . .	per ct.	10·5
Total Water.		
Total weight water used, ...	lbs.	96,880
Factor of evaporation, Boiler only, including Econ., .		1·309
Total from and at 212°, including Econ., . . .	lbs.	126,816
Water Per Hour.		
Amount used, . .	lbs.	9,688
Evaporated from and at 212° including Econ., .	lbs.	12,681
Economic Evaporation.		
Per pound of fuel (as fired)		
Apparent, per lb., .	lbs.	8·16
Equivalent from and at 212° including Econ., .	lbs.	10·68
B.T.U. in Fuel, as used,		13,172
B.T.U. in Fuel, Dry, .		13,909
Efficiency Boiler only,		
Ditto, including Econ.,		78·3
% Volatile in Fuel as used, . .		32·97
% Ash in Fuel as used, ...		6·80
% Moisture, .		5·30

Green's Economiser.—In the generation of steam in boilers a source of considerable waste heat is the escape up the chimney of high temperature flue gases. This waste may be reduced to a minimum by the installation of a Fuel Economiser, the function of which is to abstract heat from the waste gases and impart it to the boiler-feed before it is delivered to the boilers. By this means the evaporation of the plant for a given coal consumption is considerably increased; or conversely, equal evaporation is obtained with less coal.

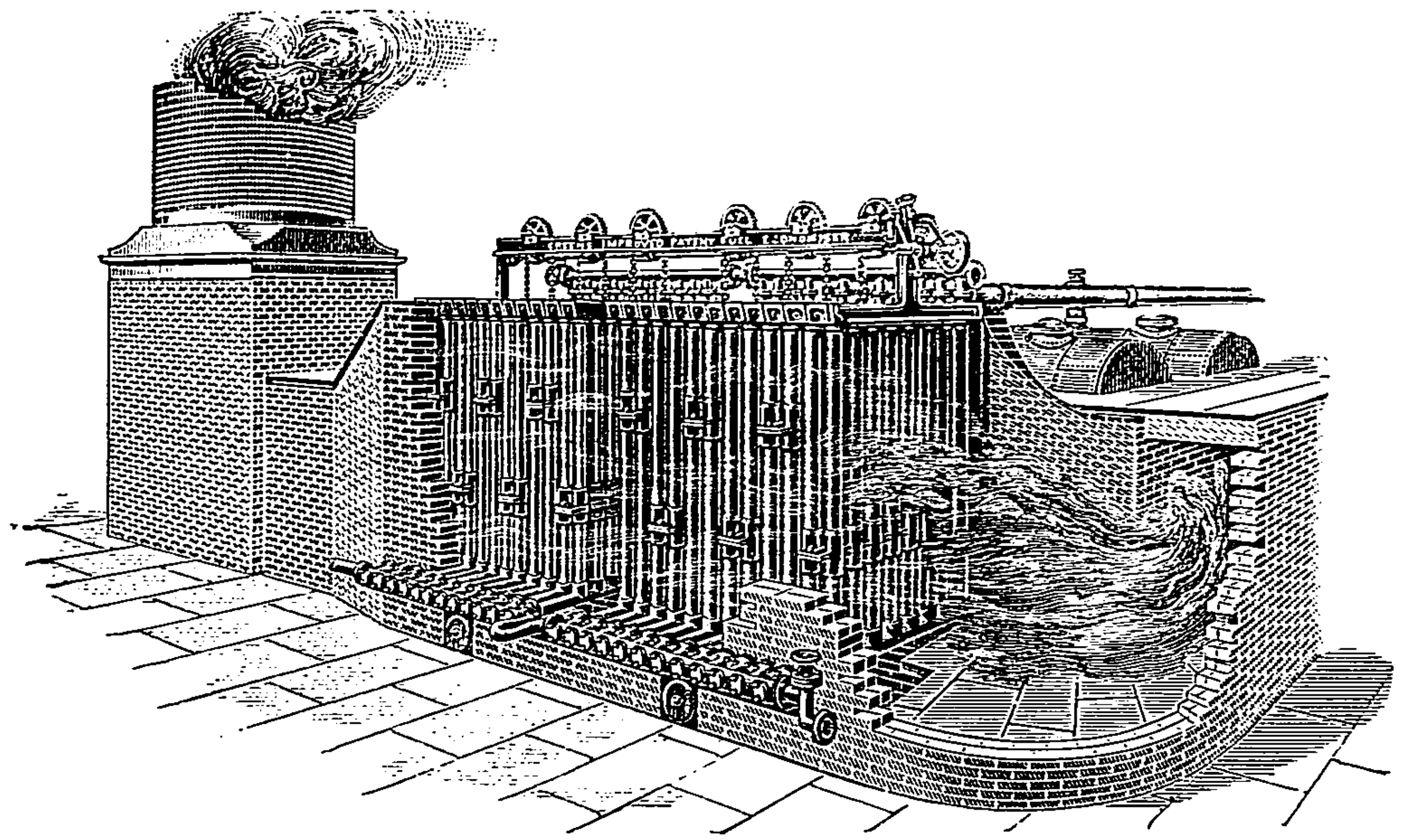

Fig. 23.—Green's Modern Economiser in operation.

Not only does an Economiser act as a fuel saver, thereby assisting in the abatement of smoke, but it also provides a large reserve of hot water to meet the sudden demands.

Green's Fuel Economiser consists of a series of cast-iron tubes $4\frac{9}{16}$ inches in external diameter and generally 9 feet long. These tubes are arranged in sections consisting of 4 or more tubes each according to the size of the Economiser, and are placed in the main flue between the boilers and the chimney, see Fig. 23. The sections are formed by forcing the tubes by hydraulic pressure into Top and Bottom Headers, the ends of the tubes being turned and the header sockets bored to gauge, thus ensuring a perfect metal to metal joint. The Top Headers are machined along the edges and form an air- and gas-tight joint. When erected in position the sections are connected by Branch Pipes running lengthwise, one at the top and one at the bottom on opposite sides. The Bottom Branch Pipe is outside the wall of the Econo-

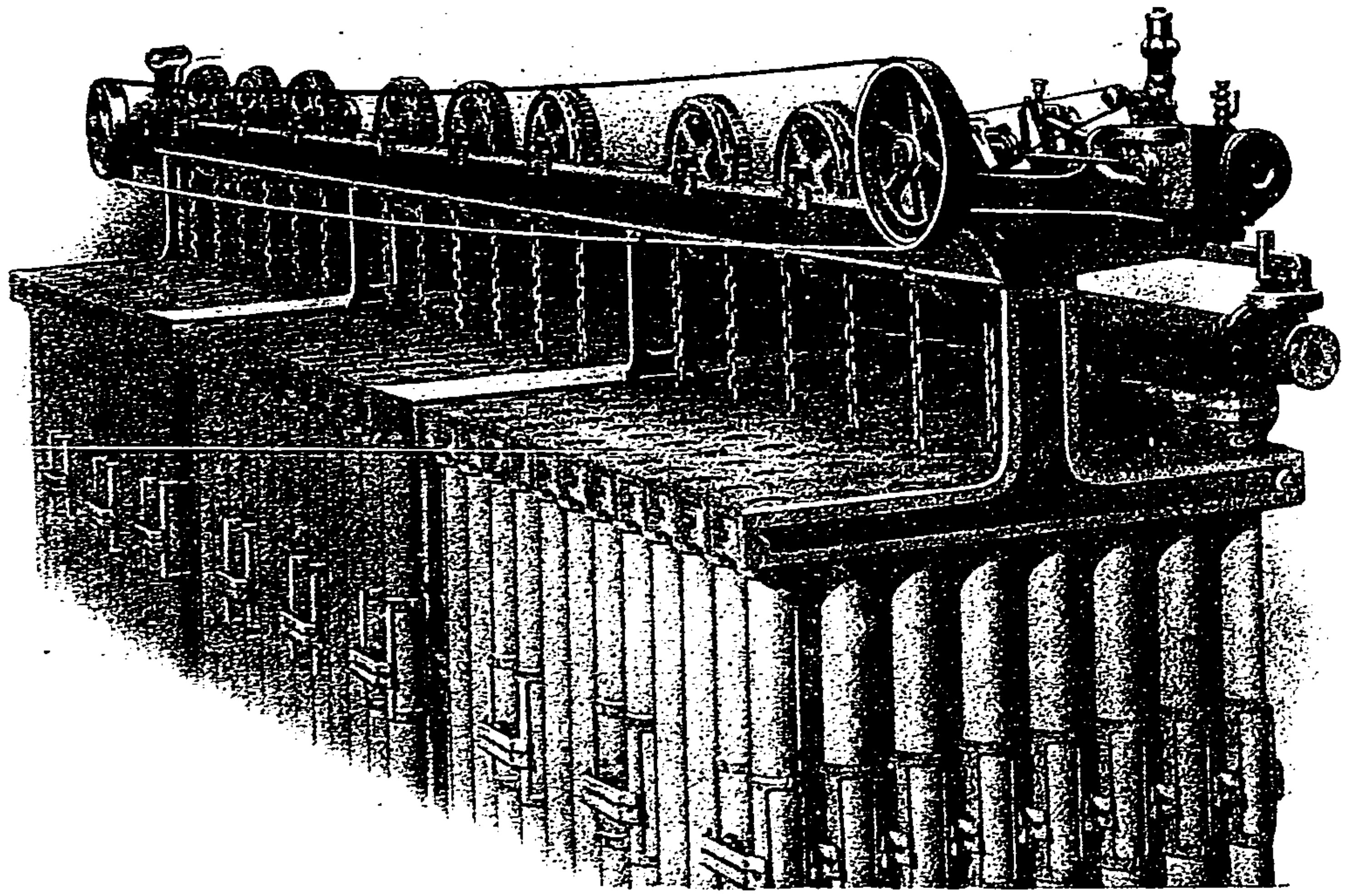

Fig. 24.—Green's Modern Economiser.

miser chamber and is fitted with access-lids opposite each Bottom Header to facilitate cleaning and flushing out.

Water is admitted into the Economiser through the Bottom Branch Pipe at the end nearest the chimney and leaves by the Top Branch Pipe at the end nearest the boilers. Simultaneously the hot gases are passing between the sections of tubes and imparting to the water a considerable proportion of their heat.

The tubes are kept clear of soot by means of scrapers

mechanically operated by gearing from above, the motive power being supplied by either a small horizontal steam engine or an electric-motor, see Fig. 24.

For use with extreme high pressure boiler plants Green's now manufacture a special design of Economiser of patented " Ringstay " type, the chief feature of which is the effective method of reinforcing the connection between tubes and Headers. This is accomplished by means of a " Ringstay " joint consisting of an external cast-iron ringplate containing a cast-iron split ring which is forced over the tube end and into the ringplate and is held in contact with a machined shoulder on the tube-end by means of four-set-screws connecting the ring-plate to the header. This type of Economiser is suitable for working pressures of 250 lbs. per square inch and over.

Green's also manufacture a horizontal Superposed Economiser of Tri-tube type for use in plants where ground space is limited. In this Economiser each section, consisting of 3 tubes only, is supported back and front on vertical supports provided with projections on which the headers lie flat. The weight of the whole Economiser casing and supports is held by the boiler supports, or if desired the apparatus can be supported on an independent structure.

Generally speaking an Economiser is designed to save approximately 13 to 15 per cent. of fuel, but as will be seen from the tests over-leaf there are Economisers actually at work effecting a saving of over 30 per cent.

The life of an Economiser averages about 15 years, but Economisers have been known to last 40 to 50 years with favourable conditions, such as warm feed and comparatively dry flue gases with a low per centage of corrosive agents.

Taking into account the present high value of coal it can be shown that an Economiser will repay its initial cost and cover average depreciation loss in from 1 to 2 years.

TEST No. I.

DAUBHILL BRICKWORKS, BOLTON.

One Lancashire boiler, 30 ft. × 8 ft.; working pressure, 100 lbs.; square feet of grate area, 38; heating surface, 966 sq. ft. One economiser, 96 pipes; heating surface 960 sq. ft. Total area of heating surface in plant, 1,926 sq. ft.

Particulars.		Economiser Working Oct. 17, 1899.	Economiser not Working Oct. 18, 1899.
1. Duration of test, . .	hours.	5	5
2. Total quantity of coal burnt,	lbs.	2,850	3,584
3. Ashes and refuse . .	,,	299·2	379·9
4. Percentage to coal burnt, .	per cent.	10·5	10·6
5. Weight of coal consumed per hour per square foot of grate area, . . .	lbs.	15	18·8
6. Weight of pure coal consumed per hour per square foot of grate area, . .	,,	13·4	16·8
7. Weight of water evaporated,	,,	25,000	24,370·5
8. Lbs. of water evaporated per lb. of coal, . . .	,,	8·7	6·79
9. Lbs. of water evaporated per lb. of pure coal, . .	,,	9·7	7·6
10. Average boiler pressure (above atmosphere), .	,,	92·4	88·6
11. Average temperature of feed water entering economiser, ...	deg. Fahr.	62·1	..
12. Average temperature of feed water entering boilers, .	,,	259·5	52
13. Number of deg. feed water was heated by economiser,	,,	197·4	..
14. Average temperature of flue gases entering economiser,	,,	656	..
15. Average temperature of flue gases entering chimney, .	,,	410·5	..
16. Number of deg. flue gases were cooled by economiser, ...	,,	245·5	..
17. Horse-power based on evaporation of 24 lbs. per H.P., ...		208·4	203·08
18. Coal burnt per H.P. per hour, . .		2·73	3·5
19. Pure coal burnt per H.P. per hour, .		2·44	3·15
20. Equivalent evaportaion from and at 212°, ...		11·15	8·81
21. Percentage gained by using economiser,		21	..

TEST No. II.

SPRING VALE WORKS, MIDDLETON,

Two Lancashire boilers, 30 ft. × 8 ft. 6 ins.; working pressure, 100 lbs; square feet of grate area, 82; heating surface, 2,080 sq. ft. One economiser. 216 pipes; heating surface, 2,160 sq. ft. Total area of heating surface in plant, 4,240 sq. ft.

Particulars.		Economiser Working Oct. 26, 1899.	Economiser not Working Oct. 27, 1899.
1. Duration of test, . .	hours	8	8
2. Total quantity of coal burnt,	lbs.	10,442	11,660
3. Ashes and refuse, . .	,,	976	962
4. Percentage to coal burnt, .	per cent.	9·34	8·25
5. Weight of coal consumed per hour per square foot of grate area, . . .	lbs.	15·9	17·76
6. Weight of pure coal consumed per hour per square foot of grate area, . .	,,	14·4	16·3
7. Weight of water evaporated,	,,	88,100	75,200
8. Lbs. of water evaporated per lb. of coal, . . .	,,	8·4	6·4
9. Lbs. of water evaporated per lb. of pure coal, . .	,,	9·3	7
10. Average boiler pressure (above atmosphere), .	,,	90·2	87·3
11. Average temperature of feed water entering economiser, ...	deg. Fahr.	59·6	..
12. Average temperature of feed water entering boilers, .	,,	301	66·1
13. Number of deg. feed water was heated by economiser,	,,	241·4	..
14. Average temperature of flue gases entering economiser,	,,	656·25	..
15. Average temperature of flue gases entering chimney, .	,,	410	..
16. Number of deg. flue gases were cooled by economiser, ...	,,	246·25	..
17. Horse-power based on evaporation of 24 lbs. per H.P., ...		458·75	391·66
18. Coal burnt per H.P. per hour, . .		2·84	3·72
19. Pure coal burnt per H.P. per hour, .		2·56	3·41
20. Equivalent evaporation from and at 212°, ...		10·60	8·05
21. Percentage gained by using economiser,		24·7	..

The Crosthwaite Furnace Bar.—The furnace is built up of best iron bars which are laid across the furnace instead of along the furnace.

Each bar has holes cut through it which, when the bars are fitted together, form complete airways through them—the main airways being closed at the back.

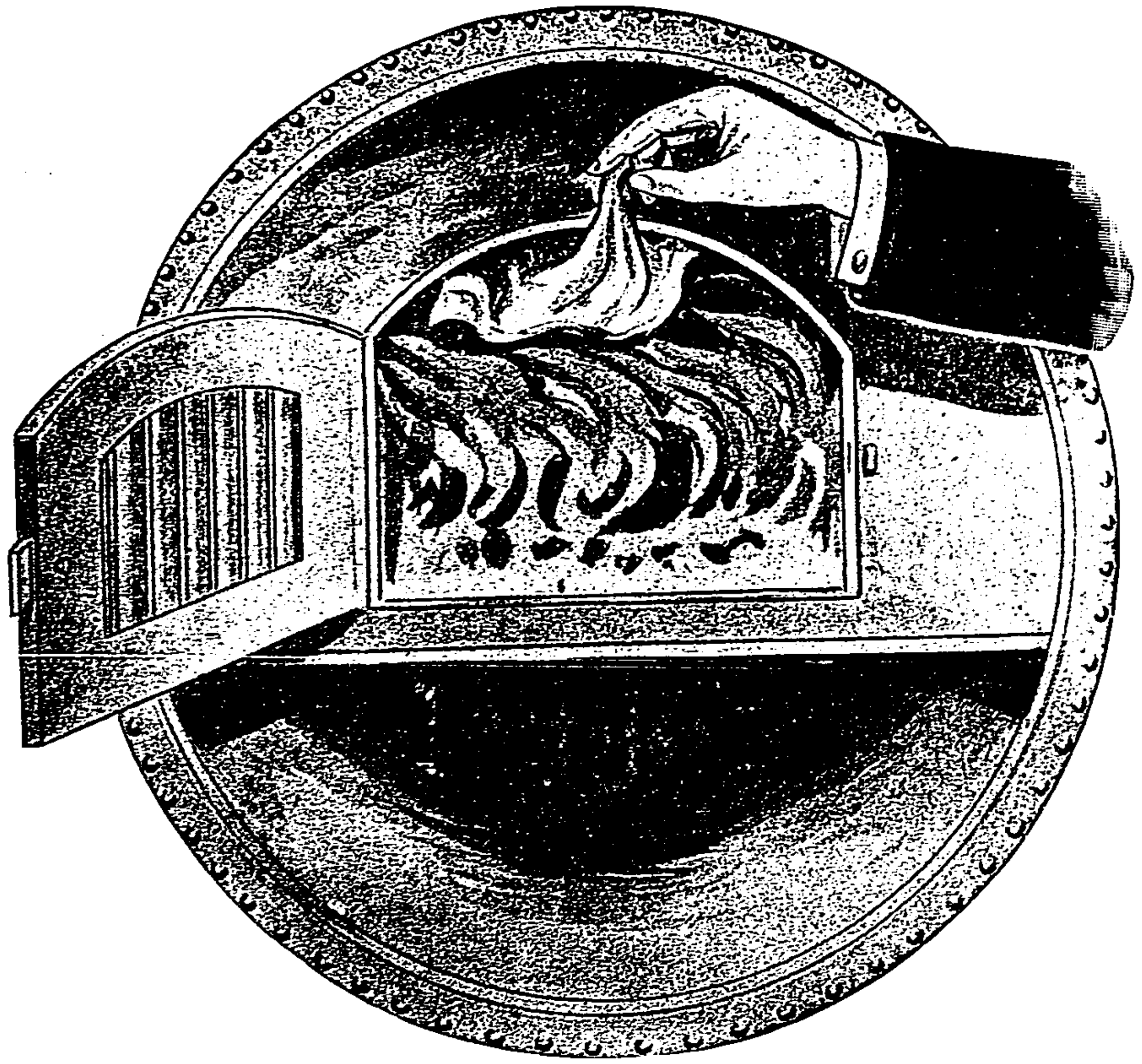

Fig. 25.—The Old Method Furnace.

These main airways communicate with the slits between the bars, allowing the air to pass through the fuel. Each main airway is filled at the end with an air injector operated by a steam jet (or by centrifugal fan). The smaller airways pass quite through the furnace and admit air to the bridge when required.

The General Hospital, Birmingham.

Statement showing the consumption of slack for the years ending October, 1917, and October, 1919.

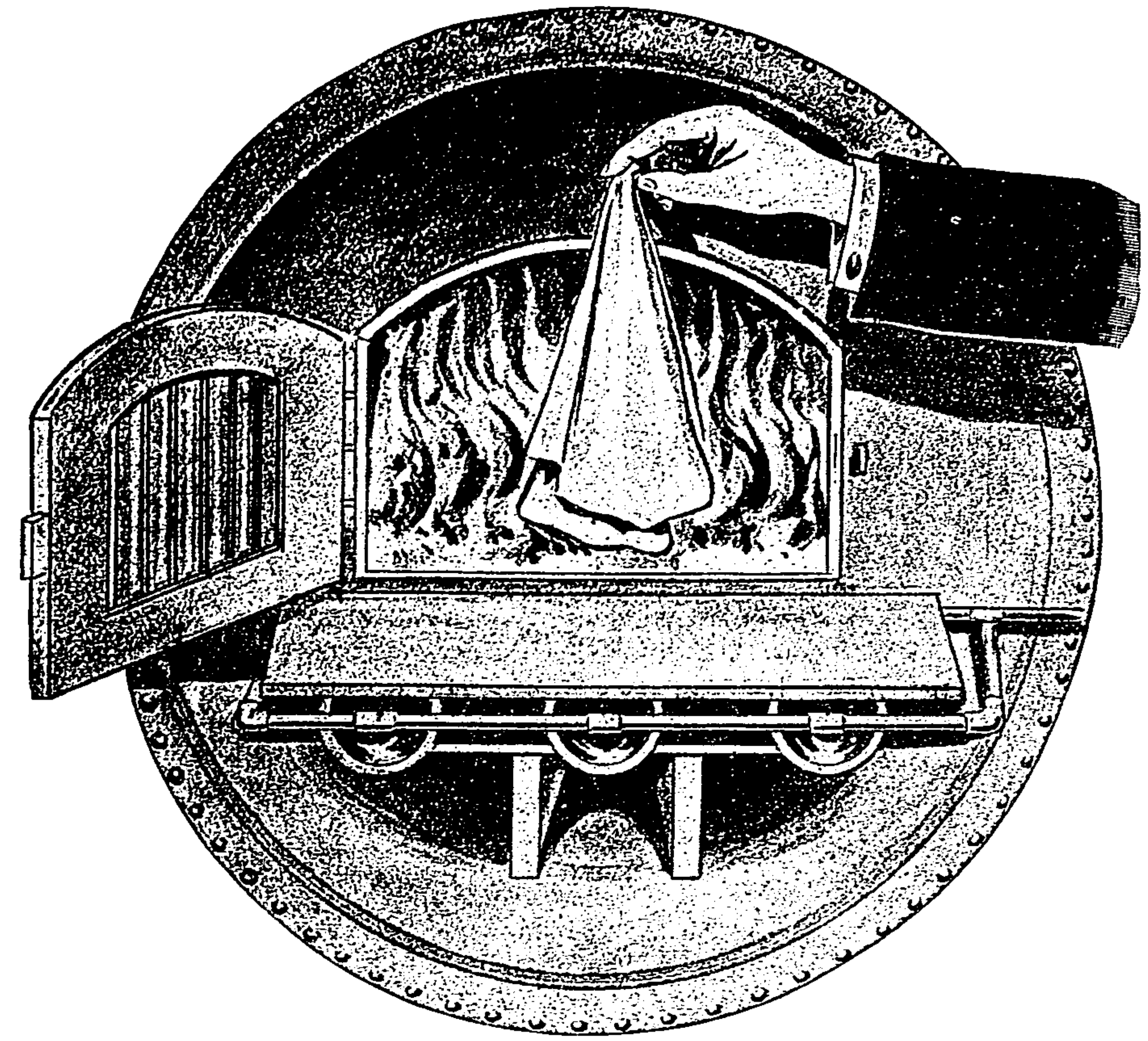

Fig. 26.—The Tuyere Crosthwaite Furnace.

Crosthwaite Furnaces were fitted on October 1st, 1918.

	1916-1917.			1918-1919.		
	T.	C.	Q.	T.	C.	Q.
October, ...	243	14	3	195	4	3
November, ...	330	11	0	250	4	1
December, ...	359	14	1	304	16	3
January, ...	390	18	2	330	11	1
February, ...	359	13	2	354	0	0
March, ...	408	7	3	344	11	3
April, ...	366	10	2	296	7	3
May, ...	247	2	0	196	0	2
June, ...	209	17	3	181	13	1
July, ...	193	18	1	202	0	2
August, ...	197	12	3	193	6	0
September, ...	237	1	2	200	7	0
	3,555	2	2	3,049	3	3

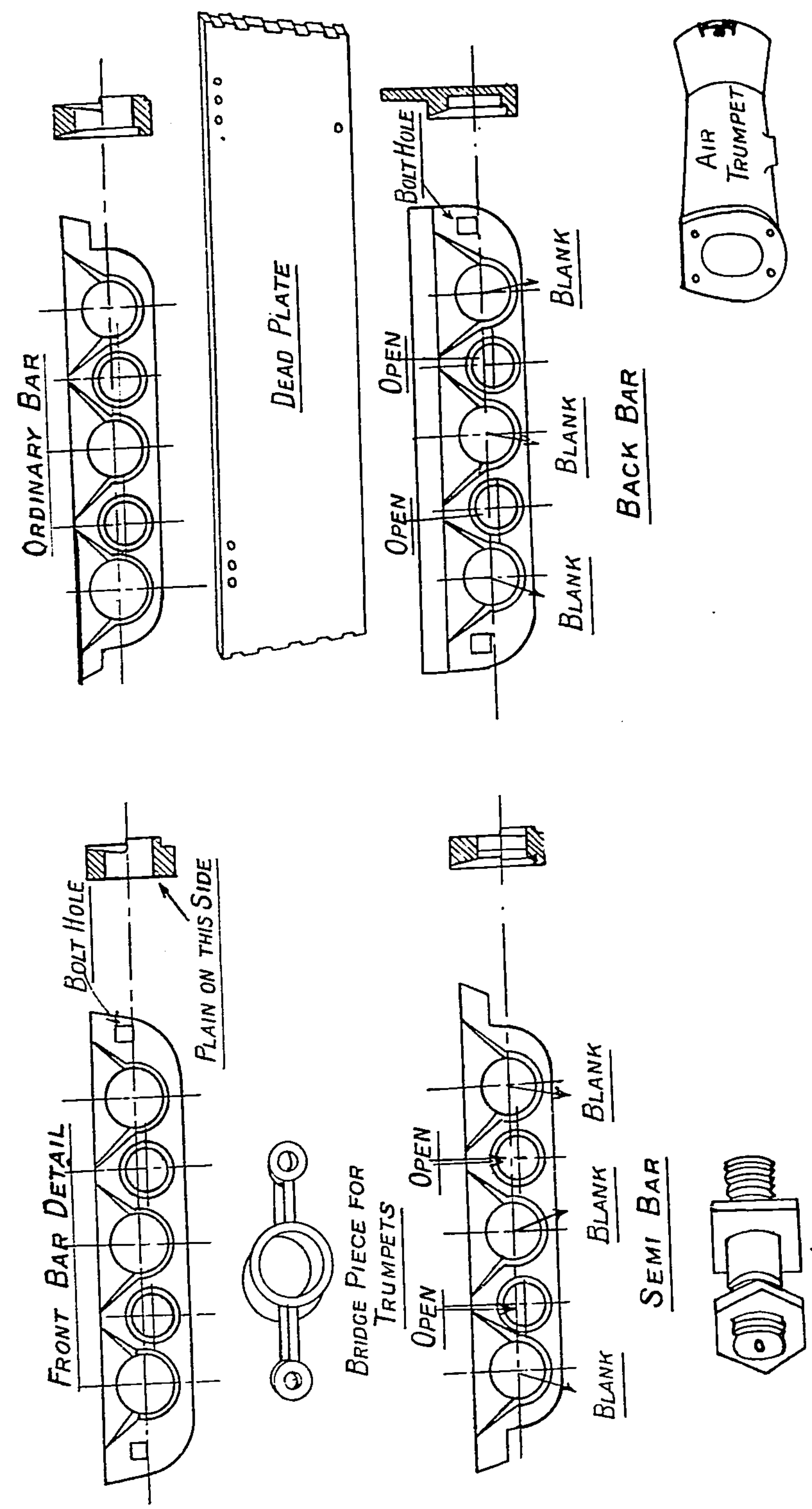

Fig. 27.—Crosthwaite Fire Bars.

This shows a saving in consumption of 505 tons 18 cwts. 3 qrs. for a year; thus at the average price for 1919 a saving of about £704 was effected by the use of the Crosthwaite Furnaces.

Machines and Men.—Of all the charges rightly or wrongly brought against inventors of Smoke Preventers and Fuel Savers, they are not guilty of *laisser faire.* Their production has been prodigious, consisting of every kind of idea, device, appliance, and machine possible for the mind to conceive. Amongst the good inventions, there have been many good for nothing, and manufacturers have been prevailed upon to purchase the useless, which have proved a failure and a waste of much money. Their experience has prejudiced them naturally against even looking at, much more purchasing, suitable appliances for their working conditions, that would stop the nuisance and save fuel. But in the main, manufacturers have spent most liberally on smoke preventers, in fact some on receipt of a statutory notice from the Local Authority, to abate a nuisance, have scrapped machines which cost thousands of pounds a few years before, for appliances they considered more efficient, a proof positive of no prejudice on their part. But in many cases the same cannot be said of Engineers and Firemen who have an antipathy to smoke preventers.

It is pleasing to note that to-day on visiting the works there is very apparent a greater sympathy existing between men and the machines. The engineers take a delight in keeping the machines in proper repair, to get the very best work out of them, and the same may be truthfully said of the firemen, with rare exceptions.

The spirit of fair treatment to the machines, and the men who invented them for the benefit of all, will further stimulate investigation, improvements, and inventions, which will prevent smoke from all sorts of furnaces and fireplaces economically, and save labour.