D. S. JACOBUS.

METHOD OF AND APPARATUS FOR OPERATING STEAM BOILER ECONOMIZERS.

APPLICATION FILED DEC. 8, 1914.

1,281,016. Patented Oct. 8, 1918.

4 SHEETS—SHEET 1.

Fig. 2.

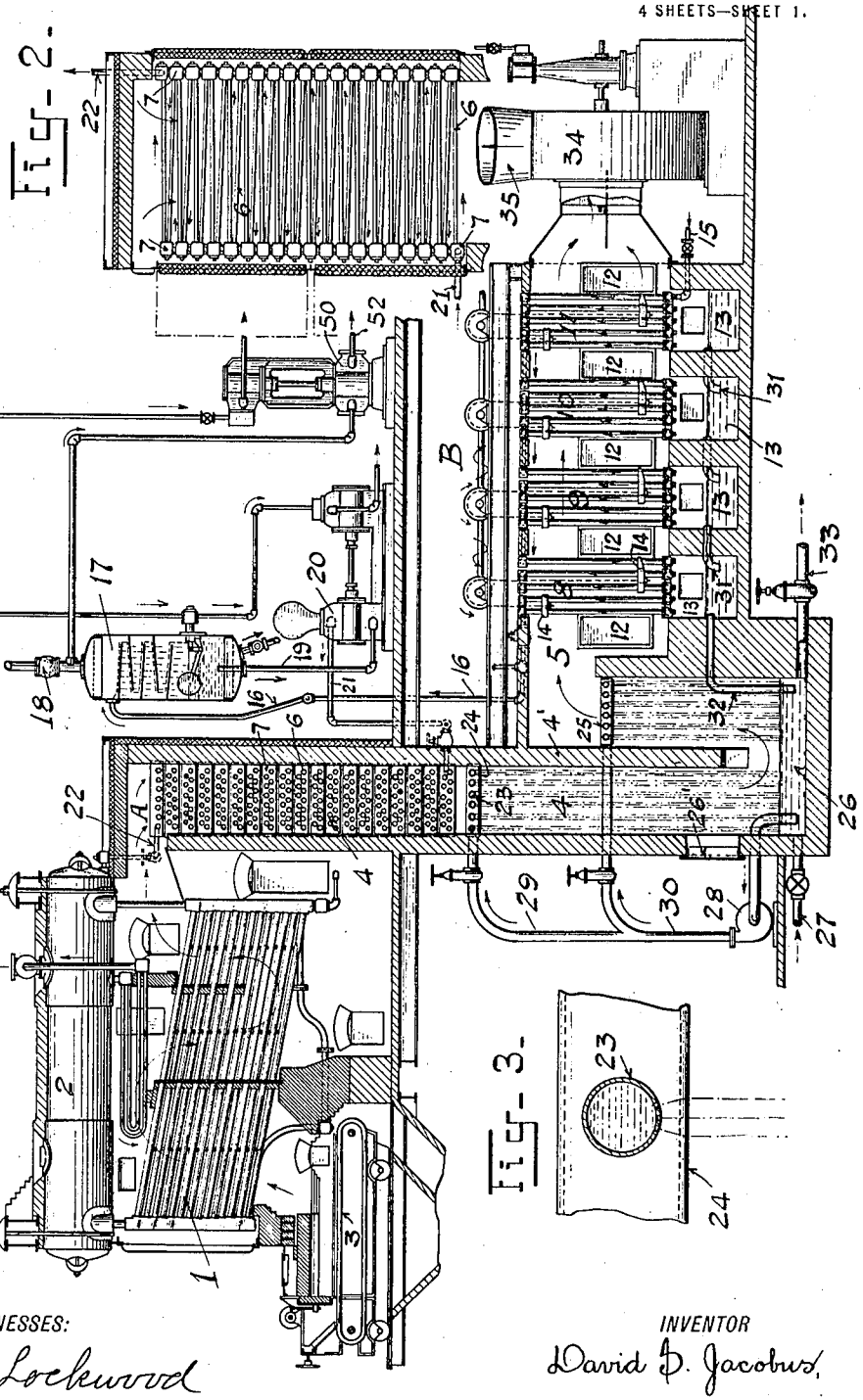


Fig. 1.

Fig. 3.

WITNESSES:

E. M. Lockwood

M. E. McNinch

INVENTOR

David S. Jacobus,

BY

Gifford & Bull,

His ATTORNEYS.

D. S. JACOBUS.

METHOD OF AND APPARATUS FOR OPERATING STEAM BOILER ECONOMIZERS.

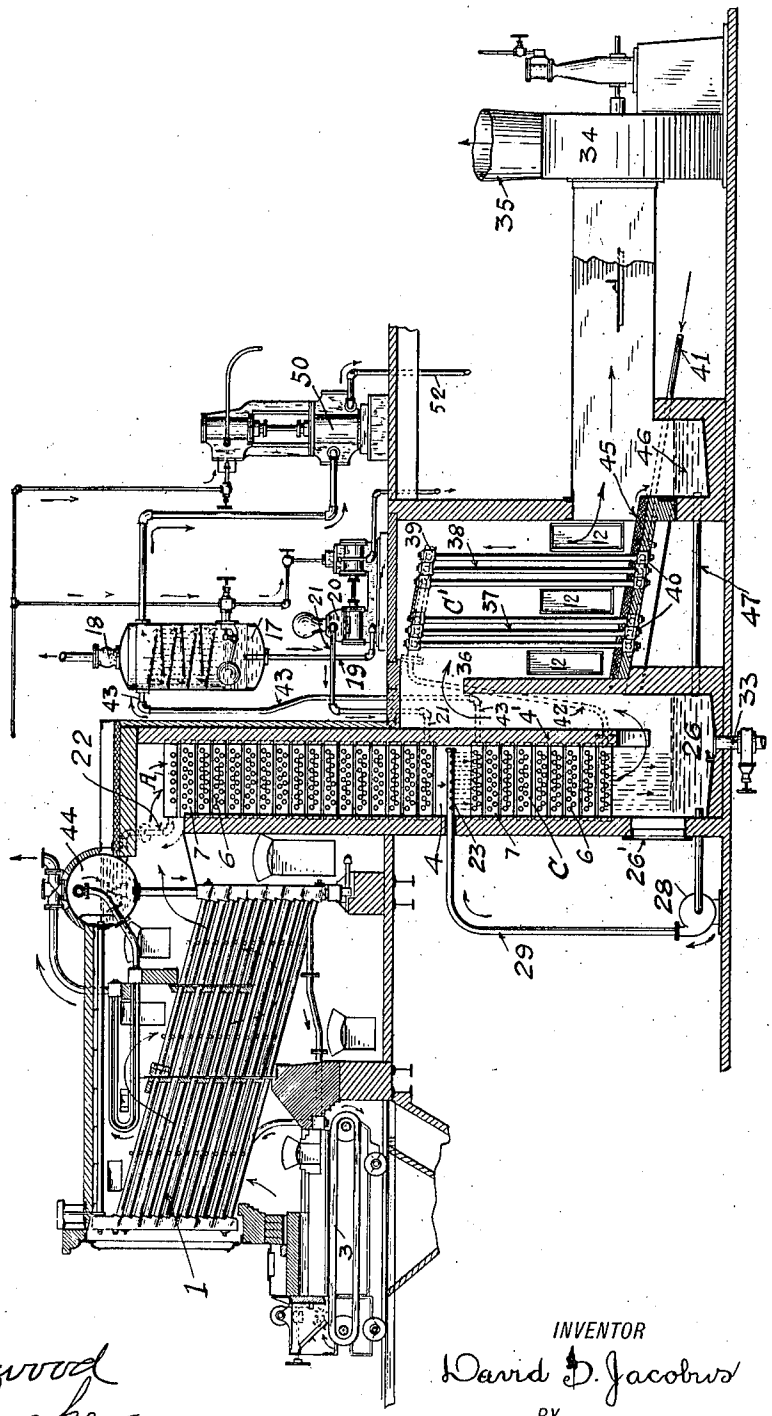
APPLICATION FILED DEC. 8, 1914.

1,281,016.

Patented Oct. 8, 1918.

4 SHEETS—SHEET 2.

Fig. 4.



WITNESSES:

E. M. Lockwood

E. C. Helmcke

INVENTOR

David D. Jacobus

BY

Gifford & Bull

His ATTORNEYS

D. S. JACOBUS.

METHOD OF AND APPARATUS FOR OPERATING STEAM BOILER ECONOMIZERS.

APPLICATION FILED DEC. 8, 1914.

1,281,016.

Patented Oct. 8, 1918.

4 SHEETS—SHEET 3.

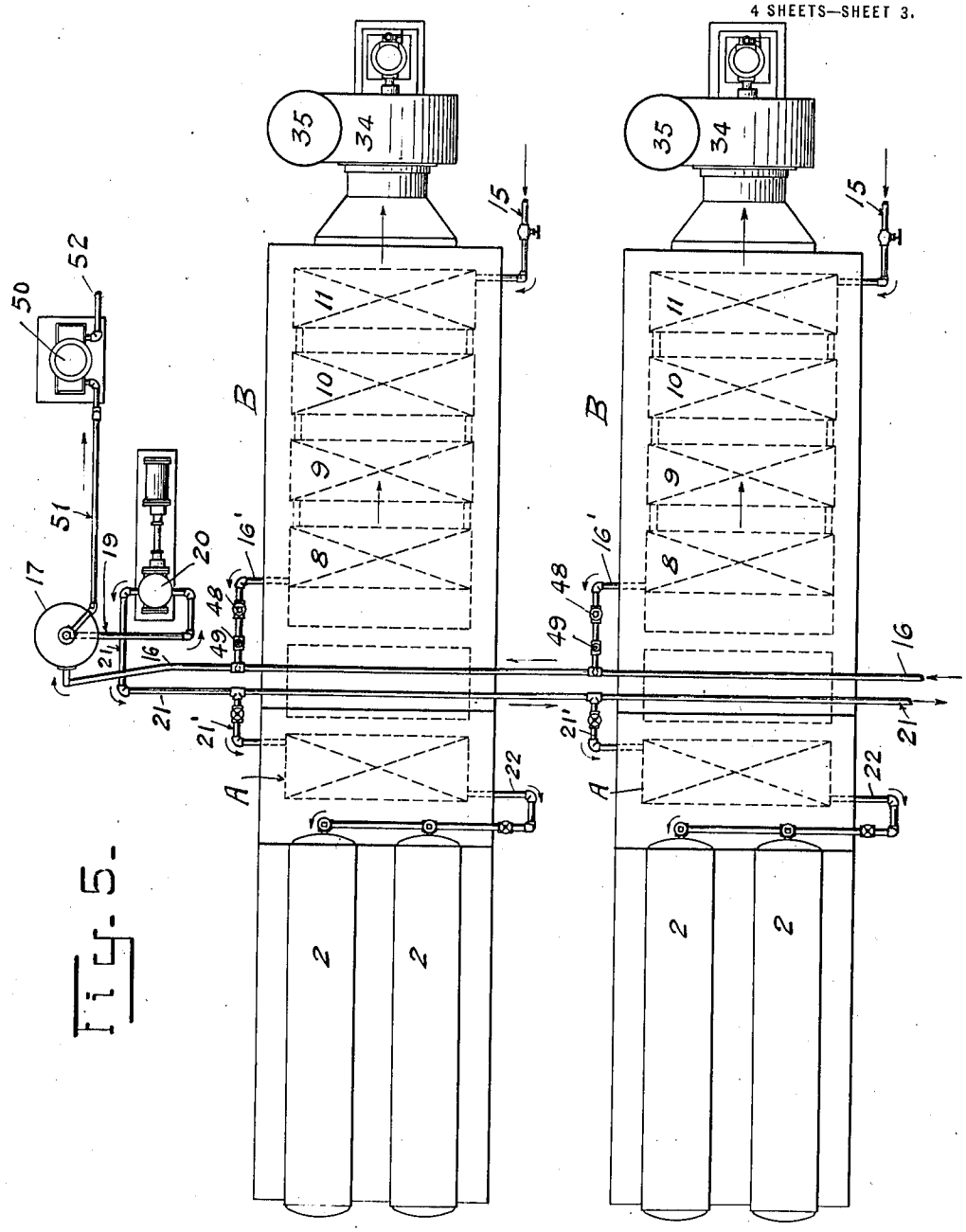


FIG. 5.

WITNESSES:

E. M. Lockwood

M. E. McNinch

INVENTOR

David S. Jacobus,

BY

Gifford & Bull

HIS ATTORNEYS.

D. S. JACOBUS.

METHOD OF AND APPARATUS FOR OPERATING STEAM BOILER ECONOMIZERS.

APPLICATION FILED DEC. 8, 1914.

1,281,016.

Patented Oct. 8, 1918.

4 SHEETS—SHEET 4.

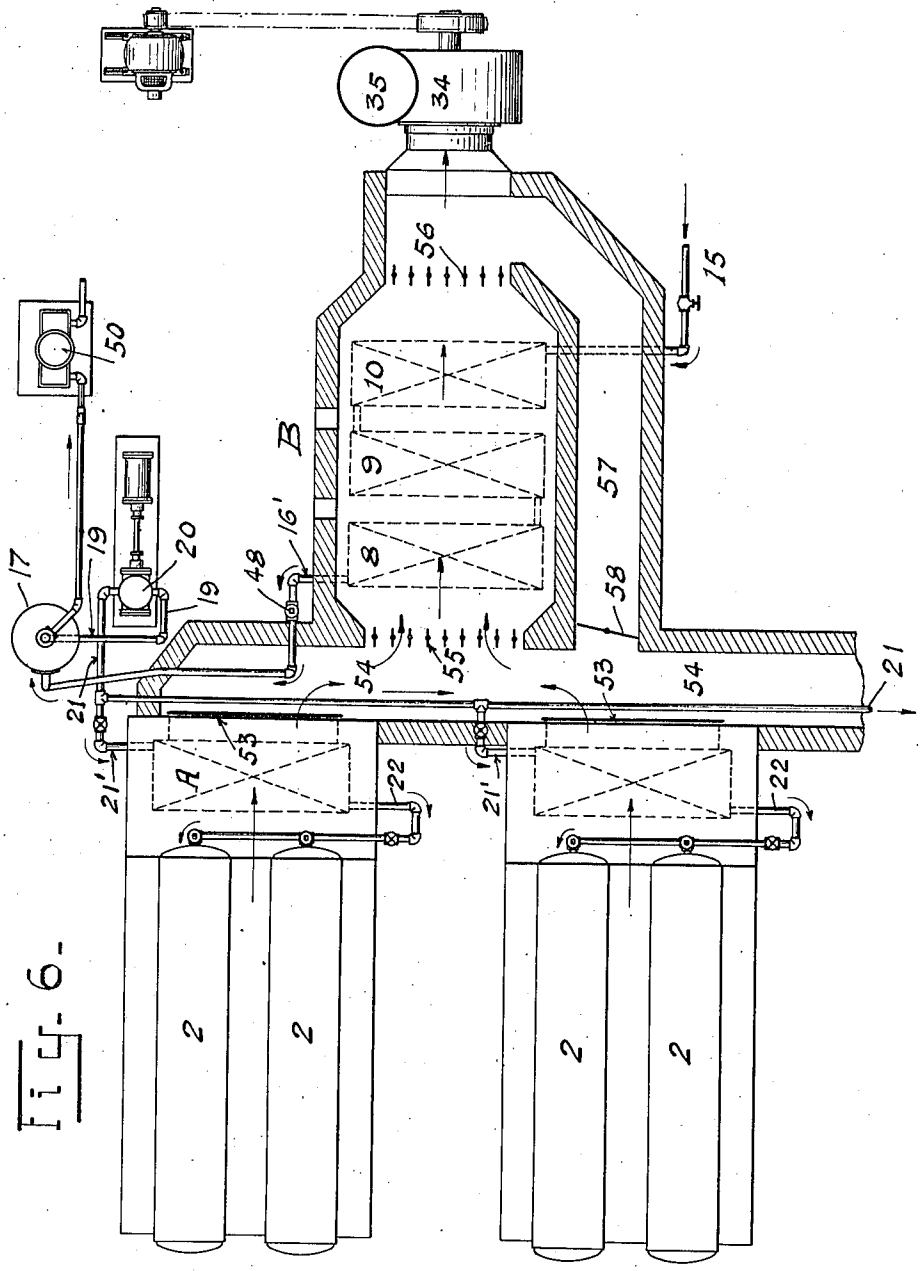


Fig. 6.

WITNESSES:

E. M. Lockwood

M. E. McNinch

INVENTOR

David S. Jacobus.

BY

Gifford & Bull,

His ATTORNEYS

UNITED STATES PATENT OFFICE.

DAVID S. JACOBUS, OF JERSEY CITY, NEW JERSEY, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

METHOD OF AND APPARATUS FOR OPERATING STEAM-BOILER ECONOMIZERS.

1,281,016. Specification of Letters Patent. Patented Oct. 8, 1918.

Application filed December 8, 1914. Serial No. 876,012.

To all whom it may concern:

Be it known that I, DAVID S. JACOBUS, a citizen of the United States, residing at Jersey City, in the county of Hudson and State of New Jersey, have invented certain new and useful Improvements in Methods of and Apparatus for Operating Steam-Boiler Economizers, of which the following is a specification.

The present invention relates to economizer practice and is designed to increase the efficiency of economizers and steam boilers, as well as the efficiency of the entire boiler and economizer system. In this connection the invention is also designed to remove dust, acid fumes and other solids from the waste gases. To that end the invention consists in introducing moisture into the waste gases of the boiler after they have passed one part or section of an economizer, and then passing the moistened and cooled gases over another part or section of the economizer and condensing thereon a portion of the introduced moisture.

This invention differs essentially from the introduction of moisture between a boiler and an economizer in the following features. (1) The introduction of the moisture between sections of an economizer has a much less deleterious effect on the draft resistance of the gases flowing through the boiler to the stack than where moisture is introduced between the boiler and the economizer as a whole. (2) The amount of heat absorbed by the economizer is greater than it would be if the moisture were introduced between the boiler and the economizer. (3) Acid fumes may be condensed and removed between the economizer sections and before the cooled gases reach those parts of the economizer where the moisture would condense.

The invention will be understood by reference to the accompanying drawings in which Figure 1 is a diagrammatic side elevation partly in section of a steam boiler plant embodying my invention; Fig. 2 a rear view of the high pressure stage of the economizer of Fig. 1; Fig. 3 a detail view of one of the sprayer pipes of Fig. 1; Fig. 4 a view similar to Fig. 1 showing a modified arrangement of parts of the plant; Fig. 5 a diagrammatic plan view of a plant showing the application of the invention to a plurality of boilers having a common distributing tank, between the low and high pressure stages of the economizers; and Fig. 6 a diagrammatic plan view of a plant having a common low pressure stage economizer used in connection with a plurality of boilers each of which has a high pressure stage economizer. Similar reference numerals indicate similar parts in the several views.

Referring to Figs. 1, 2 and 3, the numeral 1 designates a boiler of standard design having a longitudinal steam and water drum 2, and fired with a chain grate stoker 3, the waste gases from the boiler escaping through a flue in which the economizer and spraying devices are located. For the purpose of describing one method of practising the invention I have shown a two-stage economizer with means for eliminating the air from the water before it is delivered to the high pressure stage. The latter is designated generally by the letter A and is shown as located in a vertical flue 4, and as subjected to the hottest gases. The low pressure stage is designated generally by the letter B and is shown as located in a horizontal flue 5, and as subjected to the coldest gases. The gases are made to flow in a downward direction over the tubes of the high pressure stage, and the flow of water through said stage is, in general, in the reverse direction of the flow of the gases. The high pressure stage of the economizer is shown in Fig. 2 as consisting of a series of rows of tubes 6 expanded into horizontal boxes or headers 7, said tubes having a slight inclination upward in the direction of the flow of the water. The tubes and boxes are preferably of wrought iron or wrought steel to withstand the high boiler pressure to which this stage of the economizer is subjected.

The low pressure stage is shown as consisting of four separated banks or groups 8, 9, 10 and 11, each of four sections, preferably of cast iron tubes fitted into cast iron horizontal boxes or headers. The spaces between the banks provide for access to the tubes through doors 12. Beneath each of these banks is a pit 12 for collecting steam condensed from the gases, or the water which may be used for washing the outside of the tubes. Scrapers 14 are shown on the tubes of the low pressure stage of the economizer for removing any soot which may be deposited should the economizer be operated for a time without spraying water through the gases. The banks of the low pressure

stage are so connected that the feed water entering through pipe 15 is distributed through the lower connected headers of bank 11 and escapes from said bank through the upper headers thereof to the upper header of the right hand section or row of tubes of bank 10; thence down said section to the lower header thereof from which it is distributed through the remaining lower headers of bank 10, thence upward through the other sections of bank 10 to the corresponding upper headers, and thence in a similar manner through the sections of banks 9 and 8, finally leaving the low pressure stage through the pipe 16 leading to the tank 17. It is to be understood of course that I do not limit myself to this exact connection of the several banks of the low pressure stage. In tank 17 are preferably perforated plates over which the water is made to flow, and by which it is broken up, to facilitate the disengagement and escape of air and gases from the water, such disengagement being assisted by heating the water in the low pressure stage of the economizer, and, if desired, by maintaining a partial vacuum in the tank by any suitable means, such as the dry vacuum pump 50; or the air and gases are permitted to escape through a relief valve 18. From the tank 17 the water is conducted by a pipe 19, to a feed pump 20 which forces it through a pipe 21 to the lower part of the high pressure stage of the economizer. The water enters the lowermost header 7 and flows from side to side, through successive rows of tubes as indicated by the arrows in Fig. 2, and is delivered from the high pressure stage, through pipe 22, into the steam and water drum 2. This flow of the water through the high pressure stage of the economizer provides for a positive circulation, and the passage through tubes all of which are inclined upward with reference to the direction of flow of the water, and, in general in the reverse direction of the flow of the gases.

It is well-known that the rate of heat transfer from steam or liquids to a cooler surface, such as a tube wall, is much higher than the rate of transfer from gases at the same temperature to the same cooler surface, and this principle is utilized by me in the operation of a steam boiler economizer. In the arrangement shown in Fig. 1 I introduce water, or steam, or both, into the gases between the high and low pressure stages of the economizer, one means for such purpose being a series of perforated pipes 23 connected to boxes 24 located in the flue 4 below the high pressure stage A of the economizer. As shown, the wall 4′ of the flue 4 stops short of the bottom of the flue so that the gases will flow through the passage below the wall 4′, and upward to the opening into flue 5, and, if desired, a second series of perforated pipes 25 may be placed at the opening into flue 5. The water or steam is delivered to the pipes 23 and 25 by any suitable means. The water may be supplied to the well 26 at the bottom of the flue 4 by a pipe 27 and pumped from the well by a pump 28, through valved pipes 29 and 30 to the perforated pipes 23 and 25 from which it escapes in fine streams or spray. Any suitable means other than perforated pipes may be used for spraying the water. The water in the well 26 is maintained at a lower level than that in the pits 13 under banks of tubes of the low pressure stage of the economizer, and the water which collects in the pits 13 flows from one to the other through pipe connections 31, passing through the partition walls. These connections are water-sealed to prevent the flue gases being drawn through them. The water which collets in the pit beneath the bank 8 of the low pressure stage flows through a pipe 32 to the well 26, the lower end of the pipe 32 being water-sealed as shown. When the water becomes too foul for use it may be drawn off through a pipe 33 and fresh water supplied to the well 26. When the water is circulated over and over again, a reagent to neutralize the acid fumes absorbed by the water may be added. Instead of circulating the water, the plant may be operated by having a continuous supply of fresh water through pipes 29 and 30, and a continuous withdrawal through pipe 33 with a sufficient supply in the well 26 to maintain a water seal for the pipe 32.

Doors 26′ may be provided in the wall of flue 4 through which access may be had to the well 26 for the purpose of washing out the sediment through pipe 33, or the sediment may be shoveled out through the doors.

When the water is sprayed into the gases, as above described, the water will be partly evaporated and will reduce the temperature of the gases, as a limit, to approximately 212° F., and this will produce a considerable volume of steam which will be condensed as the gases pass over the low pressure stage of the economizer. This cooler stage of the economizer will be more active in absorbing the heat from the steam and moist gases than the same stage would be in absorbing heat from relatively dry gases.

As above stated, steam alone, or steam and water, may be used for moistening and washing the gases. In plants where the main steam motors are run non-condesing, there is a surplus of exhaust steam, and this exhaust steam could be used in place of water. Steam would give additional heat to the economizer and would serve to throw down the cinders.

In addition to the advantage of an increased rate of heat transfer due to the ad-

dition of moisture to the gases, there is a further advantage in that the means described provide for the removal of soot, cinders and tar from the gases. In certain plants there is much trouble with the deposition of tar from the furnace gases on the coolest tubes of the economizer. This tar carries with it soot from the gases, the whole forming a pasty mass which cannot be effectively scraped from the tubes and which collects at the lower ends of the tubes and above the lowermost headers. By using a water spray or steam, in the manner described, the greater part of the tar and the soot will be carried down and deposited in the well 26.

A plant arranged as described is especially useful in connection with boilers for utilizing the waste heat from cement works, as such gases carry a considerable amount of fine dust, a part of which is reclaimed by passing the gases from the kilns through large settling chambers. A certain amount of dust will, however, remain in the gases, and, if an economizer is used which reduces the gases to a temperature at which moisture will be condensed on the outer surfaces of the tubes, this moisture will cause the cement dust to set and harden on the tubes. By using the water or steam spray between the stages of the economizer practically all trace of the dust will be removed before the gases reach the low pressure stage.

In Fig. 4 I have shown a modified arrangement in which a part of the low pressure stage of the economizer, designated generally by the letter C, is located in the lower part of the flue 4 below the high pressure stage A, and another part of the low pressure stage, designated generally by the letter C′, is located in the flue beyond where the water is sprayed through the gases. The low pressure part C comprises a series of tubes expanded into horizontal headers or boxes, and is similar in construction to the high pressure stage A. The tubes and boxes of section C, if of wrought iron or wrought steel, are preferably coated both inside and outside with a protective coating to prevent corrosion. The section C′ of the low pressure stage is shown as consisting of two separated banks 37 and 38 of vertical tubes connected to upper horizontal boxes 39 placed at different levels, and lower horizontal boxes 40 also placed at different levels. In this arrangement the feed water enters pipe 41, and is distributed through the lower boxes 40; and thence flows upward through all of the tubes 37 and 38 and escapes from the upper boxes 39 through pipe 42 to the lower part of section C of the low pressure stage. The water leaves the upper part of said stage through a pipe 43 and is delivered to tank 17 from which it is fed to the lower part of the high pressure stage A by the pump 20. From the high pressure stage the water is forced into the drum 44 of the boiler.

In this arrangement the water spray is introduced through the pipes 23 between the high pressure stage A and the section C of the low pressure stage. That part of the water which is not evaporated after spraying through the gases and after passing over the section C, collects in the well 26 in the lower part of flue 4, from which it is raised by the pump 28 through pipe 29 into the sprayer 23, and may thus be used over and over again, if desired. The gases, after passing over the section C, flow over the section C′ of the low pressure stage where the steam and water vapor is condensed and flows down the inclined floor 45 into a well 46. The latter is connected by pipe 47 with the well 26 to equalize the water levels. The gases finally enter the induced draft fan 34 and from thence are delivered to the stack 35.

All of the advantages incident to the removal of the soot, tar and cinders above set forth, in connection with Fig. 1, obtain in the operation of the plant of Fig. 4. Also there is the substantially greater increase in efficiency due to the greater heat absorption, by reason of the wetting of the surfaces of the tubes of section C of the low pressure stage of the economizer, and the condensation of moisture in the section C′.

In Fig. 5 I have shown, diagrammatically, a plant in which the invention may be practised with a plurality of boilers and economizers the side view of which is shown in Fig. 1. The parts in Fig. 5 are designated by the reference numerals of Fig. 1 and the water spray or steam is introduced as shown in Fig. 1. The feed water enters the low pressure stages of the economizers of all of the boilers through pipes 15, and, after passing through the banks 11, 10, 9 and 8, flows through branch pipes 16′ to a common pipe 16 by which it is delivered to tank 17. The pipes 16′ are provided with valves 48, and thermometers 49, the temperature of the water serving as a guide to regulate the amount of flow. A dry vacuum pump is shown at 50, the air and non-condensable gases withdrawn from tank 17 through pipe 51 being discharged from the pump through pipe 52. From the tank 17 the water is conducted by pipe 19 to pump 20 and by the latter is distributed through the common pipe 21, and branch pipes 21′, into the high pressure stages A of the economizers, and from said stages the water flows through pipes 22 into the steam and water drums 2 of the respective boilers. The amount of water fed to each high pressure stage may be regulated by adjusting the valves in the pipes 21′. The pipes 16 and 21 are shown as open-ended to indicate that

more than two boilers and economizers may be connected to the plant.

In Fig. 6 I have shown, diagrammatically, a plant in which is employed a single low pressure stage, of a two-stage economizer, in connection with two or more boilers each having a high pressure stage. The water spray or steam is introduced into the gases below the high pressure stages. The feed water enters through pipe 15 and, flowing through the low pressure stage, passes by the pipe 16′ into tank 17. From the latter the water is taken by the pump 20 through common pipe 21 to the several high pressure stages, entering the same through the branch connections 21′, the amount of water being regulated by the valves in the pipes 21′. From the high pressure stages the water enters the steam and water drums of the respective boilers through the pipes 22.

The gases leaving the high pressure stages of the economizers pass through the sliding dampers 53 and enter the flue 54 from whence they pass either to the low pressure stage of the economizer through the louver dampers 55, or are by-passed around the economizer through the flue 57. When the low pressure stage of the economizer is in action the dampers 53, 55 and 56 are open and the damper 58 in the by-pass flue is closed. When the economizer is out of action, and the flue gases are by-passed, the dampers 55 and 56 are closed and the by-pass damper 58 is open. The gases finally enter the fan 34 from whence they are forced into the uptake 35. The slide dampers 53 enable one boiler to be cut out without interfering with the running of the others. The pipe 21 is shown as open-ended to indicate that it may be connected to other boilers than those shown; and the flue 54 is also shown as open-ended to indicate that it may serve more than the two boilers shown.

As has been stated, the drawings are diagrammatic. Certain common and well-known features such as safety valves for the economizers have not been shown in order to emphasize the features which apply more particularly to the invention. Regulating the supply of make-up water and of maintaining the proper levels of water in the hot wells as well as regulating the water levels in the mixing tanks or heaters may be carried out in many well-known ways. These are operating features aside from the principles of my invention which I have described.

What I claim and desire to secure by Letters Patent of the United States is:—

1. The herein-described method which consists in reducing the temperature of gases leaving a boiler by causing them to contact with the hotter part or section of an economizer, thereafter introducing sufficient moisture into the cooled gases to cause deposition of the excess moisture, collecting the said deposited moisture with any contained solids, passing the moistened and cooled gases over another cooler part or section of the economizer, condensing on this cooler part of the economizer a portion of the introduced moisture, and feeding water first through the cooler part or section of the economizer and then through the hotter part or section of the economizer, and thence to the boiler.

2. The herein-described method which consists in reducing the temperature of gases leaving a boiler by causing them to contact with the hotter part or section of an economizer, thereafter introducing sufficient moisture into the cooled gases to cause deposition of the excess moisture, collecting and reintroducing the collected moisture to the gases after contacting with the hotter part or section of the economizer, and passing the moistened and cooled gases over another cooler part or section of the economizer.

3. The herein described method which consists in feeding water into a low pressure section of an economizer, thereafter forcing the water through a high pressure economizer section and thence into a boiler, maintaining different pressures in said economizer sections, passing the gases from a boiler over the high pressure economizer section, then introducing moisture into the cooled gases, and then passing the moistened and cooled gases over the low pressure economizer section, and condensing thereon a portion of the introduced moisture.

4. In a steam boiler plant, an economizer having separated low and high pressure stages, means for maintaining different pressures in said stages, and means for introducing moisture into the gases after they flow over the high pressure stage, the succeeding low pressure stage or stages being arranged to condense a portion of the introduced moisture.

5. In a steam boiler plant, an economizer having a high pressure stage and a low pressure stage, said low pressure stage comprising separated banks or groups of sections of tubes, and means for adding water vapor to the gases after they leave the high pressure stage and before they flow over the low pressure stage.

6. In combination, a steam boiler, an economizer comprising separated banks or groups of sections of tubes, means for moistening the gases, and an inclosing casing for the economizer, the lower part of which is formed with pits to receive condensed vapors from the gases, and water sealed connections between the pits.

7. In combination, a steam boiler having a chamber through which the gases are caused to flow, means for introducing water or steam into the gases in said chamber, an

economizer over which the gases are caused to flow after leaving said chamber, partition walls in the lower part of the economizer casing to form pits to receive the condensed vapors from the gases, water-sealed connections between said pits, and means for conducting the condensed vapors therefrom to said chamber.

In testimony whereof I have hereunto signed my name in the presence of two subscribing witnesses.

DAVID S. JACOBUS.

Witnesses:
M. E. McNINCH,
CHARLES S. JONES.