Feb. 9, 1971 R. K. ALLEN ET AL 3,561,922

WASTE SULPHITE LIQUOR RECOVERY

Original Filed Sept. 16, 1965 5 Sheets-Sheet 1

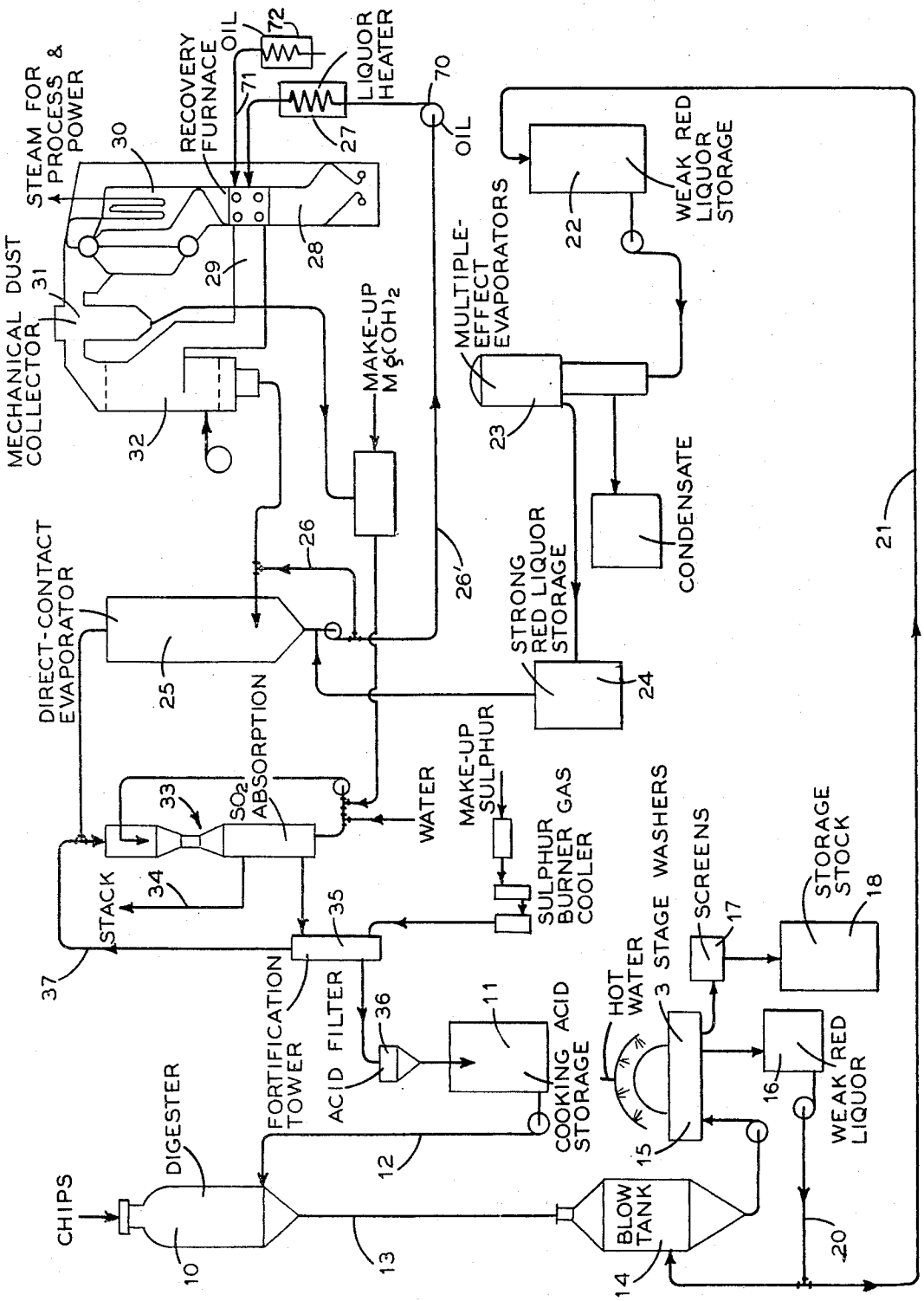


FIG. 1

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FIG. 2

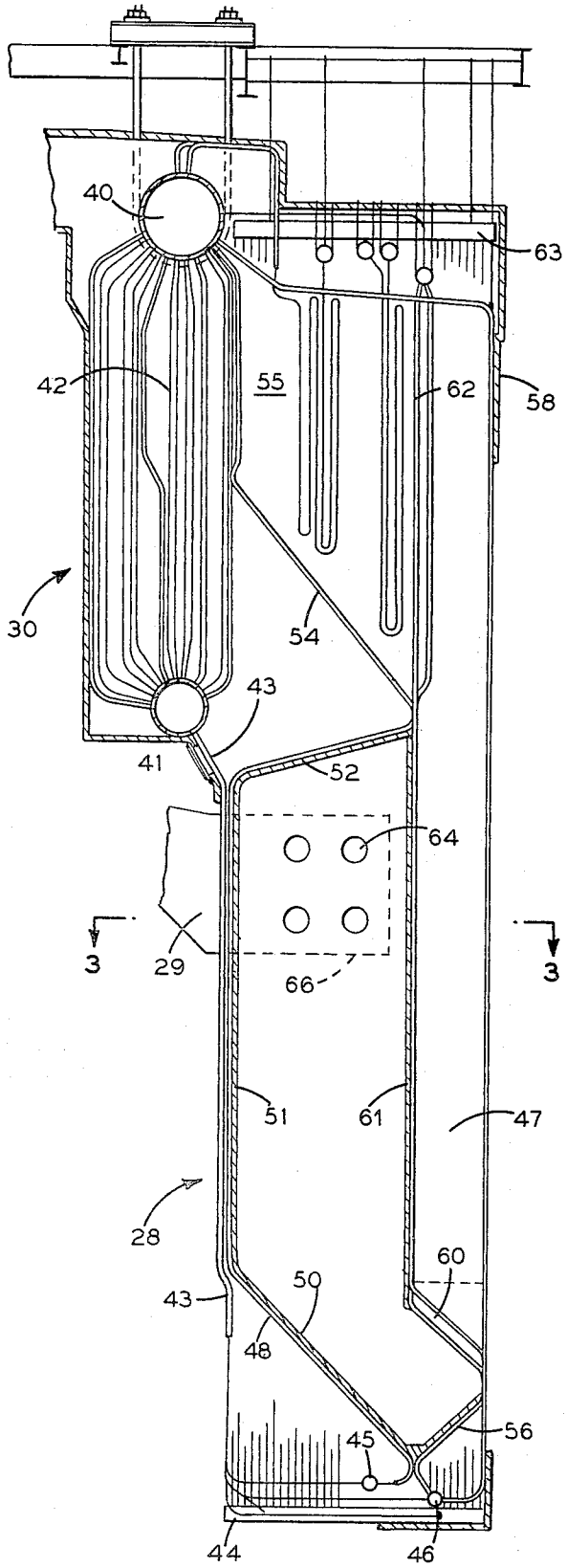

40
63
42
55
62
58
30
54
43
41
52
64
3
29
66
3
51
61
47
28
60
50
43
48
56
45
44
46

FIG. 3

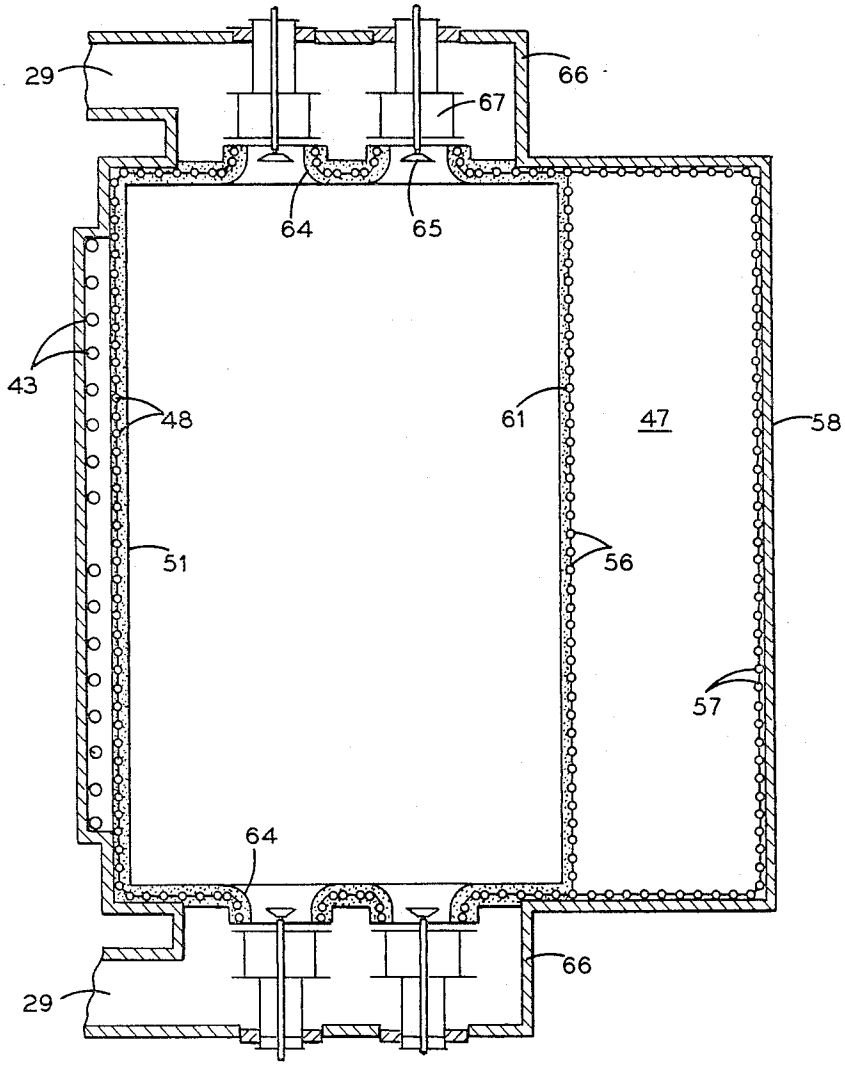
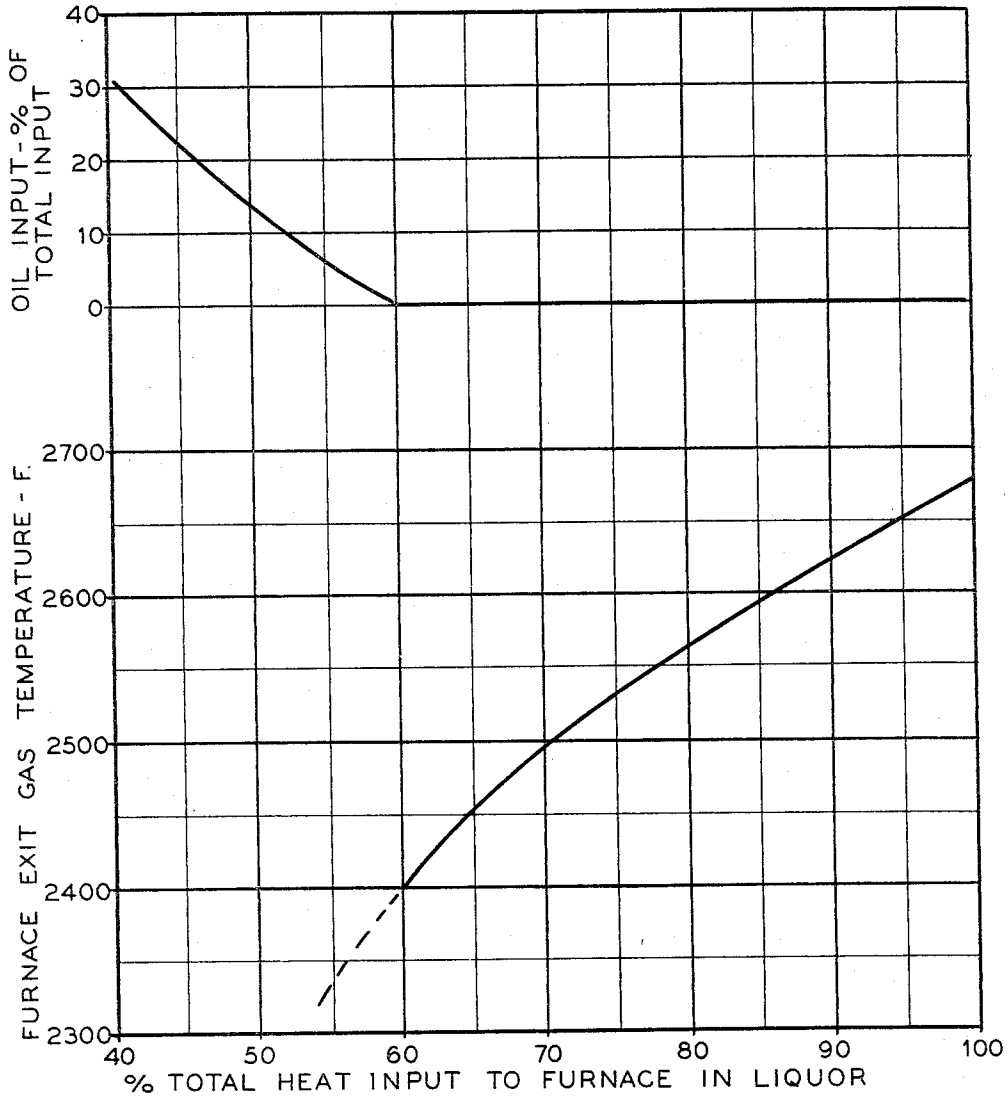


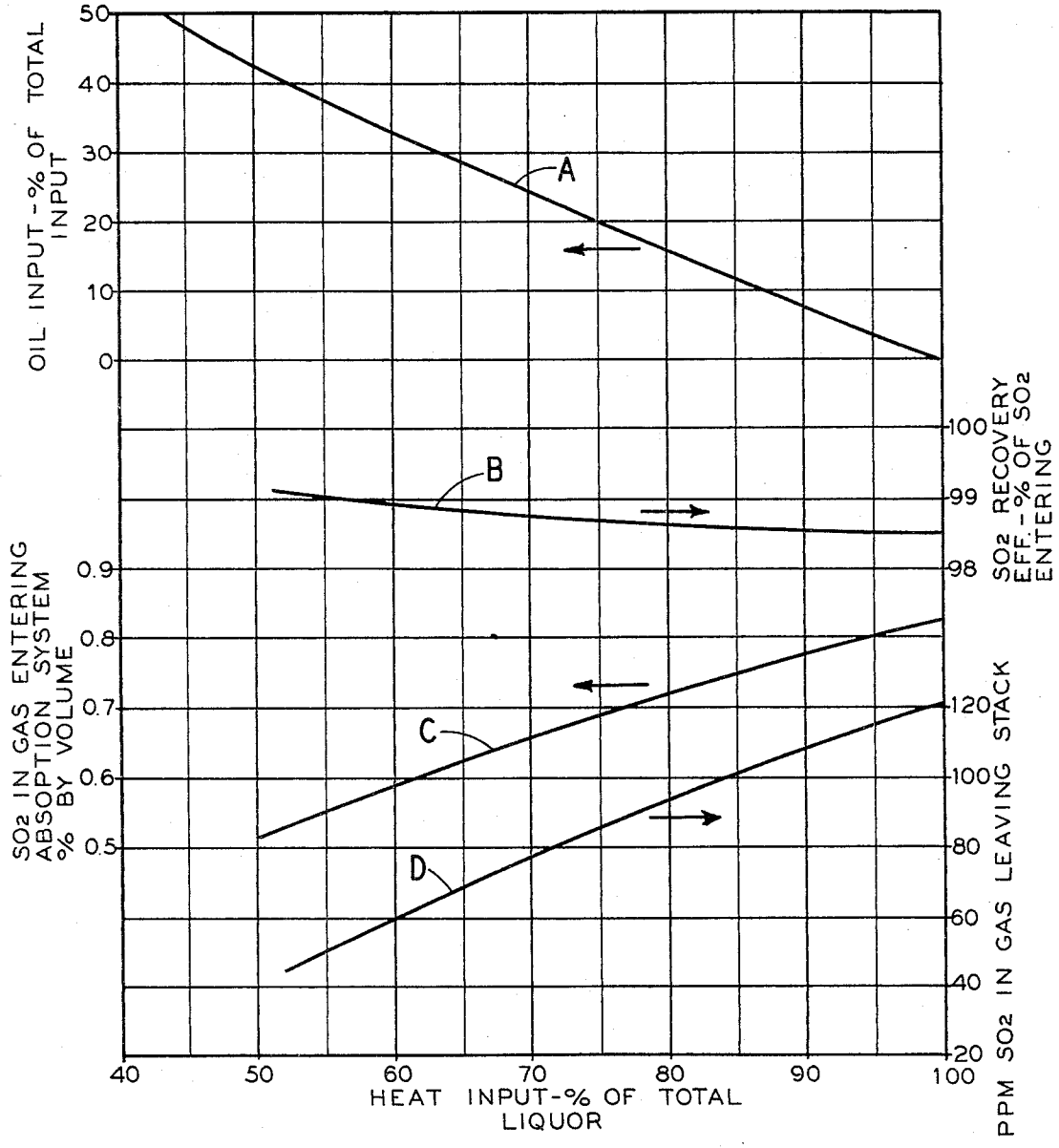
FIG. 4


OIL INPUT - % OF TOTAL INPUT
40
30
20
10
0
FURNACE EXIT GAS TEMPERATURE - F.
2700
2600
2500
2400
2300
40
50
60
70
80
90
100
% TOTAL HEAT INPUT TO FURNACE IN LIQUOR

WASTE SULPHITE LIQUOR RECOVERY

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FIG.5



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3,561,922

WASTE SULPHITE LIQUOR RECOVERY

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Continuation of application Ser. No. 487,869, Sept. 16, 1965. This application Sept. 8, 1969, Ser. No. 860,151
Int. Cl. D21c 11/12; C01f 5/06
U.S. Cl. 23—201 4 Claims

ABSTRACT OF THE DISCLOSURE

A chemical and heat recovery system wherein magnesium base pulp residual liquor is burned in a fluid cooled furnace to produce particle-form magnesium oxide and sulphur dioxide. Supplemental fuel is added when necessary with the pulp residual liquor to maintain combustion gas temperatures above a predetermined value to eliminate carbon particles from the combustion products. Combustion air delivered to the furnace with either or both fuels is closely controlled to avoid formation of sulphur trioxide in the products of combustion.

This application is a streamlined continuation of application Ser. No. 487,869, filed Sept. 16, 1965 now abandoned.

The present invention relates to the recovery of chemicals and heat from the incineration of residual liquor resulting from the digestion of cellulosic fibrous material in the wood pulping process, and more particularly to a method of and apparatus for the incineration of a residual liquor resulting from the digestion of wood in a relatively pure magnesium base sulphite cooking liquor.

The inorganic chemicals used for cooking and contained in the residual liquor obtained in a cellulosic pulping process utilizing a relatively pure magnesium base cooking liquor can be converted to a recoverable state by the incineration of the liquor. Such a process and the apparatus therefore is disclosed in U.S. Pat. 2,354,175. As disclosed in the patent, the residual liquor is incinerated under controlled combustion conditions where the noncombustable magnesium compounds are converted to dry magnesium oxide particles, and the sulphur content is converted to gaseous sulphur dioxide. The combustible organic constituents of the residual liquor are burned and release heat which is useable in generating steam by heat absorption in a suitable heat exchanger.

In the incineration of the residual liquor from magnesium base cooking liquor the combustion requirements are exacting to attain satisfactory results for subsequent chemical recovery. The resiual liquor is burned in suspension under combustion conditions involving a minimum time at a temperature sufficient to consume all of the carbon in the liquor and to avoid over burning of the magnesium oxide formed during the process. Furthermore, it is extremely desirable to complete the combustion reaction with a minimum of excess air so as to minimize the formation of SO_3 and subsequent formation of magnesium sulfate. The magnesium oxide particles formed during the controlled combustion process are separated from the entraining gas, mixed with water and subsequently reacted with the SO_2 in the combustion gases to form cooking liquor. Depending upon the composition of the desired cooking liquor, the liquor prepared by contact between the SO_2 containing combustion gases and the slurry of magnesium oxide particles with water may be enriched by SO_2 gases produced in a sulphur burner.

Heretofore, it had been believed a refractory furnace was desirable for proper treatment of the residual liquor prior to chemical recovery. This belief was based on the desirability of maintaining a relatively high temperature in the furnace during incineration of the liquor and the stored heat of the walls was believed advantageous in maintaining such relatively high temperatures. While experience has indicated that furnace temperatures must be maintained above a minimum value to insure complete combustion of the carbon content of the liquor it has also been found in refractory type furnaces that there is a maximum temperature to which the refractory may be exposed before the refractory furnace walls will spall. Thus when the liquor delivery rate, on either a B.t.u. or weight basis, was below a selected rate it would be necessary to add a supplemental fuel such as fuel oil or natural gas to the furnace to maintain the temperature above the minimum chemical reaction temperature established for any particular furnace. Experience has indicated that the amount of supplemental fuel added to the residual liquor by mixing therewith, or by separate introduction to the furnace, is limited by the ability of the refractory materials in the furnace walls to withstand the temperatures generated.

In accordance with the present invention, we have found that a refractory furnace can be replaced by a fluid cooled furnace, and while it is desirable to increase the liquor concentration above the values heretofore in use, such fuel can be successfully burned in the fluid cooled furnace with adequate chemical conversion. Furthermore, with a fluid cooled furnace it becomes possible to add supplemental fluid to the furnace in any desired quantities within the steaming capacity of the unit associated with the fluid cooled walls. Moreover, a fluid cooled furnace constructed of coplanar tubes covered by refractory material to form the boundaries of the furnace lends itself to a reduction in furnace maintenance costs. In addition, such a furnace construction can minimize infiltration of air and can be pressurized sufficiently to eliminate the use of induced draft fans, if such is desired.

The various features of novelty which characterize our invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described a preferred embodiment of the invention.

Of the drawings:

FIG. 1 is a schematic diagram of a pulp digestion and chemical recovery system;

FIG. 2 is an elevation, in section, of the furnace shown in FIG. 1 and constructed in accordance with the present invention;

FIG. 3 is a plan section taken along line 3—3 of FIG. 2; and

FIGS. 4 and 5 are charts showing the effect of changes in residual liquor and supplementary fuel inputs to the furnace and the chemical recovery system shown in FIG. 1.

The schematic diagram of the magnesium base pulping and chemical recovery system shown in FIG. 1 is generally similar to the system shown in U.S. Pat. 2,354,175, and illustrates the system in which the present invention is incorporated.

As shown in FIG. 1 wood chips are placed in a digester 10 where they are treated under selected time and temperature conditions, in contact with cooking liquor. The cooking liquor is delivered from storage tank 11 through line 12 to the digester 10. The wood pulp, with its residual liquor, is dicharged from the digester through pipe 13 to

a blow tank **14** with the pulp and residual liquor passed through multiple stage washers **15** where the separated residual liquor is discharged to a weak liquor storage tank **16**. At the same time the pulp from the washers is passed over screens **17** for delivery to a stock storage tank **18**.

The weak liquor is pumped from the tank **16** through a line **20** where controlled amounts of the liquor may be recirculated to the blow tank **14**, and the remainder of the liquor passed through the pipe **21** to a weak liquor storage tank **22**. The weak liquor is pumped from storage to multiple effect evaporator **23** where the liquor is partially concentrated and delivered to a strong liquor storage tank **24**.

As shown in FIG. 1 the strong liquor in the tank **24** is passed to a liquor discharge line from a direct contact evaporator **25**. The liquor from the evaporator **25** is selectively pumped through a pipe line **26** for spray introduction into a stream of hot flue gases which is tangentially delivered to a lower portion of the evaporator **25**, with the concentrated liquor centrifugally separated from the gases therein. The remaining portion of the concentrated residual liquor is passed through line **26** and heater **27** to the nozzles of a recovery furnace **28** where the liquor is burned as hereinafter described for the formation of SO_2 containing gases and dry magnesium oxide solids. The hot gases from the furnace **28** are passed over heat exchange surfaces of a vapor generator **30** where the gases are cooled prior to discharge to a mechanical collector **31**. Leaving the collector **31** the gases are passed through an indirect contact tubular air heater **32** before discharge into the evaporator **25**. The air heated in the air heater **32** is passed through duct **29** to the furnace **28** to aid in the combustion of the concentrated residual liquor, as hereinafter described.

The gases leaving the direct contact evaporator are passed through an SO_2 absorption apparatus indicated generally by the numeral **33**. In the SO_2 absorption apparatus **33** the gases of combustion are intimately contacted by liquor sprays containing magnesium mono-sulfite for absorption of the SO_2 and the formation of magnesium bisulfite. The gases leaving the absorption apparatus **33** are thereafter passed to the atmosphere through a stack **34**. The liquid, containing magnesium bi-sulfite, passes from the absorption apparatus **33** to a fortification tower **35** where the SO_2 content of the liquor may be increased by contact with SO_2 gases formed by the combustion of sulfur. The enriched liquor is thereafter passed through a filter **36** to the cooking liquor storage tank **11**.

It will be understood that the SO_2 content of the cooking liquor delivered to the tank **11** may be of substantially any desired composition. Changes in composition will necessitate changes in the SO_2 absorption equipment, and in some instances it may not be necessary to use a fortification tower such as that indicated in FIG. 1. When the fortification tower is used it is customary to pass any excess SO_2 gases from the fortification tower directly to the absorption apparatus **33**, as through a duct **37**.

In the enlarged elevation view of the furnace **28** and boiler **30** shown in FIG. 2, the furnace is bounded by rows of fluid cooled tubes connected into the circulatory system of the boiler. The boiler is of the well known two drum type having spaced upper and lower drums, **40** and **41** respectively, connected by generally upright tube banks **42**.

The lower drum **41** is provided with a row of down comers **43** (see also FIG. 3) opening to lower headers **44**, **45** and **46** for a supply of fluid to the wall tubes of the furnace and an upright gas pass **47**. The lower header **45** supplies fluid to a row of tubes **48** in the inclined floor **50**, front wall **51** and an inclined roof **52** of the furnace **28**. Above the upper end of the roof **52** the tubes **48** are reversely inclined to a position intermediate upper and lower drums **40** and **41**, respectively, to form the floor **54** of a gas pass **55** connecting the upper portion of the gas pass **47** with the banks of tubes

42 and are extended upwardly to open into the upper drum **40**.

The header **46** supplies fluid to a row of tubes **56** which are upwardly inclined toward the lower end portions of the tubes **48** with which they coperate to close the lower end of the furnace **28**. The tubes **56** are thereafter inclined upwardly and rearwardly substantially into the plane of a row of tubes **57** which extend upwardly from the header **46** to define the rear wall **58** of the gas pass **47**. The tubes are spaced apart and extend upwardly and forwardly to provide a gas outlet **60** from the furnace **28** into the gas pass **47**. Thereafter the tubes extend upwardly to form part of the rear wall **61** of the furnace and the front wall of the gas pass **47**. Above the roof of the furnace the tubes **56** are spaced apart to form a screen **62** between the gas passes **47** and **55**, and open to the drum **40**.

The headers **44** provide fluid for the side wall tubes which extend upwardly to corresponding upper side wall headers **63** so as to define the side walls of both the furnace **28** and the gas passes **47** and **55**. The tubes defining the walls of the furnace **27** are lined with refractory material.

The furnace **28** is provided with burner ports **64** formed in the upper end portion of the side walls in opposing relationship. In the embodiment shown, the ports **64** are each provided with a burner **65** for the admission of either residual pulp liquor or fuel oil, as hereinafter described. Each group of side wall burner ports is enclosed by a manifold **66** which receives combustion air from the duct **29** and the air heater **32** shown in FIG. 1. Each of the burners **65** is associated with an air register **67** which receives the combustion air from the manifold **66** so that the air flow to each individual burner **65** may be regulated. A suitable burner for residual liquor is disclosed in U.S. Patent 2,812,212.

In the operations of the furnace, burning residual liquor fuel is delivered to each of the burners **65** through a piping system **26'** (see FIG. 1) with the stream of liquor impinging upon the corresponding streams of liquor discharged through the opposite burner. The impinging of the streams of liquor leads to turbulent mixing, within the furnace, of the liquor and combustion air for the ignition and incineration of the liquor. It has been found desirable to provide sufficient space between the upper row of ports **64** and the roof **52** to permit some combustion above the burners. This has been found to improve ignition and incineration of the liquor.

As hereinafter discussed in connection with the operation of the combustion and secondary recovery system it is desirable, and in fact necessary, to introduce supplemental fuel into the furnace **28** during periods of low load operation. This has been accomplished by mixing fuel oil, for example, into the liquor delivered to the burners **65** as at the pump **70** or alternately, it has been found desirable to convert an opposed pair of burners **65** to fuel oil burners by the insertion of suitable atomizers in the burners. Under these conditions the fuel pipe leading to a converted burner **65** would be supplied fuel oil through pipe **71** and heater **72** connected to opposed burners.

For proper incineration of the residual liquor it has been found necessary to maintain a combustion gas temperature leaving the furnace through the gas outlet **60** of a predetermined value so as to insure complete combustion of the carbon constituents in the fuel. Such a minimum temperature is usually determined in any particular installation by the use of a thermo-couple imbedded in the wall of the furnace adjacent the burners.

In any installation the temperature values determined by the thermo-couple will be relative and not a true indication of the temperature within the furnace. For example, for a desired minimum temperature of 240° F. leaving the gas outlet **60** the temperature reading of the thermo-couple may also be 240° F. even though this

would obviously not be a true temperature value. However any changes within the furnace would cause a generally proportional change in the readings of a thermocouple, and can serve as an operating guide.

It will also be understood that any selected temperature value indicating minimum gas temperatures leaving the furnace will be dependent upon the configuration of the furnace. For example, the physical dimensions of any particular furnace will change according to its designed capacity so that the ratio of furnace volume to the area of peripheral wall area of the furnace will also differ and will influence the temperature of the gases leaving the furnace. With the minimum temperature for a particular furnace configuration established it will be also necessary to insure retention of the fuel within the furnace for a sufficient length of time to complete the combustion reactions. Generally speaking a gas retention time within the furnace of 1.5 seconds at or above the minimum selected temperature will be sufficient for carbon consumption.

The curve in FIG. 4 illustrates the operation of the unit of FIG. 2 when fired by magnesium base residual pulp liquor. The abscissa reflects the B.t.u. imput of fuel to the furnace as a percent of full furnace rating, on an assumed fuel value which would be typical of a magnesium base residual liquor recovery unit. The curve shows the nature of the decrease in furnace exit gas temperature as the percent of liquor imput is decreased. At a furnace fuel imput of 60 percent the furnace exit gas temperature has decreased to 240° F. Assuming, as hereinbefore pointed out, that the exit gas temperature in this particular furnace must be in excess of 240° F. to achieve complete combustion of the liquor, i.e., to completely burn the carbon in the ash, the 240° F. minimum is maintained at the lower ratings by the addition of fuel oil to the furnace. The amount of oil addition is shown by the curve of the oil input as a percentage of the total heat input to the furnace.

It will be understood that a change in the concentration, or the B.t.u. value, of the residual liquor from the assumed basis would change the terminal points of the illustrated curve and, to some extent, the slope of the curve.

In addition to the effect of temperature on furnace operations to produce reactive magnesia therein with an absence or minimum of carbon in the products leaving the furnace, the operations of the furnace will also affect the operation of the SO_2 absorption apparatus **33** of the system shown in FIG. 1. As the load on the furnace is decreased below 60 percent and oil added to maintain the furnace exit gas temperature (FIG. 4) the concentration of SO_2 in the combustion gases is decreased by the dilution effect of the oil combustion products. For example, if it is assumed the liquor leaving the SO_2 absorption apparatus **33** (FIG. 1) and entering the tower **35** has an acid strength of 4.5 percent total SO_2 and 2.5 percent combined SO_2, the partial pressure of SO_2 in the flue gases at 45% of liquor input with oil addition (as shown in FIG. 4) to maintain furnace temperature would equal the partial pressure of SO_2 in the acid. Furnace operation at liquor input rates less than 45% would necessitate a reduction in the acid strength produced in the absorption apparatus or a reduction in the SO_2 absorption efficiency.

Where the curves of FIG. 4 illustrate the effect on the furnace of FIG. 2 when firing liquor with or without the addition of fuel oil, the curves of FIG. 5 illustrate the effect of burning residual liquor while adding sufficient oil to the furnace to maintain the full capacity of the vapor generator or boiler. In other words where FIG. 4 illustrates the operation of the recovery system primarily for chemical recovery purposes with an incidental production of steam in the boiler. FIG. 5 illustrates operations when utilizing the equipment primarily for power generating purposes and incidental chemical recovery.

Referring to FIG. 5 it will be noted that the topmost curve A illustrates the amount of oil added to the furnace in relationship to the amount of residual liquor delivered to the furnace to maintain full capacity of the boiler. The curve B illustrates the efficiency of SO_2 recovery in the apparatus **33** of FIG. 1 when operating under the acid strengths previously assumed, and under the fuel firing conditions of curve A. Curve C illustrates the SO_2 in the gas entering the absorption system, and indicates the dilution effect from the combustion of increasing quantities of oil with a decrease in the amount of liquor burned. Curve D illustrates the p.p.m. of the SO_2 leaving the stack at different proportions of liquor and oil firing in the furnace. It will be appreciated that the curves of FIG. 5 are illustrative of a particular set of conditions in a heat and chemical unit such as depicted in FIGS. 1 and 2.

If the SO_2 absorption apparatus **33** (FIG. 1) is initially producing an acid having 4.5 percent total SO_2 and 2.5 percent combined SO_2, as in the previous example considered in connection with the operation of the unit according to the procedure illustrated in FIG. 4, the partial pressure of the SO_2 in the flue gases will equal the SO_2 partial pressure of the acid at a liquor heat input of 73 percent when operated according to the procedure illustrated in FIG. 5. When the liquor input to the furnace is below 73 percent of the total heat input, the acid strength may be reduced or the efficiency of SO_2 absorption may be reduced. Alternately, liquor firing may be discontinued and the furnace and boiler may be operated on fuel oil alone without any attempt to operate the liquor apparatus. Under these conditions the flue gases may be by-passed to the atmosphere without passing through the evaporator **25** or the absorption apparatus **33**.

It will be understood that a furnace illustrated in FIG. 2 is particularly adapted for operations under the conditions exemplified in either FIG. 4 or FIG. 5. This is in contrast to the refractory furnaces heretofore in commercial use wherein the addition of oil as supplementary fuel to the furnace has been limited by the ability of the refractory materials therein to withstand the furnace temperatures created during fuel combustion.

While in accordance with the provisions of the statutes we have illustrated and described herein the best form and mode of operation of the invention now known to us, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a chemical recovery system for the incineration of magnesium base pulp residual liquor wherein walls define an upwardly elongated furnace having vapor generating tubes in the furnace walls and the furnace is provided with a gas outlet at one end portion and opposed burners positioned in the opposite end portion thereof for the admission of fuel thereto, the method of operating said furnace which comprises firing said magnesium base pulp residual liquor through an upper range of liquor flow rates to convert the magnesium contents of said liquor to dry magnesium oxide particles which are entrained by and leave said furnace with the gases of liquor combustion while maintaining a selected gas temperature within said furnace to minimize the presence of unburned carbon in the gases leaving said furnace, supplementing the combustion of said residual liquor in an intermediate range of liquor flow rates by the addition of supplementary fuel to said furnace to maintain said furnace temperature above said selected temperature, discontinuing the supply of liquor to said furnace when the liquor flow rate decreases to a predetermined minimum rate, and firing said furnace with said supplementary fuel at a

selected rate to generate a desired vapor flow rate from said vapor generating tubes.

2. In the system of claim 1 wherein said supplementary fuel is fuel oil.

3. In the system of claim 2 wherein the fuel oil is added to said furnace separately from said residual pulp liquor.

4. In the system of claim 1 wherein the sulphur content of said liquor is converted to gaseous sulphur dioxide in said furnace and the combustion air flow to said furnace is controlled to minimize the formation of sulphur trioxide.

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JAMES H. TAYMAN, JR., Primary Examiner

U.S. Cl. X.R.

23—48, 277, 262; 110—1; 122—7; 162—30