

Aug. 28, 1934.

K. M. WATSON ET AL

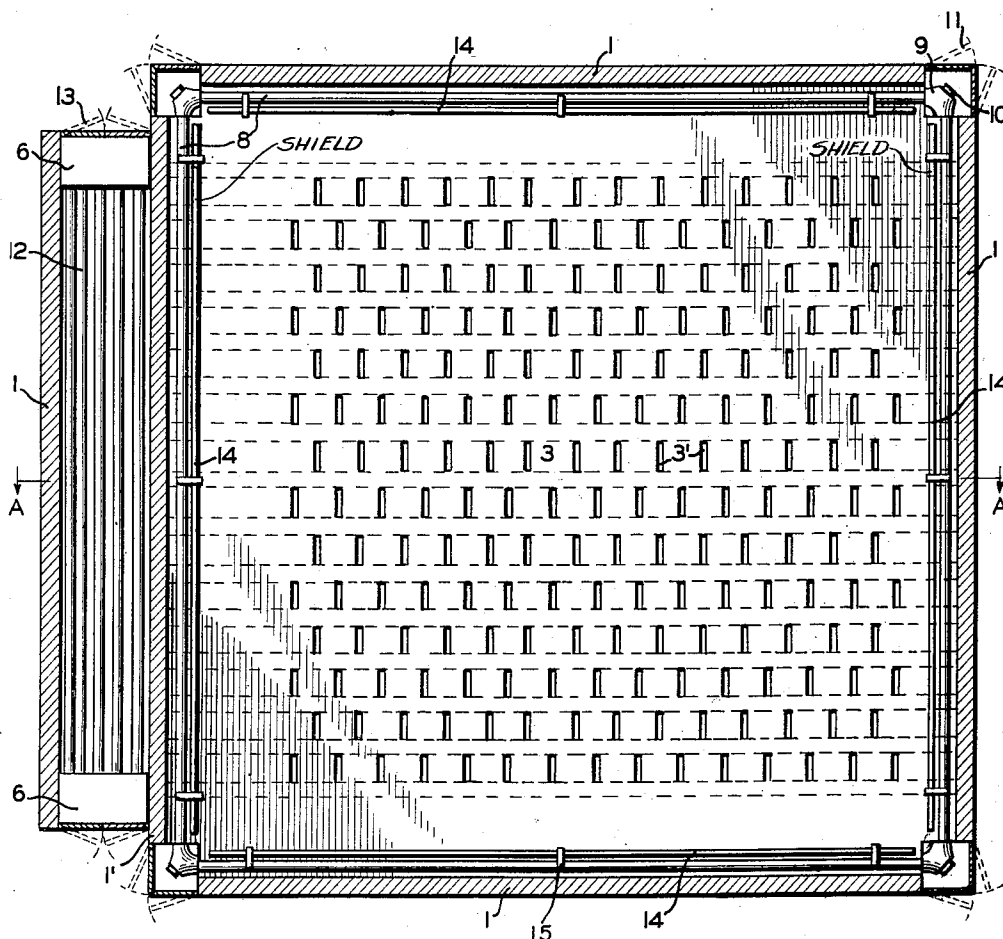
1,971,925

METHOD FOR HEATING

Filed April 9, 1931

3 Sheets-Sheet 1

Fig 1



Witness:

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3 Sheets-Sheet 2

Fig. 2

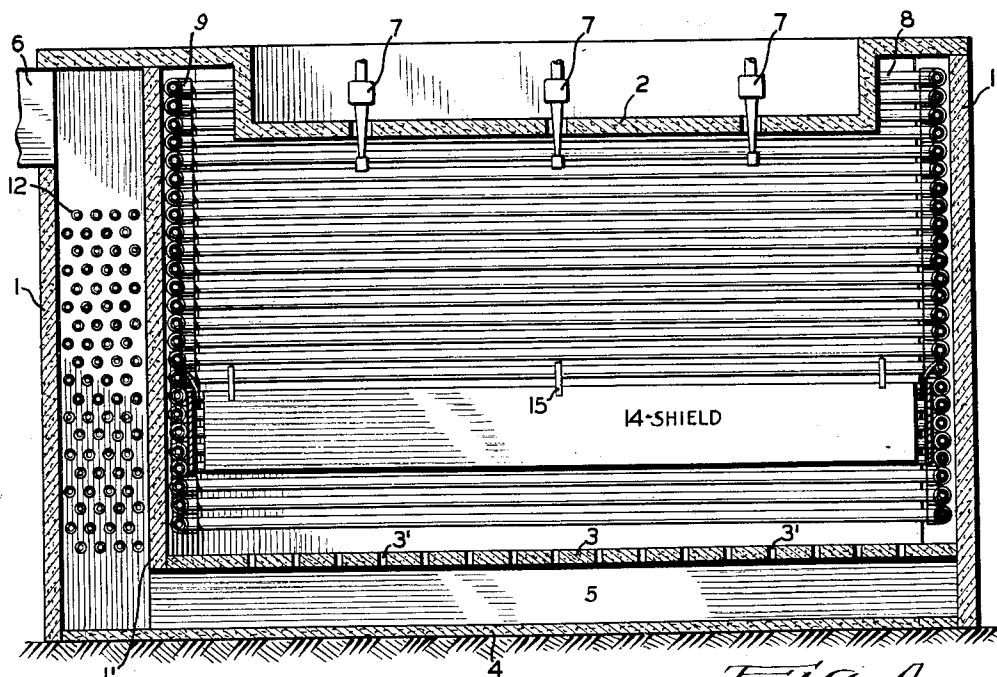
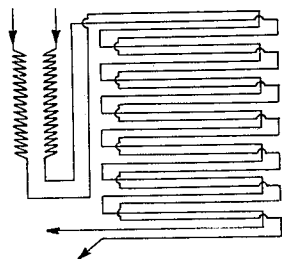


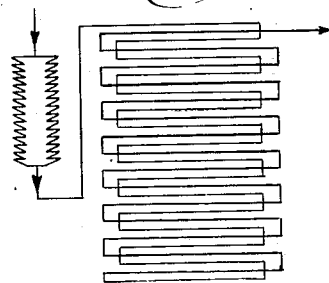
Fig. 3



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Fig. 4



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Fig. 5.

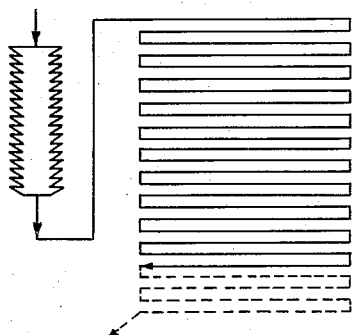


Fig. 6.

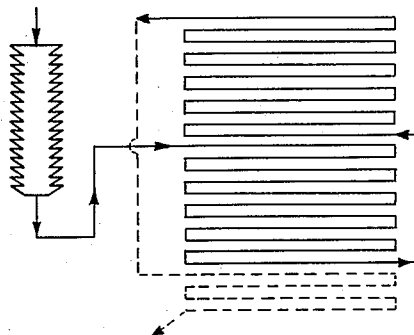


Fig. 7.

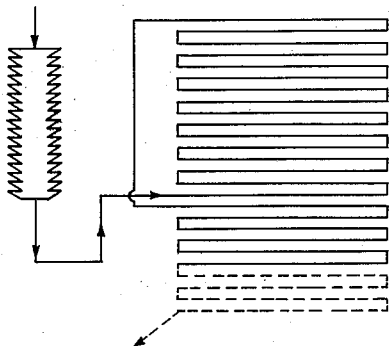


Fig. 8.

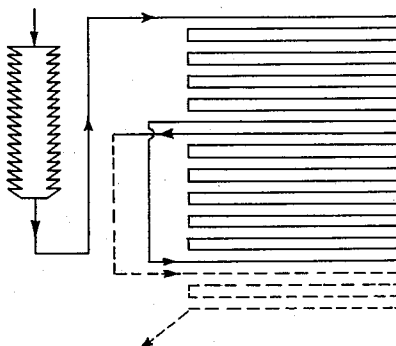
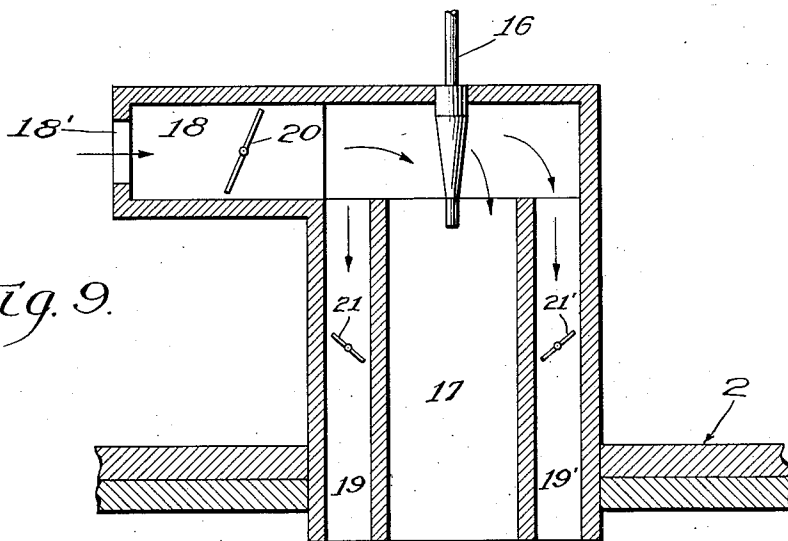


Fig. 9.



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UNITED STATES PATENT OFFICE

1,971,925

METHOD FOR HEATING

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Application April 9, 1931, Serial No. 528,728.

3 Claims. (Cl. 196—116)

This invention relates to improvements in a method for heating, and refers more particularly to a furnace which may be employed in the heating of fluids, such as petroleum oils, and the like.

More specifically, the invention contemplates the provision of a method possessing novel features of construction which eliminate the normal disadvantages inherent in types commonly employed in such heating. In present methods of oil refining, wherein hydrocarbon oil mixtures may be separated into fractions of relatively narrow boiling point ranges in fractionating equipment, or the relatively heavy portions thereof may be subjected to elevated temperatures and pressures to convert the same into lower boiling point fractions, said hydrocarbon oils may be charged through various arrangements of tubular elements disposed within furnace settings in order to impart to such oils the necessary heat to effect their fractionation or conversion. The method of passing oils through tubular heating elements or pipes of relatively small diameter, was evolved from the original ideas of batch heating in large containers, with the object of increasing the efficiency of heat transfer and the elimination of hazards and dangers arising from the direct heating of such large containers, particularly when the latter were under considerable superatmospheric pressures, in view. The first forms of tubular elements utilized to heat flowing streams of oil were either of the spiral or helical type, and were commonly suspended above a source of heat in very simple settings. From these elementary types, certain varieties have developed employing pipe sections in parallel relation with connecting elements reversing the direction of flow in successive sections.

Various expedients have been adopted to prevent local overheating of the oil under treatment, with a resultant increase in rate of heat transfer along the flow of the oil, the most common being the introduction of excess air or recirculated flue gases so that the stream of hot gases from the burners is brought to a lower temperature. Later developments have sought to utilize the radiant heat of flames to heat one section of a heating element without allowing the stream of hot gases to pass around the pipes, and afterwards passing the hot gases, devoid of a large amount of their radiant energy, around a subsequent section of the heating element to transmit further heat by convection. When fittings are employed to reverse the direction of the flow of oil between the successive sections of pipe

in a heating element, there is a considerable loss of hydraulic head due to turbulence. This condition imposed a limitation upon the capacity of such heating element and resulted in the development of return fittings having a contour adapted to minimize such turbulence during the passage of the oils therethrough.

The present invention embodies many novel and useful features which permit a more efficient utilization of the heat energy to be imparted to flowing streams of oil than is possible in other types of equipment, and provides novel means for the utilization of radiant heat, apart from the portions of heat energy absorbed by convection, as well as novel means for controlling the rate of heat transfer in various portions of a heating element.

The apparatus to be hereinafter more fully described, may be particularly adaptable to the heating of oil streams at temperatures and under pressures sufficient to effect their material conversion into mixtures containing substantial amounts of motor fuel, although it may also be adaptable to the heating of oil streams under less severe conditions.

Other and further objects and advantages of the invention will become apparent from the following description and accompanying diagrammatic drawings, in which,—

Fig. 1 is a sectional plan view of a form of furnace setting and heating element;

Fig. 2 is a vertical sectional view, taken on a line A—A of Fig. 1;

Figs. 3, 4, 5, 6, 7 and 8 are schematic views of modified flows which may be utilized; and

Fig. 9 shows a diagrammatic vertical section of a type of combustion tunnel which may be employed with the roof burners shown in Fig. 2.

Referring to the drawings, there is shown a furnace setting, having side-walls 1, a roof 2, a combustion chamber floor 3, having suitably spaced openings or apertures 3' through which gases of combustion may pass to a flue space 5 interposed between said combustion chamber floor 3 and furnace floor 4. Flue space 5 may communicate with a chamber containing a bank of convection tubes 12 through which chamber combustion gases may pass to a suitable outlet 6 leading to a stack (not shown). Gases of combustion may be introduced into said furnace by means of burners 7 disposed on said roof 2, said burners, in turn, being fed from a source of fuel supply (not shown). Radiant heat from burners 7 may be supplied to a bank of radiant heat tubes 8 disposed horizontally along and adjacent to

side walls 1, and having their successive tubular elements connected together at substantially right-angles to each other by means of bends or fittings 9. It will be evident that the use of 90° fittings between the successive pipe sections instead of the 180° or return bend fittings commonly employed when all pipe sections in a heating element are parallel to each other, will result in much less resistance to flow, so that in an element of the present character it will be possible to pump thru a given amount of oil with a smaller pressure drop than would be possible in a completely parallel heater. Disposed on said bends or fitting 9 are suitable removable clean-out plugs 10 through which tubes 8 may be opened for cleaning purposes, or otherwise, and access to said plugs 10 may be had by means of swinging doors 11 mounted on walls 1. Access may likewise be had to said convection tubes 12 by means of swinging doors 13, also suitably mounted on the walls of said furnace.

The arrangement of tubes in the radiant section of the furnace in the present invention gives marked advantages over a type sometimes employed along with similar down-draft heating. In other types the combustion space is sometimes vertical-cylindrical and the tubular element receiving radiant heat is comprised of parallel end-connected vertical sections of pipe disposed adjacent to the wall of the combustion chamber with their axes parallel to the axis of the chamber. In such elements the direction of flow of the oil stream is alternately upwards and downwards and since the zone of maximum radiation from the flames is approximately in the middle section of the combustion chamber, the stream of oil passes through zones of relatively low heat transfer at the ends of the sections and a zone of high heat transfer rate in the middle of the sections.

In order to control the heat input to various sections of the radiant tubes 8, and particularly those sections wherein a close temperature control must be effected in order to prevent overheating and consequent over-cracking and coke-formation when hydrocarbon oil may be subjected to treatment within said tubes. We may provide suitable shields 14 having lugs or hooks 15 for suspending or otherwise disposing said shields on said tubes over the sections or parts in which it is desired to effect such temperature control. Said shields 14 may comprise sheets of chromium steel or any metal alloy having the necessary heat and corrosion resistant qualities under high temperatures.

With reference to Fig. 9, a form of combustion tunnel is shown positioned in roof 2 of the furnace setting, this tunnel consisting of an inner flue 17 through which fuel is discharged from a burner 16. Primary air for the combustion of fuel may be delivered to chamber 18 through aperture 18', the chamber being provided with a damper 20. Inner flue 17 may be surrounded by a plurality of parallel flues represented by 19 and 19' containing control dampers 21 and 21' respectively. By proper manipulation of primary air damper 20 and secondary air dampers 21 and 21' the length of flame may be adjusted to raise or lower the zone of maximum temperature in the furnace, this furnishing an additional means of controlling heat inputs in the radiant section.

In one specific embodiment, the invention may comprise passing a stream of hydrocarbon oil through a tubular heating element wherein said

oil may be heated principally by convection, and thereafter into a tubular element composed of successive substantially horizontal pipe sections connected at right angles and adapted to receive heat principally by radiation, and controlling the degree of radiant heat absorbed by successive sections of said tubes by the positioning of suitable shields or the location of the flames constituting the primary source of heat.

The direction of flow of the combustion gases through said furnace may be downward in a radiant heat section and upward in a convection heating section, and, in general, the direction of flow of said combustion gases may be generally in the same direction as the flow of the materials being heated in the radiant section. A certain degree of control may be furnished by the reentrant roof 2 which removes the upper rows of tubes in the radiant heat section of said furnace from the direct influence of radiant heat, and the pressure drop through said radiant heat section may be minimized by the use of special fittings, such as said bends 9.

As a feature of the invention, the employment of a checkered or apertured floor 3 provides a reradiating surface which assists in equalizing the distribution of radiant energy to the wall tubes 8, which, in turn, partly shield the side walls 1, preventing the development of excessive temperatures therein, making possible the utilization of cheaper materials in their construction or the use of insulating refractories which, by being considerably lighter than ordinary refractories, require smaller steel supports and reinforcements and thus effecting a saving in costs.

Referring specifically to Figs. 3 to 8, inclusive, and the illustrated flows therein represented, as well as to some of the advantages resulting from a change of flow through a heating element,—

Fig. 3 illustrates a parallel flow of two substantially equal streams of materials to be heated through a convection and a radiant heating section in succession, the flow of said streams being generally countercurrent to the combustion gases in the convection section and generally concurrent in the radiant section. Flows of this type may be utilized when it is especially desirable to avoid high pressure drops.

Fig. 4 illustrates a flow of material to be heated which is divided or parallel in the convection sections and in series in the radiant heat section, the oil passing through the convection section countercurrent to combustion gases and then through the radiant section first downwardly and concurrent with the combustion gases and then upwardly countercurrent to the same to provide a "soaking section" which is frequently very advantageous when light charging oils are being cracked and a relatively high time factor is advisable.

Fig. 5 illustrates another type of flow utilizing the same parallel or divided flow countercurrent to combustion gases in the convection section and a generally downwardly series flow concurrent with the combustion gases in the radiant section, the dotted portion of the radiant section indicating a portion of the tube bank placed behind the exposed row of the tubes in the radiant section and partially shielded by the exposed row to reduce the rate of heat transfer and form a "soaking zone."

Fig. 6 represents a combination convection and radiant type of heating element, the flow through the convection section being divided and countercurrent to the combustion gases and the flow

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through the radiant section being such that the oil stream is admitted into the radiant section at a point corresponding to a high rate of heat input, flows downwardly concurrent with the combustion gases so that it is heated at a decreasing rate of heat input, is then passed to an upper section corresponding to a higher rate of heat input than the last part of the downflow bank, then passes upwardly through the remainder of the radiant section where it is again heated at a decreasing rate of heat input and then to a lower shielded section as in Fig. 5 represented by the dotted lines so that the oil is subjected to two cycles of decreasing rate of heat input.

Fig. 7 illustrates a parallel flow through a convection section, countercurrent to the combustion gases, an introduction of the materials under heat treatment into a radiant section at a point substantially in the lowest portion of the zone of highest rate of heat input, after which the materials may flow upwardly to the top of said section and thence downwardly through the remaining tubes below the point of admission with the dotted rows of tubes representing a partly shielded section utilized as in flow 5 as a "soaking zone."

Fig. 8 illustrates a parallel flow of materials through the convection zone as in Figs. 5, 6 and 7, the materials then entering a radiant section at the uppermost row thereof, passing downwardly to a point above the central portion of said radiant section, during which passage they are heated at an increasing rate of heat input, thence passing to the bottom of the radiant heat section and passing upwardly through the remainder of said radiant section and then downwardly to the "soaking section" comprising the tubes shielded by the exposed rows.

It is to be understood, of course, that the above illustrations of flows which may be adopted are shown merely as examples of flows which may be employed in controlling the rate of heat transfer to obtain temperature conditions most suitable in particular cases, particularly in the cracking of hydrocarbon oils. It has been found, for example, that in the cracking of relatively heavy residual oils, such as topped crudes, troublesome carbon deposition is encountered quite commonly within the points wherein the oil stream is heated to temperatures of approximately 850 to 890° F. and pressures of approximately 200 to 500 pounds per square inch. By the employment of the principles of the present invention, we are enabled to effect a control over the rates of heat transfer to the oil under treatment between these points, (which may represent the approximate critical points of this particular oil), so that carbon deposition will occur at a minimum rate and deposits will be swept from the pipe walls by the velocity of the stream.

We have found as a matter of observation that the hottest zone in the combustion chamber corresponds approximately to the middle third. At this zone the flame is hottest on account of the substantial completion of combustion and the products of combustion have the highest temperature. It is to be expected therefore that the rate of heat input will be highest at this zone, the exact location of which will vary, however, with the type of fuel, the rate of combustion and the recirculation of combustion gases and other factors.

In this manner, while the average rate of heat absorption for the whole radiant heat section may be designed for, say 8,000 to 10,000 B.t.u. per hour per square foot of tube area, the rate

of heat transfer in the zone of potential carbon deposition may be maintained as low as 4,000 to 6,000 B.t.u. per hour per square foot of tube area, or lower.

It is to be understood, of course, that while 850° to 890° has been given as an illustration of a sensitive zone with reference to carbon deposition in the case of a heavy residue, this range, obviously, may be quite different for distillates or lighter charging stocks, and the control of radiant heat will therefore be altered in such specific cases.

As an example of one apparatus and method of operation the following is illustrative: A furnace with a total of about 90 5' x 30' tubes in the radiant heat section and about 76 4' x 24' tubes in the convection section may be constructed. The inside dimensions of the radiant heating compartment or combustion zone may then be approximately 29' x 29' x 20' high without the fire boxes and the convection compartment will be about 3½' x 24' x 15' high without the breechings. The flow of oil through the tubes may be that generally similar to either Figs. 4 or 5, and approximately 13,000 barrels of oil, comprising approximately one-third heavy residual charge and about two-thirds partially converted intermediate stocks from a cracking process, may be passed thru the heating element in twenty-four hours. The temperature rise effected may be from approximately 750° to 930° F., and the pressure drop may be approximately 400 pounds per square inch. In such case, the thermal capacity of the unit may be 60 million B.t.u. developed per hour and 44 million B.t.u. per hour delivered to the oil. As a result of this heat input approximately 4,000 barrels of 20 to 25 gravity topped crude charge may be cracked in twenty-four hours to produce a yield of approximately 60% of hydrocarbons within the motor fuel boiling point range.

We claim as our invention:—

1. A process for heating hydrocarbon oil to a cracking temperature and pressure within a tubular heating element disposed within a furnace through which said oil passes, which comprises initially passing said oil downwardly countercurrent to combustion gases through a convection zone of said furnace, thereafter introducing said oil into a relatively cool portion of a radiant heat zone of said furnace to pass downwardly there-through in concurrent flow with heating gases and in progressive horizontal planes throughout said zone to the hottest portion thereof, and controlling independent of the heat input in the remainder of said radiant zone the degree of heat imparted to the oil within said radiant heat zone during its passage through that portion of said zone maintained at the highest temperature.

2. A process for heating hydrocarbon oil to a cracking temperature and pressure during its passage through a tubular heating element within a furnace, comprising initially passing said oil through a convection zone of said furnace in a direction generally countercurrent to the flow of heating gases therein, thereafter introducing said oil into a radiant heat zone of said furnace through which combustion gases pass downwardly, passing said oil through a series of horizontal planes and in a progressive, downward direction through said radiant heat zone, and controlling the degree of radiant heat imparted to said oil during its passage through the hottest portion of said latter zone, independent from the heat input applied to the remaining portions of said radiant heat zone.

3. A process for heating hydrocarbon oil to a cracking temperature and pressure during its passage through a tubular heating element within a furnace, comprising initially passing said oil through a convection zone of said furnace counter-current to the flow of heating gases passing there-
5 through, thereafter introducing said oil into a radiant heat zone of said furnace wherein combustion heating gases pass downwardly, passing said
10 oil through said latter zone throughout a plurality of horizontal planes and in a progressive, downward direction, and controlling the heat input to the oil passing through said tubular heating element within said radiant heat zone by shielding the portions of the heating element within the
80 radiant heat zone and otherwise in position to be exposed to the most intense radiation, against direct radiant heat absorption.

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