Oct. 14, 1958 A. T. ENK ET AL 2,856,173

HEAT-TREATING FURNACE

Filed Nov. 13, 1956 2 Sheets-Sheet 1

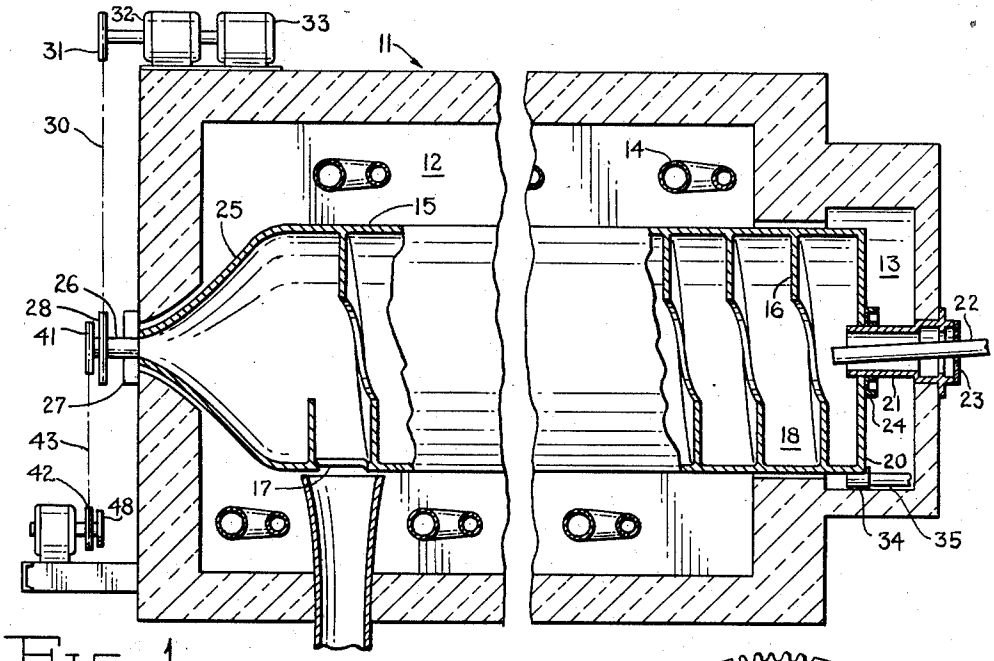


FIG. 1.

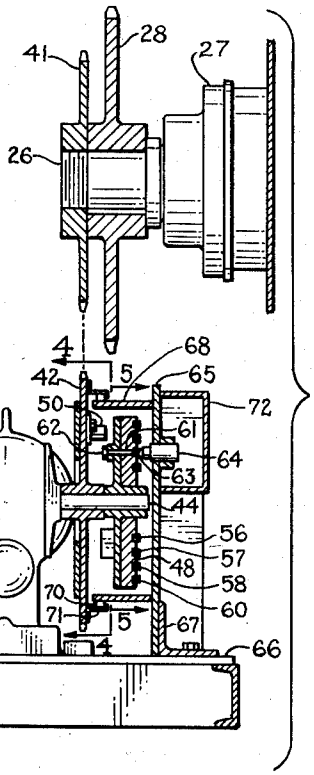


FIG. 2.

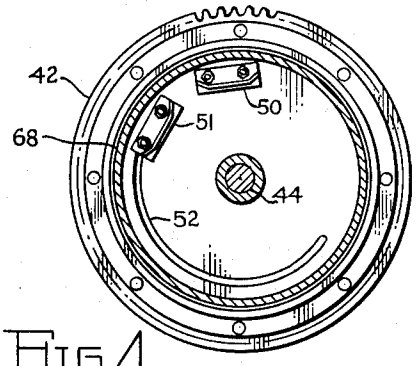


FIG. 4.

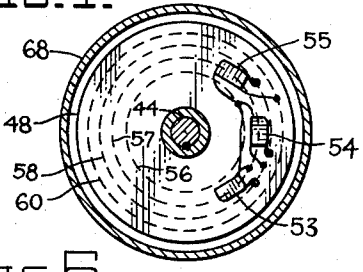


FIG. 5.

INVENTORS
A. T. ENK
C. CONE

BY Charles S. Haughey

ATTORNEY

Oct. 14, 1958 A. T. ENK ET AL 2,856,173

HEAT-TREATING FURNACE

Filed Nov. 13, 1956 2 Sheets-Sheet 2

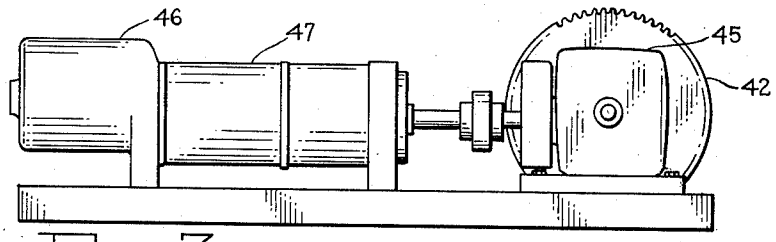


FIG. 3.

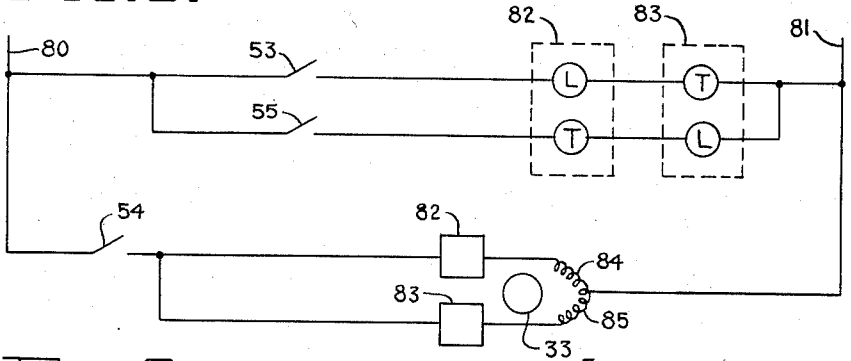


FIG. 6.

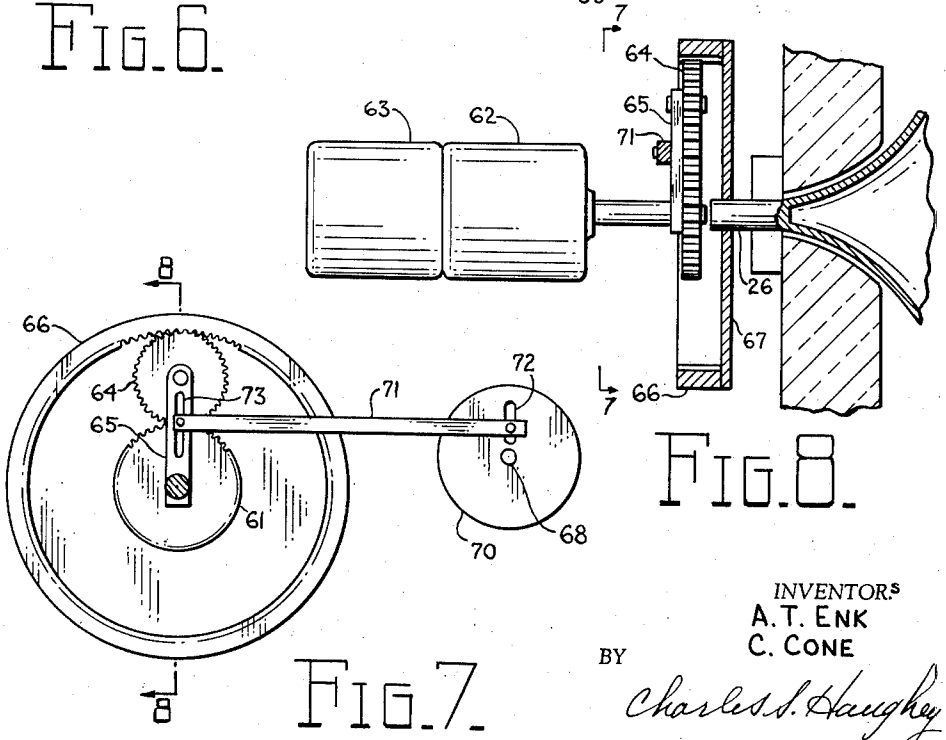


FIG. 8.

FIG. 7.

INVENTORS
A. T. ENK
C. CONE

BY Charles S. Haughey
ATTORNEY

United States Patent Office

2,856,173

Patented Oct. 14, 1958

2,856,173

HEAT-TREATING FURNACE

Albert T. Enk and Carroll Cone, Toledo, Ohio, assignors to Surface Combustion Corporation, Toledo, Ohio, a corporation of Ohio

Application November 13, 1956, Serial No. 621,676

12 Claims. (Cl. 263—7)

This invention pertains to the heat-treatment of articles and more particularly to the art of heat-treating, in a gaseous atmosphere, small articles that are conveyed in an oscillating retort.

The art of heat-treating, especially carburizing, small articles in a continuous atmosphere furnace has proven difficult. A suitable conveyor for transporting these small parts to the furnace in large quantities while uniformly exposing them to the heat-treating atmosphere has been the principal obstacle in this art. This obstacle has been substantially overcome by the rotary drum conveyor of patent 2,624,561, Heyn, assigned to applicant's assignee. However, it has been found that certain small parts, particularly those of such size or shape that relatively small interstices are formed among them, are not uniformly exposed to the atmosphere with the result that some parts have greater case depths than others.

By oscillating the drum or retort with a net forward rotation or oscillation, the parts receive more tumbling action and are more uniformly subjected to the atmosphere. To accomplish this, the drum is driven by a reversible motor which is periodically reversed with the period of rotation in one direction being greater than in the opposite direction. This results in a net rotation in one direction which, by means of a helical wall in the drum, carries the articles from the charge end to the discharge end. The degree of oscillation is determined by the amount of tumbling required to obtain uniformity of case depth which, in turn, depends on the depth to which the articles are loaded and the characteristics of the articles. A greater amount of oscillation is required when the articles are of such shape that they closely pack, leaving small interstices, and when they do not readily tumble and mix. The amount of oscillation for most articles ranges between 60° and 160°. Occasionally tumbling bars are helpful in the retort although generally there is sufficient friction between the walls of the cast retort and the articles, particularly at elevated heat-treating temperatures, to effectively cause tumbling rather than sliding.

The properties of the case of the carburized articles are determined in part by the time the articles are exposed to the carburizing atmosphere. If the desired case is achieved in eight hours in the furnace, a variation from this as small as 10 to 15 minutes can produce a noticeable variance in the case. A small inaccuracy in the amount of net forward rotation of the retort can easily change the time the articles are in the furnace by a half hour or more. It is therefore essential that the forward and rearward rotations of the retort be closely controlled.

In a typical example, bearing rollers are to be carburized with surface carbon of 1.0% and with .40% carbon content to a depth of .050". They are placed in the bottom of the retort to a depth of 6", the retort having ten flights between the charge end and the discharge hole, thus requiring ten revolutions to transport the articles through the furnace. With a given carburizing atmosphere at 1700° F., eight hours are required in the furnace

for the articles to attain the desired case and the retort must make a net advance of 1¼ revolutions per hour. Further, assuming the retort rotates at a speed of 20 revolutions per hour and a forward rotation of 90° is necessary to effectively tumble the parts, then the degrees of rearward rotation may be found by the following formula:

$$T=\frac{N\times 360}{(X-Y)}\times\frac{(X+Y)}{S}$$

where:

T=total time in furnace in minutes
X=number of degrees of forward rotation
Y=number of degrees of reverse rotation
N=total number of revolutions
S=speed of drum in degrees per minute

For this particular example then:

$$8\times 60=\frac{10\times 360}{(90-Y)}\times\frac{(90+Y)}{120}$$

$$Y=79.4°$$

With the drum rotating at 20 revolutions per hour, the time periods are 45 seconds forward and 39.7 seconds rearward to rotate the drum 90° in a forward direction and 79.4° in a rearward direction with a net advance of 10.6°. This provides proper time in the furnace and ample tumbling action.

The time periods for rotation are commonly controlled through a commercially available two-phase timer. The desired period of rotation in each direction is set by means of pointers on two separate scales. The timer then causes current to flow respectively to the forward and reverse windings of the motor driving the retort for the periods of time as set.

Frequently, the periods are not accurately set, the scale of the timer is not properly calibrated, or the timing mechanism is inaccurate. Any of these items, or combinations thereof, can easily throw off a timing period sufficiently to produce a marked variation in the resulting case of the articles.

To continue the above example, assume the period of rotation in the rearward direction is actually one second longer than that desired, a situation that is not uncommon. In such a case, the retort will rotate an additional 2° in the rearward direction and the time the articles are in the furnace will be:

$$T=\frac{10\times 360}{(90-81.4)}\times\frac{(90+81.4)}{120}$$

$$T=598$$

The time the articles are in the furnace is thus increased from eight hours to 598 minutes or almost 10 hours, a two hour increase produced by an inaccuracy of one second in the timing period.

To overcome this situation, means for accurately controlling oscillation of the retort have been developed to assure proper time in the furnace for the heat-treated articles.

For further consideration of what is novel and the invention, refer to the following portion of the specification, the appended claims, and the accompanying drawing.

In the drawing:

Figure 1 is a cross-sectional view of apparatus embodying the invention,

Figure 2 is a detailed, partially cross-sectional view of a portion of the apparatus of Figure 1,

Figure 3 is a side view of a portion of the apparatus of Figure 2,

Figure 4 is a detailed view in line 4—4 of Figure 2,

Figure 5 is a detailed view on line 5—5 of Figure 2,

Figure 6 is a schematic representation of a circuit employed with the invention,

Figure 7 is another embodiment of the invention viewed from line 7—7 of Figure 8, and

Figure 8 is a cross-sectional view on line 8—8 of Figure 7.

According to Figure 1, a furnace **11** comprises wall means forming a heating chamber **12** and a charge vestibule **13**. Chamber **12** is heated by horizontal radiant tubes **14**, placed above and below rotary retort **15**. The retort **15**, of cast alloy, contains a helical wall **16** integral therewith which extends from the charge end to the discharge opening **17**. The wall forms a helical passage **18** through which the articles to be heat-treated are carried as the retort rotates. The articles are generally charged into the retort to a depth equal to ½ to ⅔ the height of wall **16** depending on the size and shape of the articles and the quantity desired to be heat-treated.

The charge end of drum **15** has a vertical wall **20**, which encloses this end except for a central opening through which a tube **21** extends. This is sealed to and supported by the charge end wall of the vestibule. A charging trough **22**, which is preferably of the vibratory type, carries articles placed thereon into the drum. An asbestos curtain **23** is located outside the vestibule chamber **13** to cover the opening between tube **21** and trough **22** so as to maintain leakage of the atmosphere gas at a minimum. Also, a flange **24** seals the opening between wall **20** and tube **21**.

At the discharge end, the retort has a tapered portion **25** which tapers to a shaft **26** extending through the discharge end wall of the furnace. The shaft is rotatably supported by a bearing **27** and has a sprocket **28** through which the retort is driven by means of a chain **30**, sprocket **31**, reducer **32**, and motor **33** located atop the furnace. The charge end of the retort is supported in vestibule **13** by rollers **34** with shafts **35** extending through the charge end wall of the vestibule outside of which they are rotatably secured.

Referring more specifically to Figures 2, 3, 4, and 5, a second sprocket **41** is connected to shaft **26** and drives a sprocket **42** located therebelow through a chain **43**. Sprocket **42** is driven at the same speed as the retort where the diameters of the sprockets **41** and **42** are equal. Otherwise, the speed of sprocket **42** will still be in direct proportion to the speed of the retort which is equally effective. Sprocket **42** is freely supported by a shaft **44** of reducer **45** which is driven by a motor **46** and variable speed mechanism **47**. Shaft **44** has a disc **48** secured thereto which it rotates at the same speed as is desired for the net advance per unit of time of retort **15**.

Sprocket **42** has two cams **50** and **51** secured to one face thereof, the latter cam being adjustable by means of slot **52**. On the adjacent face of disc **48** are three limit switches **53**, **54**, and **55**. These switches are connected into a circuit, to be discussed later, by means of four concentric rings **56**, **57**, **58**, and **60** which are partially embedded in the opposite face of the disc and which are shown as dotted lines in Figure 5. Each ring has a rod **61** extending through the disc to a terminal **62**. Wires from the limit switch **53** are thus connected to rings **56** and **57**; wires from switch **54**, to rings **56** and **58**; and wires from switch **55**, to rings **56** and **60**. Contact is made with the rings through brushes **63** and holders **64**. The cams and limit switches may be disposed on the opposite faces, if desired, without departing from the scope of the invention.

The holders are supported in a vertical wall **65** which is secured to platform **66** through a flange **67**. A cylinder **68** extends from wall **65** and co-acts with resilient material **70** and holder **71** attached to sprocket **42**. This forms a dust-free housing around the electrical apparatus. Another housing **72** extends from the other side of wall **65** to protect the electric wires connected to holders **64**.

The aforementioned limit switches are connected into

the circuit of Figure 6. When limit switch **53**, a normally open one, is depressed by cam **50**, it completes a circuit from lead **80** to lead **81** through the latch coil of a first relay switch **82** and through the trip coil of a second relay switch **83**. This causes switch **82** to open and switch **83** to close. Likewise, limit switch **55** is a normally open one and, when depressed by cam **51**, completes a circuit through the trip coil of switch **82** and the latch coil of switch **83**, causing the former to close and the latter to open.

With switch **82** closed and switch **83** open, current is supplied to forward winding **84** of motor **33** and drives the retort forward. With switch **83** closed and switch **82** open, current as supplied rearward winding **85** of motor **35**, driving the retort in the reverse direction. The switches **82** and **83** may be replaced by valves in a hydraulic system using a hydraulic motor, if preferred.

Limit switch **54** is a normally closed one and is incorporated in the motor winding circuit. If the switch is depressed by either cam **50** or **51**, it opens the line to both windings and prevents further operation of the motor. This is a safety feature that operates only if limit switch **53** and **55** fails to operate and reverse the motor. Without this switch, failure of either of the other switches would cause the retort to operate continually in one direction, either causing the parts to jam at the charge end of the retort or to go through the furnace in a short time so as to not be adequately carburized.

The operation of the above apparatus may best be illustrated by a specific example. Assuming ten rotations of the retort are required to move the work through the furnace and that eight hours are required for the parts to be properly heat-treated, then the retort must have a net advance of 1¼ revolutions per hour or 7.5° per minute. If an oscillation of 90° is desired, then it will take 90÷120 or .75 minute for the retort to travel 90° forwardly at a speed of 20 revolutions per hour, or 120° per minute. In .75 minute the disc, which is set to rotate at the speed desired for the retort, will travel

$$.75 \times 1\tfrac{1}{4} \times 360 \div 60$$

or 5.6°. Therefore, the angle through which the cam must travel will be 90—5.6 or 84.4°. When the acute angle between limit switches **53** and **55** is 80°, then the obtuse angle between cams **50** and **51** will be 80°+84.4° or 164.4°. Thus, to obtain 90° forward rotation, the cams will be set 164.4° apart. This is accomplished by adjusting cam **51** in slot **52**. In this case, the time of rearward rotation will be $120X+7.5X=84.4°$, where X is the period of time required for the rearward rotation and is equal to .662 minute; the angle of travel of the retort in the rearward direction then will be 79.4°. The retort will thus travel 10.6° forward in .750+.662 or 1.412 minutes which is equal to the desired rate of 7.5° per minute which is equal to 1¼ revolutions per hour.

The setting of cam **51** will not affect the speed of net advance of the retort regardless of how erroneous the setting may be. This is true since this speed is entirely dependent on the speed of disc **48**. If the cam **51** were mistakenly set at 150° for the obtuse angle instead of 164.4°, the time of forward rotation will be

$$120X=70°+7.5X$$

or .622 minute and the retort will rotate 74.6° forward. The time of rearward rotation will be $120X+7.5X=70$ or .549 minute and the retort will rotate 65.9° in the reverse direction. This is a net advance of 8.7° in 1.163 minutes or a rate of 7.5° per minute. Thus, it is clear that the speed of the retort is entirely dependent on the speed of the disc **48** and changes of the cams only affect the degree of oscillation and not the amount of net advance per unit of time.

Another design by which accurate control of the retort can be achieved is illustrated in Figures 7 and 8. In

this device, a disc is also used to determine the speed of the retort. Accordingly, a disc or sun gear **61** is rotated through a variable speed mechanism **62** and a motor **63**. The gear **61** rotates a planet gear **64** to which it is connected by a bar **65**. Gear **64** meshes with a ring gear **66** connected to shaft **26** of retort **15** by a plate **67** which may be integral with the gear. A shaft **68** is rotated near ring gear **66** by a motor (not shown) and has a cam or crank wheel **70** attached thereto. A second bar **71** is pivotally and adjustably connected to the cam or crank wheel in slot **72** and has its other end adjustably connected to bar **65** by means of a slot **73**.

The crank wheel **70** rotates continuously and the bar **71** functions as a connecting link to oscillate the bar **65** to and fro. The angle through which the bar **65** oscillates depends upon the position of the crank pin in the slot **72** and the position of the wrist pin in the slot **73**. The sun gear rotates at predetermined speed, and rotative movement is transmitted from the sun gear **61** through the planet gear **64** to the ring gear **66**, thus causing the ring gear and the retort to rotate at slower speed in the direction opposite to the direction in which the sun gear **61** rotates.

In operation, sun gear **61** is rotated at a speed the ratio of which to the net speed desired for the retort is equal to the ratio of its diameter or teeth to the diameter or teeth of gear **66**, and crank wheel **70** is rotated to reciprocate bar **71**, thereby oscillating bar **65**. The number of oscillations per minute and their amplitudes can be selected independently of the net speed of the retort. The retort will oscillate with a net advance equal to the amount of rotation of gear **61** multiplied by the ratio of its diameter to the diameter of gear **66**.

In an example similar to the previous example, retort **15** has 10 flights and eight hours are required to achieve proper case on the articles to be heat-treated. The retort thus requires a net advance of 1¼ revolutions per hour. Also, assume a 90° forward rotation is desired for the retort and at a rate of 20 revolutions per hour or 120° per minute. Gear **61** has 40 teeth; gear **64**, 30 teeth; and ring gear **66**, 100 teeth. Gear **61** is then rotated at a speed of 3⅛ revolutions per hour which, multiplied by the ratio of the ring gear teeth to the sun gear teeth, equals 1¼ revolutions per hour or 7.5° per minute for the ring gear and the retort. To achieve a speed of forward rotation of retort **15** of 120° per minute, bar **65** is oscillated with an angular velocity of 80° per minute. During one minute, gear **64** is rotated $(80 \div 360) \times 40$ or 8.9 teeth which moves ring gear **66** an additional $.089 \times 360$ or 32°. In addition, ring gear **66** is moved 7.5° forward by the rotation of gear **61**, thus making the total rotation of the ring gear and retort equal to $80+32+7.5$ or approximately 119.5° per minute. To achieve a forward rotation of 90°, the arm **65** is rotated through an angle of 60°.

In summary, to achieve a net advance of 1¼ revolutions per hour with a forward rotation of 90° at a rate of 120° per minute, gear **61** is rotated at 3⅛ revolutions per hour and bar **71** is adjusted to oscillate arm **65** through a distance of 60° at a rate of 80° per minute. For the rearward rotation, the retort will travel at a rate of $80+32-7.5$ or approximately 104.5° per minute. The retort will thus rotate a net amount forwardly of 15° in two minutes or at a rate of 7.5° per minute.

This mechanism of Figures 7 and 8 also maintains positive, accurate control of the retort regardless of the setting of the oscillation control since the retort speed is entirely dependent on the speed of rotation of disc **61**.

The invention thus consists of a disc rotated in proportion to the net advance per unit of time desired for the retort and on which the net advance is entirely dependent. Further provided is a means of oscillating the retort which does not affect the net advance thereof. The resulting accurate control affords accurate timing of the work in the heat treating chamber and thus close quality control of the treated parts.

The foregoing has been intended to serve in an illustrative and not a limiting sense, the scope of the invention being limited only by the depending claims.

We claim:

1. Apparatus for accurately controlling the net advance per unit of time of an oscillating retort for carrying articles to be heat-treated comprising: a rotatable unit whose speed of rotation determines the amount of net advance per unit of time of the retort; a motor for rotating said unit; means for setting the speed of said unit at any desired rate; means co-acting with said unit for oscillating said retort independently of its net advance; and means for varying the degree of oscillation according to a preselected amount.

2. Apparatus for accurately controlling the net advance per unit of time of an oscillating retort which carries and tumbles work through a heat-treating chamber, said apparatus comprising: a sprocket rotated in proportion to the speed of rotation of the retort; a disc adjacent said sprocket; means for rotating said disc at a speed equal to the net advance per unit of time desired for retort; a motor adapted to drive said retort at a speed faster than the rate of net advance of said retort; and means co-acting with said sprocket and said disc for reversing said motor periodically.

3. Apparatus for accurately controlling the net advance per unit of time of an oscillating retort which carries and tumbles work through a heat treating chamber, said apparatus comprising: a sprocket rotated at a speed in proportion to the speed of said retort; a disc adjacent said sprocket; means for rotating said disc at a speed equal to the net forward advance of said retort; a motor adapted to drive said retort at a speed of rotation greater than the rate of net advance per unit of time; switch means on the face of one of said sprocket and disc; two cams on the adjacent face of the other of said sprocket and disc, said cams being adapted to contact said switch means to reverse said motor at periods of time as determined by the location of said cams and switch means.

4. Apparatus for accurately controlling the amount of net advance per unit of time of an oscillating retort having a helical wall therein, which comprises: a sprocket rotated in direct proportion to the speed of said retort; a disc having a face parallel and in spaced relationship to a face of said sprocket; a motor adapted to drive said retort at a speed of rotation greater than the rate of net advance per unit of time of said retort; means for rotating said disc at a speed equal to the net advance per unit of time desired for said retort; two limit switches angularly disposed on one of said faces; two cams angularly disposed on the other of said faces, said cams contacting said limit switches when said disc and said sprocket are rotated; and means operatively connected to said limit switches and to said motor for reversing said motor each time one of said switches is contacted by one of said cams.

5. Apparatus according to claim 4 wherein one of said limit switches and cams are angularly adjustable.

6. Apparatus for accurately controlling the amount of net advance per unit of time of an oscillating retort having a helical wall therein, which comprises: a sprocket rotated in direct proportion to the speed of said retort; a disc having a face parallel and in spaced relationship to a face of said sprocket; a motor adapted to drive said retort at a speed of rotation greater than the rate of net advance per unit of time; means for rotating said disc at a speed equal to the net advance per unit of time desired for said retort; a first and a second limit switch angularly disposed on one of said faces; a first and a second cam angularly disposed on the other of said faces and so located that the first cam contacts the first switch when said sprocket rotates in one direction and the second cam contacts the second switch when said sprocket rotates in the opposite direction; and means including circuit means operatively connecting said motor and said switches for

reversing said motor each time one of said switches is contacted by its corresponding cam.

7. Apparatus according to claim 6 characterized by a third limit switch located so as to be contacted by either of said cams when said first and second limit switches fail to reverse said motor; and second circuit means operatively connecting said third limit switch and the first circuit means for stopping said motor when said third limit switch is contacted.

8. Apparatus for accurately controlling the amount of net advance per unit of time of an oscillating retort having a helical wall therein, which comprises: a first gear; means for rotating said gear at a speed in direct proportion to the rate of net advance per unit of time desired for said retort; a second gear adapted to be connected to said retort to rotate therewith; a third gear operatively connecting said first and second gears; and means for oscillating said retort.

9. Apparatus for accurately controlling the amount of net advance per unit of time of an oscillating retort having a helical wall therein which comprises: a sun gear; means for rotating said sun gear at a speed in direct proportion to the rate of net advance per unit of time desired for said retort; a ring gear adapted to be connected to one end of said retort and rotated therewith; a planet gear operatively connecting said sun gear and said ring gear; a bar connecting the shafts of said planet gear and said sun gear; and means for oscillating said planet gear to an equal angle in each direction around a portion of the axis of said sun gear, the speed of oscillation of said planet gear being greater than the speed of rotation of said gun gear.

10. Apparatus according to claim 9 wherein said means comprises a rotatable cam spaced at one side of said gears, means for rotating said cams, a second bar whose one end is attached to said cam in an offset manner and whose other end is attached to said bar between said shafts, the amount of said offset being less than the distance from the shaft of the sun gear to the point on said first bar where said second bar is attached.

11. In a heat treating furnace, in combination, a retort having a helical channel therein, means for oscillating said retort about the axis of said helical channel through a predetermined angle in one direction and through a lesser predetermined angle in the opposite direction, thereby advancing work along said helical channel by alternating relatively long progressive movements and relatively shorter retrogressive movements, an oscillatable unit connected to said retort to oscillate concurrently therewith through angles corresponding to the angles of oscillation of said retort, a continuously rotatable unit mounted adjacent said oscillatable unit to rotate on an axis coincident with the axis of oscillation of said oscillatable unit, means for rotating said continuously rotatable unit at a selective speed proportionate to a desired net rate of advance of work along said helical channel, a plurality of switch elements carried by said continuously rotatable unit, one of said switch elements when actuated being electrically so connected to said means for oscillating said retort as to cause said retort to oscillate in one direction, another of said switch elements when actuated being electrically so connected to said means for oscillating said retort as to cause said retort to oscillate in the opposite direction, said oscillatable unit carrying actuating elements, each of said actuating elements projecting into the path of movement of one of said switch elements to actuate such switch element upon engagement therewith, and means for adjusting the relative angular positions of said actuating elements upon said oscillatable member.

12. In a heat treating furnace, in combination, a retort, means for advancing work through said retort by alternating relatively long progressive movements and relatively shorter retrogressive movements, a switch actuating unit, means for moving said switch actuating unit forward and back concurrently with and proportionately to such alternating progressive and shorter retrogressive movements, a continuously movable unit, means for moving said continuously movable unit at a selective speed proportionate to a desired net rate of advance of work through said retort, a plurality of switch elements carried by said continuously movable unit, one of said switch elements when actuated being electrically so connected to said means for advancing work as to cause relatively long progressive movements thereof, another of said switch elements when actuated being electrically so connected to said means for advancing work as to cause relatively shorter retrogressive movements thereof, said switch actuating unit carrying actuating elements, each of said actuating elements projecting into the path of movement of one of said switch elements to actuate said switch elements upon engagement therewith, and means for adjusting the relative positions of said switch actuating elements upon said switch actuating unit.

References Cited in the file of this patent

UNITED STATES PATENTS

2,151,439 Pittman et al. ---------- Mar. 21, 1939