Dec. 3, 1963 W. F. STEVENS ETAL 3,112,918

ROTARY HEARTH FURNACE CONTROL

Filed March 28, 1961 2 Sheets-Sheet 1

Fig. 1.

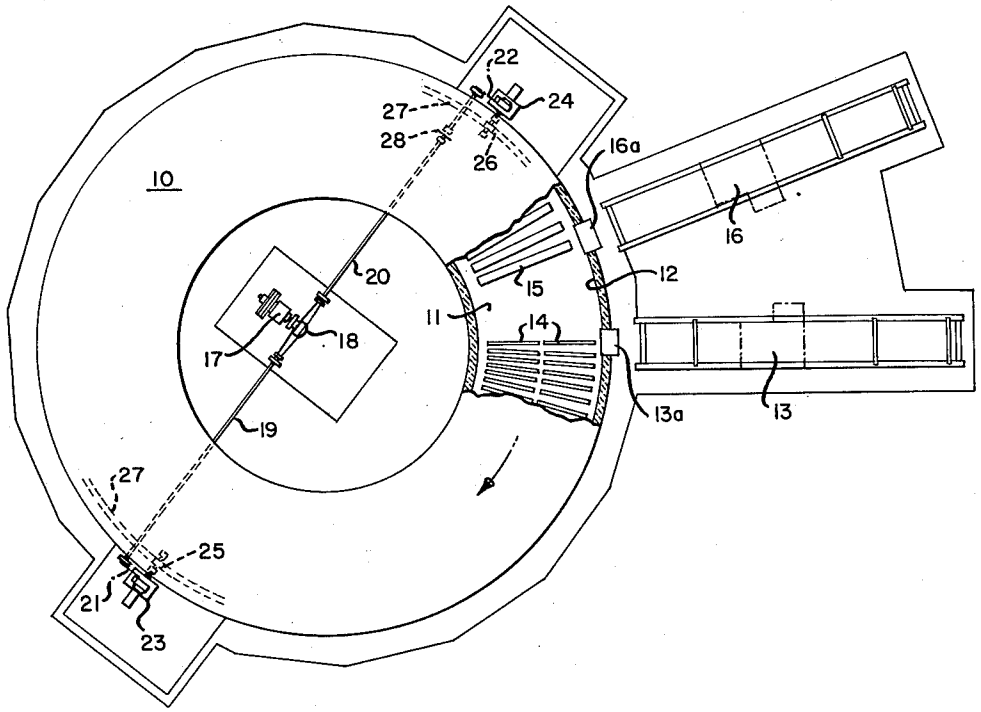
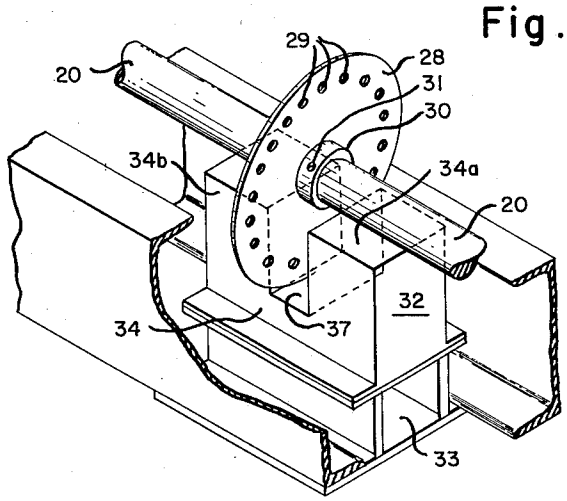


Fig. 2.



Inventors
William F. Stevens &
George R. Bauer
By Hooper, Leonard & Duell
their attorneys

Dec. 3, 1963 W. F. STEVENS ETAL 3,112,918

ROTARY HEARTH FURNACE CONTROL

Filed March 28, 1961 2 Sheets-Sheet 2

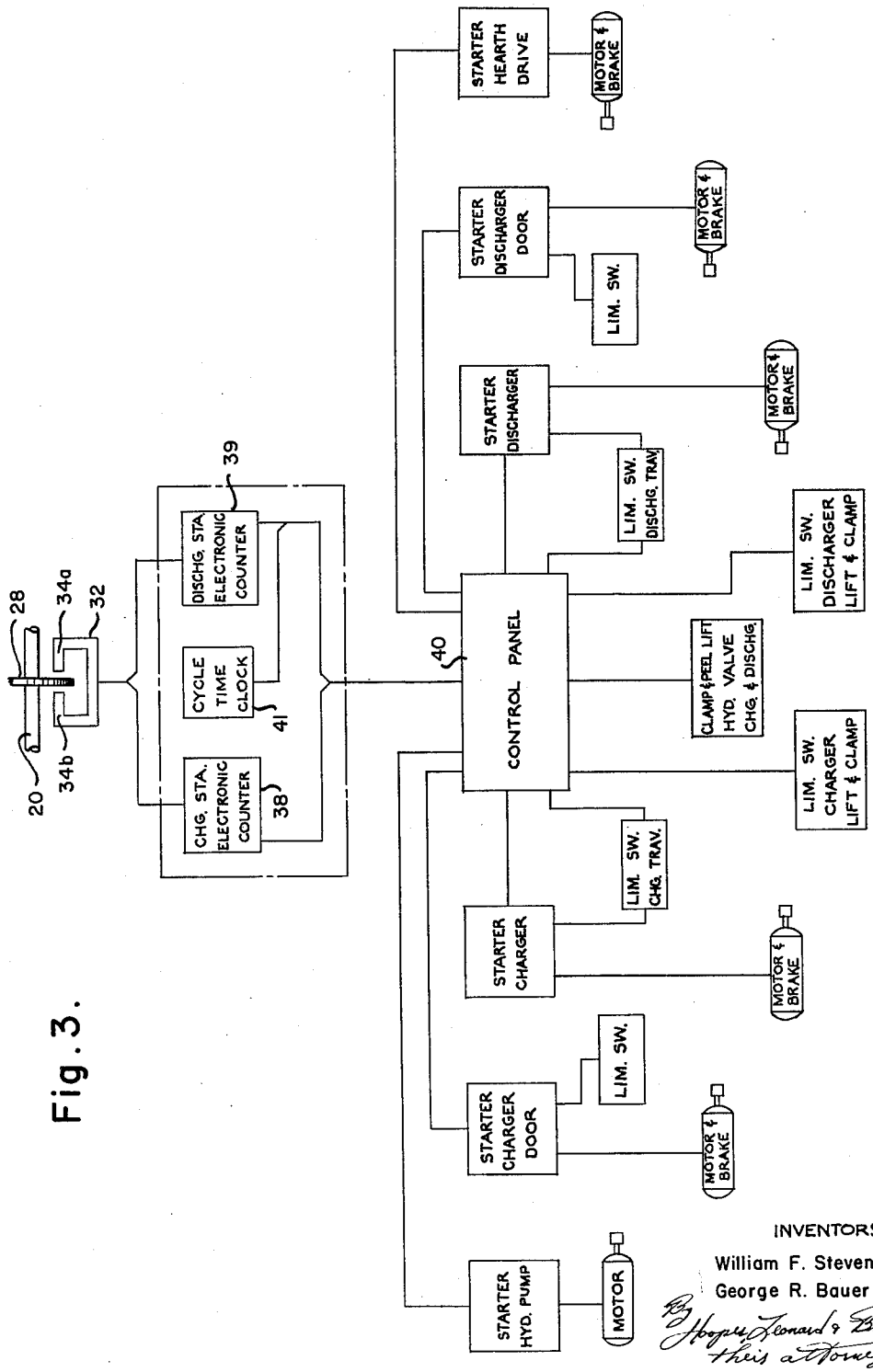


Fig. 3.

INVENTORS
William F. Stevens &
George R. Bauer
By Hoppe, Leonard & Buell
their attorneys

United States Patent Office 3,112,918 Patented Dec. 3, 1963

3,112,918

ROTARY HEARTH FURNACE CONTROL

William F. Stevens, Greentree, and George R. Bauer, Bridgeville, Pa., assignors to Salem-Brosius, Inc., Pittsburgh, Pa., a corporation of Pennsylvania

Filed Mar. 28, 1961, Ser. No. 98,809
7 Claims. (Cl. 263—7)

This invention relates to rotary hearth furnaces and more particularly to a control system for a rotary hearth furnace having automatic charging and discharging means.

Hearth positioning for charging and discharging has been formerly accomplished by use of hearth station switches such as shown and described in United States Patent Number 2,622,861 to Talley. Basically, the hearth station switch is a geared type cam limit switch. In the hearth station switch, the cams are notched and the gearing provides a ratio of cam revolutions to hearth revolutions. The number of stations, wherein the hearth is temporarily stopped for charging or discharging the articles being heated therein, is determined by choice of cams and gearing. The number of stations therefore is limited by the number of notches on a particular cam disc and the gear ratio used. Of course, a plurality or bank of cam discs may be provided to allow some flexibility of choice; however, the fact remains that the number of stations is limited to the particular selection of cam discs available in the bank. For example, a bank may be comprised of as many as ten different cams. Each divides the hearth into a particular and different number of stations or stops. To use a hearth most efficiently, the articles being heated should be spaced as closely as possible, which means that generally the most desirable spacing is some number and fraction of inches. With a selection of only ten different divisions of stops, more often than not, the most efficient division is not available. Thus, as a practical matter, the operator has to settle for the cam and gear arrangement that most nearly approaches the desired spacing. Sometimes the desired number of station stops is not even nearly available in the disc bank and the operator must change the cams or gears, i.e., replace the cams or gears or both with ones that will come closer to providing the number of hearth station stops desired. Such changes are inefficient and time-consuming.

Such problems of efficient spacing of billets on the hearth and of flexibility in choice of the number of station stops are old and well known to those skilled in this art.

We have invented a control system in a rotary hearth furnace that minimizes the above problems to the point of negligibility. We provide a counting system for control of a rotary hearth furnace comprising, in combination, a rotary hearth furnace having a rotatable hearth, hearth charging means, hearth discharging means, hearth travel measuring means having electric pulse generating and pulse counting means and control means operatively responsive to said counting means coordinating the starting and stopping of the hearth and the energizing and deenergizing of the charging means and discharging means including cycling means controlling the duration of hearth stoppage. In our preferred embodiment the hearth travel measuring means comprises disc means coaxially mounted on and rotating with the drive or jackshaft of the hearth drive means, said disc means having alternately light transmitting and opaque portions, a light source and photosensitive element operatively associated with said disc means whereby portions of said disc means permit the passage of light from said source to said element as said disc rotates and electronic counting means operable to count said light passages.

Other details, objects and advantages of the invention will become apparent as the following description of a present preferred embodiment thereof proceeds.

In the accompanying drawings, we have shown a present preferred embodiment of the invention in which

FIGURE 1 is a plan view diagrammatically illustrating a rotary hearth furnace with automatic charging and discharging machines;

FIGURE 2 is a fragmentary isometric view of the hearth drive jackshaft and photoelectric counting mechanism associated therewith; and

FIGURE 3 is a diagrammatic showing of a control system for a rotary hearth furnace embodying our invention.

Refering now to FIGURE 1, we have illustrated generally a rotary hearth furnace 10 having a rotatable hearth 11 in a furnace chamber 12. A charging machine 13 is disposed opposite a furnace chamber opening 13*a* or charge door and automatically charges articles to be heated, such as billets 14 and 15, into furnace chamber 12 and deposits them on hearth 11. A discharging machine 16 is disposed opposite another furnace chamber opening 16*a* or discharge door and automatically discharges or removes the heated articles from the hearth and furnace chamber. The operation of the automatic charging and discharging machines is old and well known to those skilled in the art and will not be further described in this specification. The automatic opening and closing of the furnace chamber doors to facilitate charging and discharging of articles on the hearth is likewise old and well known.

Rotating hearth 11 is driven by an electric motor 17 through a differential gear unit 18 which revolves or rotates the jackshafts 19 and 20. The power from jackshafts 19 and 20 is transmitted respectively through chain drives 21 and 22 to reducers 23 and 24 thence to pinion gears 25 and 26 which engage ring gear 27 attached to hearth 11 and thus rotates the hearth. It is clear that jackshafts 19 and 20 rotate much faster than hearth 11 due to the great gear reduction from the jackshafts to the hearth.

For example, in a preferred embodiment, we employ a 7½ horsepower 1200 r.p.m. 230 volt electric motor. The differential 18 has about a 4 to 1 reduction so that with the motor at full speed the jackshafts are rotating at approximately 300 revolutions per minute. This is subsequently very greatly reduced through the chain drives, reducing gear box and pinion gear to the hearth by approximately 5000 to 1. Thus the hearth makes about .06 revolution per minute or takes approximately 17 minutes to make one revolution when rotating at full speed without interruption. Given the distance of any point on the hearth from the hearth center, it is possible to compute the rate of hearth travel at that point per revolution of jackshaft 20. For example, if the diameter of ring gear 27 is 55 feet, as it is in the described apparatus, we can calculate by simple mathematics that hearth travel at the ring gear is approximately .4 inch per revolution of jackshaft 20. This does not mean to suggest that motor 17 will be at full speed at all times and in fact it will not; for in some instances motor 17 must be slowed down to allow articles that require longer heating periods to be properly heated. However, regardless of the speed of motor 17, in the above example, hearth 11 will travel approximately .4 inch at ring gear 27 per revolution of jackshafts 19 or 20 due to the unchanged gear reduction ratio. The importance of such calculations will become apparent as the description continues.

Referring to FIGURE 2, we illustrate a disc 28 coaxially mounted on jackshaft 20 having holes 29 evenly spaced radially equidistantly in the outer portion thereof. Disc 28 has a hub portion 30 through which jackshaft 20 passes. Hub 30 is secured to jackshaft 20 by set screw 31 and

thus disc 28 rotates with jackshaft 20. A photo-pickup assembly 32 is mounted beneath jackshaft 20 on support 33. Assembly 32 comprises a divided housing 34 having a light source such as an electric light bulb in portion 34*a* and an opposing photosensitive element in the other portion 34*b*. The photosensitive element in 34*b* is shielded by housing portion 34*b* from any light source other than the light from 34*a*. Housing 34 is divided by a gap 37 into which a portion of disc 28 intrudes. Disc 28 is positioned in gap 37 so as to interfere between the light from 34*a* and the photosensitive element in 34*b* so that as disc 28 rotates with jackshaft 20, disc holes 29 will permit a beam of light from 34*a* to impinge upon the photosensitive element in 34*b* as each of said holes 29 passes therebetween. The number of holes 29 in disc 28 may be greatly varied according to the degree of control desired. The degree of control being directly proportional to the number of holes 29. We have found that as a practical matter, twenty holes 29 in disc 28 provide a more than adequate degree of control. Referring back to our earlier calculations, if the point on hearth 11 at ring gear 27 travels .4 inch per revolution of jackshaft 20, then said point travels .02 inch per hole 29 on disc 28. Thus we provide a control over the positioning of articles on hearth 11 to within .02 of an inch of hearth travel, which those skilled in the art will recognize is more than adequate for a rotary hearth furnace.

Obviously, it is immaterial whether disc 28 and photo-pickup assembly 32 are associated with jackshaft 19 or as described with jackshaft 20. In fact the positioning of said disc and pickup assembly may be on the drive shaft of motor 17 or a shaft extending from the reducer gear box, just as long as the shaft rotating disc 28 has a speed geared to and much higher than the hearth. We placed the disc and photo-pickup assembly on jackshaft 20 for several reasons including the convenience for servicing and available space.

Referring to FIGURES 2 and 3, it is clear that each time a hole 29 permits a beam of light to pass from 34*a* to the photosensitive element in 34*b* an electric pulse is created in the photosensitive element. The construction of the photosensitive element and its ability to create the described pulse is old and well known; likewise, light sources suitable for projecting beams in such circumstances are old and well known and thus these elements are not shown or further described herein.

Referring now to FIGURE 3, we diagrammatically show a pair of electronic counters 38 and 39 connected to photo-pickup assembly 32, each of which counts the electrical pulses created in the photosensitive element.

From our earlier calculations, it is clear that each count made by counter 38, and likewise counter 39, represents .02 inch of hearth travel at ring gear 27. Counters 38 and 39 are selectively presettable to produce an electrical signal at any given number of pulses counted from 1 to 10,000 and can be coordinated to a secondary circuit to operate relays or any other type of control when the desired count is reached. Such counters are available on the market (for example, see the catalogue dated January 1, 1961 published by the Post Electronic Products Division of Reid Brothers Company, Inc. of Beverly, Massachusetts), and therefore will not be further described in detail. As shown in FIGURE 3, counters 38 and 39 are electrically connected to a control panel 40. Control panel 40 contains relay switches which respond to the electrical signals transmitted by the counters. These relay switches, of course, control and operate the starters, drives and subsequent controls shown in FIGURE 3. Control panel 40 is made up of standard hardware and circuitry well within the knowledge and skill of those skilled in the art and thus will not be further described in detail. In our invention, control panel 40 responds to signals transmitted to it by counters 38 and 39 instead of signals transmitted to it by the hearth station switches earlier referred to. Likewise, the starters, drives and subsequent controls controlled by panel 40, as diagrammatically shown more fully in FIGURE 3, are familiar to those skilled in the art and thus will not be described in detail. Suffice it to say, that control panel 40 is preset to energize and deenergize the appropriate circuits which it controls as it receives the signals from the counters.

Very often, the operator will be heating different sized articles such as billets 14 and 15 which require different spacing on hearth 11. This means that the charging and discharging rates will be different and thus the station stops required for charging will be different from the station stops required for discharging. Therefore, hearth 11 must be divided up into one set of station stops for charging and another set of station stops for discharging. For this reason two counters are necessary and in the present described embodiment counter 38 counts the light pulses for charging stops and counter 39 counts the light pulses for discharging stops. Each counter is independently set to signal panel 40 when it has counted a certain number of pulses. For example, if billets 14 each require 4.6 inches of hearth space adjacent ring gear 27, then at the rate of .02 inch of hearth travel per pulse as calculated earlier a billet 14 should be charged every 230 light pulses. This being the case, counter 38 is preset to signal panel 40 at every 230 counts, at which signal panel 40 deenergizes hearth travel motor 17 and energizes the charging circuits to charge the hearth. Thus, jackshafts 19 and 20 are stopped and no further pulses are created until the charging is completed and the hearth drive circuit is reenergized by panel 40. To continue, if billets 15, which are being discharged, were previously placed on hearth 11 every 20 inches of hearth space at ring gear 27, then we can calculate that they must be removed every 1000 light interruptions or pulses. This being the case, counter 39 is preset to signal panel 40 at every 1000 counts, at which signal panel 40 stops hearth 11 as just described above, and energizes the discharging circuits to discharge a billet 15 from hearth 11. Upon completion of said discharge, panel 40 again energizes the hearth drive circuit and the hearth resumes its travel. In the above example, it is clear that hearth 11 will be stopped several times for charging before it will be stopped again for discharging and that the charging and discharging stops are made independently of each other. Of course, once all of billets 15 are discharged and billets 14 are now ready for discharge, counter 39 will have to be reset to signal panel 40 at 230 counts to discharge billets 14. Thus, it is clear that hearth space can be utilized for the most efficient spacing of articles to within .02 inch per article.

Even finer hearth divisions could be accomplished by increasing the number of holes 29 in disc 28 to lower the amount of hearth travel per light pulse. However, as earlier stated, it is highly unlikely that a finer division than that provided by the twenty hole disc 28 would ever be desired. The counters can be set to signal at any pulse count from 1 to as high as the operator would ever need to go. The exceptional flexibility of our system is obvious and the earlier described occasions for changing cams or gears or for using less than the most efficient spacing of articles on the hearth, obviated.

In some instances, the hearth is capable of out-producing the capabilities of the mill to which the articles being heated are to be transferred. To prevent a pile up of heated articles at the mill during which time they may cool too much, we further provide a cycle time clock 41 at the discharge end of the furnace. Clock 41 may be set to deenergize the hearth drive motor 17 for certain lengths of time. For example, if the mill can only take a billet 15 every seven minutes and the hearth is producing one every five minutes it is necessary to delay the hearth two minutes after each billet 15 is discharged. Thus, cycle time clock 41 is set to deenergize the hearth drive motor 17 for two minutes after the completion of each discharge operation. Of course, after clock 41

times out the hearth drive motor circuit is energized by control panel 40 and hearth 11 will resume its travel. Cycle time clock 41 may also be utilized to lengthen the heating cycle of articles that take a longer period of time to become heated by the delaying action just described.

While we have shown and described a present preferred embodiment of the invention, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied within the scope of the following claims.

We claim:

1. A rotary hearth furnace control comprising, in combination, a rotary hearth furnace having a rotatable hearth, charging means delivering articles to be heated onto said hearth, discharging means removing heated articles from said hearth, hearth travel measuring means having electric pulse generating and pulse counting means and control means operatively responsive to said counting means coordinating the starting and stopping of the hearth and the energizing and deenergizing of the charging means and discharging means.

2. A rotary hearth furnace control comprising, in combination, a rotary hearth furnace having a rotatable hearth, charging means delivering articles to be heated onto said hearth, discharging means removing heated articles from said hearth, hearth travel measuring means having electric pulse generating and pulse counting means and control means operatively responsive to said counting means whereby the hearth is stopped at predetermined stops for both charging and discharging said hearth each independently of the other and then restarted.

3. A rotary hearth furnace control comprising, in combination, a rotary hearth furnace having a rotatable hearth, charging means delivering articles to be heated onto said hearth, discharging means removing heated articles from said hearth, drive means having a drive shaft rotating said hearth, disc means coaxially mounted on said drive shaft and rotating therewith, a light source and photosensitive element operatively associated with said disc means whereby portions of said disc means permit the passage of light from said source to said element as said disc means rotates, electronic counting means operable to count said light passages and control means operatively responsive to said count of light passages to stop and start the hearth and energize and deenergize said charging means and discharging means.

4. A rotary hearth furnace control comprising, in combination, a rotary hearth furnace having a rotatable hearth, charging means delivering articles to be heated onto said hearth, discharging means removing heated articles from said hearth, drive means having a drive shaft rotating said hearth, disc means coaxially mounted on said drive shaft and rotating therewith, said disc means having alternately light transmitting and opaque portions, a light source and photosensitive element operatively associated with said disc means whereby said transmitting portions permit the passage of light from said source to said element as said disc means rotates, electronic counting means operable to count said light passages and control means operatively responsive to said count of light passages coordinating the stopping and starting of the hearth and the energizing and deenergizing of the charging means and discharging means including cycling means controlling the duration of hearth stoppage.

5. A rotary hearth furnace control comprising, in combination, a rotary hearth furnace having a rotatable hearth, charging means delivering articles to be heated onto said hearth, discharging means removing heated articles from said hearth, drive means having a drive shaft rotating said hearth, disc means coaxially mounted on said drive shaft and rotating therewith, said disc means having alternately light transmitting and opaque portions, a light source and photosensitive element operatively associated with said disc means whereby said transmitting portions permit the passage of light from said light source to said photosensitive element as said disc means rotates, electronic counting means operable to count said light passages and control means operatively responsive to said count of light passages whereby the hearth is stopped at predetermined stops for both charging and discharging said hearth each independently of the other and thereafter restarted including cycling means controlling the duration of hearth stoppage.

6. A rotary hearth furnace control comprising, in combination, a rotary hearth funace having a furnace chamber with a rotatable hearth therein, charging means delivering articles to be heated into said chamber and depositing them on said hearth, discharging means removing the heated articles from said hearth and chamber, hearth drive means including a drive shaft, disc means coaxially mounted on said shaft and rotating therewith, said disc means having alternately light transmitting and opaque portions, a light source and photosensitive element operatively associated with said disc means whereby said transmitting portions permit the passage of light from said light source to said photosensitive element as said disc means rotates, electronic counting means operable to count said light passages and control means responsive to said count of light passages operable to stop said hearth drive means and appropriately energize and deenergize said charging means and discharging means including means operable to restart said hearth rotation and cycling means controlling the duration of stoppage of said hearth.

7. A rotary hearth furnace control comprising, in combination, a rotary hearth furnace having a furnace chamber with a rotatable hearth therein, charging means delivering articles to be heated into said chamber and depositing them on said hearth, discharging means removing the heated articles from said hearth and chamber, hearth drive means including a drive shaft, disc means coaxially mounted on said shaft and rotating therewith, said disc means having alternately light transmitting and opaque portions, a light source and photosensitive element operatively associated with said disc means whereby said transmitting portions permit the passage of light from said light source to said photosensitive element as said disc means rotates, electronic counting means operable to count said light passages and control means operatively responsive to said count of light passages coordinating starting and stopping the hearth and appropriately energizing and deenergizing the charging means and discharging means including cycling means controlling the duration of hearth stoppage whereby the travel of said hearth is interrupted at predetermined instances for both charging and discharging said hearth each independently of the other.

References Cited in the file of this patent

UNITED STATES PATENTS

2,091,562	Palmer	Aug. 31, 1937
2,622,861	Talley	Dec. 23, 1952
2,656,106	Stabler	Oct. 20, 1953
2,865,103	Lolley et al.	Oct. 23, 1958