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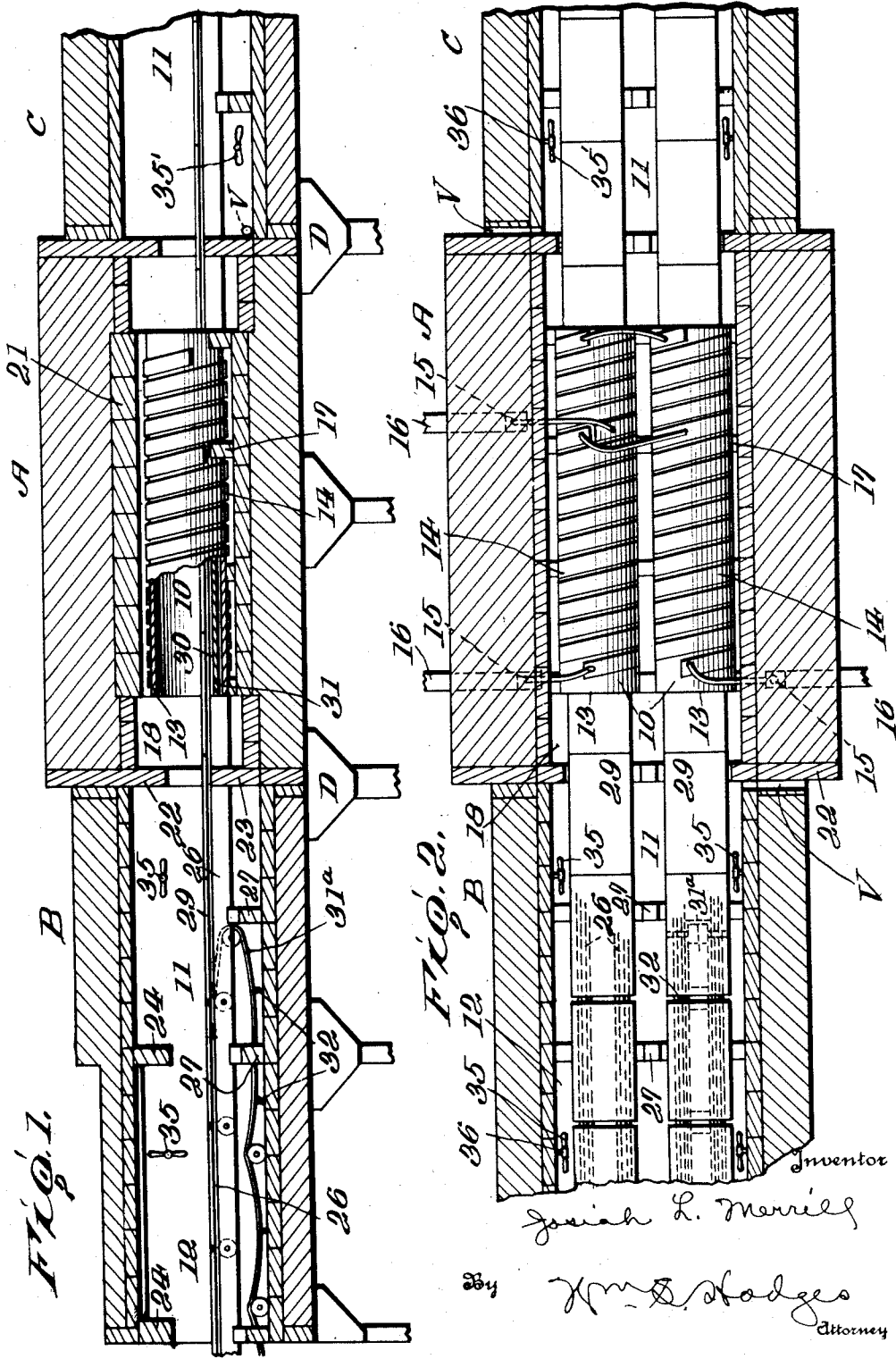
J. L. MERRILL

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ELECTRIC KILN

Filed June 5, 1929

2 Sheets-Sheet 1



Oct. 27, 1931.

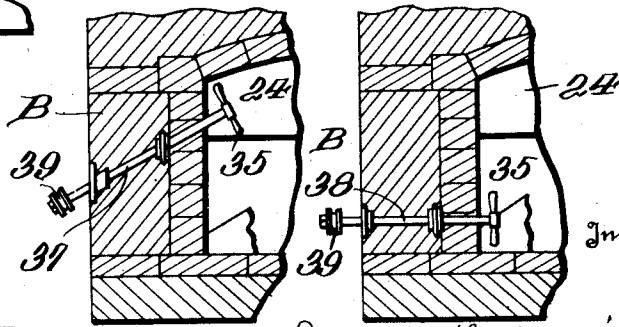
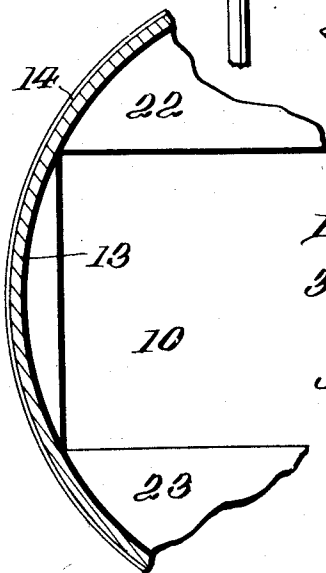
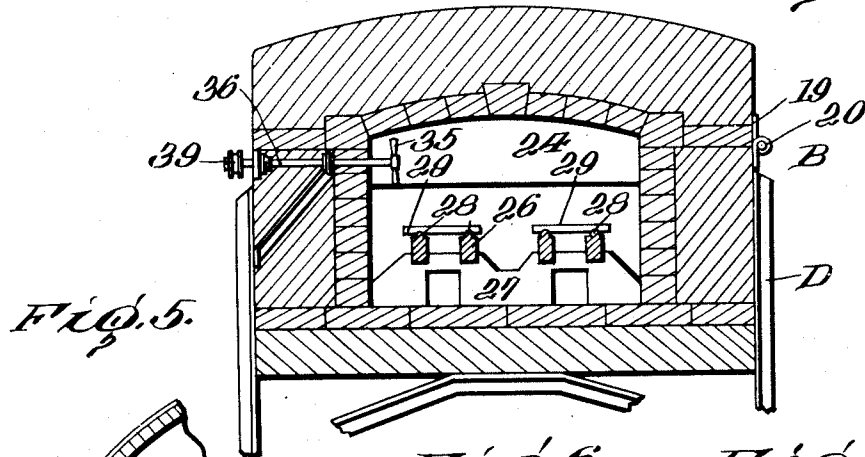
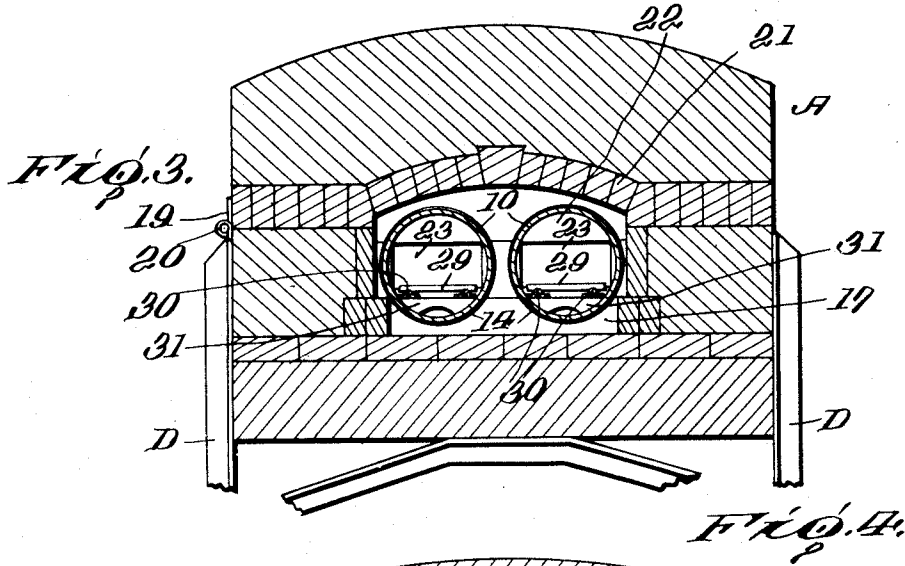
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ELECTRIC KILN

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This invention is a kiln for firing porcelain and other ceramic articles.

In general, kilns of the continuous type for firing ceramic products, to be economical must not only be designed for large capacity, but it is very essential that they be operated at full capacity. In those installations where the natural radiation of the ware in cooling is depended upon, the preheating and cooling chambers normally incorporated in kilns of this type necessarily have to be very long. This is because such ware should not ordinarily leave the kiln at a temperature above 400° F. In kilns of this character, employing hard fuel, oil or gas as the firing medium, the total length is normally between 200 feet to 300 feet, or over. The extreme length of these kilns is due to the necessity of providing space for preheating and cooling zones, the actual firing chamber occupying a comparatively small portion of the total length. It has been demonstrated, however, that kilns need not be nearly so long if electricity is utilized as the heating medium. In fact, kilns of the electrical type now in commercial use run from 104 feet to 140 feet.

One of the objects of the invention is to provide an electrically heated kiln of the counter-flow type, so constructed as to transfer heat by radiation from the outgoing hot ware to the incoming cold ware. A further object is to provide an electrically heated kiln equipped with means to artificially accelerate this heat exchange, so that preheating and cooling zones may be shortened to such an extent as to materially reduce the cost of installing and maintaining the furnace, making it possible to build kilns of smaller size for more economical operation than is possible where this forced method of heat transfer is not used. A further object is to provide a kiln of the character referred to of a plurality of sections, so constructed and arranged that the sections may be constructed as independent units and readily assembled at the site of installation.

The invention will be hereinafter fully set forth and particularly pointed out in the claims.

In the accompanying drawings:—

Figure 1 is a vertical longitudinal sectional view of a kiln constructed in accordance with the invention. Figure 2 is a transverse sectional view on the line 2—2 of Figure 1. Figure 3 is a similar sectional view on the line 3—3 of Figure 1. Figure 4 is a detail view illustrating the muffle. Figures 5, 6 and 7 are sectional views illustrating slight modifications.

Referring to the drawings, the kiln therein illustrated comprises three sections, to wit, a middle or muffle section A and two end sections B and C. The walls of these chambers are formed of any suitable or desired refractory material in a manner which is well understood in the art and need not here be explained in detail. The sections are supported in alignment with each other by suitable frameworks D.

As illustrated in the drawings, the kiln is constructed so as to provide two complete but independent passages for the ware to be heated. Each middle section A is provided with two parallel muffle portions 10, and each end section B and C is provided with an initial or preheating chamber 11 extending from one end of the muffle in one direction, combined with an annealing or cooling chamber 12 extending from the other end of the muffle portion in the other direction. The double form illustrated is desirable for many reasons, but obviously the kiln may be constructed of a single passageway arranged with the preheating, muffle and cooling chambers mentioned, without departing from the spirit of the invention.

Each muffle 10 may be constructed of any desired material, but preferably consists of a refractory tube 13, upon which is exteriorly wound a conductor 14, in the form of a relatively wide ribbon extending helically around the tube. It is preferred to construct the ribbon 14 of platinum because of high melting point and inertness at high temperatures, and in order to obtain the best resistance effects the tape or ribbon form is employed. The ends of the ribbon 14 are fastened in suitable manner so as to be connected with the terminal block 15 in the re-

fractory brick lining of the kiln. From said terminal block a conductor 16 is taken to the terminal on the side of the kiln. This last mentioned conductor is made of any desired
 5 type of heat resisting metal, but it has a very large cross section to make the resistance through the insulation as low as possible.

The refractory tubes 13 may be supported in any suitable or desired manner, but it is
 10 preferred to mount them on refractory saddles 17, preferably a material which has a very small co-efficient of expansion over a wide range of heat. The tubes are so supported that their ends are free to permit unrestrained expansion and contraction. The
 15 ends of the tubes 13 communicate with extension chambers 18 of refractory material formed in section A adjacent the ends of the tubes 13 and positioned to cooperate with said tubes so as to complete the heating section A.

The portion of the kiln containing the muffles is so constructed that the tubes 13 may be lifted out and replaced if necessary. For
 25 this purpose, the space immediately above said tubes is bridged by a metal shell 19 hinged to the supports of the kiln as indicated at 20, and surmounted by an arch 21, of refractory blocks superposed by a filling of refractory material.

The sections B and C are of similar construction and a description of either will apply to both. At both ends of each muffle, i. e. the outer ends of each of the extension chambers 18, are located upper baffles 22 and lower baffles 23, so positioned as to confine the heat as much as possible within the muffles. The chambers 11 and 12 at their outer ends are also provided with baffles 24, depending from
 40 the roof of each and said chambers are also provided with similar intermediate baffles 25. All of said baffles together with the radial forced circulation serve to retard the escape of heat as much as possible, so as to confine
 45 said heat within the respective chambers and thereby prevent any sudden lowering of the temperature to which the ceramic articles are to be treated. It is preferred to provide vents V for allowing escape of gases given
 50 off by the incoming ware.

The ware to be fired may be transferred through the kiln in any suitable or desired manner. For the purpose of illustration, refractory tracks 26 are mounted upon refractory track supports 27 in the chambers 12 and 13, and slidably mounted upon reduced portions 28 of said refractory tracks are ware-carriers 29. Refractory tracks 30 are also mounted on track supports 31 arranged
 60 in the muffles, so as to connect the tracks of the respective sections 12 and 13 and thereby provide continuous tracks throughout the kiln.

The carriers may be caused to travel
 65 through the kiln in any suitable or desired

manner, but for purposes of illustration an endless drive belt 31* is shown, operated from a source not shown, said belt being equipped with carrier pushers 32 positioned to engage the carriers as they are placed by operators
 70 upon the tracks at the entrance to each initial heating chamber 11. It is obvious that as the belt operates, pushers 32 successively engage the carriers and push them along in a succeeding train, passing from the initial
 75 heating chamber 11 through the muffle and out through the cooling chamber 12.

The tracks are so arranged that as the ware is introduced through the initial heating chamber it is greatly raised in temperature
 80 as it approaches the muffle chamber, the operation of the driving chain being regulated to propel the ware at the desired speed for effective firing. In other words, the speed at which the ware travels through the
 85 muffle is regulated to insure the completion of the firing step while passing through the muffle. As it leaves the muffle the ware enters the cooling chamber 12 in line with the initial heating chamber through which it was
 90 introduced, and gradually cools as it approaches the outlet end of said chamber 12. As the fired ware passes through the cooling chamber 12, the heat radiated during the cooling process is transferred to an incoming
 95 train of unfired ware which is being introduced in the initial heating chamber 11 which lies beside the said cooling chamber 11. In this manner there is a heat exchange from the outgoing hot ware to the incoming
 100 cold unfired ware, so that by the time said unfired ware reaches the muffle it has absorbed quite a substantial degree of heat and is thus gradually brought up to the firing
 105 temperature. In a similar manner, as this ware moves out into its cooling chamber its heat is transferred to the incoming ware of the adjoining preheating chamber.

In order to facilitate the heat exchange which takes place between the unfired ware
 110 and the fired ware, fans 35 are located in spaced apart positions in the upper part of each of the preheating and the cooling chambers. These fans may be mounted on horizontal supporting shafts 36, as illustrated in
 115 Figure 3 or on inclined shafts 37, as illustrated in Figure 5, or they may be located at the bottom as illustrated at 38 in Figure 6. These fans by setting up a positive or forced circulation cross-wise of the chambers, as indicated by the arrows in Figure 3, greatly
 120 facilitate the heat exchange between the hot and the cold ware. The fans also, by establishing currents of air at approximately right angles to the line of travel of the ware, serve
 125 to break up any leakage of cold air into the furnace through the doors. In other words, these cross currents in effect form a series of seals between the baffles in the preheating and cooling chambers. There appears to be
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two critical temperatures in cooling the ware, one a little above 1000° F. and one at approximately 600° F. where the cooling has to be more gradual than at other temperatures, to prevent the setting up of cracking strains. This situation is effectually taken care of by the arrangement of baffles and positive cross currents between them. The gases discharged by the ware during the preliminary heating are normally heavier than air and there is an advantage in also placing fans 35' at the bottom of the chamber, as shown in Figure 6, because they distribute these gases in the cross currents which are created. The fans are operated in any desired manner for instance, by means of belts not shown engaging pulleys 39 on their shafts.

The advantages of the invention will be readily understood by those skilled in the art to which it belongs. For instance, an important advantage is that because of the forced heat exchange between the hot and the cold ware, the length of the preheating and cooling zones may be shortened so as to materially reduce the cost of the furnace. Also, the kilns may be built of much smaller size for economical operation than is possible with the old type kilns which do not employ the forced method of heat transfer. This not only reduces the cost of the initial installation, but also relieves the manufacturer of the necessity of carrying a large stock of finished ware as now has to be done where large kilns have to be operated at full capacity, because the electric kiln of the invention does not have to be operated at full capacity where a fluctuating seasonal demand has to be met. A further advantage lies in the fact that by shortening the length of the kiln it is possible to push the ware through the kiln on carriers sliding on refractory tracks. These carriers are constructed of a light refractory material so that the heat carried by them out of the furnace is much less than that carried out by the cars now commonly used in existing types of furnaces. Another important advantage is that the three sections of the kiln may be constructed as independent units of proper dimensions, so as to provide when assembled, a continuous commercial furnace of the capacity of the 9 and 12 foot standard bottle kilns, said sections being completely constructed at the factory and shipped to the point of installation as independent sections, and there readily assembled.

Having thus explained the nature of the invention and described an operative manner of constructing and using the same, although without attempting to set forth all of the forms in which it may be made, or all of the forms of its use, what is claimed is:—

1. A kiln of the character described comprising a middle muffle section formed with

two independent parallel muffle chambers, and two independent end sections connected to the opposite ends of said middle section, each end section having a single combined preheating and cooling chamber communicating with the adjacent ends of both muffle chambers, means supporting said muffle chambers so that their ends are free to expand and contract, and means for causing the ware to travel in opposite directions through the kiln, so that cold ware traveling in one direction toward a muffle chamber is preheated by radiation from cooling ware leaving the other muffle chamber.

2. A kiln of the character described comprising a middle muffle section formed with two independent parallel muffle chambers, and two independent end sections connected to the opposite ends of said middle section, each end section having a single combined preheating and cooling chamber communicating with the adjacent ends of both muffle chambers, means supporting said muffle chambers so that their ends are free to expand and contract, means for causing the ware to travel in opposite directions through the kiln, and means within said combined preheating and cooling chambers for creating currents of air transversely of said chambers, so as to facilitate temperature exchange between the adjacent hot ware and cold ware.

3. A kiln of the character described comprising a middle muffle section formed with two independent parallel muffle chambers, and two independent end sections connected to the opposite ends of said middle section, each end section having a single combined preheating and cooling chamber communicating with the adjacent ends of both muffle chambers, means supporting said muffle chambers so that their ends are free to expand and contract, means for causing the ware to travel in opposite directions through the kiln, and spaced apart fans mounted on the side walls of the preheating and cooling chambers and positioned to direct air currents transversely across said chambers, so that air heated by radiation from the outgoing hot ware will be directed against the incoming cold ware.

4. A kiln of the character described comprising two parallel muffle chambers and two combined preheating and cooling chambers, each connected with an end of a muffle chamber, so that a preheating chamber and a cooling chamber are connected with the respective ends of each muffle chamber, spaced apart baffles depending from the tops of said combined preheating and cooling chambers, and means for creating currents of air transversely of the heating and cooling chambers at positions between the baffles so as to form a series of air seals between said baffles.

5. A kiln of the character described comprising two parallel muffle chambers and two combined preheating and cooling chambers, each connected with an end of a muffle chamber, so that a preheating chamber and a cooling chamber are connected with the respective ends of each muffle chamber, spaced apart baffles depending from the tops of said combined preheating and cooling chambers, and fans mounted on the side walls of said heating and cooling chambers at locations between the baffles and positioned to direct currents of air transversely of said chambers so as to form a series of air seals between said baffles.

6. A kiln of the character described comprising a middle muffle section formed with two independent parallel muffle chambers and with extension chambers at the ends of the muffle chambers, and two end sections connected to the respective extension chambers, each end section having a single combined preheating and cooling chamber communicating with the adjacent ends of both muffle chambers through said extension chambers, said muffle chambers each being constructed of a refractory tube provided with an exteriorly wound electric heating element, and means for causing the ware to travel in opposite directions through the kiln so that the cold ware travelling in one direction toward a muffle chamber is preheated by radiation from cooling ware leaving the other muffle chamber.

7. A kiln of the character described comprising a middle section having a tubular muffle chamber and extension chambers with which the ends of said muffle chamber connect, said muffle chamber being encircled by an electric heating element, an initial heating chamber connected with one end of the tubular muffle chamber, and a cooling chamber connected with the other end of said muffle chamber.

8. A kiln of the character described comprising an initial heating chamber, a muffle supported so that its ends are free for unrestrained expansion and contraction, and a cooling chamber arranged end for end so as to provide a continuous passageway, and an electric heating element encircling said muffle.

9. A kiln of the character described comprising a structure of refractory material supported so that its ends are free for unrestrained expansion and contraction, said structure being provided with a continuous longitudinal passageway extending therethrough, and an electrical heating element surrounding a portion of said passageway.

10. A kiln of the character described comprising a structure of refractory material supported so that its ends are free for un-

restrained expansion and contraction, said structure being provided with a continuous passageway extending therethrough from end to end, and an electrical heating element helically wound around a portion of the wall of said passageway.

11. A kiln of the character described comprising a muffle supported so that its ends are free for unrestrained expansion and contraction, an initial heating chamber having one end joined to an end of the muffle, an annealing chamber joined to the other end of the muffle, a track extending through said chambers and muffle, and an electric heating medium encircling said muffle.

12. A kiln of the character described comprising a tubular muffle provided with an axial passageway said muffle being supported so that its ends are free for unrestrained expansion and contraction, an initial heating chamber having one end joined to an end of the muffle and also provided with a passageway, an annealing chamber joined at one end to the other end of the muffle and also provided with a passageway, said passageways combined forming one continuous passageway, a track extending through the continuous passageway, and an electric heating medium encircling the wall of said muffle so as to enclose the bore thereof.

13. A kiln of the character described comprising a tubular muffle having extension chambers extending from either end thereof, an initial chamber having one end joined to the outer end of one of said extension chambers, an annealing chamber having one end joined to the outer end of the other extension chamber, said muffle and chambers being arranged to provide a continuous passageway from end to end, and an electric heating medium encircling said muffle.

14. A kiln of the character described comprising a tubular muffle having extension chambers extending from either end thereof, an initial chamber having one end joined to the outer end of one of said extension chambers, an annealing chamber having one end joined to the outer end of the other extension chamber, said muffle and chambers being arranged to provide a continuous passageway from end to end, and a tape of electroconductive material wound about said muffle so as to provide a heating element therefor.

15. A kiln of the character described comprising a middle muffle section formed with two independent parallel muffle chambers, and two end sections connected to the opposite ends of said middle section, each end section having a single combined preheating and cooling chamber communicating with the adjacent ends of both muffle chambers, spaced apart baffles within said combined preheat-

ing and cooling chambers, means for causing the ware to travel in opposite directions through the kiln, and means for establishing cross currents of air in the spaces between said baffles.

In testimony whereof I have hereunto set my hand.

JOSIAH L. MERRILL.

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