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PROCESS AND APPARATUS FOR COOLING FOUNDRY SAND ON A VIBRATORY CONVEYOR

Filed May 27, 1963 2 Sheets-Sheet 1

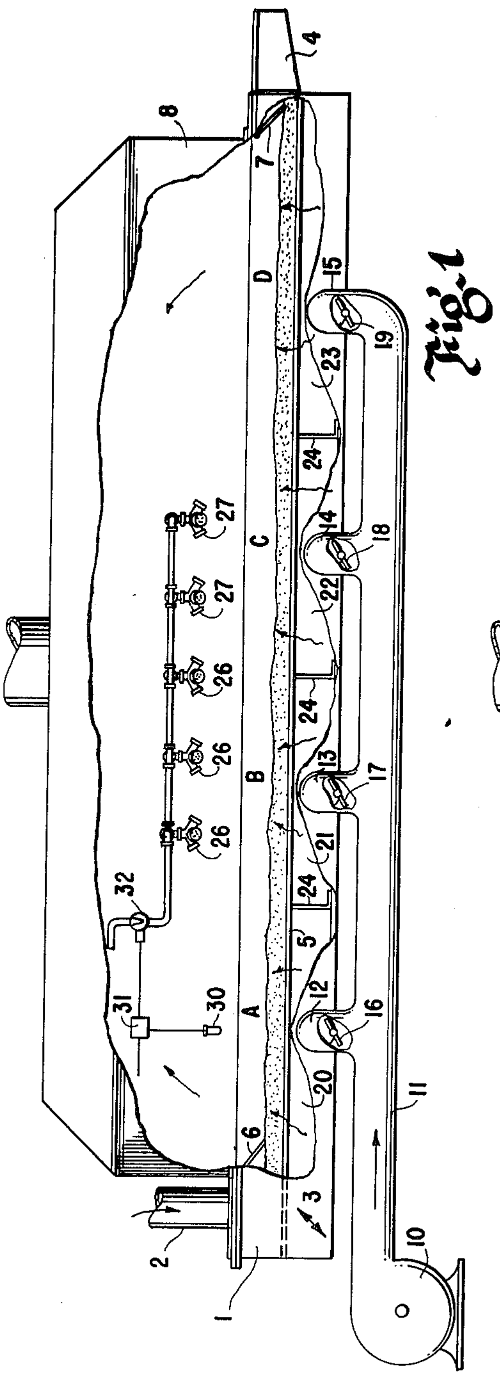

Fig. 1

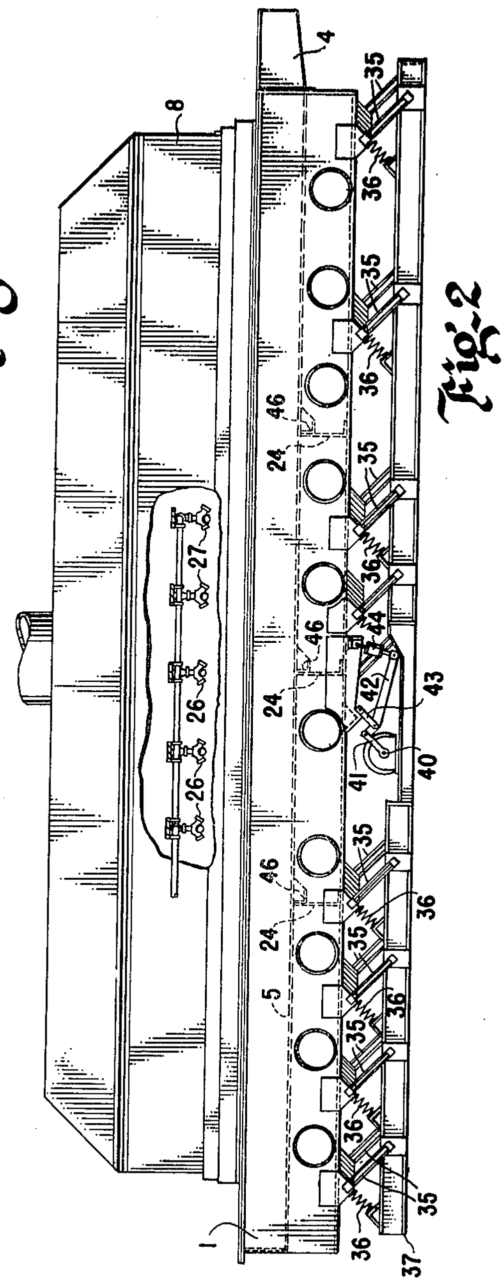

Fig. 2

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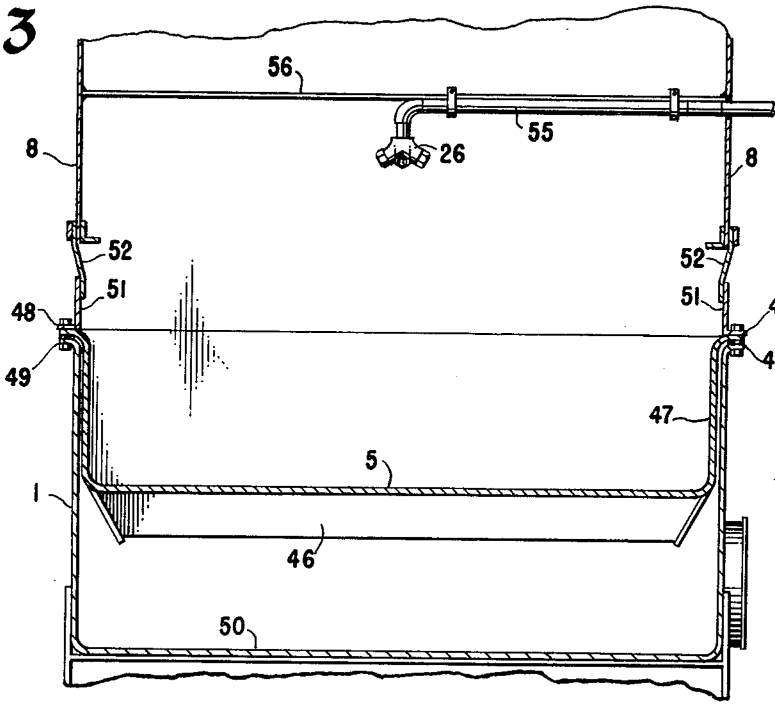
Fig. 3



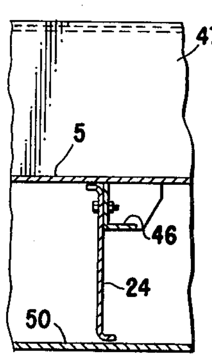


Fig. 5

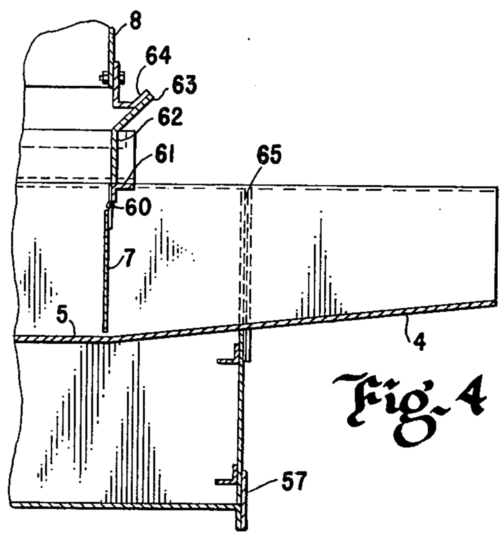


Fig. 4

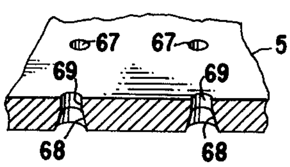


Fig. 6

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PROCESS AND APPARATUS FOR COOLING FOUNDRY SAND ON A VIBRATORY CONVEYOR

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6 Claims. (Cl. 22—89)

This invention relates to a method and apparatus for cooling foundry sand and similar materials as it is recovered from molds immediately after casting.

In ordinary foundry practice after the molten metal poured into a mold has hardened the mold is opened and the casting along with the sand in the mold is dumped onto a vibrating conveyor having a perforated deck so that the sand is shaken loose from the mold and separated from the castings and the mold. The sand at this stage is hot and must be cooled before reuse. The sand contains a certain amount of resin and moisture, the resin being included with the sand to act as a binder to hold the sand in position in the mold after the pattern is removed. For economical operation it is desirable to cool the sand without reducing its moisture content to the point where the resin becomes powdery and is lost to the atmosphere.

A principal object of this invention is to provide a process and apparatus for rapidly cooling the sand as it comes from the mold and casting.

Another object of the invention is to provide means for cooling the foundry sand without reducing its moisture content below certain limits.

A still further object of the invention is to provide a combination of evaporative cooling and direct heat transfer cooling for cooling a hot foundry sand without reduction of its moisture content.

An ancillary object of the invention is to provide a perforated deck in which the perforations occupy a small percentage of the total area of the deck but in which the perforations are shaped to provide a high velocity jet stream of air through each perforation to prevent the ingress of particles of material from the bed of materials carried on the deck.

These and more specific objects and advantages are apparent from the following description of a preferred process and apparatus for cooling foundry sand and similar materials constructed and operated according to the invention.

According to the invention the hot foundry sand is carried on a vibratory conveyor that is effectively divided into four zones. In the first zone cool air is blown upwardly through the bed of sand on the vibratory conveyor to reduce its temperature by direct heat transfer to the air and also reduce the temperature by evaporation of some of the moisture in the sand. The second zone supplies air at a reduced rate which in combination with the vibratory action of the conveyor keeps the material agitated while water is sprayed from a plurality of fog nozzles onto the bed of hot sand. The vibration keeps the material agitated so that the water droplets from the fog are transmitted to all parts of the bed of sand. In this stage the moisture content may be raised above that of the incoming hot sand or it may be maintained at approximately the initial amount. From the second stage or zone the material moves into the third zone where moisture is also added in the form of a fog or mist at the same time that the air velocity up through the deck is increased to increase the amount of conductive cooling. From the third zone the material moves into the fourth zone where the air is supplied at a low velocity to effect an evaporative cooling of the material at an air flow rate that is insufficient to

carry off any fine particles of the material. From the fourth zone the material is discharged under a swinging gate onto an upwardly inclined portion of the conveyor which serves to maintain a certain amount of back pressure on the material to maintain the depth of sand on the vibratory conveyor in the various zones and at the same time provide an ascending ramp up which the large chunks of material or portion or castings may be conveyed out of the cooler. The perforations through the deck are generally conical in shape with the large end down so that the air flow is from the large end to the small end of each perforation as it passes from the plenum chamber beneath the perforated deck into the material on the deck.

An apparatus for carrying out the invention is illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 is a schematic side elevation of a vibratory conveyor and dryer constructed according to the invention.

FIGURE 2 is a side elevation generally similar to FIGURE 1 showing the mounting and the drive for vibrating the conveyor.

FIGURE 3 is a cross section of the conveyor taken substantially along the lines 3—3 of FIGURE 2.

FIGURE 4 is a fragmentary vertical section of the discharge end of the conveyor taken substantially along the vertical center line.

FIGURE 5 is a fragmentary vertical section showing one of the partitions dividing the enclosure beneath the conveyor deck into a plurality of chambers.

FIGURE 6 is a fragmentary enlarged view of a section of the deck showing the shape of the apertures or perforations.

These specific figures and the accompanying description are intended merely to illustrate the invention and not to impose limitations on its scope.

In a cooling system according to the invention the hot material is fed into the up stream end of a vibratory conveyor trough **1** through an inlet chute **2**, and, in response to vibratory motion of the trough along an inclined path indicated by the double tipped arrow **3**, is conveyed along the trough and over an upwardly inclined portion **4** at the discharge end and then transferred to some suitable take away conveyor or receptacle. While in the conveyor trough **1** the material is carried on a perforated deck **5** that extends from an inlet gate **6** to a discharge gate **7** that cooperate with a hood **8** arranged to collect the hot air rising from the bed of material on the conveyor deck **5**.

Cooling air for cooling the material is supplied from a fan **10** through a duct **11** and branch ducts **12, 13, 14** and **15** equipped with dampers **16, 17, 18** and **19**. The branch ducts open into plenum chambers **20, 21, 22** and **23** formed in the conveyor trough **1** beneath the deck **5**. The plenum chambers are separated by partitions **24** so that the air pressure under the perforated deck in the various zones may be independently adjusted. Unperforated extensions of the conveyor deck **5** extend over the first plenum chamber **20** and under the chute **2** at the receiving end of the conveyor and over the plenum chamber **23** at the exit end.

As the hot material enters the conveyor it is conveyed under the gate **6** into the first zone over the plenum chamber **20** and is, in this zone, cooled by conduction of air flow from the plenum chamber **20** up through perforations in the deck **5** and through the material. In this zone a relatively higher air pressure is maintained by opening the damper **16** so that an air flow approximating a fluidizing condition exists in the bed of sand. This air flow produces cooling of the sand and at the same time carries off some of the moisture producing an evaporative cooling in addition to the conductive cooling and as the material reaches the down stream end of the zone becomes quite dry even though still quite hot. Under these conditions the material tends to break up and the resin tends to dust off and be entrained with the air flow going up through the hood **8**.

Since the incoming hot sand may have a temperature as high as 400° F. the air flowing up through the material in the first zone, over the plenum chamber **20**, tends to extract all of the moisture from the material leaving it extremely dry. The material is conveyed through this section fast enough so that at the downstream end of this section or zone the material still has approximately 1½ percent moisture, that being enough to prevent the resin from separating and being carried away in the air stream.

As the material passes the first of the partitions **24** and into the second zone it is sprayed with droplets of water from fog nozzles **26** mounted in the hood **8** over the second zone. The vibration of the deck **5** in combination with a low air velocity from a low pressure region in the second plenum chamber **21** keeps the material agitated so that the added moisture reaches most of the grains of sand to replace the moisture lost in the first zone. These water droplets coming in contact with the sand tend to cool the sand and some of the water evaporates thus cooling the sand still further. The addition of the water in the form of fog or droplets continues throughout the second zone and the third zone. The only difference with respect to the cooling is that in the third zone, between the second and third one of the partitions **24**, a higher air velocity is used to induce fluidization of the material. Throughout the second and third zone the addition of the water droplets from the fog nozzles **26** and **27**, the latter being over the third zone, keeps the finer particles of material moistened so that they are not carried off in the air stream.

As the material passes the last of the partitions **24** it enters the fourth zone and is subjected to low velocity air filtering up through the bed of vibrated material which cools the material still further while evaporating some of the moisture added in the third zone. This continues till the end of the fourth zone when the material is reduced to a moisture content of approximately 1½ percent and is cooled down to a temperature approximating room temperature.

Since the temperature of the incoming hot sand may vary quite widely, a temperature sensitive bulb **30** is preferably installed in the hood **8** over the first zone with the bulb connected through a controller **31** arranged to operate a valve **32** in the pipe line feeding the nozzles **26** and **27**. With this control in operation, if the incoming sand is very hot, the air, after being heated while passing through the hot sand in the first zone, strikes the temperature responsive element **30** which causes the valve **32** to open and supply the water spray or fog in the second and third zones. If the temperature of the incoming sand is low the air is not as hot as it leaves the bed and strikes the resistance thermometer **30** thus causing the controller to reduce the volume of water supplied to the nozzles. In this way the addition of moisture in the form of the droplets or fog from the nozzles is controlled according to the temperature of the incoming sand.

The details of construction of the various portions of the apparatus are illustrated in the accompanying figures. Thus in FIGURE 2 the conveyor **1** is shown equipped with flat cantilever leaf springs **35** spaced at intervals along its length and cooperating with coil springs **36** to support the conveyor trough **1** from a base **37**. In a commercial embodiment the conveyor is approximately 30 feet long by 5 feet wide and, including the perforated deck with its supports, weighs approximately 5 tons. For this size equipment approximately 70 of the coil springs **36** are required these being spaced in **7** rows with ten springs in each row crosswise of the conveyor. The cantilever guide springs **35** are arranged in groups there being **4** groups in each transverse row with those located

near the center line of the conveyor and being offset to the right with respect to those located at the sides of the conveyor.

This conveyor system is designed to be resonant at approximately 600 cycles per minute, i.e. ten cycles per second. The conveyor is driven by a motor driven crank shaft **40** which is connected to the conveyor **1** through a connecting rod **41** pivotally connected to a first end of a lever **42** that is fulcrumed on a bracket **43** extending downwardly from a center portion of the conveyor trough. The far end of the lever **42**, away from the connecting rod **41**, is connected through a shock absorber **44** to the conveyor trough **1**. The shock absorber **44** is similar to those used on automotive vehicles, connected between the axles and the frame of the vehicle, to absorb the energy from shock resulting from bumps in the road and prevent continued oscillation of the frame on the springs. As used in the conveyor drive, the shock absorber allows the lever **42** to pivot about its fulcrum in the bracket **43** and thus allow the distance from the conveyor to the base to vary according to load without transmitting static force through the lever **42**. This type of drive is illustrated in greater detail in Patent No. 2,630,211 to Robert M. Carrier et al. In this particular type of drive the shock absorber yields during starting and stopping of the conveyor to prevent the transmission of excessive force through the lever **42** and the crank shaft but serves as a practically invariable link at the operating frequency when the only forces required to be transmitted through the connecting rod and lever are the forces to overcome the losses in the vibrating system as it operates at its resonant frequency.

In the actual device a number of air inlets are provided into each section of the plenum chamber rather than the single branch duct as shown in FIGURE 1. Thus there are three inlets into the first chamber **20** two each into the second and third chambers **21** and **22**, and three into the fourth chamber **23**.

FIGURE 3 illustrates in greater detail the construction of the conveyor trough **1** including its perforated deck **5** and its cooperation with the hood **8**. As indicated in this figure the perforated deck **5** has reinforcements **46** extending transversely beneath the deck. These appear also in FIGURE 2 at the top of each of the partitions **24**. The conveyor itself comprises a first trough, including the perforated deck **5**, having upstanding sides **47** including outwardly turned flanges **48** that fit over corresponding flanges **49** on the sides of a deeper trough **50** that extends downwardly to include the plenum chambers **20–24**. The deeper trough **50** is fitted with brackets that carry the upper ends of the supporting springs **35** and **36**.

Immediately above the out-turned flanges **48**, **49** and the troughs **47** and **50** is an upstanding slide plate **51** that cooperates with a flexible lip or plate **52** extending downwardly from the edge of the hood **8** to form a rubbing seal between the members. This rubbing action occurs because of the vibratory motion of the conveyor relative to the stationary hood **8**.

The fog nozzles **26** and **27**, appearing in FIGURES 1 and 2, are attached to pipes **55** supported from cross members **56** extending laterally of the hood **8**.

The discharge end of the conveyor as illustrated in FIGURE 4 includes the upwardly inclined portion **4** that regulates the depth of the material being conveyed. This figure also shows a plate **57** closing the lower downstream end of the deep trough **50** that may be removed periodically to allow discharge of any fine material that may have fallen through the apertures in the perforated deck **5**.

Escape of air with the discharged material is limited by the discharge gate **7**, which is preferably constructed of steel with an asbestos covering, supported on a piano hinge **60** extending horizontally along the upper edge of the gate and attached to a cross member **61** of the conveyor trough structure. The gate is swung open as required by the sand leaving the conveyor. An upwardly extending wall **62** immediately above the cross member **60** terminates in an inclined portion **63** that cooperates with a rub plate **64** mounted on the hood **8**. The inclined portion **63** and the rub plate **64** have their rubbing surfaces directed in a plane parallel to the path of vibration of the conveyor deck which, in this case, is at an angle of 45 degrees to the horizontal. FIGURE 4 also indicates sealing material **65** that is included at the end of the deep trough **50** to prevent leakage of air out of the end of the plenum chamber **23** and past the edge of the shallow conveyor trough.

FIGURE 5 illustrates some of the details at one of the partitions **24**, including the cross member **46** which supports the perforated deck **5** and the partition **24**. As illustrated in this figure the partition **24** does not quite reach the bottom of the trough **50** but a small space is provided so that any sand dropping through the perforated deck **5** may be conveyed along the bottom of the trough **50** to the downstream end of the conveyor and removed after removal of the end plate **57**.

The perforated deck **5** as shown in FIG. 6, has regularly spaced perforations **67** which are formed with a conical lower portion **68** and a cylindrical upper portion **69**. These perforations are preferably 5/32 of an inch in diameter and are spaced one inch apart. The conical portion may have a maximum diameter of 1/4 of an inch and extend approximately 2/3 of the way through the perforated plate. This particular shape provides a nozzle effect to provide maximum air velocity through the perforations for a given pressure drop through the deck.

The apparatus constructed and operated according to the invention provides means for rapidly cooling a granular material having a high heat content while maintaining its moisture content at a level to prevent loss of fine powdery components as well as breakdown of components that tend to form a fine powdery material when dried. This makes possible the economical cooling of the material without deterioration.

Various modifications may be made in the structure of the apparatus without departing from the spirit and scope of the invention.

Having described the invention, we claim:

1. A process for cooling foundry sand upon discharge from a mold, comprising, conveying the sand on a vibratory conveyor over a series of portions of a perforated conveying deck, blowing air at generally atmospheric temperature upwardly through a first portion of the perforated deck at a substantial velocity to cool the sand by conduction and evaporation of the moisture from the sand, blowing air at a reduced velocity through a second portion of said conveyor deck and the partially cooled and dried sand while introducing water in droplet form into the partially dried and cooled sand to replace a substantial portion of the loss by evaporation, blowing air at substantial velocity through a third portion of the deck and the moistened sand thereon while continuing the addition of water in droplet form to replace at least that lost by evaporation, and blowing air at reduced velocity through a fourth portion of the deck and moistened sand thereon to complete the cooling by evaporation of the moisture.

2. A process for cooling foundry sand upon discharge from a mold comprising vibratorily conveying the sand through a succession of zones, blowing gas at substantial velocity upwardly through the sand in a first zone for conductive and evaporative cooling, blowing gas at low velocity upwardly through the sand in a second zone while adding liquid in droplet form to replace a portion of the moisture lost by evaporation in said first zone, blowing gas upwardly through the sand at substantial velocity in a third zone while adding liquid in droplet form, and removing a portion of the added liquid by evaporation by passing gas upwardly through the sand at low velocity in a fourth zone.

3. A process for cooling foundry sand upon discharge from a mold comprising the steps of conveying the material in a bed through a plurality of zones on a vibratory conveyor while first blowing gas upwardly through the bed of material while in a first zone at substantial velocity to cool the material by conduction and evaporation until the material tends to disintegrate, subjecting the material to reduced gas velocity in a second zone while adding liquid in droplet form until the loss by evaporation is substantially replaced, subjecting the material to increased gas velocity in a third zone while continuing to add liquid in droplet form until at least the original moisture content is regained, and subjecting the material to reduced gas velocity in a fourth zone to evaporate a substantial portion of the added liquid to complete the cooling of the material.

4. An apparatus for cooling foundry sand comprising, in combination, a conveyor having a first trough suspended in a deeper trough and joined along the upper portions of their sides, means for vibrating the conveyor to convey material therealong, the first trough having a perforated deck, said deeper trough serving as a plenum chamber, a plurality of partitions dividing the plenum chamber into sections, means for supplying air under individually controlled pressure to the sections of the plenum chamber, and means for adding liquid in droplet form to intermediate sections of the bed of material to replace the liquid lost by evaporation.

5. An apparatus for cooling foundry sand from a molding operation comprising, in combination, a conveyor having a first trough suspended in a deeper trough and connected along the upper edges of their sides, means for vibrating the conveyor along an inclined path to convey material therealong, the first trough having a perforated deck, said deeper trough serving as a plenum chamber, a plurality of partitions dividing the plenum chamber into sections, each of said partitions being separated from the bottom of the trough to leave a narrow slot, means for supplying gas to at least some of said plenum sections to flow directly upwardly through the perforated deck and through the slots to other plenum sections whereby different pressures are produced in different sections, means along the upper edges of the trough to engage a stationary hood, a gravity closed gate near each end of the trough at the limits of said hood engaging means to complete the enclosure of the cooling zones, and means for adding liquid in droplet form in amounts to replace that lost by evaporation in the cooler.

6. An apparatus according to claim **5** in which the conveyor trough is substantially horizontal through the cooling zone and inclines upwardly exterior of the cooling zone to retard the flow of material from such zone.

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MARCUS U. LYONS, *Primary Examiner.*