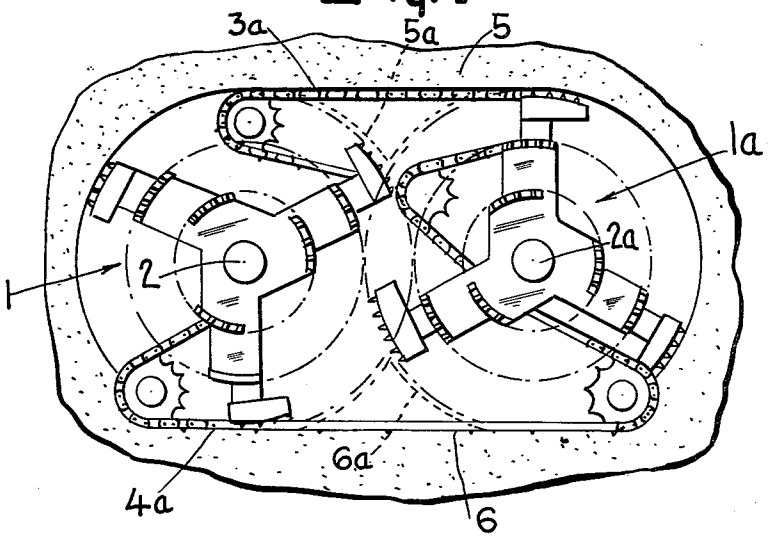
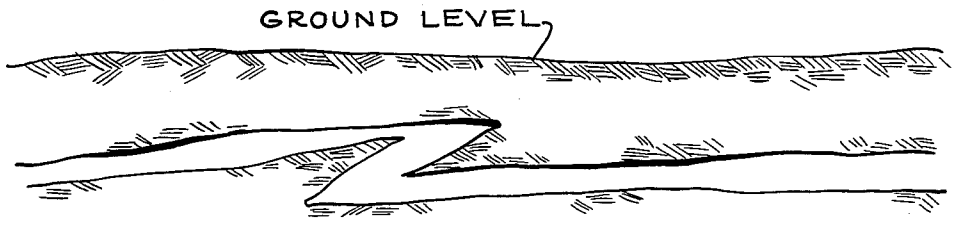
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METHOD OF MINING TRONA USING A CONTINUOUS MINER

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Fig. 1





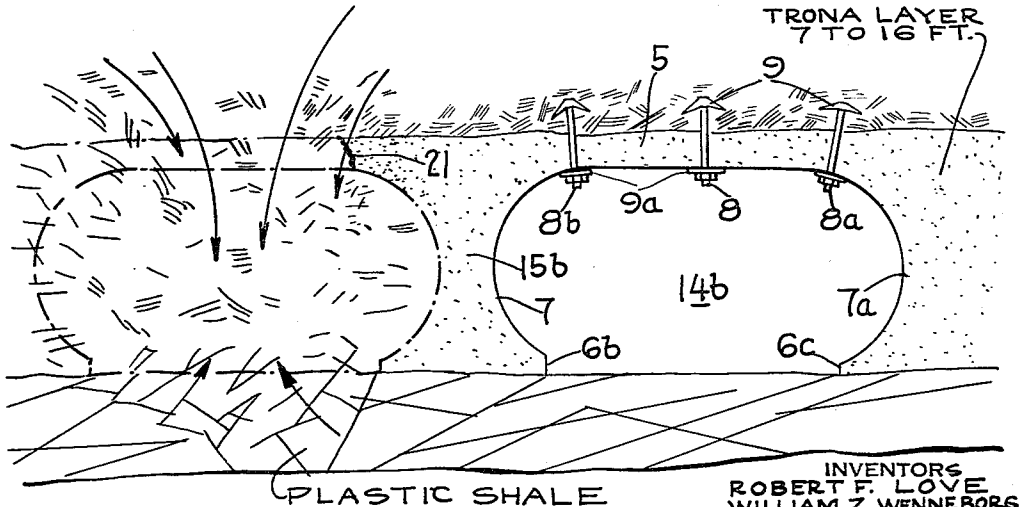


Fig. 2

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METHOD OF MINING TRONA USING A CONTINUOUS MINER

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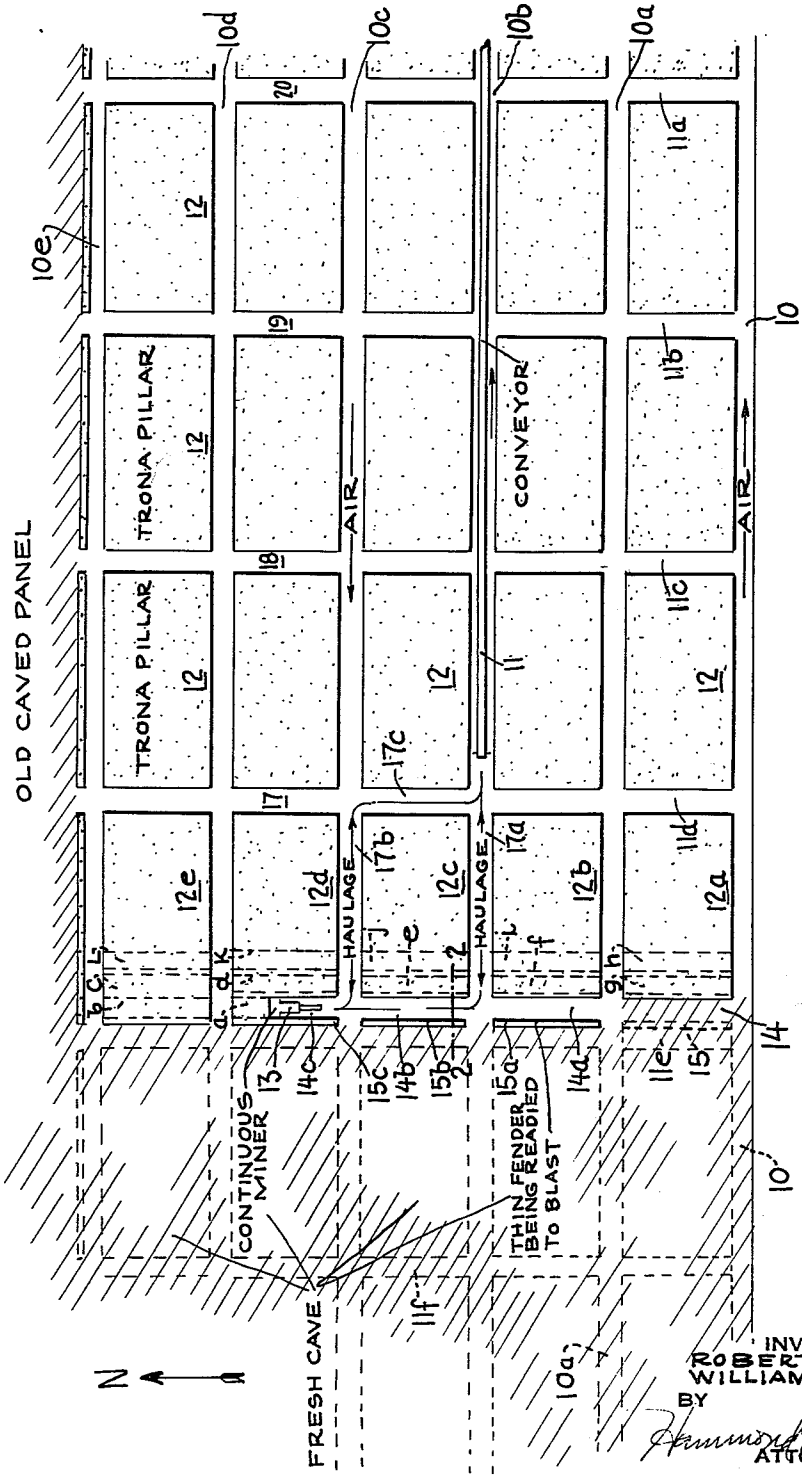


Fig. 3

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METHOD OF MINING TRONA USING A CONTINUOUS MINER

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6 Claims. (Cl. 262—1)

This invention relates to the mining of trona as found in large underground deposits in Sweetwater County and adjacent counties in Wyoming, and in similar trona deposits found elsewhere.

The trona deposits in Sweetwater County and adjacent counties in Wyoming consist of a main trona bed having a varying thickness up to about 16 feet, averaging more nearly 7 to 13 feet, located at a depth of about 1500 to 1800 feet underground.

This trona has a hardness index of 2.5 to 3.0, whereas soft coal has a hardness index of 1.5 to 2.0 and anthracite coal has a hardness index of 2.0 to 2.5. Because of its great depth below the surface and its relative hardness, the main Wyoming trona bed is hard to mine and this difficulty is increased by the fact that the main trona bed is stronger than the formation above and below it.

The main trona bed lies substantially horizontal. The overlying strata is also horizontal in attitude and is chiefly composed of unconsolidated shales and fine grained sandstones. The 400 feet of strata immediately above the main trona bed is mainly weak, laminated grey shales and oil shale and an approximately 8 foot bed of somewhat plastic oil shale lies immediately below the main trona bed. Occluded in the shales are substantial quantities of methane gas which is released when the shale is broken, as when the roof of a mine caves.

The comparative strength of the trona layer and of the overlying and underlying shale layers in average values is substantially as follows:

	Compressive Strength, p.s.i.	Tensile Strength, p.s.i.
Trona	7,500	500
Roof Shale	3,700	60
Floor Shale	3,700	400

These conditions make conventional mining operations very difficult because unlike coal and similar mining operations under a slate, compacted sandstone or other firmly compacted roof, trona mining essentially comprises removing the only strong layer in the formation and leaving an essentially weak roof structure in the structurally weak overlying formation while the plastic shale immediately below the trona bed is pushed upward into the mine cavity when the overlying weight is relieved by the removal of a portion of the trona bed in the mining operation.

In past Wyoming trona mining operation, it has been the practice to mine essentially rectangular tunnels in the trona formation according to the conventional room-and-pillar mining system used in coal mining by shear cutting and drilling the trona mining face and blasting out the trona, and to leave a substantial portion of 1 to 4 feet of the trona adjacent the top thereof to provide a roof support for the mine opening and to further support this roof

section by roof bolting and timbering as in coal mining practice. This thin trona supporting roof is, however, essentially weak and because of the blasting has been further weakened by the formation of cracks and fissures therein.

The rectangular shape of the tunnels or passages leaves the weight of the overburden to be supported by the thin trona layer left in place at the roof, and provides no support for the span between the substantially vertical walls of the tunnels from the trona bed left in place at each side of the tunnels, and the side walls, weakened by the blasting, tend to buckle. Due also to the rectangular shape of the mining tunnels the overburden weight bears at the bottom edges of the side walls, on the plastic shale layer below the trona bed and heaving and creeping of the lower shale layer into the mining cavities is aggravated thereby.

Continuous mining of the trona formation by the use of continuous mining machines of the type illustrated, for example, in United States Patents Nos. 2,753,167, 2,836,407 and 2,872,169 is, therefore, desirable if it can be done in an economical way because the elliptical shaped tunnels provided by the continuous miner provide greater roof support for the uncaved tunnels, there is less heaving of the mine floor into the mining tunnels, fewer working faces are necessary and as blasting is kept to a minimum, blasting fumes and blasting cracks are reduced.

One of the objects of this invention is to provide a method of mining trona by the use of rotary cutter boring type continuous mining machines in which the periods of idleness of the machines is materially reduced over the conventional mining systems.

Another object of the invention is to provide a method for continuously mining trona by the use of continuous mining machines in which the transport, "tramming" or turning of the machines from one mining face to another is substantially reduced.

Another object of the invention is to utilize the arched or elliptical side walls produced by rotary cutter boring type continuous mining machines for additional roof support in the essentially weak formation in which the trona beds are found, whereby roof bolting may be reduced and smaller fenders may be left between the tunnel being mined and the adjacent mined out portion of the formation and caving of the mined out areas controlled without danger to the mining operation.

Another object of the invention is to use the arched or elliptical contour produced by a continuous miner in a trona mining operation and to use roof bolting only at the center of the tunnel to additionally support the roof at this point and to use fenders to break the caving and prevent the caving from extending beyond a fender until such fender is to be removed.

Another object of the invention is to cave a mined out section of the mine as closely as possible to the area being mined to reduce the overburden pressure on the area being mined.

Various other objects and advantages of the invention will appear as this description proceeds.

Referring now to the drawings which illustrate a preferred application of the invention to trona mining,

FIG. 1 is a diagrammatic face view of a typical type of continuous mining machine showing the rotary cutters and of the type of tunnel which is cut in a trona formation.

FIG. 2 is a sectional view approximately on the line

2—2 of FIG. 3 of two mining tunnels produced by a continuous mining machine illustrating the roof support by roof bolting and the fender left between the tunnels.

FIG. 3 is a plan view of a trona mining operation illustrating one application of the method herein described.

In the operation of a continuous mining machine as illustrated in FIG. 1 two rotating cutters 1 and 1*a* mounted on a movable frame carried by caterpillar treads are advanced into the trona face to take circular cuts out of the trona face around axes 2 and 2*a*. The cuts preferably overlap at the midpoint of the tunnel being cut and the somewhat triangular section indicated by dotted lines 5*a* and 6*a* left suspended from the roof 5 and projecting from the floor 6 by the operation of the circular cutters 1 and 1*a* is then cut away by the horizontal sections 3*a* and 4*a* of a chain cutter on the mining machine to leave an elliptically shaped tunnel substantially as illustrated in FIGS. 1 and 2.

A section 5 of the trona 1 to 4 feet in thickness is preferably left at the top of the trona bed to provide roof support for the tunnels, in the otherwise structurally weak formation and inwardly projecting sections 6*b* and 6*c* of the trona as the base of the tunnels provide greater bearing surfaces on the underlying plastic shale layer than the rectangular tunnels, provided by conventional mining methods, and decrease heaving of the shale floor into the mining tunnels.

Due to the curved or elliptical sides 7 and 7*a* of this shape tunnel, the trona roof section 5 of the mine, consisting preferably of a layer of the hard trona one to four feet in thickness, is better supported than a rectangular mine tunnel with vertical side walls. Mine openings of this type up to 16 feet in width, in the trona formation, can be adequately supported by two or three rows of roof bolts 8 having expandable anchors 9 at one end and support plates 9*a* at the other end driven into the overlying formation, as illustrated. In many tunnels only one row of roof bolts through the center of the tunnel may be necessary.

We have found that tunnels up to 100 feet in length can be cut, without withdrawing the mining machine, by merely putting in one row of roof bolts 8 spaced approximately 4 feet apart along the center line of the tunnel. Rows 8*a* and 8*b* of roof bolts may then be inserted along each side of the tunnel after the machine has advanced far enough that the additional rows of roof bolts may be installed without interfering with the operation of the mining machine or the haulage of the mined trona away from the rear of the mining machine, if such additional roof bolting appears necessary. A lift, for example, may be driven entirely through a pillar up to 100 feet in thickness by installing only one row of roof bolts down the center of the lift. A row of roof bolts may then be installed along each side of the tunnel approximately in the position indicated, if this becomes desirable.

FIG. 3 illustrates the use of this type of continuous mining machine in the extraction of pillars in a trona mine. In this figure parallel entries 10, 10*a*, 10*b*, 10*c*, 10*d* and 10*e* are illustrated as having been driven into the trona formation from primary development entries (not shown) at the right side of this figure. Entry 10*e* may be an uncaved entry of a previous secondary entry development panel to the north of the mining area shown in FIG. 3. Entries 10, 10*a*, 10*b* and 10*c* may be part of the entries of new secondary development panel which when first driven extended further into the now caved formation to the left, as indicated by the dotted line extension of entries 10 and 10*a*, 10*b* and 10*c*. Entry 10*b* is shown as provided with a belt conveyor 11 on which the trona removed from the formation is deposited for removal from the mine. Entries 10 and 10*c* are used for the main inlet and outlet of ventilating air as indicated.

At right angles to the entries 10, 10*a*, 10*b*, 10*c* and 10*d*, rooms 11*a*, 11*b*, 11*c*, 11*d*, 11*e*, 11*f*, etc., have been driven to divide the trona area to be extracted into tiers of substantially rectangular pillars 12. The outlines of two former rooms 11*e* and 11*f*, which are now in the caved area of the mine, are indicated in dotted lines. Originally the entries 10, 10*a*, 10*b*, etc., and the rooms 11*e*, 11*f*, etc., extended further to the left of FIG. 3, but as the trona pillars 12 were mined, on retreat from the furthest extension of this development, the roof over the mined out area was caved to relieve pressure on the formation and these former entries and rooms are now lost in the caved area to the left of FIG. 3.

The exact number and arrangement of the entries and rooms is not material to the invention herein described as long as the number and arrangement is sufficient to provide access to the formation for the purpose of mining and removal of the trona and as long as the arrangement is sufficient to provide two or more pillars through which the continuous mining machine can be driven substantially without turning to drive lifts through two or more pillars for the purpose of removing the pillars.

The use of a continuous miner in this operation is shown on the still existent pillars 12*a*, 12*b*, 12*c*, 12*d* and 12*e*, at the left of FIG. 3. As here illustrated a rotary cutter continuous miner 13 of the type illustrated in FIG. 1 and more completely illustrated and described, for example, in United States Patents Nos. 2,753,167, 2,836,407 and 2,872,169, has been started from the entry 10 and has driven lifts 14, 14*a*, 14*b* through pillars 12*a*, 12*b* and 12*c* and lift 14*c* partial through pillar 12*d* in the tier of pillars at the left of FIG. 3. The direction and sequence of mining the future lifts is indicated by the letters *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*, *l*, in pillars 12*a* to 12*e*.

In this operation the miner 13, which is a heavy piece of equipment, difficult to move and turn in the cramped quarters of the mine operates continuously in one direction (from south to north) to drive lifts through the tier of pillars 12*a*, 12*b*, 12*c*, 12*d* and 12*e*, is turned around in entry 10*e* and drives lifts *c*, *d*, *e*, *f*, and *g* (from north to south) through the tier of pillars 12*e*, 12*d*, 12*c*, 12*b* and 12*a* where it is again turned around to start mining lifts *h*, *i*, *j*, *k*, and *l* in the opposite direction. This operation is continued until all of the tier of pillars 12*a*, 12*b*, 12*c*, 12*d* and 12*e* have been extracted, after which mining the next adjacent tier of pillars 12 to the right is started.

Between each lift 14, 14*a*, 14*b*, 14*c*, etc., and the next adjacent room or lift to the left of FIG. 3 a narrow fender of trona 15, 15*a*, 15*b*, 15*c*, etc., approximately three feet wide at its narrowest portion, is left in the mining operation and as soon as the lift is driven through the next pillar 12 this fender is removed, by drilling and blasting, to permit the roof of the mined out section of the pillars to cave and relieve the pressure. As indicated on the drawings, the fender 15 formerly left between the lift 14 and the previously caved area has been blasted and the roof caved and the fender 15*a* is being readied to blast. As soon as the miner 13 has passed entirely through lift *a* in pillar 12*d*, fender 15*b* in pillar 12*c* may be blasted and the roof caved. In this way caving of the mined out area, to relieve pressure in the active mining area, proceeds as the mining operation proceeds.

As only one working face is required, by the use of a continuous miner, and as the caving in the rear of the miner is planned and can be controlled, no unexpected release of gas into the mine is encountered and the amount of ventilating air required in each active working area can be reduced approximately 40% below that required for the same mine output in the older process of drilling and blasting out the trona.

By the arrangement of entries 10, 10*a*, 10*b*, 10*c*, etc., as illustrated, during the driving of any lift the mined trona can be hauled from the rear of the miner 13 to the nearest entry and from this entry to the conveyor 11, and when a given lift is finished and a lift started in the next adjacent pillar, a new haulageway is opened up in the entry just crossed by the miner so that the portion of the

lift to be abandoned and caved may be caved by drilling and blasting the fender without interfering with the haulage from the miner **13**.

For example, during the driving of lift **14***b* in pillar **12***c* the haultage, normally by shuttle car, will be along passage **17***a* in the entry **10***b* to the conveyor **11**. When lift **14***b* is finished and lift **14***c* started, a new haulageway is available and the haulage will be through haulageways **17***b* and **17***c* to conveyor **11**. Haulageway **17***a* will no longer be needed and caving of lift **14***a* can proceed, without fear that the caving will block haulageway **17***b*. Likewise when lift **14***c* is finished and the lift *b* in pillar **12***e* started, another new haulageway in entry **10***d* is opened so that blasting of the fender **15***b* and caving of the roof of lift **14***b* can be started. It is preferable to leave the fender adjacent the just completed lift in place until the next lift has been completed so that there is at least one unblasted fender behind the lift being driven. This plan of mining can be followed regardless of whether the miner is proceeding from bottom to top (south to north) or top to bottom of the mining plan illustrated in FIG. 3.

In the mining plan described, the miner **13** can proceed substantially in a straight line to drive lifts through pillars **12***a*, **12***b*, **12***c*, **12***d*, **12***e*, etc., and then with one turn in the end entry to drive lifts *c*, *d*, *e*, *f* and *g* in the opposite direction, through these pillars until this series of pillars is extracted. Roof bolting to the extent necessary can proceed behind the miner **13** without withdrawing or idling the miner during the roof bolting. The fenders **15**, **15***a*, **15***b*, etc. can be drilled and blasted to cave the roof of the mined sections as soon as the next succeeding lift is finished, and by the arrangement of rooms or cross entries **17**, **18**, **19** and **20** haulageways are always available as each new lift is started, Blasting of the fender on the outside of a lift does not cause shattering or blasting cracks in the roof toward the inside of the lift.

In the cross section of FIG. 2, the lift **14***b* is indicated and, in dotted lines, the outline of the next adjacent lift (or room) to the left has been shown. The fender to the left of this lift (or room) has been blasted and the roof caved as indicated by the arrows prior to the driving of lift **14***b*. Due, however, to the arched contour of the top of fender **15***b* formed in driving the previous lift to the left of fender **15***b*, the roof caving has broken along the line **21** so that the caving does not extend into the arched top of fender **15***b*, which at the time of the previous caving was an arch from a solid pillar, and the roof of lift **14***b* when driven remains substantially intact until fender **15***b* is blasted out. Blasting cracks do not extend substantially outside the fender being blasted. If desired, the roof bolts **8** may be withdrawn before a lift is caved.

While a representative section of a mine has been shown, for purpose of illustration, in FIG. 3, it will be understood that a greater or lesser number of longitudinal entries may be in use at the same time and that the transverse entries will vary in number from the mining face most remote from the main development entries, to the mining area closest to the main development entries as the mining and caving progresses, on retreat, from the remote to the nearest transverse entry. It will also be understood that various modifications and changes can be made in the mining plan described, without departing from the spirit of this invention or the scope of the following claims.

We claim:

1. The method of mining trona by the use of a continuous miner, which comprises driving a series of substantially parallel entries into the trona bed, driving a series of substantially parallel rooms at angles to the entries to divide the area to be mined into tiers of pillars and driving lifts in a substantially straight line through a tier of pillars, turning the mining machine and driving lifts in a substantially straight line in the opposite direction through

said tier of pillars until each successive tier of pillars is extracted leaving a narrow fender of trona between each lift and the previously mined area and when a lift through the next pillar of a series of pillars has been completed, caving the fender and the roof of said previously mined lift.

2. The method of mining trona by the use of a continuous miner, which comprises driving a series of substantially parallel entries into the trona bed, driving a series of substantially parallel rooms at substantially right angles to the entries to divide the area to be mined into tiers of substantially rectangular pillars and driving lifts in a substantially straight line through a tier of pillars, turning the mining machine and driving lifts in a substantially straight line in the opposite direction through said tier of pillars until each successive tier of pillars is extracted leaving a narrow fender of trona between each lift and the previously mined area and when a lift through the next pillar of the tier has been completed, caving the fender and the roof of the previously mined lift.

3. The method of mining trona by the use of a continuous miner, which comprises driving a series of substantially parallel entries into the trona bed, driving a series of substantially parallel rooms at substantially right angles to the entries to divide the area to be mined into tiers of substantially rectangular pillars and driving lifts in a substantially straight line through a tier of pillars, turning the mining machine and driving lifts in a substantially straight line in the opposite direction through said tier of pillars until each successive tier of pillars is extracted leaving a narrow fender of trona between each lift and the previously mined area and when a lift through the next pillar of the tier has been completed, caving the fender of the previously mined lift and caving the roof of said previously mined lift, and using the entry at the rear of each lift in the direction of mining as a haulageway for the mined trona.

4. The method of mining trona by the use of a continuous miner, which comprises driving a series of entries into the trona bed, driving a series of rooms at angles to the entries to divide the area to be mined into a plurality of pillars and driving lifts in a substantially straight line through a plurality of pillars, turning the mining machine and driving lifts in a substantially straight line in the opposite direction through the same plurality of pillars until each successive group of pillars is extracted leaving a narrow fender of trona between each lift and the previously mined area and when a lift through the next pillar of a series of pillars has been completed, caving the fender and the roof of the previously mined lift.

5. The method of mining trona by the use of a continuous miner, which comprises driving a series of substantially parallel entries into the trona bed, driving a series of substantially parallel rooms at substantially right angles to the entries to divide the area to be mined into substantially rectangular pillars, driving elliptically shaped lifts through the pillars to remove the pillars while leaving narrow fenders between each lift and the previously mined area, leaving a portion of the trona in place at the top of each lift to provide a supporting roof, installing a row of roof bolts through the center of the lift roof as the driving of the lift progresses, turning the mining machine and driving lifts in a substantially straight line in the opposite direction through the said pillars until each successive group of pillars is extracted and caving the fender and roof of the previously mined lift adjacent to the mined out area after the next lift is completed.

6. The method of mining trona by the use of continuous miner, which comprises driving a series of substantially parallel entries into the trona bed, driving a series of substantially parallel rooms at substantially right angles to the entries to divide the area to be mined into substantially rectangular pillars, driving elliptically shaped

lifts with narrow fenders through the pillars to remove the pillars, leaving a portion of the trona in place at the top of each lift to provide a supporting roof, installing a row of roof bolts through the center of the lift roof as the driving of the lift progresses, installing a row of roof bolts on approximately four foot centers along the roof at each side of the elliptical shaped lift at substantially the point where the sides of the ellipse begin to curve downwardly, turning the mining machine and driving lifts in a substantially straight line in the opposite direction through the said pillars until each successive group of pillars is extracted and where a lift has been completed caving the fender and the roof of the completed lift after the next lift is completed.

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