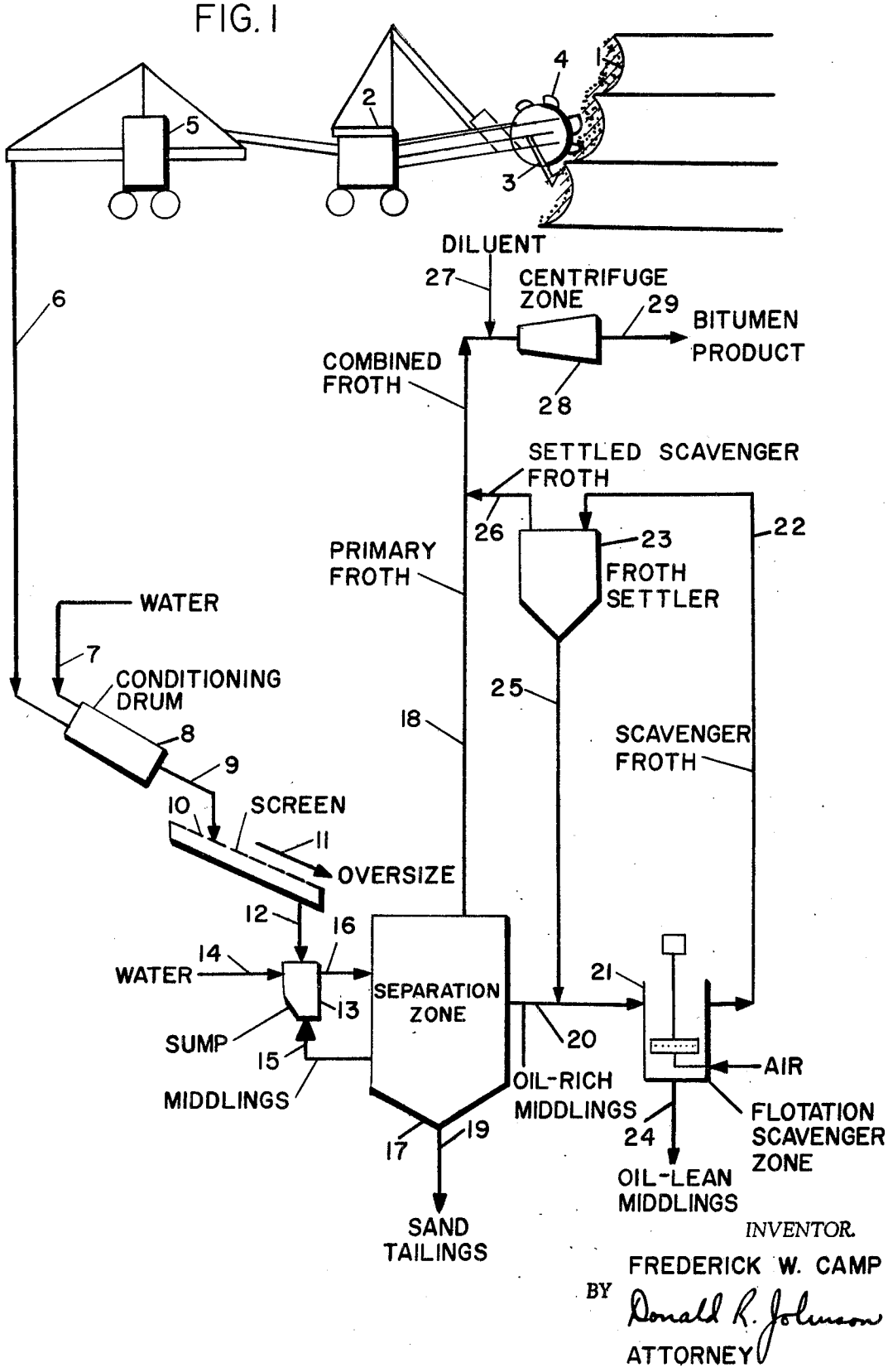
May 5, 1970 F. W. CAMP 3,510,168

METHOD OF MINING BITUMINOUS TAR SANDS

Filed July 3, 1968 3 Sheets-Sheet 1

FIG. 1

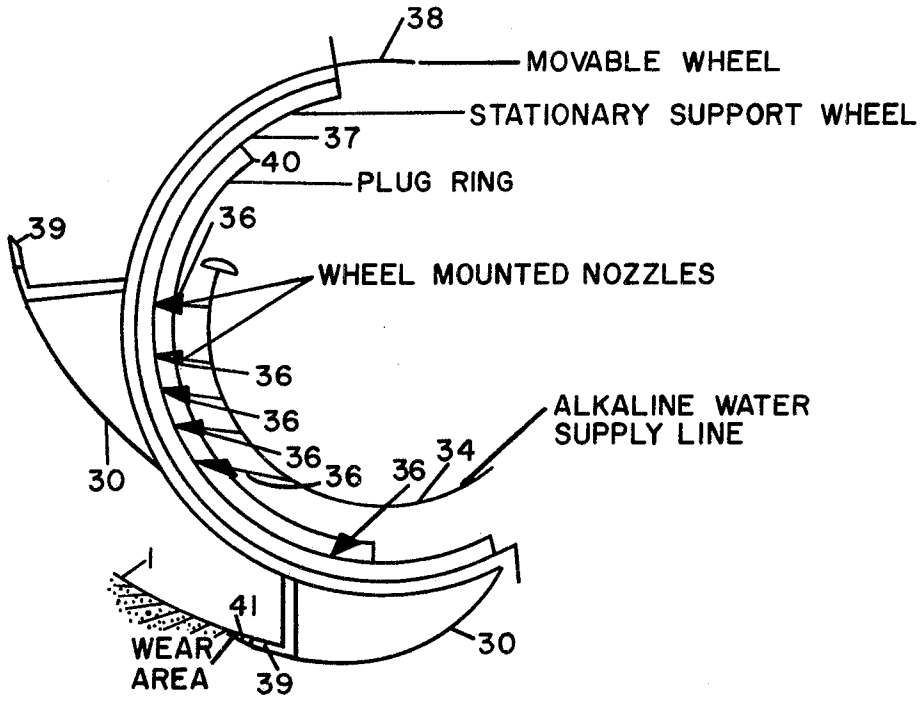


INVENTOR.
FREDERICK W. CAMP
BY Donald R. Johnson
ATTORNEY

METHOD OF MINING BITUMINOUS TAR SANDS

Filed July 3, 1968 3 Sheets-Sheet 2

FIG. 2



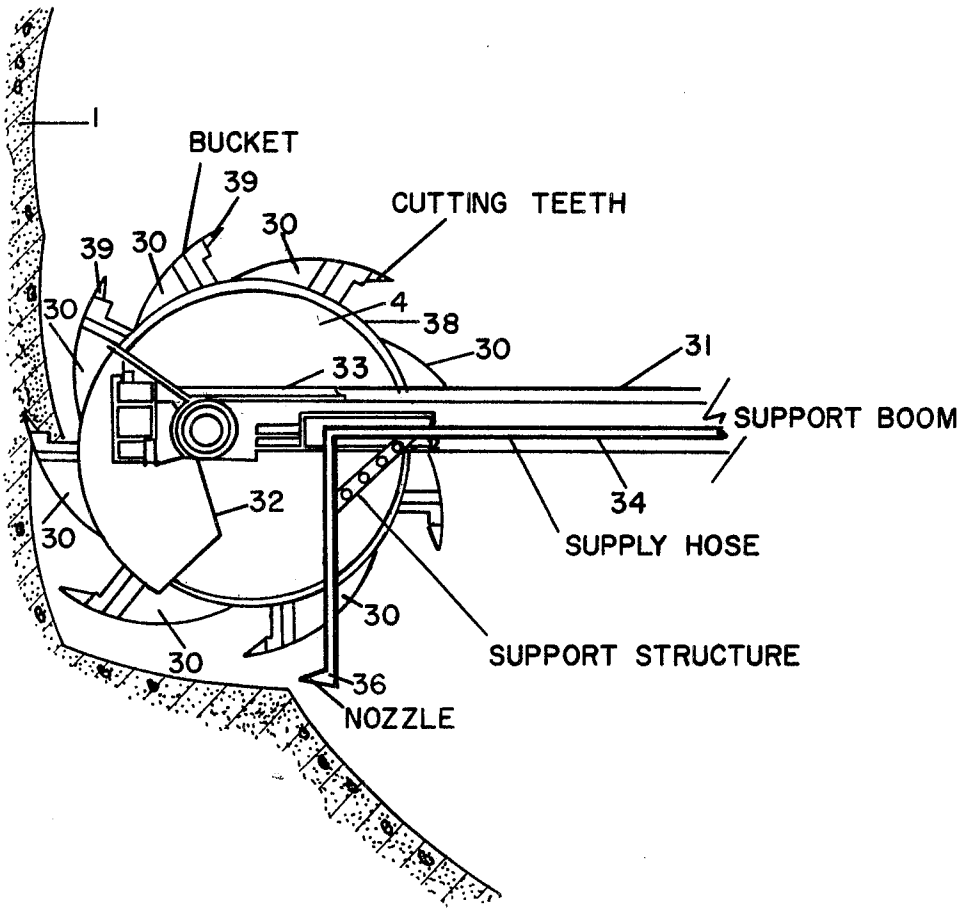
INVENTOR.
FREDERICK W. CAMP
BY Donald R. Johnson
ATTORNEY

May 5, 1970 F. W. CAMP 3,510,168

METHOD OF MINING BITUMINOUS TAR SANDS

Filed July 3, 1968 3 Sheets-Sheet 3

FIG. 3



INVENTOR.
FREDERICK W. CAMP
BY
Donald R. Johnson
ATTORNEY

United States Patent Office 3,510,168
Patented May 5, 1970

3,510,168

METHOD OF MINING BITUMINOUS TAR SANDS

Frederick W. Camp, West Chester, Pa., assignor to Great Canadian Oil Sands Limited, East Toronto, Ontario, Canada, a corporation of Canada

Filed July 3, 1968, Ser. No. 742,359
Int. Cl. E21b 43/28, 47/00
U.S. Cl. 299—5 5 Claims

ABSTRACT OF THE DISCLOSURE

The specification discloses an improvement to the mining of bituminous tar sands with bucketwheel excavators. Tar sands are mined by moving the excavator cutting teeth across an opposed face of the tar sands deposits to cut a layer of sands from the face. The improvement of the present invention comprises directing a stream of alkaline water at the zone of contact between the excavator teeth and the face.

This invention relates to a method for mining bituminous tar sands. The invention particularly concerns a mode of operation for removing tar sands from their natural deposits for charging into a treating process.

Numerous deposits of bituminous tar sands exist throughout the world. The most extensive deposits are found in northern Alberta, Canada. The deposits are of Mesozoic Age. They underlie truncated Paleosoic limestones and are usually overlain by Pleistocene sediments. The deposits underlay more than 13,000 square miles at depths of 0 to 2000 feet. Total recoverable reserves of oil from the deposits after extraction and processing are estimated at more than 300 billion barrels.

The sands are composed of a siliceous material, generally having a size greater than that passing a 325 mesh screen, saturated with a relatively heavy, viscous bitumen in quantities of from 5 to 21 weight percent of the total composition. More typically, the bitumen content of the sands is about 8 to 15 percent. This bitumen is quite viscous and contains typically 4.5 percent sulfur and 38 percent aromatics. Its specific gravity at 60° F. ranges typically from about 1.00 to about 1.06. The tar sands also contain clay and silt in quantities of from 1 to 50 weight percent of the total composition. Silt is normally defined as mineral which will pass a 325 mesh screen but which is larger than 2 microns. Clay is mineral smaller than 2 microns including some siliceous material of that size.

There are several well-known processes for effecting the separation of bitumen from the tar sands. In the so-called "cold water" method, the separation is accomplished by mixing the sands with a solvent capable of dissolving the bitumen constituent. The mixture is then introduced into a large volume of water, water with a surface agent added, or a solution of a neutral salt in water. The combined mass is then subjected to a pressure or gravity separation.

In the hot water method, the bituminous sands are jetted with steam and mulled with a minor amount of hot water at temperatures in the range of 140° to 210° F. The resulting pulp is dropped into a stream of circulating hot water and carried to a separation cell maintained at a temperature of about 150° to 200° F. In the separation cell, sand settles to the bottom as tailings and bitumen rises to the top in the form of an oil froth. An aqueous middlings layer containing some mineral and bitumen is formed between these layers. A scavenger step may be conducted on the middlings layer from the primary separation step to recover additional amounts of bitumen therefrom. This step usually comprises aerating

the middlings as taught by K. A. Clark, "The Hot Water Washing Method," Canadian Oil and Gas Industries 3, 46 (1950). These froths can be combined, diluted with naphtha and centrifuged to remove more water and residual mineral. The naphtha is then distilled off and the bitumen is coked to a high quality crude suitable for further processing. The hot water process is described in detail in U.S. patent application, Ser. No. 509,589, Floyd et al., now U.S. Pat. No. 3,401,110 issued Sept. 10, 1968.

The present invention is directed to a mode of operation for mining tar sands for feed to a process which produces bitumen or petroleum from the sands. In its most specific and preferred embodiment the invention covers a mode of operation for mining tar sands with bucketwheel excavators for feed into a hot water process.

In the use of a wheel excavator, the wheel is rotated to force the bucket teeth or blades into the tar sands deposits to carry the sands upwardly and to discharge the sands by gravity adjacent the top point of the bucket rotation. Continuous contact between the bucket teeth or blades and the deposits wears the teeth to a point where they are no longer of service and must be replaced. The wearing process is accelerated during winter operations when the deposit faces are frozen and extremely hard.

Shutdown of the excavators for the purpose of replacing teeth is extremely expensive. Some idea of the expense is obtained by a consideration of the size of bucketwheel excavators now in use. These excavators are 100 feet high from the bottom treads of their caterpillar crawlers to the top of their bucket-wheel riggings. They are about 210 feet in length and weigh about 1,700 tons each.

The present invention relates to operation of bucketwheel excavators, particularly those described above. By the present invention, improved cutting teeth life is obtained, thus reducing the frequency of shutdown for teeth replacement. By the invention, a stream of alkaline water as hereinafter defined is directed at the zone of contact beween the excavator teeth and the tar sands deposit face. To accomplish this, the stream can be directed against the operating excavator teeth or against the tar sand deposit face on which the excavator is operating or against both the teeth and the face. It has been found that the stream of alkaline water cools the cutting teeth. Additionally, the alkalinity of the stream serves to free small amounts of bitumen from the tar sands in which the stream is directed. The freed bitumen coats the operating excavator teeth and lubricates the cutting operation. Both the cooling function and the lubricating function brought about by directing the stream of alkaline water as per the present invention improve the life of the excavator cutting teeth. Additionally it has been found that use of the alkaline water stream decreases power consumption of the excavators at a fixed mining rate.

The invention can be described as an improvement to a process for excavating bituminous tar sands from a deposit where the process comprises sweeping a series of excavator teeth across an opposed face of the deposit to engage the teeth with and to cut into the face and to cut from the face a layer of bituminous tar sands material. The improvement is describable as comprising directing a stream of alkaline water at the zone of contact between the excavator teeth and the face. For the purpose of description herein the term "alkaline water" means water to which a reagent has been added to raise the pH to the range 7.5 to 9.0, and preferably to 8.0 to 8.5. Any suitable base may be used as the reagent, for instance, lime or caustic soda. If the tar sands are to be subjected to processing in a hot water process, the choice of base should be restricted to the monovalent alkali materials. Further examples beside caustic soda are the carbonate, bicarbonate, silicate or other basic salts of

sodium or the other monovalent alkalis. Caustic soda is the preferred reagent. Very small concentrations of the base, from a few parts per million to a few (1 to 5) weight percent are sufficient to make the water alkaline.

In the invention, the alkaline water stream can be directed at the zone of contact by directing the stream against the teeth and/or the deposit face as a mist or spray by discharging under pressure through nozzles as illustrated in FIGS. 2 and 3 which show detailed operation of the buckets of typical bucketwheel excavators. FIG. 1 illustrates a preferred embodiment of the present invention and shows schematically the mining of tar sands and charge of the sands into a hot water process. All of the drawings will be described in detail infra.

The tar sands mined by the process of this invention can be charged into any process for treating tar sands. These treating processes include pyrolytic or retorting processes as well as cold water and hot water processes. In the preferred embodiment of the present invention, the tar sands are mined and charged into a hot water process. In this embodiment certain advantages are obtained in controlling pH of the separation cell by using alkaline water streams in the mining step. Generally the invention is an improvement to any known process for mining bituminous tar sands using cutting teeth preferably on a bucketwheel excavator. Such processes are numerous and detailed descriptions of both the processes and apparatus used in the processes can be found inter alia in U.S. Pats. 1,763,769; 2,291,669; 2,757,463; 2,834,-127; 3,020,656; 3,258,865; 3,298,117; and 3,304,634.

The initial step in the preferred mining process is the removal of overburden preceded by cleaning of the ground surface. The surface of tar sands mining areas is often characterized by swamps and muskeg with poor drainage. Initial removal of trees and plant cover helps the surface to dry naturally. After removal of trees and roots, etc., the overburden can be removed with conventional earth-moving equipment such as electrical shovels and trucks. In order to produce synthetic crude from the tar sands at an economic rate, the mining step must be capable of removing and transporting large quantities of material. A preferred method of mining utilizes large bucketwheel excavators with a maximum capacity of 9,000 tons per hour each, and high speed conveyors. The material discharging from the excavators is picked up by crawler-mounted conveyors for transfer to the conveyor system. The conveyor system consists of a face conveyor and a trunk conveyor for each excavator discharging into a single plant feed conveyor. The face conveyors and trunk conveyors are shiftable and extendable to follow the progress of the excavation.

A preferred embodiment of the present invention is describable as an improvement to a method of excavating tar sands where the method comprises removing overburden from bituminous tar sands deposits, mining the tar sands deposits by moving a series of cutting teeth across an opposed face of the deposits to cut a layer of tar sands from the face, and directing tar sands from the cut layer into a hot water process for separating bitumen from the sands. The improvement is describable as directing a stream of alkaline water at the zone of contact between the excavator teeth and the deposit face.

The drawings illustrate the invention. FIG. 1 is a schematic representation of the improved process of the present invention for mining tar sands for feed to a hot water process for separating bitumen from tar sands. FIG. 2 is a schematic side elevtaion on an enlarged scale and shows a bucket of a bucketwheel excavator with one means of applying the water wash to the wheel teeth cutting area and FIG. 3 is another schematic side view and shows another bucket and another means of applying a water wash.

Referring to the drawings, FIG. 1 shows a preferred embodiment of the present invention and illustrates a method of mining tar sands for charge into a hot water process. In the drawing, the tar sands deposit is illustrated by **1**. The tar sands are mined by the giant excavator **2** while the water spray **3** of the present invention is directed onto the teeth of the bucketwheel **4**. The digging wheel on each excavator is 29.5 feet in diameter and has ten buckets, each bucket being capable of holding nearly two tons of tar sands. The excavators are designed for a maximum digging of 215,000 tons of sands per day; operation range, however, is about 5,000 to 6,000 tons per hour. Length of the digging boom is 97 feet and the discharge boom 82 feet. Installed horsepower in each wheel is 3,700 HP. The belt wagon weighs 433 tons and has 1,325 HP. Length of its loading boom is 88.5 feet and the discharge boom is 105 feet. The sands mined are discharged from the excavator **2** to the conveyor illustrated by **5**. This conveyor is crawler mounted and double boomed and about 197 feet long. It is rotatable to allow for wide increases in minable area. The crawler-mounted conveyors transfer the sands to a belt conveyor system illustrated by line **6** for charging into a conditioning drum **8** of a hot water process. The belt system comprises a face conveyor which is a 60-inch shiftable-type conveyor running parallel to the mining face at 1,000 feet per minute. This face conveyor discharges onto a truck conveyor which leads to the main conveyor and thence to the conditioning drum **8**.

Water and steam are introduced into the conditioning drum from **7** and mixed with the sands. Enough steam is introduced to raise the temperature in the conditioning drum to above 170° F. Monovalent alkaline reagent can also be added to the conditioning drum to maintain the pH of the middlings layer in separator zone **17** within the range of 7.5 to 9.0. One of the advantages of the present invention is that when alkaline water is used in the mining operation, somewhat less alkaline reagent is necessary in the conditioning step to maintain the pH of the middlings in the separator zone. Mulling of the tar sands produces a pulp which then passes from the conditioning drum as indicated by line **9** to a screen indicated at **10**. The purpose of screen **10** is to remove from the tar sand pulp any debris, rocks, or oversized lumps as indicated generally at **11**.

The pulp then passes from screen **10** as indicated by **12** to a sump **13** where it is diluted with additional water from **14** and a middlings recycle stream **15**. The pulped and diluted tar sands are pumped from the sump **13** through line **16** into the separation zone **17** which comprises a settling cell which contains a relatively quiescent body of hot water which allows for the formation of a bitumen froth which rises to the cell top and is withdrawn via line **18** and a sand tailings layer which settles to the bottom to be withdrawn through line **19**. An aqueous middlings layer between the froth and tailings layer contains silt and clay and some bitumen which failed to form froth.

A relatively bitumen-rich middlings stream is withdrawn from separator **17** through line **20** and is sent to a scavenger zone **21** wherein an air flotation operation is conducted to cause the formation of additional bitumen froth. The processing conducted in the scavenger zone involves air flotation by any of the air flotation procedures conventionally utilized in processing of ores. The air causes the formation of additional bitumen froth which passes from the scavenger zone **21** through line **22** to a froth settler zone **23**. A bitumen-lean middlings stream is removed and discarded from the bottom of the scavenger zone **21** via line **24**.

In the settler zone **23** the scanvenger froth forms into a lower layer of settler tailings which is withdrawn and recycled via line **25** to be mixed with bitumen-rich middlings for feed to the scavenger zone **21** via line **20**. In the settler zone an upper layer of upgraded bitumen froth forms above the tailings and is withdrawn through line **26** and is mixed with primary froth in line **18**. The combined froths are at a temperature of about 160° F. They are heated with steam and diluted with sufficient

naphtha or other diluent from **27** to reduce the viscosity of the bitumen for centrifuging in zone **28** to produce a bitumen product **29** suitable for further processing.

FIGS. 2 and 3 of the drawings show in detail the operation of the directed stream of alkaline water in combination with the operation of a bucketwheel excavator. In FIG. 2, the wheel **4** carries a plurality of circumferentially spaced buckets **30** at its periphery which buckets are adapted to dig into and scoop up tar sands as illustrated in FIGS. 2 and 3. In use, the wheel excavator works along the face illustrated diagramatically by **1** in the figures. The wheel rotates and moves horizontally across the face, a support boom **31** being extensible and retractable to engage the wheel to the proper extent in the face. As the wheel is moved horizontally the buckets are rotated into and upwardly with respect to the face to scoop up tar sands and carry them upwardly. To prevent premature discharge of the sands a stationary plug **32** is carried by the support boom **31** in cooperative rotation to the wheel. As the buckets **30** pass the upper edge of the plug, the tar sands therein gravitate downwardly onto the belt conveyor means **33** in the interior of the wheel which directs the excavated sands laterally to crawler conveyor **5**. The supply hose **34** for delivering the alkaline water stream to the cutting area runs along support boom **31** and is supported at the bucketwheel by structure **35**. On this drawing delivery of the alkaline stream to the cutting zone is indicated generally through hose nozzles **36**.

A conventional bucket **30** is generally beak-shaped as shown and consists of a solid, arcuate back wall, solid side walls and a tooth cutting lip **39** at the leading end of the back and side walls. In one design, the rim diameter of the wheel **4** is 29.5 feet. The lip of each bucket **30** projects beyond the wheel rim, and the tail extends slightly inwardly from the rim. The back wall of the bucket is formed on the smooth arc of a quarter circle. The plug **32** complements the buckets and includes a base wall spaced about two feet inwardly of the wheel rim to accommodate passage of the bucket tail. The plug also includes a radial wall closing a portion of the wheel to the open side thereof. The plug may also support a set of nozzles as shown in FIG. 3. Each bucket as it cuts into the tar sands moves into the plug so that the effective vertical area of the bucket comprises a segment of a circle having about a 4 foot radius and a peripheral arc of approximately 8 feet.

Specifically, horizontal slewing is conducted so that each bucket is entered into a fresh cut to an extent less than full bucket width. Wheel diameter is 29.5 feet and the cutting arc is approximately one-third of a circle, so that cut height is about 10 feet. Effective capacity of the excavator is about 9,000 tons per hour at the upper limits of operational speeds. At the lower limits, effective capacity is about 5,000 to 6,000 tons per hour.

FIG. 3 of the drawings shows the operation of the bucketwheel and alkaline water wash in combination with a bucketwheel of slightly different design than that shown in FIG. 2. The water wash is delivered as a mist or spray by discharging under pressure through nozzles **36**. The supply line **34** to the nozzles **36** can be supported from, and travel with, the boom **31** of a bucketwheel excavator, as shown generally in FIG. 2 of the drawings. In addition, or alternatively, a set of nozzles may be mounted in the stationary support wheel or ring **37** as shown in FIG. 3. The buckets are supported on movable wheel **38** which is shown in both figures. FIG. 3 shows a plug ring **40**, different in design from the stationary plug **32** of FIG. 2. This ring closes off the buckets **30** during the digging part of each revolution. From one or both sets of nozzles **37** the water stream is directed onto each cutting tooth **39**. Teeth are heated by friction with the tar sands in the "wear area" **41**. The water, splashing about in the cutting area, thoroughly washes the tooth **39** thereby carrying away the frictional heat developed in the wear area **41** and cooling the tooth. In addition, small amounts of bitumen are freed from the tar sand by the caustic action of the water. This bitumen adheres to the tooth—even if only briefly—in the wear area, thus lubricating the tooth and reducing wear and frictional heat generation.

The above drawings illustrate the improved method of mining of the present invention utilizing a stream of alkaline water to cool and lubricate the teeth of the tar sands excavators thereby improving cutting teeth life and decreasing power consumption of the mining operation.

What is claimed is:

1. In a process for excavating bituminous tar sands from a deposit of said sands which process comprises: sweeping a series of excavator teeth across an opposed face of said deposit to engage the teeth with and to cut into said opposed face and to cut from said face a layer of bituminous tar sands material, the improvement which comprises directing a stream of alkaline water at the zone of contact between said teeth and said face to cool said teeth while concurrently extracting at least a part of the bitumen from said tar sands thereby lubricating said teeth.

2. The process of claim **1** in which said excavator teeth are deposed around the wheel of a bucketwheel excavator.

3. The process of claim **1** in which said stream of alkaline water comprises water containing added caustic soda.

4. The process of claim **1** in which said stream of alkaline water is at a pH in the range of 7.5 to 9.0.

5. The process of claim **1** in which said stream of alkaline water is at a pH in the range of 8.0 to 8.5.

References Cited

UNITED STATES PATENTS

1,607,586	11/1926	Claytor	299—5
1,612,611	12/1926	Claytor	299—5
2,495,840	1/1950	Findlater	299—81 X
3,307,625	3/1967	Johnson	175—66 X

ERNEST R. PURSER, Primary Examiner

U.S. Cl. X.R.

37—189; 175—64; 299—7