Feb. 24, 1970 E. G. FERRIS 3,497,061

APPARATUS FOR TREATING MAGNETIC ORE

Filed Jan. 23, 1968 2 Sheets-Sheet 1

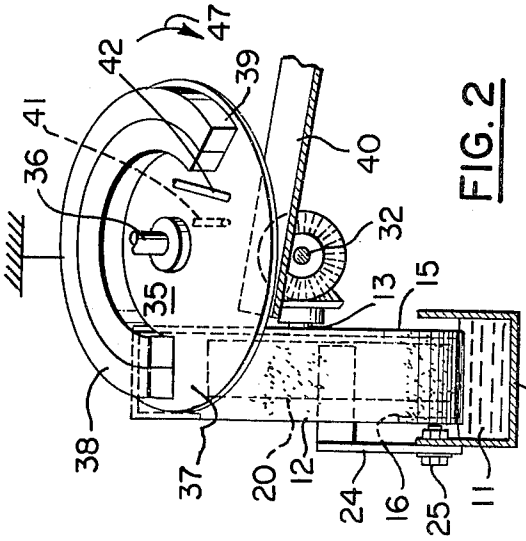


FIG. 2

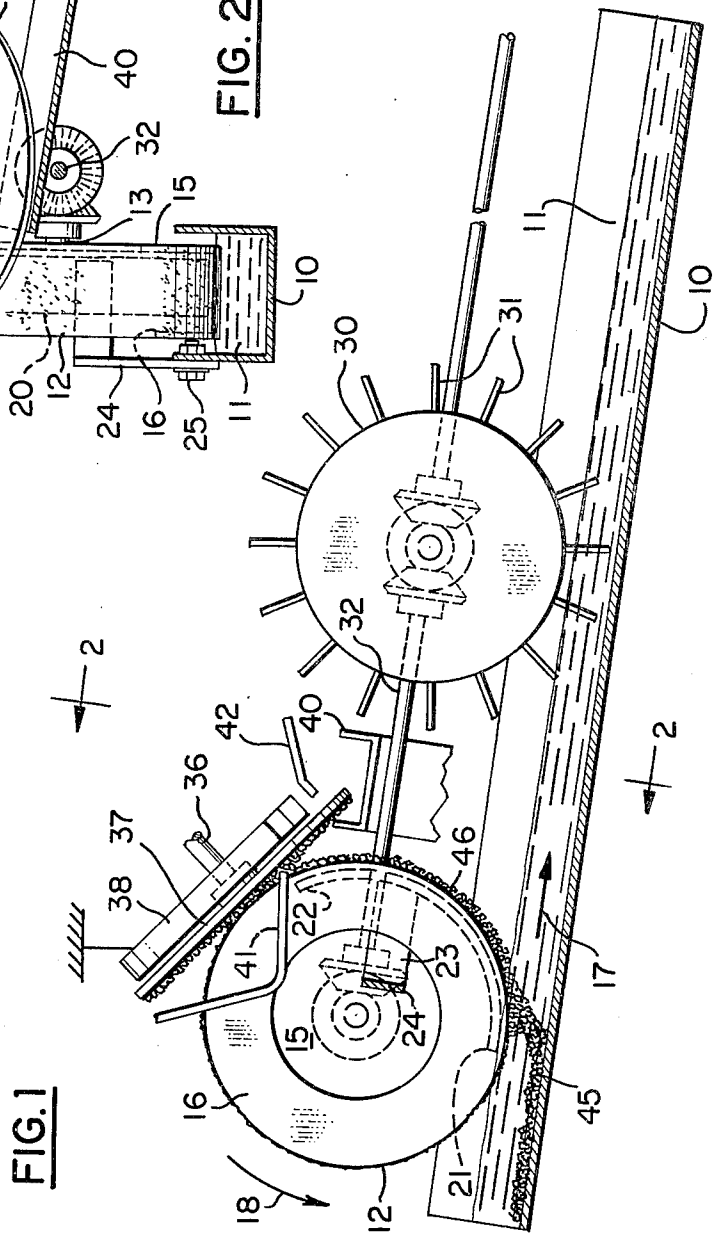


FIG. 1

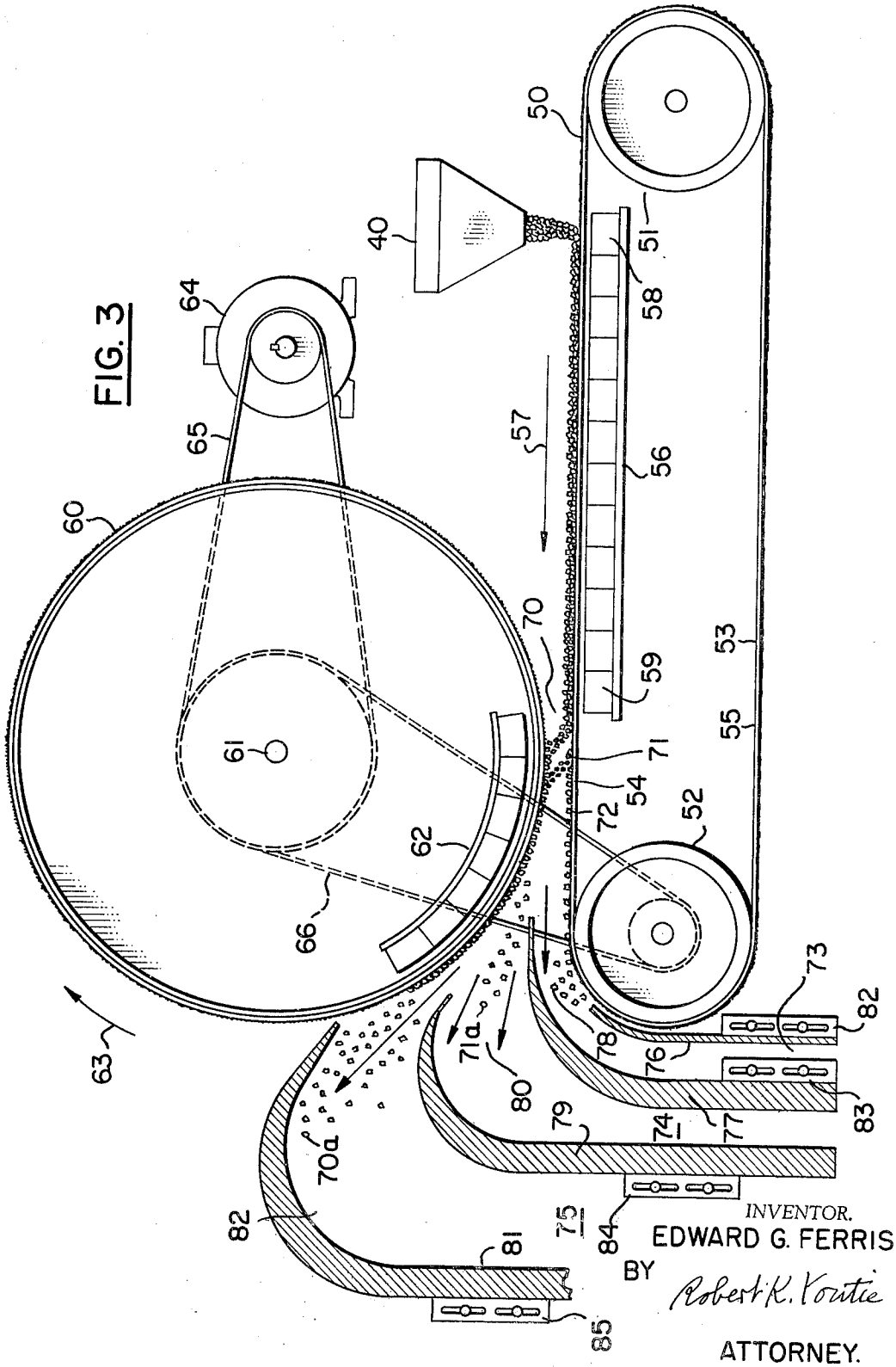
INVENTOR.
EDWARD G. FERRIS
BY Robert K. Voute
ATTORNEY.

Feb. 24, 1970 E. G. FERRIS 3,497,061

APPARATUS FOR TREATING MAGNETIC ORE

Filed Jan. 23, 1968 2 Sheets-Sheet 2

FIG. 3



INVENTOR.
EDWARD G. FERRIS
BY Robert K. Voutie
ATTORNEY.

United States Patent Office 3,497,061 Patented Feb. 24, 1970

3,497,061

APPARATUS FOR TREATING MAGNETIC ORE

Edward G. Ferris, 22 Hudson St.,
Gibbstown, N.J. 08027

Filed Jan. 23, 1968, Ser. No. 699,848
Int. Cl. B03c 1/30
U.S. Cl. 209—223 4 Claims

ABSTRACT OF THE DISCLOSURE

A magnetic ore-treatment apparatus wherein a rotary drum is located for movement in a trough carrying a slurry containing magnetic ore and magnet means is located interiorly of the drum for attracting the magnetic ore from the slurry to the drum, so that the drum delivers the attracted ore to a rotary plate also having associated magnetic means. The magnetic ore is attracted to the plate from the drum and carried by the plate to a discharge location beyond the associated magnetic means.

Background of the invention

As is well known to those versed in the art, magnetic ores are highly desirable, such as magnetite. These magnetic ores are often found in sand- and gravel-mining operations, but the percentage of magnetic ore is quite small and in the past has not economically justified its removal. That is, the capital expenditure and operating expenses required to remove magnetic ores from sand and gravel have been economically prohibitive.

Summary

Accordingly, it is an important object of the present invention to provide a novel and greatly improved apparatus for recovering magnetic ore, which apparatus is sufficiently economical, both in initial cost and operation, to justify the processing of and removal from sand and gravel of even small percentages of magnetic ore.

It is another object of the present invention to provide a magnetic-ore-removal apparatus of the type described which requires relatively little power, being operable in many instances from the power of a slurry being operated upon.

It is still another object of the present invention to provide a magnetic-ore-removal apparatus of the type described which may include one or more stages or ore removal for successive refinement thereof and employs a relatively simple, durable and entirely reliable structure incorporating permanent magnets and rotating parts to achieve highly effective magnetic-ore separation with little or no supervision and maintenance.

Other objects of the present invention will become apparent upon reading the following specification and referring to the accompanying drawings, which form a material part of this disclosure.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts, which will be exemplified in the construction hereinafter described, and of which the scope will be indicated by the appended claims.

Brief description of the drawings

FIGURE 1 is a longitudinal elevational view, partly in section, showing apparatus constructed in accordance with the teachings of the present invention.

FIGURE 2 is a sectional elevational view taken generally along the line 2—2 of FIGURE 1.

FIGURE 3 is a longitudinal sectional view showing further apparatus of the instant invention.

Description of the preferred embodiment

Referring now more particularly to the drawings, and specifically to FIGURES 1 and 2 thereof, the apparatus illustrated therein includes an upwardly opening trough **10** disposed at a slight angle to the horizontal, declining rightward in the drawing, for gravitational flow through the trough of a slurry **11** containing the magnetic ore to be removed, such as an aqueous slurry of sand and gravel.

At an upstream region of the trough or channel **10**, there is mounted a drum **12**, as on a shaft **13**, for rotation about a generally horizontal axis. That is, the drum **12** is arranged longitudinally of the trough or channel **11** having its lower portion entering into the channel for partial submergence beneath the level of slurry **11**. The drum **12** may have one side closed, as at **15**, its other side being provided with an inturned peripheral flange **16**. In this manner, the closed drum side or wall **15** may be suitably fixed to the shaft **13** to mount the drum **12** for its rotative movement, while the interior of the drum remains open to access through the other side, for purposes appearing presently.

The flow of slurry **11** is in the rightward direction, as indicated by arrow **17**, and the direction of rotation of drum **12** is counterclockwise, see arrow **1**, so that the lower drum region within the trough **10** moves in the same direction as the slurry **11**. Further, by means appearing more fully hereinafter, the linear velocity of rotation of drum **12** is advantageously approximately equal to that of the slurry **11**.

Interiorly of the drum **12** is a magnet, generally designated **20**. The magnet **20** extends from a lower interior region of the drum, as at **21**, counterclockwise approximately 120° to an upper discharge region **22** within the drum **12** is counterclockwise. see arrow **18**, so that the may be varied, but the configuration illustrated has been found advantageous. In practice, the arcuate magnet **20** may consist of a plurality of separate permanent magnets suitably secured together with their magnetic directions extending radially of the arcuate configuration. A mounting plate **23** may be fixed to the magnet **20**, extending radially inwardly therefrom, and in turn connected to a bracket **24** extending laterally exteriorly of the drum **12** for fixed securements to a suitable supporting member, as by fasteners **25** to the adjacent side of channel **10**.

Advantageously the external peripheral surface of drum **12** is frictional, say being serrated or roughened. In practice, Carborundum cloth laminated to the external peripheral surface of drum **12** has been found highly advantageous, but other particulate material or grains may be employed. Of course, the drum **12**, particularly the circumferential wall thereof, is advantageously of a non-magnetic material so as to not adversely affect the action of magnet **20**.

Downstream of the drum **12** there is provided a water wheel **30** arranged longitudinally of the channel **10** and having radial vanes **31** depending into the channel beneath the level of slurry **11**. The water wheel **30** is mounted by any suitable means for rotation about a generally horizontal axis to be driven by movement of the slurry. In turn, the water wheel **30** may be connected by any suitable transmission means **32**, say bevel gears or the like, to drum **12** for driving the latter. Additional water wheels may be employed, depending upon the driving power required.

A generally circular transfer plate or disc **35**, advantageously of non-magnetic material, is mounted in generally downwardly facing relation over the drum **12**. More specifically, the rotary plate or disc **35** may be carried by a rotatable shaft **36** and disposed in an inclined plane with one marginal portion **37** adjacent to and facing

downwardly toward the peripheral surface of drum **12** proximate to the discharge end **22** of magnet **20**. The rotary plate or disc **35** is advantageously of a nonmagnetic material, and an arcuate magnet **38** is disposed adjacent to and on the upper side of the rotary plate extending in an arcuate path about the axis of plate rotation generally from the transfer region **37** approximately 225° to a discharge region **39**. The angle of the arcuately extending magnet **38** may be varied, if desired. Also, the magnet **38** may advantageously be fabricated of a plurality of separate permanent magnets arranged with their magnetic fields extending normal to the plate **35**. In the same manner as the peripheral surface of drum **12**, it has been found highly advantageous to provide a roughened or frictional surface on the underside of plate **35**, as of Carborundum or other suitable means. Conventional journal and drive means of any desired type may be provided for shaft **36**. Also, shaft **36** and its rotary plate **35** may be driven from the water wheel **30**, if desired.

Beneath the lower region of rotary plate **35**, just beyond the discharge end of arcuate magnet **38**, there is provided a receptacle or hopper **40**. In addition, a pair of fluid conduits **41** and **42** are respectively directed to the lower and upper surfaces of the rotary plate **35** at the discharge region thereof. The fluid conduits or nozzles **41** and **42** may be connected to suitable fluid supplies, say a source of water, for impingement upon the lower and upper surfaces of the rotary plate **35** and gravitational draining into receptacle **40**.

As thus far described, it will be appreciated that the slurry **11**, containing magnetic ore or ores, such as magnetite, moves downwardly past the drum **12**. At this region the magnetic ore is attracted by the lower region **21** of magnet **20** to the underside of the drum **12**, as shown at **45** in FIGURE 1. By reason of the magnetic action of magnet **20** and the abrasive surface of drum **12**, the attracted ore moves counterclockwise upwardly with the drum, as at **46**, to an upper region proximate to the upper terminus **22** of magnet **20**. Upon continued drum rotation past the upper end region **22** of magnet **20**, the magnetic ore is no longer attracted to the drum **12**, but becomes attracted upwardly to the underside of rotary plate **35**, at approximately the transfer region thereof. The plate **35** rotates, as in the direction of arrow **47** in FIGURE 2, to displace attracted ore particles laterally to the discharge region **39**, where the ore tends to fall from the underside of the plate, having passed the field of magnet **38**. From the plate **35**, the ore falls into receptacle **40**, and effectively complete removal of the ore from plate **35** is achieved by impingement of water against the plate from conduits **41** and **42**. The flowing of water against the upper side of the plate through conduit **42** has been found desirable, as a small amount of particles tend to move about the plate edge. The ore thus recovered in receptacle **40** is desirable for many purposes and may, in this condition, be employed by steel mills.

Should further refinement be desired, say to separate pure magnetite from impure magnetite, or to achieve classification of the ore in grades, the product collected in receptacle **40** may be further treated in the apparatus of FIGURE 3.

Referring now to FIGURE 3, there will be seen the receptacle or hopper **40** disposed above the input region of an endless conveyor **50**. That is, the endless conveyor **50** may include a pair of generally parallel, horizontally spaced rotary rolls **51** and **52**, about which is trained an endless belt **53** having an upper, conveying run **54** and a lower, return run **55**. The belt **53** is advantageously of a nonmagnetic material, and mounted closely beneath the upper run **54** is a magnet **56**. The magnet **56** may, in practice, be constituted of a plurality of permanent magnets arranged with their magnetic fields generally parallel to each other and normal to the upper conveyor run **54**. The rolls **51** and **52** are mounted for rotation in the counterclockwise direction, so that the upper conveyor run **54** moves in the direction of arrow **57**. The magnet **56** has one end region **58** at the inlet end of the upper run **54** beneath the hopper or dispenser **40**, and extends therefrom beneath the upper run to a transfer region **59** adjacent to and short of the discharge end of the upper conveyor run. Advantageously the outer surface of belt **53** is frictional in nature, as by the adherence of Carborundum, or by other suitable means.

Arranged adjacent to and spaced slightly over the upper run **54** of conveyor **50**, in the region of the transfer end **59** of magnet **56**, there is mounted a drum **60**. The drum **60** may be mounted for rotation about the generally horizontal axis of shaft **61**, generally parallel to the axes of rolls **51** and **52**, and is interiorly hollow, being provided therein with an arcuate magnet **62** extending from a lower interior region of the drum proximate to the transfer end **59** of magnet **56**, in a clockwise direction upwardly. The magnet **62** may be composed of a plurality of separate permanent magnets arranged with their poles parallel and generally radially of the drum **60**. The peripheral wall of the drum **60** is of a nonmagnetic material, and the outer surface thereof is advantageously roughened, as by Carborundum grains, or other suitable frictional material. While omitted from the drawings for simplicity, suitable fixed support means are employed in conjunction with the magnets **56** and **62** to maintain the same in their illustrated positions. Also, the drum-mounting shaft **61** is suitably journaled, and rotates in the clockwise direction, as indicated by arrow **63**, being driven by any suitable means, such as a motor **64** through a belt **65**. Also, the conveyor **50** may be driven, indirectly from the motor **64**, as by a belt **66** from the drum **60** to roll **52**. Of course, other suitable power-transmission means may be employed, if desired, say sealed gears, or the like.

In operation, the ore particles of varying quality are delivered from the hopper **40** to the upper belt run **54**, being effectively retained thereon for movement at belt speed by the magnet **56**. The ore particles progress to the transfer end region **59** of belt magnet **56**, moving at belt speed, which is substantially equal to the peripheral speed of drum **60**. Upon release from the field of magnet **56**, the ore particles on belt run **54** are attracted to the drum **60** by magnet **62**. The high-grade ore particles will be attracted first, as at **70**, the intermediate-grade particles being attracted next, as at **71**, and the relatively low-grade particles or waste rock remaining on the belt, as at **72**. The rotational speed of drum **60** is selectively adjustable, as by drive motor **64**, so that the high-grade ore particles will remain attracted to the drum throughout their movement along the magnet **62**, and when past the magnet will be centrifugally thrown from the drum, as at **70***a*. Particles of lesser magnetic quality will be centrifugally thrown from the drum at an earlier stage or lower location, as at **71***a*.

In addition to selective adjustment of drum speed and belt speed, the ore-refining apparatus of FIGURE 3 is provided with a plurality of adjustable receivers or collectors **73**, **74** and **75**. The receiver **73** is lowermost, being defined between a pair of vertically adjustable blades or vanes **76** and **77** which have an inlet opening **78** located just above the upper belt run **54** for receiving the waste particles **72**. The receiver **74** is defined between the blade or vane **77** and a next upper blade or vane **79**, and provide an inlet opening **80** for receiving the intermediate ore grade **71***a* centrifugally discharge from drum **60** at a lower elevation. The receiver **75** is defined between the blades or vanes **79** and **81**, which provide an inlet opening **82** at an uppermost level for receiving the highest ore grade **70***a*.

In addition to the variable-speed controls afforded for the belt conveyor **50** and drum **60**, the receiver blades or vanes **76**, **77**, **79** and **81** are respectively provided with vertical adjustability, as by pin-in-slot mounts **82**, **83**, **84** and **85**, respectively. Hence, the degrees of ore separa-

tion may be selectively varied, as desired. Of course, additional receivers may also be employed.

The materials collected at the respective receivers **73**, **74** and **75** may be utilized, as desired. The highest-grade ore **70***a* being substantially pure magnetite, if desired, and the intermediate ore grade **71***a* being adapted for grinding to obtain pure magnetite.

Also, it will be appreciated that a further degree of versatility may be achieved by utilizing magnets of varying strength along their extents, say to assure more definite separation of grades and different materials in the embodiment of FIGURE 3.

From the foregoing, it is seen that the present invention provides an ore-recovery process which fully accomplishes its intended objects and is well adapted to meet practical conditions of manufacture, installation, maintenance and use.

What is claimed is:

1. Apparatus for removing particles of magnetic ore from sand, gravel and the like, said apparatus comprising a generally flat inclined trough for gravitationally conveying a slurry containing magnetic ore, an upright rotary drum of nonmagnetic material disposed longitudinally of and over said trough having it lower peripheral region in said trough and rotatable in the direction of slurry movement, said drum having a roughened external surface, a fixedly positioned permanent arcuate magnet in said drum extending continuously from the lower drum region upwardly in the direction of drum rotation to an upper transfer region, a rotary plate of nonmagnetic material mounted in an inclined plane with one portion facing obliquely downwardly toward said drum proximate to said transfer region and the remainder of said plate extending laterally beyond said drum and trough, and a second fixedly positioned permanent arcuate magnet above and extending continuously along the path of plate movement from said transfer region to a discharge location spaced laterally from said drum, whereby magnetic particles in said trough are attracted to said drum and carried by the latter to said transfer region where they are magnetically attracted to said plate and carried by said plate to said discharge region for discharge therefrom.

2. Apparatus according to claim **1**, in combination with a rotary water wheel located in driven relation with said slurry, and transmission means connected between said water wheel and drum for driving the latter.

3. Apparatus according to claim **1**, in combination with fluid-flow means directed against said plate at said discharge region for aiding in particle removal from the plate.

4. Apparatus according to claim **1**, in combination with a rotary endless conveyor belt having an upper run arranged to receive at one location the particles removed from said plate, magnetic means beneath said upper run extending from said one location in the direction of belt movement to a second location, a second rotary drum over and facing said upper run proximate to said second location and having its facing surface moving generally in the same direction as said belt, additional magnet means in said second drum extending from proximate to said second location a predetermined distance in the direction of second drum movement, and a plurality of particle receivers located along said second drum for centrifugally receiving successively discharged particles from said second drum, to thereby separate particles of greater and lesser magnetic content, said receivers comprising vertically spaced vanes extending generally tangentially of said second drum, and mounting means adjustably mounting said vanes for selective vertical spacing.

References Cited

UNITED STATES PATENTS

422,732	3/1890	Conkling	209—223
739,741	9/1903	Sweet	209—223
765,013	7/1904	King	209—223
780,870	1/1905	Dawes	209—229 X
939,523	11/1909	Ludwick	209—223 X
1,177,981	4/1916	Wright	209—229 X
1,391,400	9/1921	Neville	209—216
1,686,917	10/1928	McAdams	209—222
1,729,095	9/1929	Crist	209—223
2,256,728	9/1941	Stearns	209—223

FOREIGN PATENTS

116,785	6/1961	U.S.S.R.

HARRY B. THORNTON, Primary Examiner

ROBERT HALPER, Assistant Examiner

U.S. Cl. X.R.

209—229, 232