March 14, 1967 A. PERRY ET AL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

Filed Sept. 27, 1965 12 Sheets-Sheet 1

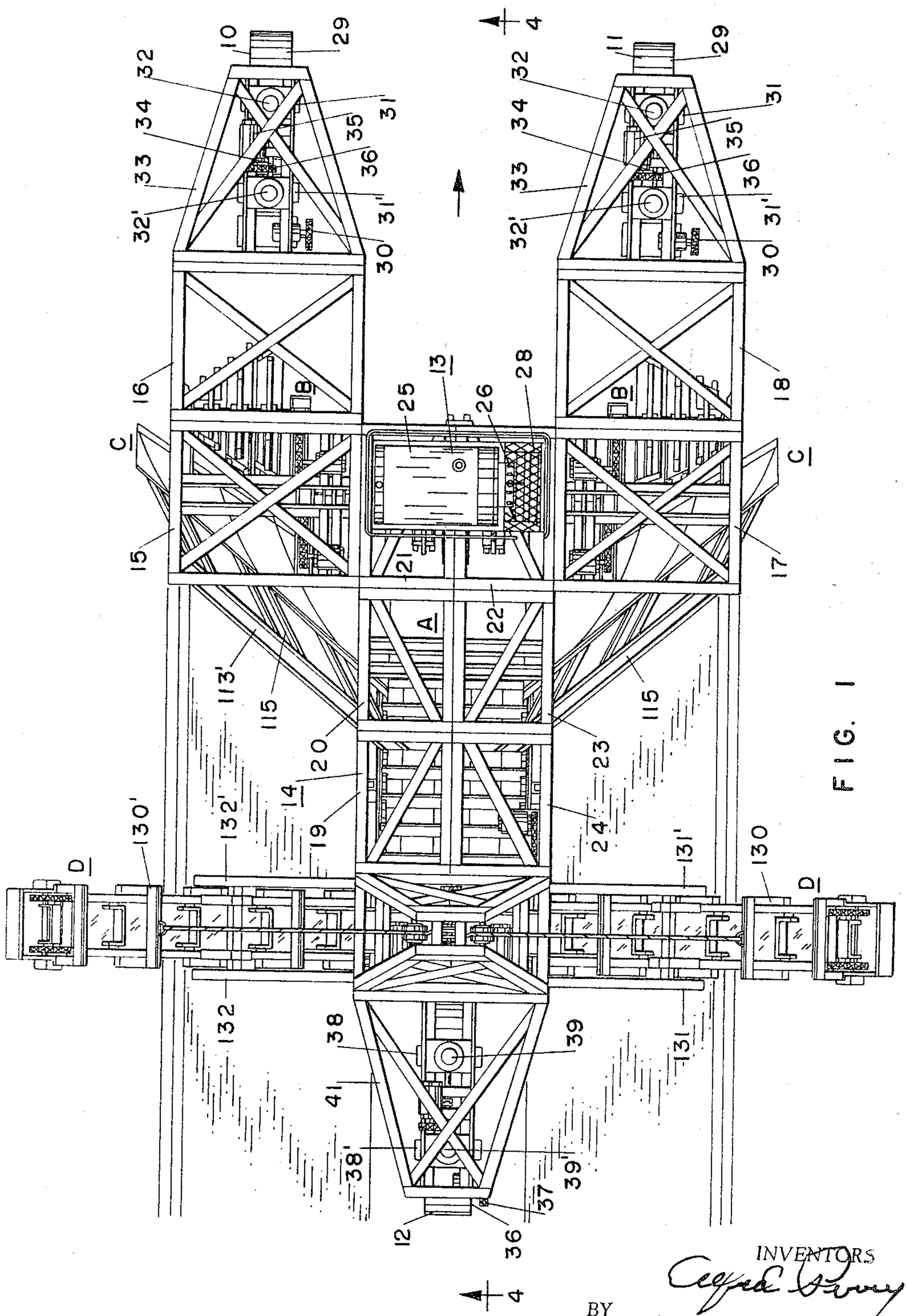


FIG. 1

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Harry D Dunston

BY

March 14, 1967 A. PERRY ET AL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

Filed Sept. 27, 1965 12 Sheets-Sheet 2

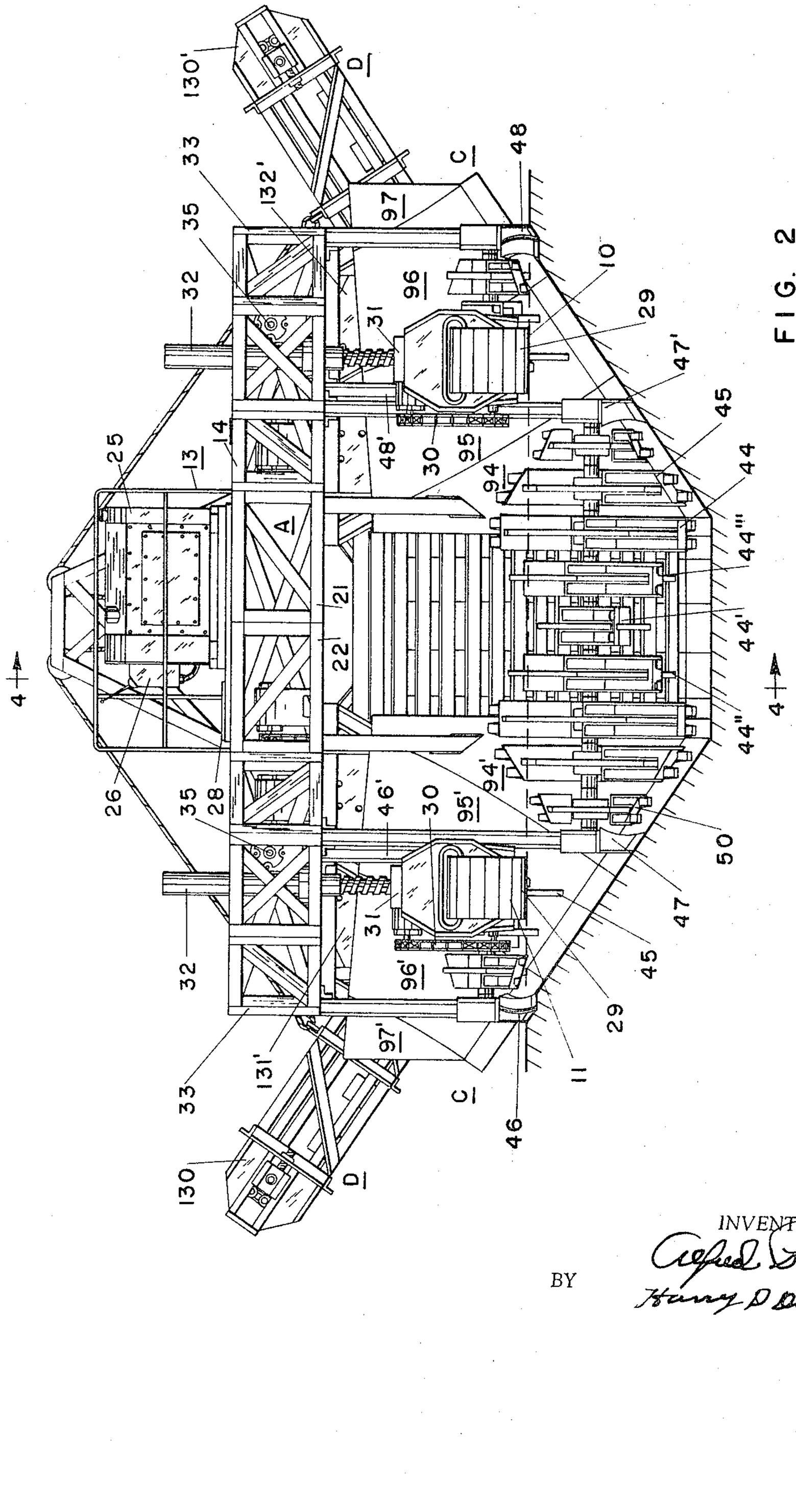


FIG. 2

INVENTORS
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Harry D Dunston,

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March 14, 1967 A. PERRY ETAL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

Filed Sept. 27, 1965 12 Sheets-Sheet 3

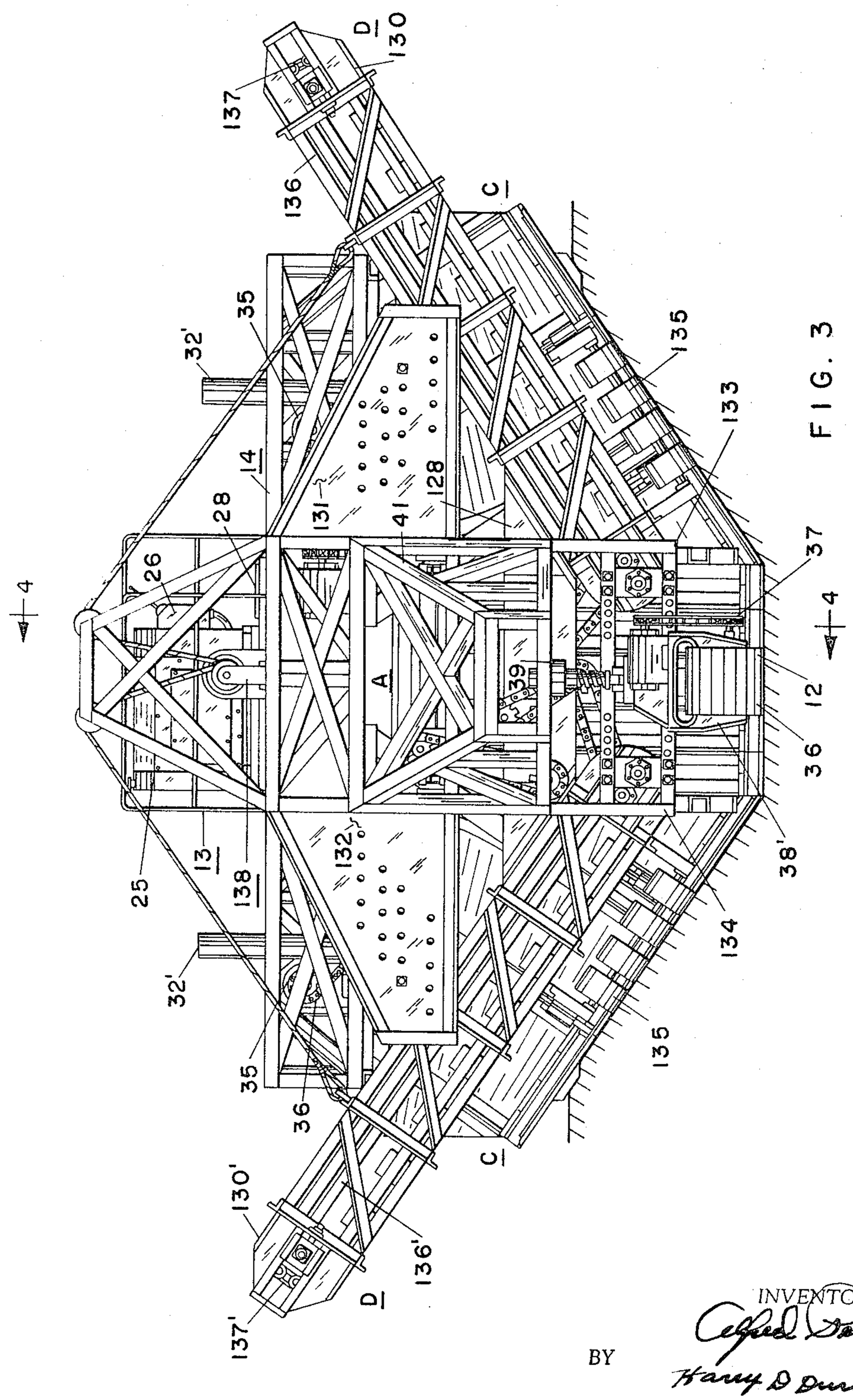


FIG. 3

INVENTORS
Alfred Perry
Harry D Dunston

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March 14, 1967 A. PERRY ET AL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

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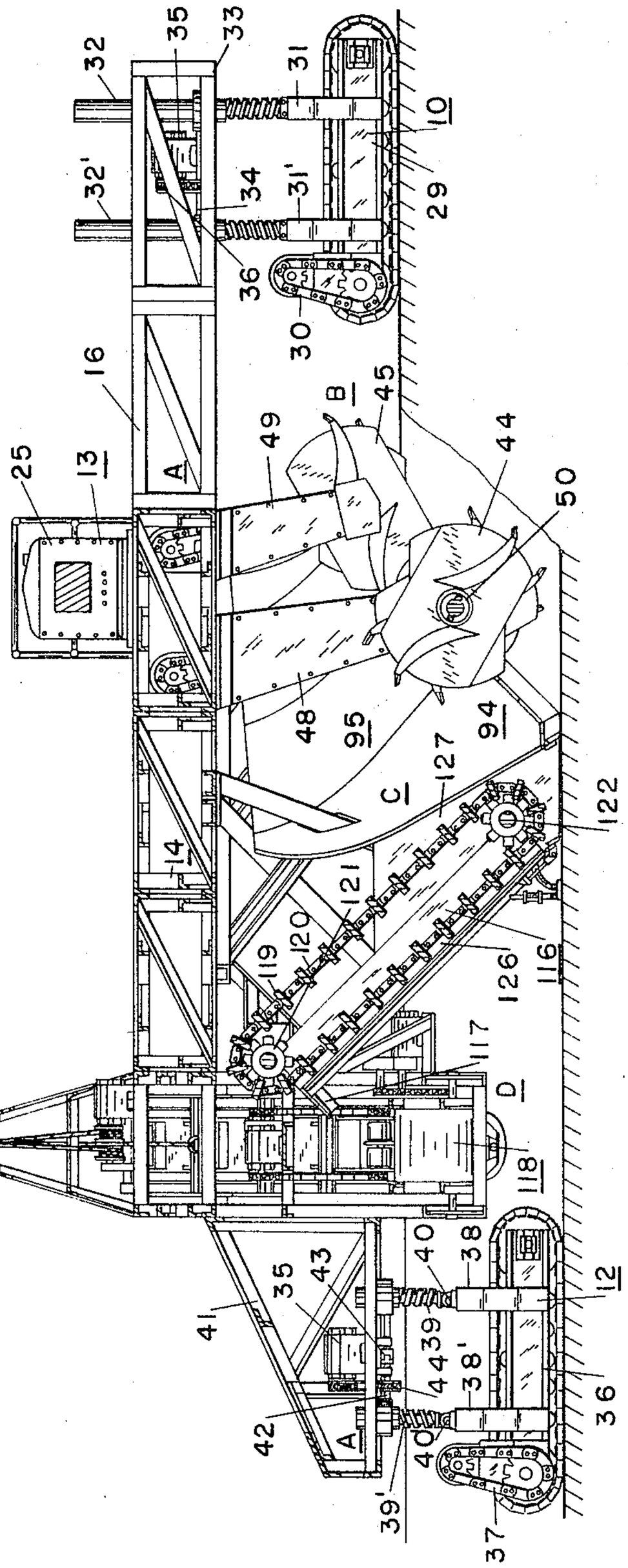


FIG. 4

INVENTORS
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Harry D Dunston

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March 14, 1967 A. PERRY ETAL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

Filed Sept. 27, 1965

12 Sheets-Sheet 5

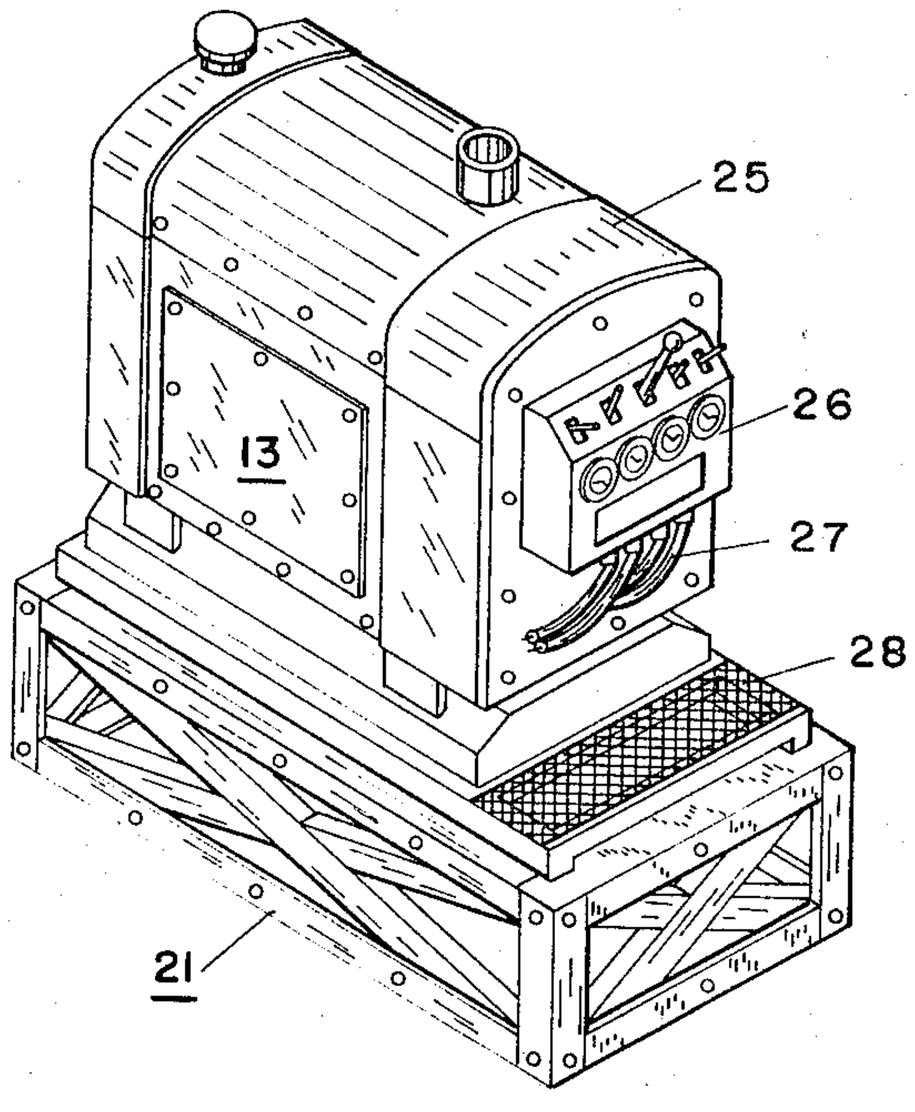


FIG. 5

FIG. 6

INVENTORS

BY Alfred Perry
Harry D Dunston

March 14, 1967 A. PERRY ET AL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

Filed Sept. 27, 1965 12 Sheets-Sheet 6

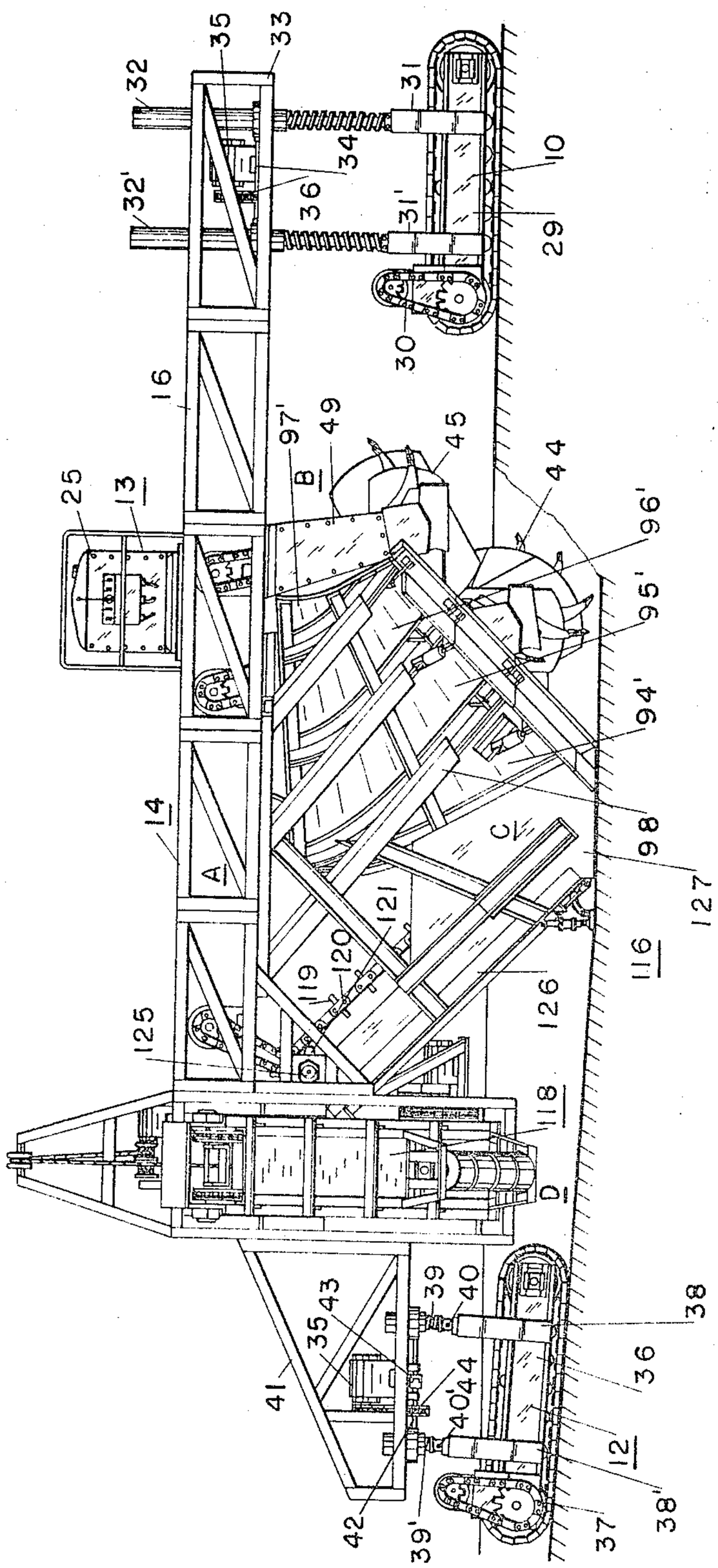


FIG. 7

INVENTORS
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March 14, 1967 A. PERRY ETAL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

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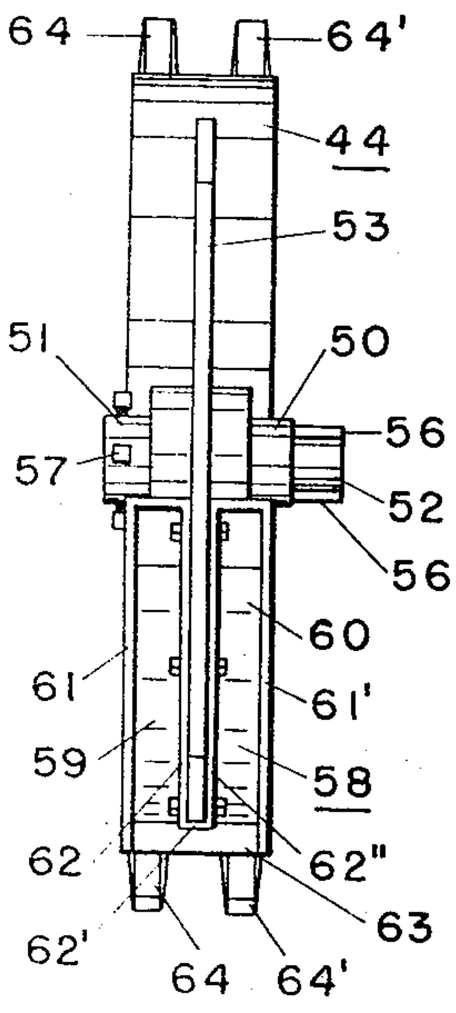


FIG. 8

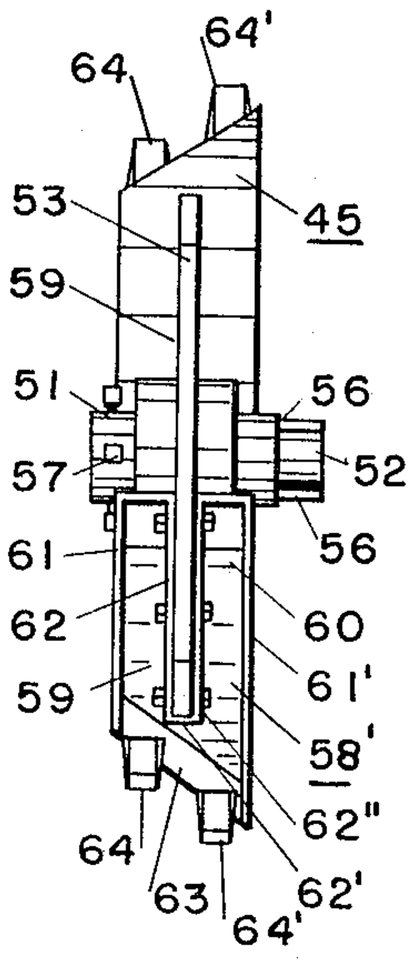


FIG. 9

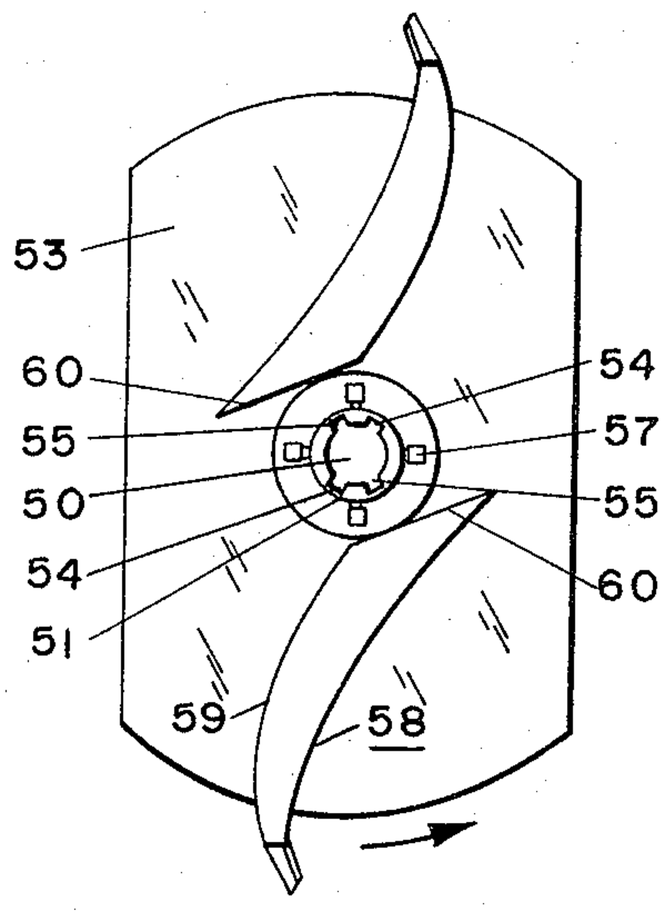


FIG. 10

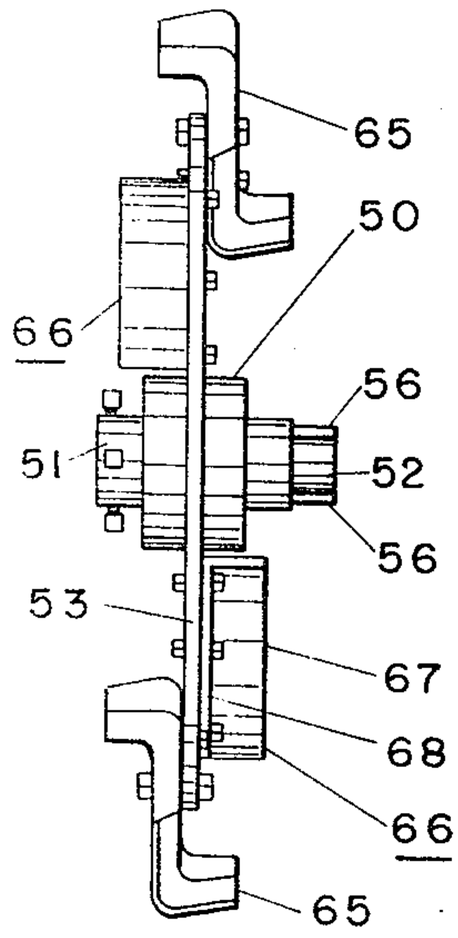


FIG. 11

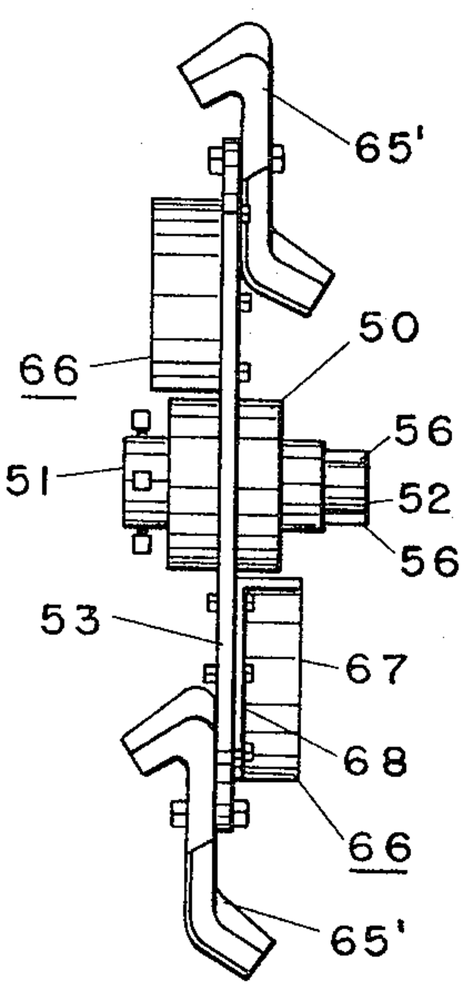


FIG. 12

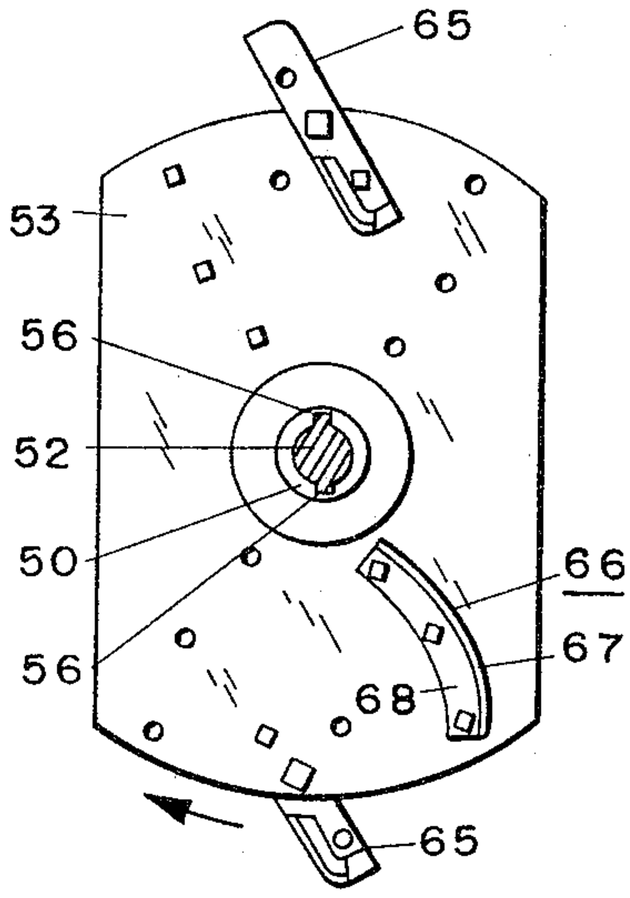


FIG. 13

INVENTORS
Alfred Perry
Harry D Dunston

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March 14, 1967 A. PERRY ET AL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

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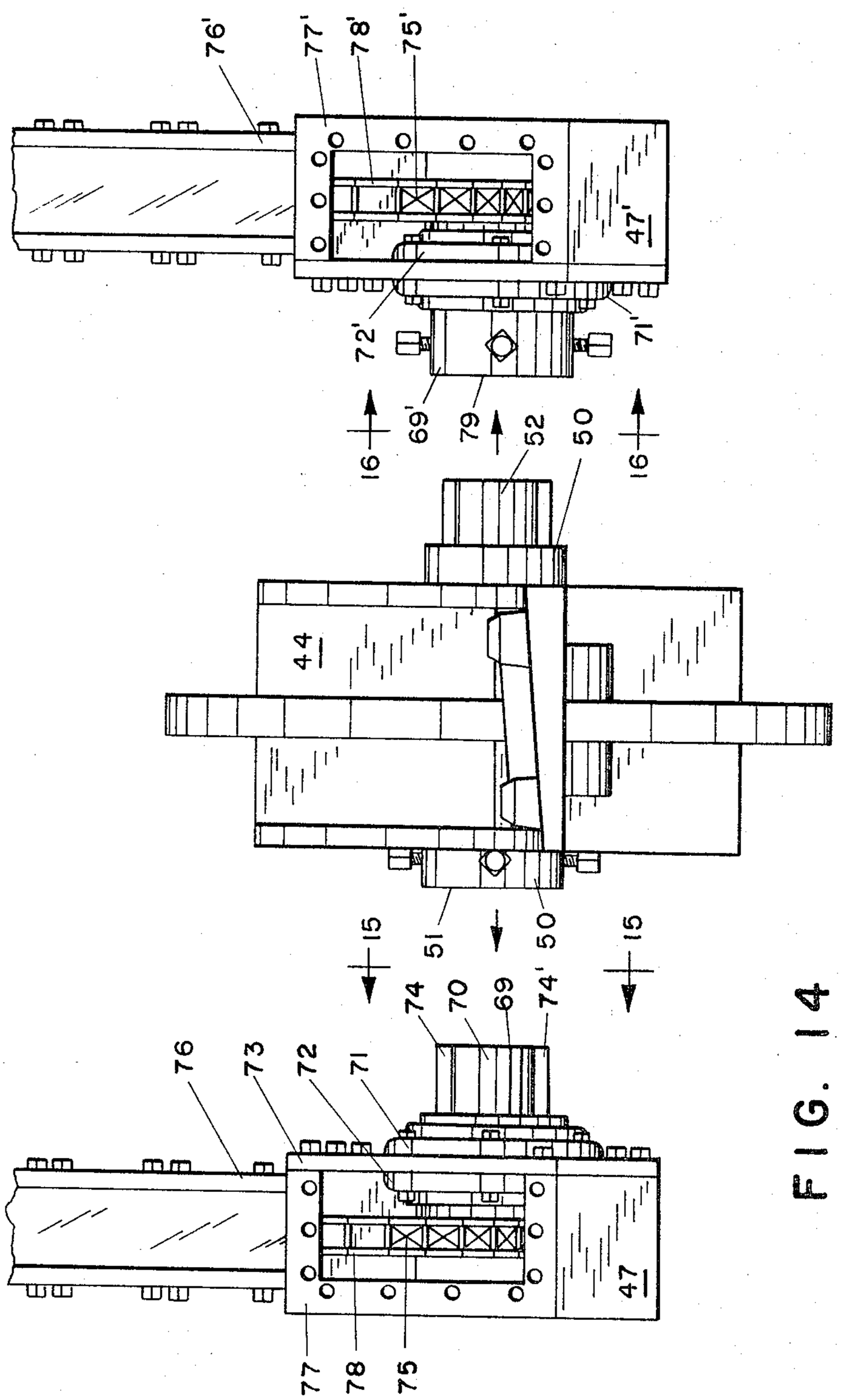


FIG. 14

INVENTORS
Clifford Perry
Harry D Ruston

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March 14, 1967 A. PERRY ETAL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

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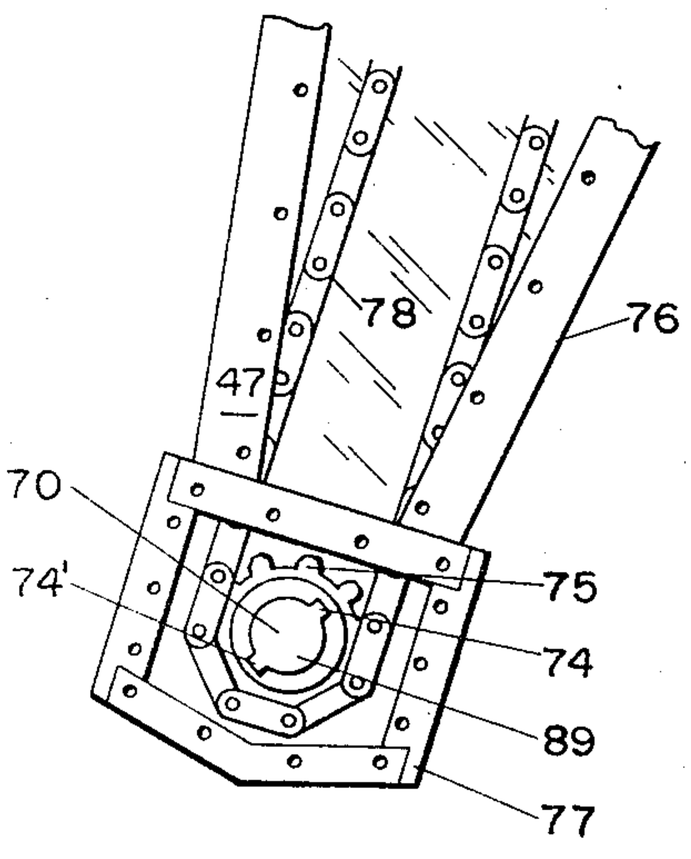


FIG. 15

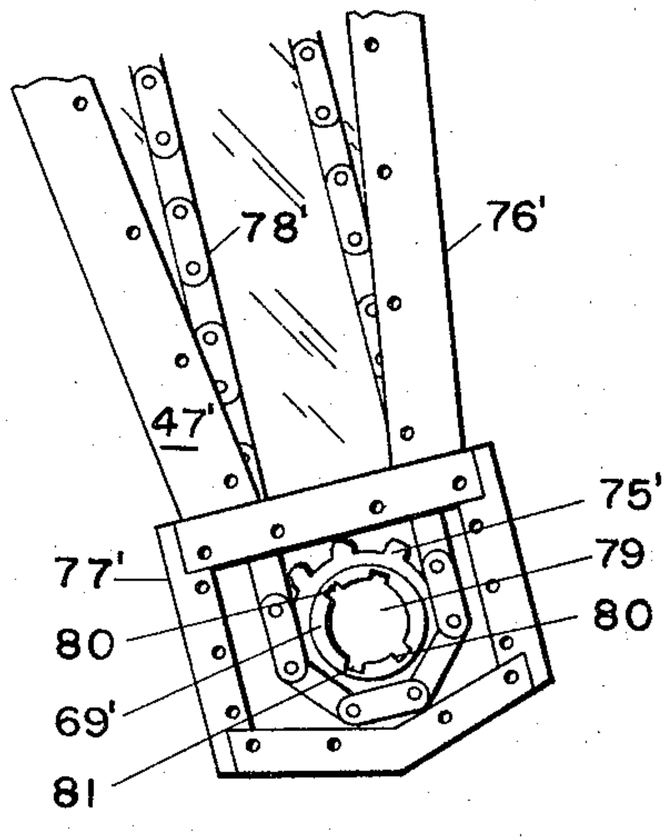


FIG. 16

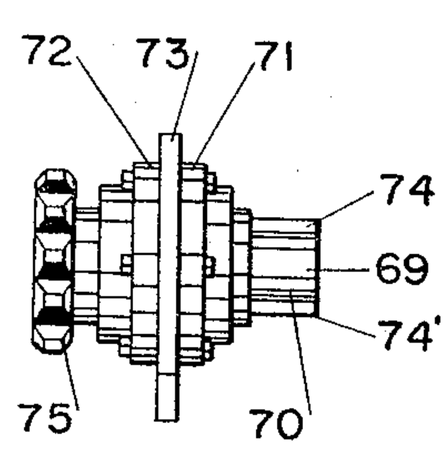


FIG. 17

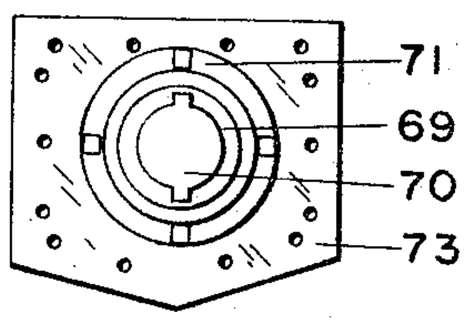


FIG. 18

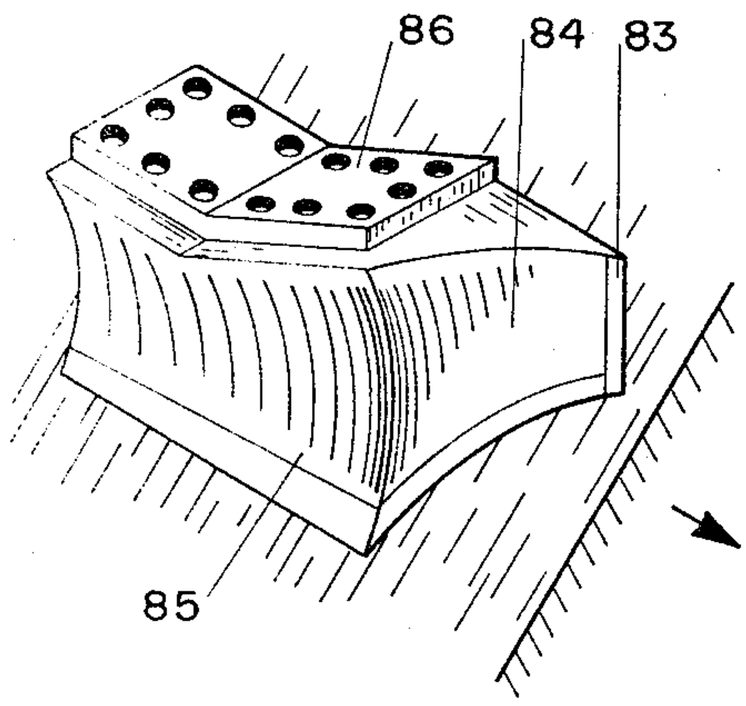


FIG. 19

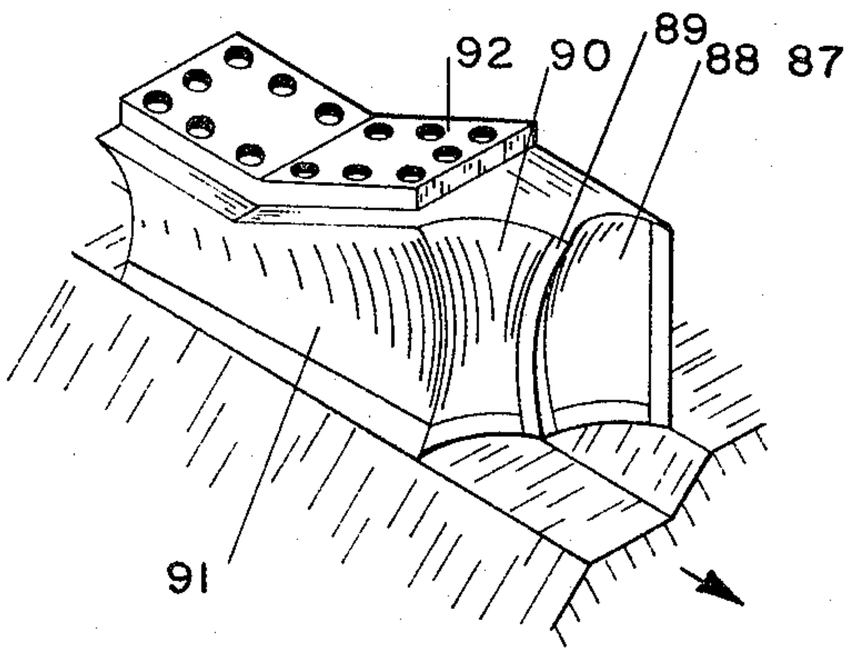


FIG. 20

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COMBINATION EXCAVATING TRIMMING MACHINE

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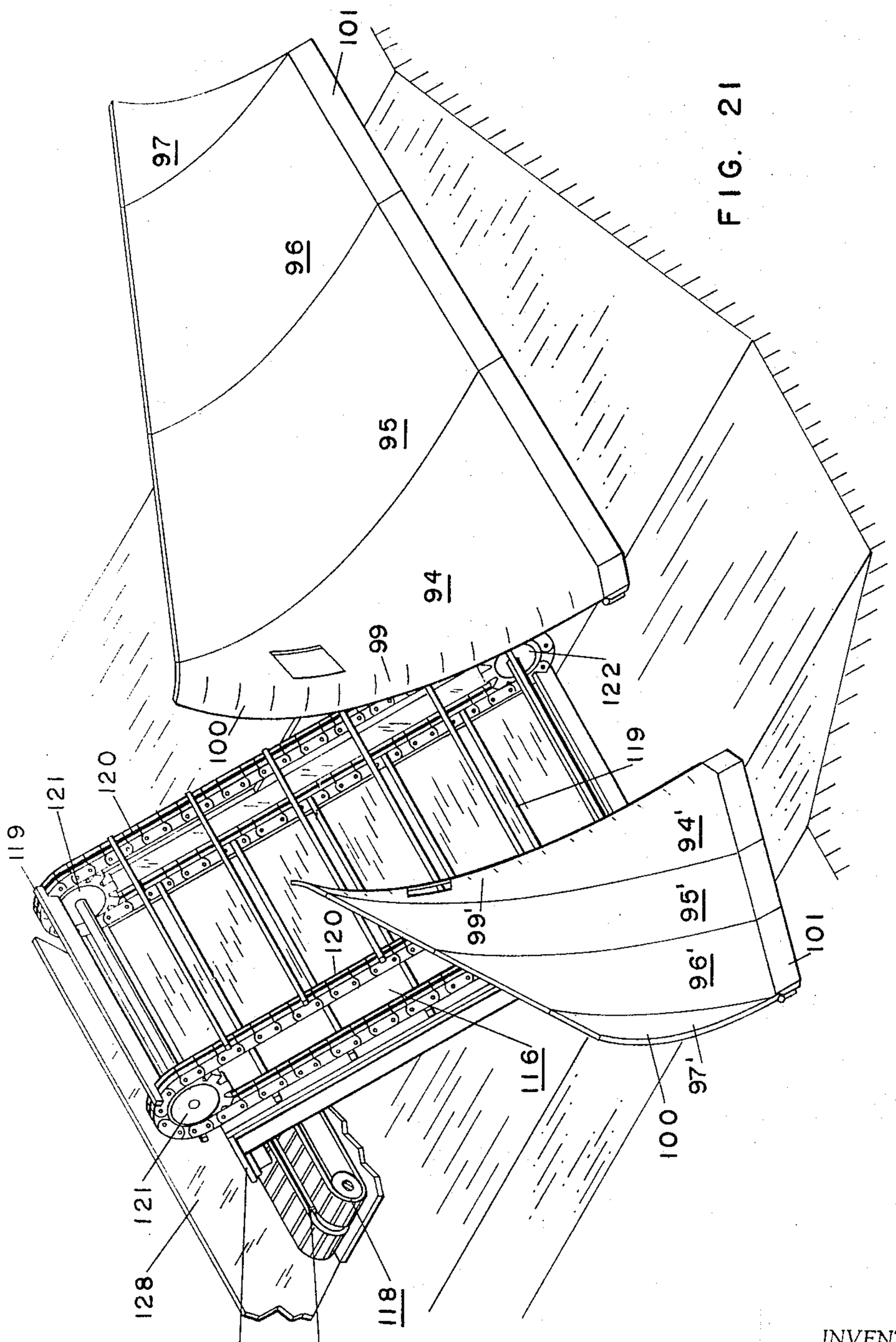


FIG. 21

INVENTORS
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March 14, 1967 A. PERRY ET AL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

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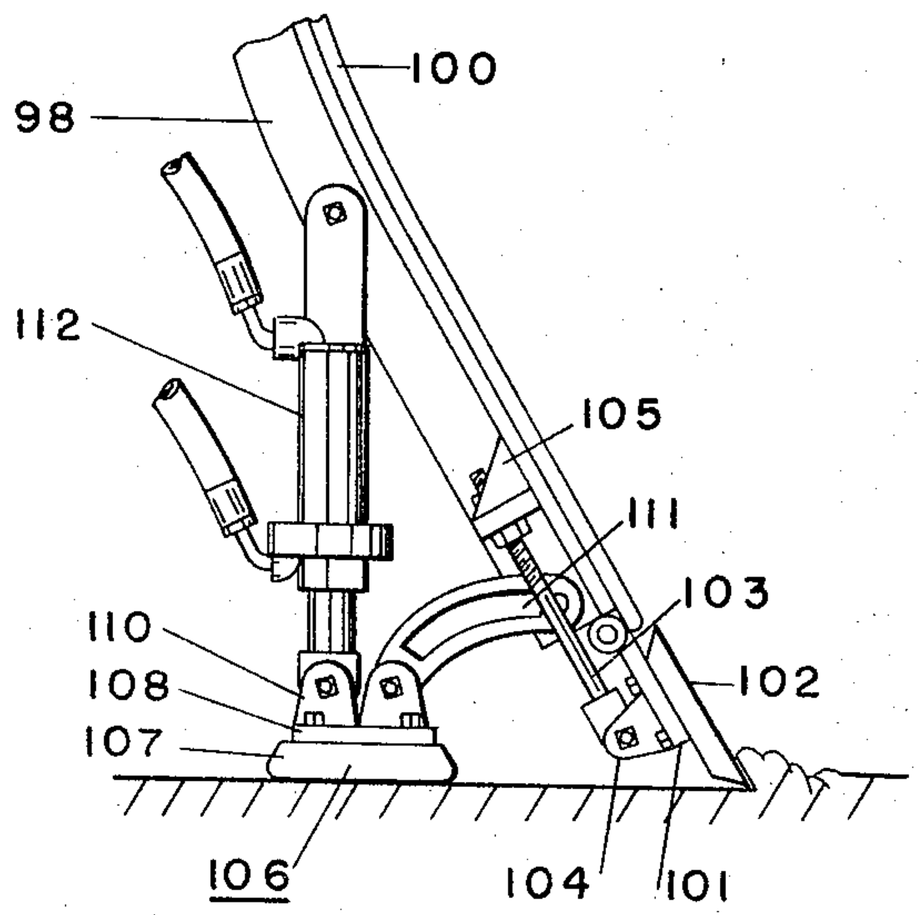


FIG. 22

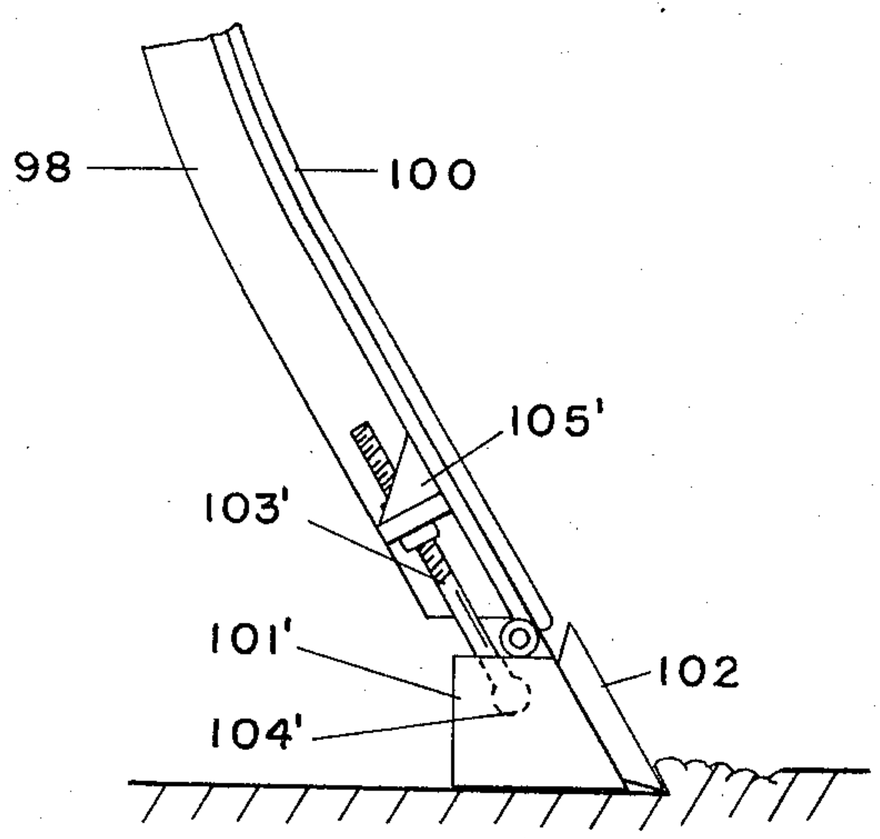


FIG. 23

INVENTORS
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Harry D Dunston

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March 14, 1967 A. PERRY ET AL 3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

Filed Sept. 27, 1965 12 Sheets-Sheet 12

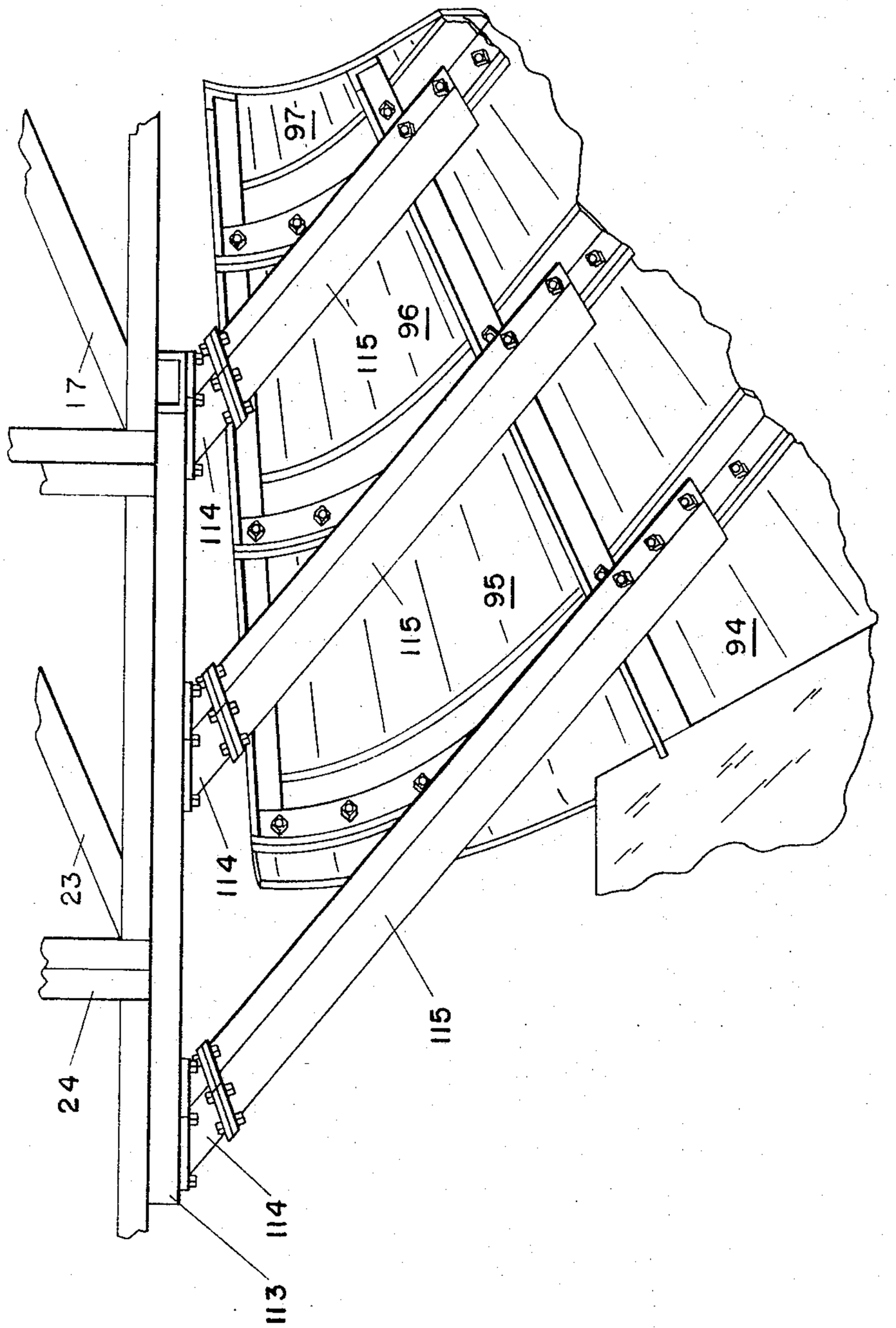


FIG. 24

INVENTORS
Alfred Perry
Harry D. Durston

BY

United States Patent Office

3,308,564

Patented Mar. 14, 1967

3,308,564

COMBINATION EXCAVATING TRIMMING MACHINE

Alfred Perry, Moses Lake, and Harry D. Durston, Kennewick, Wash., assignors to J. A. Terteling & Sons, Inc., Boise, Idaho

Filed Sept. 27, 1965, Ser. No. 490,376
12 Claims. (Cl. 37—96)

The present invention relates to a combination excavating-trimming apparatus and, more particularly, to an excavating-trimming apparatus used in the construction of irrigation canals, distribution laterals, wasteways, channels, flumes, aqueducts, water conduits, and the like.

In the design and construction of such conduits, an attempt is made to select a mean elevation for the conduit at the highest optimum point at which water may be diverted from any water source, including other conduits, into the particular conduit, and to maintain that elevation with the least nominal declination sufficient to produce a hydraulic flow along the course of the conduit. In this manner, the conduit may become far above a natural drainage area in its course, and consequently, above the terrain which the conduit is intended to serve. The natural undulations of the original ground profile in the course of the conduit are usually reduced by cutting and filling respective profile sections to that pre-selected mean elevation, after which a trapezoidal cross-sectioned conduit is excavated to a flow line elevation below the pre-selected mean elevation, wherein that mean elevation may become the berm of the finished conduit.

It is well known in the art that a cross-section configuration for a conduit having the least wetted perimeter will produce the most efficient hydraulic section, because frictional resistance is reduced. It is of equal importance to know that a conduit may best be supported and will maintain its form if the sides of the configuration of the conduit are at an angle not greater than the angle of natural repose of the earth material supporting it. Thus, a trapezoid, being a compromise between a semicircular configuration having the least wetted perimeter and a square configuration having the greater perimeter, is such a configuration as may be readily fitted to the natural angle of repose of the earth material upon which the conduit may be supported. The physical material characteristics of the local terrain may be such as to require one side slope of the conduit cross section configuration to be at a greater angle than the other. It is also frequently necessary to vary the conduit cross sectional configuration along the course of the conduit in order to maintain a relatively constant flow velocity throughout the course of the conduit. Notwithstanding such design criteria, all such configurations shall be here considered as being included in the phrase "trapezoidal cross section."

The mode and manner of excavation and the equipment used is largely determined by the character of the terrain through which the conduit shall pass and by the physical limitations of the equipment imposed by the configuration and the cross sectional size of the conduit. In a few instances, conventional types of excavating equipment will suffice to perform excavation operations to the mean line cut and fill elevation as well as the shaping and removal of material for the trapezoidal cross sectioned conduit. Additional equipment is usually required to transport and distribute excavated material where conventional excavating equipment is so employed. Notwithstanding the use and employment of conventional types of excavating equipment for such purposes, only specialized trimming equipment has been found practical for trimming excess material to neat line dimensions

where a uniform blanket of impervious lining material is required in conduits passing through porous ground. In addition, it may be logically presumed that many types of specialized excavating equipment have been required to meet the especial peculiar character of the several kinds of excavating operations necessary in the construction of each of the particular conduits. The further requirement of frequent change in the configuration and dimension of the hydraulic cross section in order to maintain a relatively constant flow along the course of the conduit has therefore limited the use of most of the several types of excavating equipment formerly known in the art.

It is an object of the present invention to provide an apparatus which may be used and employed to simultaneously perform the excavating of the trapezoidal cross-sectioned conduit, and the trimming operations after the natural undulating profile of the original ground is at, or has been brought to, that pre-selected mean elevation for the conduit, and to effect ready and expeditious excavating and trimming operations without interference to such operations caused by obstructions adjacent to or contiguous with the conduit.

Other objects of this invention are to provide an improved combination excavating and trimming apparatus for accurately and economically excavating, trimming, compacting, and removing of material for water conduits and the like, wherein each of these operations may be performed in sequence in a continuous operation by a single pass of the apparatus; to provide an apparatus of stable construction, which obviates the tendency of such apparatus to contort and thereby misalign the conduit; and to provide an apparatus of the character described, adapted for arrangement for an infinite number of cross section configurations and sizes for the various hydraulic sections desired.

Further objects are to provide an apparatus for excavating and trimming conduits which may be self propelled; which includes means to put the apparatus in and remove the apparatus from normal operating position in the conduit; means for digging; means for depositing excavated material from said digging means on an elevating scraper means; a compacting shoe means on an elevating and mouldboard scraper means for compacting material in the conduit; and means for stabilizing the apparatus and to compact the excavated slopes of the conduit.

The excavating-trimming apparatus herein disclosed comprises a bridge-like framework having mounted therebeneath, in successive order as oriented from the direction of travel of the machine, a plurality of longitudinally disposed digging wheels of various diameters conforming to the trapezoidal configuration of the conduit cross-section; a pair of sloping mould board scraper blades contiguous with each of the side slopes of the conduit which are inwardly disposed in a funnel-like manner toward the center or invert portion of the conduit; a center or invert material elevating scraper; and a pair of material side discharge drag conveyors having slope compacting and stabilizing wheels mounted on the under portion thereof, said wheels being in contact with each of the finished slopes of the conduit. The bridge-like framework may be carried by three dirigible elevating transport vehicles. Two of the vehicles may be mounted on the forward portion of the framework and may be disposed to travel over that portion of ground which is at that pre-selected mean elevation which shall become the trapezoidal cross-section of the conduit after the apparatus has passed over it, or disposed at the forward sides of the framework to move over that portion of the ground which is at that pre-selected mean elevation which may form the berm of the finished conduit. The third transport vehicle may be mounted on the underside of the bridge-like framework

at the aft end of the apparatus, and moved along the bottom or invert portion of the finished conduit.

The hubs of each of the longitudinally disposed digging wheels are internally bored on one side for engagement in axial alignment with reduced shaft extensions or terminal ends forming the other side or portion of each hub. In this manner, any number of wheels of various diameters may be fitted together to produce an infiinte variety of cross sectioned configurations and sizes for conduits. The center or invert material elevating scraper is intended to be fabricated in sections so that the width thereof may be made wide or narrow by adding or removing sections. Further, the sloping mould board scraper blades and the material side discharge drag conveyors are fitted to brackets on the framework in such a manner that they may be fixed at any angle conforming to the respective slopes of the conduit. Thus, the machine may be fitted to the hydraulic configuration desired for the conduit.

As the apparatus of the present invention moves along the intended course of the conduit, the digging wheels excavate the material in its path. The mould board scraper blades push the excavated material in their respective paths ahead, and cause that material to be moved down and toward the center or invert material elevating scraper. The elevating scraper may then lift that material by means of upwardly moving drag bars and discharge it into the side discharge drag conveyors. The side discharge drag conveyors are provided with upwardly moving drag buckets which move the material out of the conduit and discharge it away from the conduit. The side discharge drag conveyors are arranged in such a manner that they may both be used to discharge material equally to both sides of the conduit, or so that either one may be used to discharge material to only one side of the conduit.

The compacting wheels on the underside of the discharge drag conveyors provide stability for the apparatus as well as providing compacting means for the slopes, by running normal to the slopes.

The invention will now be more fully described in conjunction with drawings showing preferred embodiments thereof, from which the attainment of the foregoing and further objects by the apparatus of the invention shall become manifest.

In the drawings,

FIGURE 1 is a plan view of the apparatus of this invention showing the forward transport vehicles mounted on the forward portion of the framework and disposed to move over that portion of ground which shall become the trapezoidal cross-section of the conduit after the apparatus has passed over it.

FIGURE 2 is a front elevational view of the apparatus of FIG. 1 as viewed when the apparatus is in normal operative position approaching the work face of the conduit, and wherein work face has been removed.

FIGURE 3 is a rear elevational view of the apparatus of FIG. 1 as viewed when the apparatus is in normal operative position leaving the completed conduit cross section.

FIGURE 4 is a sectional side elevation view of a portion of the apparatus taken generally along line **4—4** of each of the preceding figures.

FIGURE 5 is an elevational side view of a mounted power plant and control center fixed onto a box-like incremental half frame section.

FIGURE 6 is an isometric view of a forward transport vehicle with a portion of the mounting frame cut away to show the apparatus of the transport vehicles.

FIGURE 7 is a side elevational view of the apparatus of FIG. 1 as viewed when the apparatus is entering operative position from that pre-selected mean elevation to approach the flow line elevation, and wherein the side slope work face of the conduit has been removed.

FIGURE 8 is a front elevational view of a preferred embodiment of an invert or bottom digging wheel of this invention.

FIGURE 9 is a front elevational view of a preferred embodiment of a side slope digging wheel.

FIGURE 10 is a side elevational view of the digging wheel of FIGURE 8.

FIGURE 11 is a front elevational view of a further embodiment of the present invention showing an invert or bottom digging wheel.

FIGURE 12 is a front elevational view of a further embodiment showing a side slope digging wheel.

FIGURE 13 is a side elevational view of the digging wheel of FIGURE 11.

FIGURE 14 is a fragmentary portion to a larger scale of a front elevational view of a typical digging wheel driving hanger means with the cover plate removed, and with a typical wheel disposed therebetween.

FIGURE 15 is a side elevational view of a typical female digging wheel driving hanger means with the cover bearing plate removed.

FIGURE 16 is a side elevational view of a typical male digging wheel driving hanger means with the cover bearing plate removed.

FIGURE 17 is a front elevational view of a typical digging wheel male end drive assembly.

FIGURE 18 is a side elevational view of the assembly of FIGURE 17 as seen from the point of connection of a digging wheel.

FIGURE 19 is an isometric view of a typical side slope plow.

FIGURE 20 is an isometric view of a typical berm plow.

FIGURE 21 is an isometric view of the trimming assembly of this invention.

FIGURE 22 is a side elevational fragmentary view of the cutting bit and crumbing shoe of the present invention.

FIGURE 23 is a side elevational fragmentary view of further embodiment of the cutting bit and crumbing shoe of the trimming assembly of this invention.

FIGURE 24 is an elevational side view of one of the sloping mould board scraper blade hanger assembly.

Referring now to the drawings, the comprehensive views of FIGURES 1 through 4, inclusive, show to advantage a preferred embodiment as a whole, of this invention. The apparatus shown may be classified and described by functional assemblies which include a transport framework designated by the letter A, and excavating assembly generally shown at B, a trimming assembly identified by the letter C, and a material discharge and slope compacting means D.

The transport framework A comprises transport vehicles **10**, **11**, and **12**, a mounted power plant and control center **13**, and a bridge-like framework generally indicated at **14**. A plurality of box-like incremental frame sections fabricated from steel shapes are suitably fastened together to form bridge-like framework **14** into a unit of suitable dimension and size to carry the apparatus necessary to excavate and to trim the specific configuration of a particular conduit. Thus, any number of a plurality of incremental frame sections may be fastened together in infinite arrangements to form bridge-like framework **14**. The plan view of FIGURE 1 shows to advantage the use and employment of square box-like incremental frame sections **15**, **16**, **17** and **18**, and rectangularly shaped box-like incremental half frame sections **19**, **20**, **21**, **22**, **23**, and **24**. FIGURE 1 also illustrates the manner in which mounted power plant and control center **13** may be arranged so as to assure proper weight distribution on the apparatus. Assuming, however, that the bottom or invert section of the conduit was only one-half of that shown in the drawings, then only sections **19**, **20**, and **21** would be required and mounted power plant and control center **13** may then be articulated 90° to the arrangement shown in FIGURE 1, and mounted on box-like incremental half frame section **21**, as illustrated in FIGURE 5.

Mounted power plant and control center **13** is mounted

on platform **28** and comprises an engine driven electric generating set **25** commonly known in the art, having mounted thereon control means **26** to operate the various components of the apparatus herein disclosed, and appropriate receptacles **27** for connecting the several driving means to the power source **25**. Platform **28** is larger than electric generating set **25** in order to provide an operator station from which the mechanisms of the apparatus may be centrally controlled.

Crawler type, electrically driven transport vehicles commonly known in the art have been selected to describe the present invention, although any dirigible vehicles are suitable to carry the framework which may provide means by which the apparatus can travel over the course of the intended conduit. Forward transport vehicles **10** and **11** are intended to travel upon ground at that pre-selected mean elevation which has been previously prepared by cutting and filling the natural undulating profile of the original ground while other mechanisms hereinafter described shall excavate the earth materials below that pre-selected mean elevation to a flow line elevation and to trim the excavated trapezoidal cross-sectioned configuration of the conduit to neat line dimensions. Therefore, a limiting criteria in the mounting of forward transport vehicles **10** and **11** is that the vehicles are disposed so that sufficient subjacent support is provided to sustain the vehicles and, consequently, the apparatus itself. In any of the several types of cut profile sections which may present lateral obstacles adjacent to the sides of the apparatus, transport vehicles **10** and **11** may be disposed directly in the course of the intended conduit ahead of bridge-like framework **14** as shown in FIGURES 1 through 4, inclusive. However, if such obstacles are not present, incremental frame sections **16** and **18** may be fixed to respective incremental frame sections such as incremental frame sections **15** and **17** respectively, or to respective incremental frame half sections which may be similarly disposed.

Transport vehicles **10** and **11** are identical units and a description of one may suffice for both. These transport vehicles, shown to advantage in FIGURE 6, comprise crawler vehicles **29** commonly known in the art, which are driven by electric motor and chain drive assemblies **30**; a pair of crawler mounting yokes **31** and **31'** fixed to the carrier frames of crawler vehicles **30**; a pair of framework raising and lowering means **32** and **32'**; and a box-like incremental frame transport mounting section **33**. Raising and lowering means **32** and **32'** are rigidly fixed to crawler mounting yoke members **31** and **31'**. Means **32** and **32'** as shown are driven screw type jack assemblies. A drive shaft **34**, having gears fixed at its ends to drive mating jack driving gears of means **32** and **32'** simultaneously, is disposed between means **32** and **32'**. Drive shaft **34** is driven in either of two directions to raise and lower means **32** and **32'** by a reversible gear motor **35** through a chain and sprocket assembly **36**.

Transport vehicle **12** is intended to travel over the bottom or invert portion of the completed conduit. Transport vehicle **12** is of similar character to vehicles **10** and **11**. Vehicle **12** comprises a crawler vehicle **36** and an electric motor and chain drive assembly **37**; and a pair of crawler mounting yokes **38** and **38'** fixed to the carrier frame of crawler vehicle **36** wherein each of these components correspond with identical crawler vehicles **29**, drive assemblies **30** and yokes **31** and **31'** of transport vehicles **10** and **11**. Transport vehicle **12** also includes, however, a distinct pair of framework raising and lowering means **39** and **39'** connected by shafts **40** and **40'** journalled there through to members on yokes **38** and **38'**, and a triangular box-like incremental frame transport mounting section **41**. Raising and lowering means **39** and **39'** are driven screw type jack assemblies similar to jacks **32** and **32'** on transport vehicles **10** and **11**. The drive shaft **42** on transport vehicle **12** differs from drive shaft **34** on vehicles **10** and **11** only in that a clutch

assembly **43** is disposed between the chain and drive sprocket assembly **44** and the gear connecting means on raising and lowering means **39**. Shaft **42** is driven in either of two directions by reversible gear motor **35**. When clutch **43** is engaged, raising and lowering means **39** and **39'** are simultaneously driven up or down in response to the direction of rotation of shaft **42**. However, when clutch **43** is disengaged only raising and lowering means **39'** is driven in response to the direction of rotation of shaft **42**.

In order for the appartus to enter operative position from that previously prepared pre-selected mean line elevation to approach the flow line elevation of the conduit, raising and lowering means **32** and **32'** on transport vehicles **10** and **11** are retracted so that the framework, and consequently, the operating mechanisms carried thereby are lowered to operative position. FIGURE 7 shows to advantage the apporach to operative position and may be compared with FIGURE 4 in order to best determine the relative position and attitude of the several transport vehicles. It may be observed in FIGURE 7 that raising and lowering means **39** on transport vehicle **12** is extended while means **39'** is retracted. Yokes **38** and **38'** are thus caused to be articulated about respective shafts **40** and **40'** and crawler vehicle **36** of transport vehicle **12** tends to be forced downwardly at its forward portion to be moved over the declining excavated bottom or invert portion of the conduit. When the apparatus has reached that pre-selected flow line elevation, all of the rising and lowering means of the several transport vehicles are adjusted to the relative operating position shown to advantage in FIGURE 4. The apparatus here disclosed may be removed from the conduit to that pre-selected mean line elevation or to the elevation of the original ground by merely adjusting respective rising and lowering means in the direction opposite to that above described.

The excavating assembly generally shown at B in the drawings comprises a plurality of longitudinally disposed invert digging wheels **44** and side slope digging wheels **45** mounted in axial alignment between drive containing, plow carrying hangers **46**, **46'**, **47**, **47'**, **48** and **48'** digging wheels **44** and **45** are of various selected diameters. FIGURE 2 advantageously shows the manner in which wheels **44** and **45** may be fitted together in detachable engagement with each other to conform to a given trapezoidal cross section configuration for excavating a desired conduit.

Hubs **50** suitably fastened to a wheel plate **53** on each of the wheels **44** and **45**, are shown to advantage in FIGURES 8 through 13, inclusive. Hubs **50** are provided with an internally bored portion **51** on one side for engagement in axial alignment with reduced shaft extensions or terminal ends **52** forming the other side or portion of each of the hubs **50**. Bored portion **51** is provided with two pairs of opposing keyways **54** and **55**. It may be observed in FIGURE 10 that respective opposing keyways **54** and **55** are offset approximately 30° to either side of the perpendicular of plate **53**, or approximately 60° from each other. The terminal ends **52** of hubs **50** are provided with only one pair of opposing keys **56** shown in FIGURE 13. When a plurality of wheels **44** and **45** are fitted together in axial alignment opposing keys **56** of terminal ends **52** may be alternatively inserted in either of the opposing respective keyways **54** or **55** of the bored portion **51** of a preceding digging wheel **44** or **45**. Therefore, when keys **56** are engaged with only opposing keyways **54** in a series of wheels **44** or **45**, the successive keyways **54** and, consequently, wheel plates **53** of each succeeding adjacent wheel **44** or **45** are oriented at approximately 30° to the keyways **54** and plates **53** of the preceding wheel **44** or **45**. Similarly, when keys **56** are engaged with only keyways **55** in a series of wheels **44** or **45**, the successive keyways **55**, and consequently wheel plates **53** of each successive adjacent

wheel **44** or **45** are oriented at approximately 30° to the keyways **55** and plates **53** of the preceding wheel **44** or **45**, and at approximately 60° to a plate **53** of a preceding wheel **44** or **45** wherein keys **56** are engaged in keyways **54** of a wheel **44** or **45** disposed therebetween.

It has been found in practice that substantial mechanical advantage may be derived when excavaitng means of the several wheels **44** and **45** do not simultaneously impinge the work face. Additional stability has been observed when digging wheels **44** and **45** are spirally engaged outwardly in directions opposite from the center of the apparatus, because impact forces of the several wheels at the points of impingement are then simultaneously distributed from points equi-distant from the centerline of the apparatus. Referring to FIGURE 2, the central invert digging wheel is identified by the numeral **44'**, the wheel adjacent to the left is identified by the numeral **44''**, and the wheel connected at the right is identified as **44'''**. In this arrangement, the opposing keys **56** of hub **50** on wheel **44''** are engaged with keyways **55** of hub **50** on wheel **44'**. Opposing keys **56** of hub **50** on successive wheels **44** adjacent to wheel **44''** are similarly engaged in keyways **55** of the hubs **50** of preceding wheels. Opposing keys **56** of hub **50** on wheel **44'** are engaged in keyways **54** of hub **50** on wheel **44'''**. Opposing keys **56** of hubs **50** on successive wheels **44** adjacent to wheel **44'''**, are similarly engaged in keyways **54** of hubs **50** of successive wheels. Thus, wheels on either side of wheel **44'** are in spiral axial alignment outwardly in directions opposite from the wheel **44'**. It may be observed in FIGURES 8, 9, 10, 11, and 12 that internally bored portions **51** of hubs **50** are provided with bolt means **57** in order to secure terminal ends **52** of preceding hubs **50** in internally bored portions **51**.

FIGURES 8, 9, and 10 show to advantage a novel bucket type invert excavating means, generally identified by the numeral **58**, and a bucket type side slope excavating means designated **58'**. Bucket means **58** and **58'** are substantially the same except that the configuration of side slope bucket means **58'** is modified to approximately conform to the slope of the conduit. Bucket means **58** and **58'** comprise an arcuate sloped back portion **59**, an unloading recede portion **60**, side wall portions **61** and **61'**, mounting wall portions **62**, **62'** and **62''**, a mould board bit **63**, and teeth portions **64**, and **64'**. Bucket means **58** and **58'** are suitably fastened to wheel plate **53** by bolts or the like extending through mounting wall portions **62** and **62''** and wheel plate **53**. The mould board bit **63** and teeth **64** and **64'** of side slope bucket means are offset at an angle approximating the intended slope of the conduit either to the right or to the left as determined by the right or left sloping leg of the conduit configuration where the wheel **45** shall be placed. It has been found in practice that bucket means **58'** need not precisely conform to a given slope. An angular offset greater than the slope angle of the conduit may suitably excavate the side slope. However, a lesser angular offset will gouge out a conduit having a greater or steeper slope.

As the wheels **44** and **45** are rotated upwardly, the teeth **64** and **64'** dig into the work face to be excavated and the material is scraped into the buckets by the mould board bits **63**. When the buckets **58** and **58'** approach their respective upright perpendicular positions, the material collected in the buckets in the upward flight tends to be discharged away from the buckets over the then sloping recede bucket portion **60**. The remaining material in the buckets **58** and **58'** may be thrown rearwardly by reason of the centrifugal motion of the wheel, and thus discharged.

FIGURES 11, 12, and 13 advantageously show a further embodiment of excavating means of the present invention. Reversible invert scarifier teeth **65** and side slope scarifier teeth **65'** are suitably fastened to a wheel plate **53**. Teeth **65** and **65'** are mounted at an angle toward the direction of rotation of wheels **44** and **45** respectively,

so that teeth **65** and **65'** cut material of the work face of the conduit in a scraping or shaving like manner in an upwardly moving flight. The rotation of wheels **44** and **45** and of the teeth **65** and **65'** carried thereby is such that the earth material of the conduit is merely broken up. The S-shaped configuration of teeth **65** and **65'** makes it possible to interchange the respective teeth on a given wheel and thereby obtain a new cutting edge when the other exposed edge of the respective teeth become worn.

Invert scarifier teeth **65** differ from side slope scarifier teeth **65'** only in regard to the angular configuration of teeth **65'** which are intended to approximately conform to the sloping sides of the conduit.

It has been found preferable that wheels **44** and **45** rotate upwardly so that rocks and boulders interspersed in the earth material may be lifted up toward the relieved surface rather than being driven downwardly by the excavating means when the direction of rotation is opposite. However, where rocks and boulders are not present, downward rotation of wheels **44** and **45** has proven satisfactory.

Where scarifier teeth **65** and **65'** are used, it has been found that the mass of earth loosened by the teeth impedes the rotation of the wheels particularly on wheels **44** and **45** of larger diameters. Therefore, wheels **44** and **45** are provided with centrifugal discharge buckets **66** suitably fastened to wheel plate **53**. Buckets **66** comprise an arcuate shaped back portion **67** and a mounting wall portion **68**. Buckets **66** are bolted or suitably fastened to wheel plate **53** and are disposed behind the exposed cutting edge of the respective teeth **65** and **65'**. Buckets **66** pick up earth materials loosened by teeth **65** and **65'** and centrifugally discharge it rearwardly in a flinging motion. In this manner, wheels **44** and **45** may be relieved of excessive burden of loosened earth material.

Referring now more particularly to FIGURES 14, 15, 16, 17, and 18, typical digging wheel driving means hanger assemblies are shown to advantage. Inasmuch as all of the pairs of hanger assemblies and components thereof are similar, a description of one pair, such as **47** and **47'**, may suffice for all such assemblies.

In FIGURE 17, a shaft **69**, having reduced shaft extension or terminal end **70**, similar to shaft extensions **52** of the hub portions **50** of wheels **44** and **45**, is journalled through a pair of bearings **71** and **72** mounted on either side of a cover mounting plate **73**. Shaft extension **70** is provided with a pair of keys **74** and **74'**. The terminal end of shaft **69** opposite shaft extension **70** is provided with a sprocket suitably fastened thereon. The assembly above described and shown in FIGURE 17, is shown in place on digging wheel driving means hanger **47** in FIGURE 14. Similarly, an end elevational view of the assembly described and as shown in FIGURE 18, is shown in place in FIGURE 15, except, however, that cover mounting plate **73** and bearings **74** and **74'** are removed in FIGURE 15 for clarity. It may be observed in the drawings that cover mounting plate **73** may be bolted or suitably fastened to the body portion of digging wheel driving means hanger assembly **47**.

The body portion of hanger **47** comprises a chain containing, enclosed, fabricated box-like member **76** suitably fastened to the underside of respective incremental frame sections of the apparatus herein earlier described, and a digging wheel drive sprocket box portion **77** disposed at the lower terminal end of member **76**. An endless drive chain **78**, which is driven by a motor mounted on an incremental frame section of the apparatus, extends from around a sprocket suitably fastened to the shaft of the motor, through member **76**, to around sprocket **75** on shaft **69**. FIGURE 14 shows to advantage the manner in which digging wheels **44** and **45** may be oriented so that the internally bored portions **51** of a hub **50** may be secured in axial alignment on a shaft extension **69** of a digging wheel driving means hanger assembly such as hanger **47**, and thus be driven.

FIGURES 14 and 16 advantageously show a companion hanger assembly, such as **47'**, which is identical to

hanger assembly **47** in all aspects, except that shaft **69'** of companion assembly **47'** is provided with an internally bored portion **79** similar to bored portion **51** of a hub **50** on a digging wheel **44** and **45**, rather than a reduced shaft extension **70** as on shaft **69** of opposing hanger assembly **47**. Therefore, identical and interchangeable members of hanger assembly **47'** shown in FIGURES 14 and 16 are identified by the same numerals identifying corresponding members of hanger assembly **47**, however, a prime indicia (') is used in addition to the numeral identification for such members on hanger assembly **47'**. Internally bored portion **79** of shaft **69'** is provided with two pairs of opposing keyways **81** and **82** similar to keyways **54** and **55** of a hub **50** on digging wheels **44** and **45**. Therefore, a reduced shaft extension **52** of hub **50** on a wheel **44** and **45** may be fitted into bored portion **79** as shown in FIGURE 14. In this manner, a plurality of wheels **44** and **45** may be driven from each of the terminal ends in hanger assemblies, such as **47** and **47'**.

In practice, it has been found that excavated earth material tends to be obstructed by respective hanger assemblies. Therefore, each of the several hanger assemblies is provided with especial plow members which tend to keep the moving excavated earth material in motion as the apparatus here disclosed moves along its work path. Substantial mechanical advantage has been observed in actual operation according to the especial configuration of each of the plows.

FIGURES 19 and 20 illustrate advantageously the plows which are intended to be fitted and suitably fastened to the under body of slope hanger assemblies, such as **47** and **47'**, and to berm hanger assemblies, such as **47** and **48**, respectively. No advantage has been observed by fitting plows to intermediate support hanger assemblies such as **46'** and **48'**, which are shown in FIGURE 2, since such hanger assemblies are not usually in contact with the excavated earth material.

A typical side slope plow, as shown in FIGURE 19, comprises a share **83** on the up slope side of the plow, a downwardly sloping mouldboard **84**, and an arcuate landside **85**. A mounting plate **86** is welded or suitably fastened to the upper portion of the plows so that the plows may be suitably fastened to the hanger assemblies by which they are carried. The rear portion of the plow is open and provides access to the under portion of mounting plate **86**. Thus, bolts may be inserted through holes provided in mounting plate **86** which extends through the plate and into holes provided in the under portion of a sprocket box **77** of a hanger assembly **47** and a sprocket box **77'** of a hanger assembly **47'**. It should be pointed out that the plow shown in FIGURE 19 is intended to be used on a right side slope hanger assembly as observed when the apparatus here disclosed is approaching such as hanger **47'**, and that a left side slope plow such as would be fitted to a left side slope hanger assembly, such as **47**, would be of a configuration reflecting that shown.

Conduits which may pass through porous earth material must be lined with a uniform blanket of impervious material in order to avoid water loss from the conduit. Additionally, wearing blankets are frequently required to avoid conduit failures resulting from scouring, erosion, and the like. Where such blanket linings are required over the excavated foundation of a conduit, the conduit is usually over excavated so that the blanket lining, when placed, will be at that elevation required to provide a given hydraulic cross section. Similarly, the berm portion, shown to advantage in FIGURE 20, is also over excavated to provide termini of adequate structure for the blanket lining. In the apparatus here disclosed, a berm plow is carried by each of the opposite digging wheel hanger assemblies disposed at the outer-most portion of the conduit cross sectioned configuration, such as by hanger assemblies **46** and **48**, respectively. A typical right berm plow is shown to advantage in FIGURE 20. The berm plow carried by the opposite hanger assembly, such as **46**, is similar, except that its configuration is the

reflection of the configuration of the berm plow shown. The berm plow comprises a first or leading mitered share **87** on the up slope side of the plow, a downwardly and rearwardly sloping mitered mould board **88**, a second plane or flat share **89**, a rearwardly oriented plane or flat mould board **90** and an arcuate landside **91**. The berm plow is provided with a mounting plate **92** similar to and employed in the manner described for mounting plate **86** of the side slope plows. Each of the mounting plates is intended to be interchangeable as here disclosed because where a blanket lining is not required over a conduit foundation, it may be desirable to employ side slope plows in place of berm plows to complete the termini of the conduit configuration.

The excavated earth material discharged from the excavating assembly B hereinabove described is directed toward a pair of sloping mould board scraper blades contiguous with each of the respective side slopes of the trapezoidal cross section of the conduit, and toward a bottom or invert elevating scraper, which, together, comprise the trimming assembly generally designated by the indicia C in the drawings. The sloping mould board scraper blades are inwardly disposed in a funnel like manner such as will cause the excavated material to be cascaded down the respective slopes and to be carried toward the invert elevating scraper, and thereby be removed from the conduit. Trimming assembly may be generally comprehended from the description following taken in connection with FIGURES 1, 2, 4, and 7; however, particular references to specific details thereof will be had in connection with FIGURES 21, 22, 23 and 24.

Each of the sloping mould board scraper blades is carried by the transport framework assembly A in the manner herein later described and is disposed forwardly of the invert elevating scraper. The sloping mould board scraper blades each comprise a plurality of incremental blade sections such as **94**, **95**, **96**, and **97**, and **94'**, **95'**, **96'** and **97'** respectively which are shown to advantage in FIGURES 27, and 23. The respective blade sections are bolted or suitably fastened together through mating members, such as angle iron portions **98** fixed on the rearward side edges of the blade sections. In this manner, a greater or lesser number of blade sections may be fastened together to either extend or shorten the sloping mould board scraper blade, or either of them, according to the desired configuration and size of a particular conduit.

Incremental blade sections **94** and **94'** are provided with a recede return portion **99** and **99'**, respectively, at the invert or terminal end thereof. Recede return portions **99** and **99'** provide means whereby the excavated earth material is directed toward the center portion of the invert elevating scraper, and, at the same time, provide a guard fender for the moving mechanical drive apparatus of the invert elevating scraper herein later described. It is intended in commercial practice that a plurality of a variety of pairs of blade sections **94** and **94'** will be supplied with each apparatus of the type here disclosed. Each pair of blade sections **94** and **94'** shall have a different angular configuration such as will cause the respective sloping mould board scraper blades to conform to a variety of trapezoidal slope legs for conduits, such as 1 to 1, 1.25 to 1, 1.5 to 1, and 2 to 1 slope angles. Such slope angles appear to be common to conduits constructed. In this manner, incremental blade sections such as **95**, **96**, **95'** and **96'** may be disposed and are made contiguous with slopes of conduits having any of a variety of common slope angles.

Each of the incremental side slope trimming blade sections comprise a curvilinear blade portion **100**, mating and reinforcing members, such as angle iron portions **98**, welded or suitably fastened on the back of blade portion **100** in alignment with each of the vertical terminal edges thereof; and an adjustable mould board bit hinge mounting member **101** or **101'**. A mould board bit **102** extending substantially along the length of the lower termi-

nal end of the incremental side slope trimming blade sections is disposed below blade portion **100**, and bolted or suitably fastened to a hinge mounting member **101** or **101'**. FIGURE 22 shows to advantage one embodiment of an incremental blade section of this invention. A plurality of adjusting bolt members **103** having an inverted U-shaped portion**104** at its lower terminal end is pivotally mounted in an eye member (not shown) which is welded or suitably fastened to hinge mounting member **101**. Adjusting bolt member **103** extends through an associated bracket **105** welded or suitably fastened to blade portion **100**. A pair of nuts is provided on bolt member **103** to secure it to bracket **105**. Hinge mounting member **101**, and consequently, mould board bit **102** carried thereby, is adjusted as to the respective angles of attack by threading the nuts upwardly or downwardly on bolt member **103**, whereby hinge mounting member is pivoted about its hinged axis.

A compacting and stabilizing shoe assembly is provided on the incremental trimming blade sections. It is commonly known in the art that machines of the type and character employing blade assemblies are least stable at the point of blade contact because there is minimal support for the machine by the blade. Frequently, a strong vibration is set up by the rhythmic flexing of the machine supporting members which bridge the blade, and the blade gouges the surface in its downward flexing. In the present invention, both the pair of sloping mould board scraper blades and the invert elevating scraper blades are substantially the same, at least to the extent of the components above described. Thus, the pair of sloping mould board scraper blades and the invert elevating scraper blade each being provided with compacting and stabilizing shoes which conform to the cross sectioned configuration of the conduit and which substantially increase the area contact at the blades provide means whereby the trimming assembly C is prevented from contorting and thereby causing the conduit to be misaligned. Further, because substantial weight of the apparatus is carried by the shoes, the earth foundation of the conduit is caused to be compacted.

FIGURE 22 shows to advantage one embodiment of a compacting and stabilizing shoe assembly identified generally by the numeral **106**. Compacting and stabilizing assembly **106** comprises a plurality of contact shoe members **107**, a pressure distributing plate **108** to which shoe members **107** are bolted or suitably fastened, a plurality of pressure mounting brackets **109** bolted or suitably fastened to pressure plate **110**, a pivotally mounted arcuate shoe positioning member **111**, and a plurality of pivotally mounted pressure members such as piston **112**. Brackets **109** are provided with a pair of mounting eyes **113** and **114**. Eye **113** is intended to receive piston **112**, while eye **114** is intended to receive shoe positioning member **111**. It is intended that a piston **112** and a shoe positioning member **111** shall be pivotally mounted through each of the mated angle iron members **98** after members **98** are joined together. Additionally, one piston and one shoe positioning member are mounted on a bracket provided on incremental scraper blade sections **94** and **94'** to assure proper distribution of pressure over the length of shoe assembly **106**. Shoe assembly **106** is similarly mounted on invert elevating scraper assembly herein later described. All of the several pistons are connected in parallel to a pressure reservoir so that fluid under pressure in the pressure system shall be uniform throughout. Therefore, when an obstruction is encountered at a point along the length of the shoe, the piston **112** at or near the point of contact may yield.

In a further embodiment of a compacting and stabilizing shoe assembly, shown to advantage in FIGURE 23, the shoe assembly is combined with an adjustable mould board bit hinge mounting assembly identified by the numeral **101'**. In this embodiment, the mould board bit is bolted to the combination shoe-hinge mounting assembly **101'**. An adjusting bolt member **103'** is provided with a ball portion **104'** at its lower terminal end. Ball portion **104'** and bolt **103'** are fitted into a slot and socket provided in combination shoe-hinge mounting assembly **101'**. In this matter, combination shoe-hinge mounting assembly **101'** is pivotally and adjustably mounted.

The sloping mould board scraper blades are carried by respective hanger assemblies suitably fastened to transport framework assembly A as shown to advantage in FIGURE 24. Frame mounting members **113** and **113'** are bolted to respective incremental frame sections, such as to sections **24** and **17**, and to sections **19** and **15** and are disposed therebetween. Since the hanger assemblies for each of the sloping mould board scraper blades are identical, a description of one may suffice for both hanger assemblies. A plurality of wedge members **114** are suitably fastened at intervals on frame mounting member **113**. Wedge members **114** have a configuration such as will cause sloping mould board scraper blades to be set at a given angle conforming to the side slopes of a given conduit. It is thus necessary to provide a variety of wedge members of different angular configurations, in order to change the slope angle of sloping mould board scraper blades from one slope angle to another. Each of the wedge members **114** is provided with bolting flange portions at each of their respective terminal ends. A plurality of channel strut members **115** are bolted through mating flange members provided thereon to respective wedge members **113**. Channels **115** are fitted over mating angle iron members **98** of respective incremental mould board sections such as sections **94, 95, 96,** and **97**. Respective incremental mould board sections are secured to channel strut members **115** by bolts extending through the legs of each of the channel members **115** and through the respective mating angle iron members **98**.

Referring now to FIGURES 4 and 21, an understanding may be had of the invert elevating scraper portion of trimming assembly A. The invert elevating scraper is disposed aft and rearwardly of respective sloping mould board scraper blades hereinbefore disclosed. The basic structural elements or components of the elevating scraper portion are substantially the same as sloping mould board scraper blade assemblies, with, however, additional mechanisms and structure forming a part of the elevating scraper. That is to say, the invert elevating scraper comprises a plurality of incremental blade sections similar to incremental blade sections **94, 95, 96,** and **97**, each section thereof having a blade portion **100**, an adjustable hinged bit mounting member **101**, a mould board bit member **102**, and a compacting-stabilizing member **106**. In addition thereto, elevating scraper portion is provided with an elevating mechanism generally designated by the numeral **116**, a discharge pan **117**, and a pair of partially enclosed reversible split discharge conveyors identified by the numeral **118**. It should be pointed out, however, that incremental blade sections of the elevating scraper portion are flat rather than curvilinear as are sloping mould board scraper blades. Suffice it to say that the invert scraper blade here disclosed may be adapted to use and employ the several embodiments hereinbefore described in connection with the sloping mould board scraper blades.

Elevating mechanism **116** comprises a plurality of flat bar type blades **119** carried by a pair of endless chains **120**, chains **120** are driven about respective pairs of sprockets **121** and **122**. The pairs of sprockets **121** and **122** are mounted on respective axles **123** and **124** disposed at the top and the bottom of the invert scraper blade, and are journalled in respective bearings **125** provided on material retaining side members **126**. The side members **126** extend along each of the outer edges of the invert scraper blade assembly to form a trough-like portion in which blades **119** carry material in their upwardly moving flight. Axle **123** is connected through a suitable driving assembly to gear motors, which may be mounted on an

incremental frame section of transport framework assembly A.

As the apparatus here disclosed moves along its intended work path, earth material is dragged up incremental blade sections of the invert elevating scraper by upwardly moving blades **119**, and is caused to be discharged over a downwardly sloping discharge pan **117** provided across the upper rear portion of incremental blade sections. A pair of side wall members **127** disposed between the invert elevating scraper portion and the aft side of sloping scraper blade incremental blade sections **94** and **94'** is provided to form a hopper-like portion for material being carried from the respective sloping scraper blade toward the invert elevating scraper portion. Similarly, earth material trimmed from the invert portion of the conduit is contained therein until it is carried upwardly by blades **119** and discharged over pan **117**.

A pair of reversible discharge conveyors **118** is provided below discharge pan **117** to receive earth material discharged thereby. Discharge conveyors **118** are disposed in a trough-like enclosure **128**, which extends the sides and under portion of conveyors **118**. A splitter member **129** is provided between each of the conveyors **118** so that earth material may not fall therebetween. It is intended that conveyors **118** may operate together in either of two directions to discharge material into either of the two drag conveyors commonly known in the art which are provided on material discharge assembly D herein later described, or, alternatively, that each of the conveyors **118** operate in opposite directions to each other to simultaneously discharge material to both discharge drag conveyors. In this manner, earth material from the apparatus here disclosed may be disposed of to either of the sides of the conduit, or equally to both sides. Conveyors **118** are intended to operate at relatively high speed so that material therefrom may be centrifugally discharged therefrom away from the conveyors and into buckets of the drag conveyor assembly D. Therefore, it is preferable that the belts of conveyors **118** have protrusions thereon such as molded earth belts commonly known in the art. In this manner, the earth material may be moved at high speeds by the belts.

Discharge assembly D is shown to advantage in FIGURE 4. Discharge assembly D comprises a pair of discharge drag conveyors **130** and **130'**; a pair of discharge conveyor mounting frames **131, 131', 132** and **132'** suitably fastened to transport framework assembly A and disposed at the forward and aft sides of each of the drag conveyors **130** and **130'**; a pair of drag conveyor tail mounting brackets **133, 133', 134** and **134'** suitably fastened to the under portion of transport framework assembly A and disposed at the forward and aft sides of the tail portion of each of the discharge drag conveyors **130** and **130'**; and a plurality of compacting rollers **135** carried by each of the drag conveyors **130** and **130'** and which are contiguous with each of the side slopes of the conduit. Discharge drag conveyors **130** and **130'** are typical of drag conveyors known in the art wherein a plurality of U-shaped buckets are carried by a pair of chains running in recessed slots of trough-like frame, and the buckets are caused to drag material over the bottom or pan portion of the trough-like frame. In the apparatus here disclosed, the trough-like frame is in the upper portion of the conveyor assembly, and is generally designated by the numerals **136** and **136'** respectively, on each of the drag conveyors **130** and **130'**. The plurality of drag buckets are carried upwardly and thereby drag the earth material from discharge conveyors **118** up and over the head portions generally designated **137** and **137'** respectively, dumping the material on the sides of the conduit as earlier described.

Discharge frame mounting frames **131, 131', 132** and **132'** and conveyor tail mounting brackets **133, 133', 134** and **134'** are provided with a plurality of holes through which bolts in conveyors **130** and **130'** may be inserted

to securely fasten the respective conveyors thereto. The holes are located so that each of the drag conveyors may be fixed so as to severally conform to each of the side slopes of a particular conduit. In practice, a split winch and cable assembly generally shown at **138** mounted on transport framework assembly greatly facilitates such adjustments in the field. In the drawings, the plurality of holes are located so as to illustrate the placement of the conveyors **130** and **130'** in one foot increment invert size changes for slopes which are 1:1, 1.25:1, 1.5:1, 1.75 and 2:1. For example, the conveyors as shown, as well as the other portions of the apparatus shown illustrate the apparatus disclosed in a conduit approximately five feet wide at the invert and having nearly 2:1 side slopes.

The plurality of compacting rollers **135** are disposed on the under portion of each of the drag conveyors in such a manner that they run normal to the slope. In addition to providing means by which the trimmed slopes may be further compacted, the rollers tend to provide stabilizing means for the apparatus, and thereby eliminate twisting and contorting of the apparatus. A pair of structural members having bearings suitably fastened at the lower ends thereof are bolted or suitably fastened to each of the conveyors **130** and **130'**. An axle, on which the rollers are mounted is journalled in the bearings on the structural members.

Conventional means may be located on the machine of the present invention to effect operation of the various types of driving assemblies, including electric, hydraulic, pneumatic, and the like herein shown and described. Although preferred combinations and sub-combinations of the present apparatus and method is herein shown and described, it is, of course, to be understood that various changes may be made herein. More particularly, as earlier indicated in this specification, the entire apparatus hereinabove described is of great utility in other than conduits having a trapezoidal cross section. Moreover, the more advantageous features of the invention, forming assemblies, sub-assemblies and components of this apparatus, have utility apart from each other. Accordingly, the invention is not to be considered limited to the structure and uses particularly described herein, but rather, only by the scope of the appended claims.

We claim:

1. An apparatus for forming open trapezoidal water conduits in an earth foundation, which foundation has been previously cut and filled from the natural undulating ground profile to a preselected mean elevation, and which conduits include an invert portion, a pair of respective upwardly extending side slope portions commencing at the sides of said invert portion, and at least one berm portion at the upper end of each of said respective side slope portions, the apparatus comprising a mobile bridgelike framework mounted on transport vehicles for movement along a projected work path overlying the conduit to be excavated, digging means carried by said framework and disposed below said framework and extending across the conduit at the front end of said framework with respect to the direction of travel thereof, said digging means having outer digging edges generally conforming to and extending entirely across the preselected cross sectional configuration for the conduit, excavating means carried by said digging means to remove dug material, scraper means carried by said framework aft of said digging means, smoothing and compacting means carried by said framework aft of said scraper means, said scraper means and said smoothing and compacting means extending entirely across and substantially conforming to the pre-selected cross-sectional configuration for the conduit and extending deeper into the conduit than said digging means to cut and trim and compact the said several portions of the conduit to uniform neat line dimensions in a single pass therealong, and means carried by the framework to convey away dug, excavated and trimmed earth material from the conduit.

2. The apparatus of claim 1 wherein a pair of said transport vehicles are positioned at the front of said frame to travel on said preselected mean elevation ahead of the digging operation inside the width of the conduit to be excavated, and one of said transport vehicles is positioned at the rear of said frame in the trimmed conduit, said frame having its outer sides substantially within the width of the conduit.

3. The apparatus of claim 2 including means to progressively lower said rear transport vehicle together with said digging means, said scraper means and said smoothing and compacting means while said transport vehicles are moving to initiate the conduit forming operation.

4. The apparatus of claim 1 wherein said digging means comprises a plurality of digging wheels mounted in side by side relation, each of said digging wheels having a plurality of circumferentially spaced scarifier blades having outer digging edges conforming to said conduit configuration.

5. The apparatus of claim 4 wherein said digging wheels are symmetrically arranged in pairs on opposite sides of the center line of said conduit with the scarifier blades of adjoining wheels being circumferentially staggered relative to each other but with all pairs of said wheels which are symmetrically disposed on opposite sides of said center line having their scarifier blades aligned with each other.

6. The apparatus of claim 5 wherein said scarifier blades are defined by the outer ends of buckets mounted on said wheels, said buckets providing said excavating means.

7. The apparatus of claim 4 wherein each of said buckets includes a generally radial container to receive and throw the dug material rearwardly.

8. The apparatus of claim 7 wherein each said bucket wheel includes a radial reinforcing plate dividing each of said generally radial containers into two compartments.

9. The apparatus of claim 1 wherein said scraper means comprises a plurality of blades conforming respectively to said invert and side slope portions, said smoothing and compacting means comprises a plurality of continuous pressure shoes mounted immediately behind said blades.

10. The apparatus of claim 9 including means connected to said scraper means to urge said shoes downwardly relative to said blades.

11. The apparatus of claim 10 wherein said shoe urging means comprises a plurality of fluid pressure operated cylinders.

12. An apparatus for forming open trapezoidal water conduits in an earth foundation, which foundation has been previously cut and filled from the natural undulating ground profile to a preselected mean elevation, and which conduits include an invert portion, a pair of respectively upwardly extending side slope portions commencing at the sides of said invert portion, and at least one berm portion at the upper end of each of said respective side slope portions, the apparatus comprising a mobile bridgelike framework mounted on transport vehicles for movement along a projected work path overlying the conduit to be excavated, digging means carried by said framework and disposed below said framework and extending across the conduit at the front end of said framework with respect to the direction of travel thereof, said digging means comprising a plurality of axially aligned bucket wheels having outer digging edges generally conforming to and extending entirely across the pre-selected cross-sectional configuration for the conduit, excavating means carried by said bucket wheels to remove dug material, scraper means carried by said framework aft of said digging means, smoothing and compacting means carried by said scraper means and positioned aft of said scraper means, said scraper means and said smoothing and compacting means extending entirely across and substantially conforming to the pre-selected cross-sectional configuration for the conduit and extending deeper into the conduit than said digging means to cut and trim and compact the said several portions of the conduit to uniform neat line dimensions in a single pass therealong, elevating conveyor means carried by said frame and extending upwardly from a position adjacent said scraper means to receive material therefrom, said conveyor means including an endless elevating chain and a plurality of elevating scrapers, material discharge conveyor means mounted on said frame and extending laterally from the upper end of said elevating conveyor means to receive material therefrom, a pair of drag conveyor assemblies carried by said frame and positioned to receive material from said material discharge conveyor means, said drag conveyor assemblies extending beyond the side edges of the conduit to carry the excavated material to a disposal area, and a plurality of compaction rollers mounted on said frame and positioned on the underside of said drag conveyor assemblies.

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