Jan. 24, 1967 F. KOCKS ET AL **3,299,685**

DRIVE FOR A MULTIPLE-STAND ROLLING MILL

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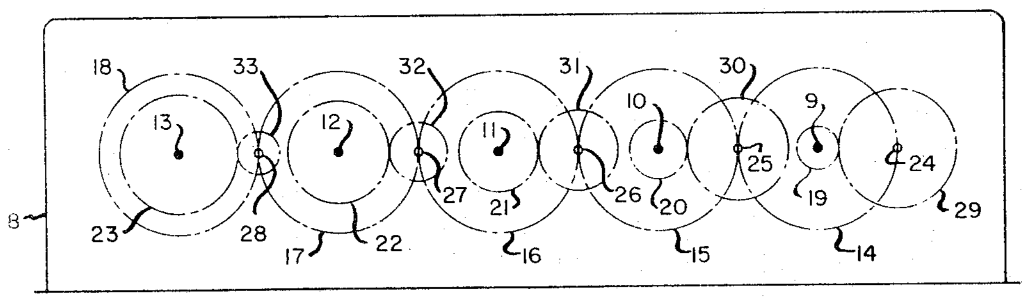
Fig. 2.



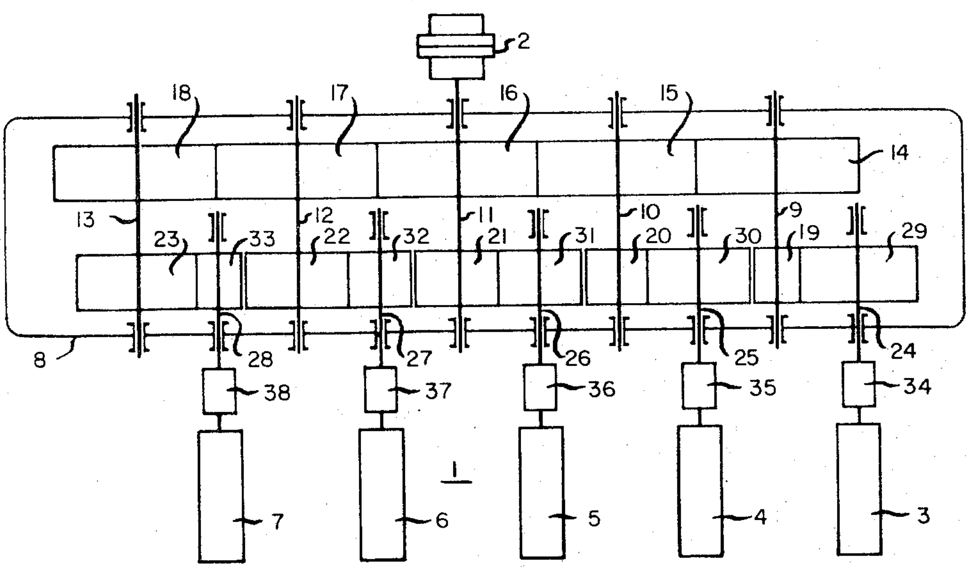


Fig. 1.

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Fig. 4.

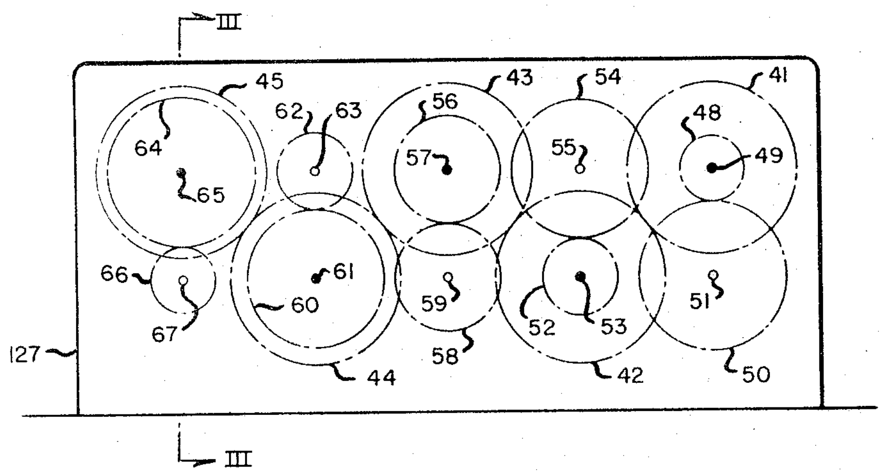
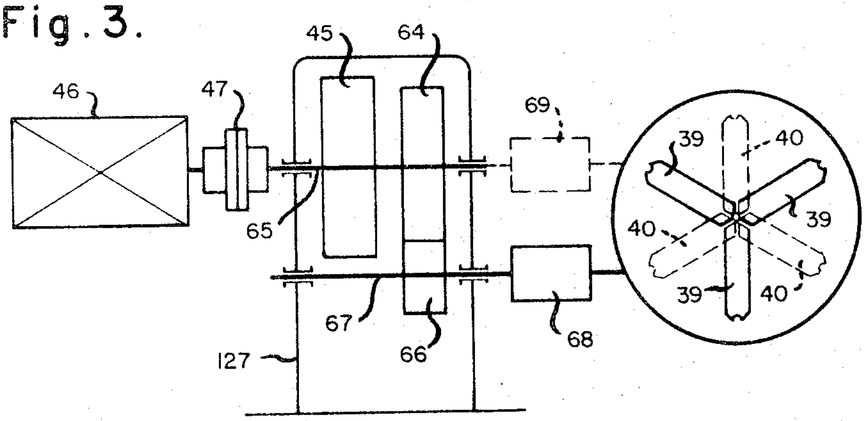


Fig. 3.



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DRIVE FOR A MULTIPLE-STAND ROLLING MILL

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Fig. 5.

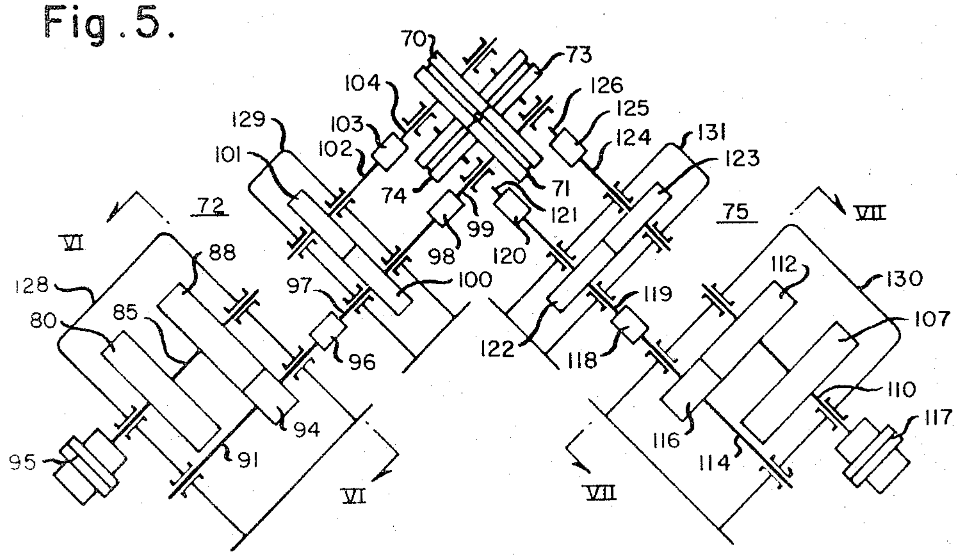

Fig. 6.

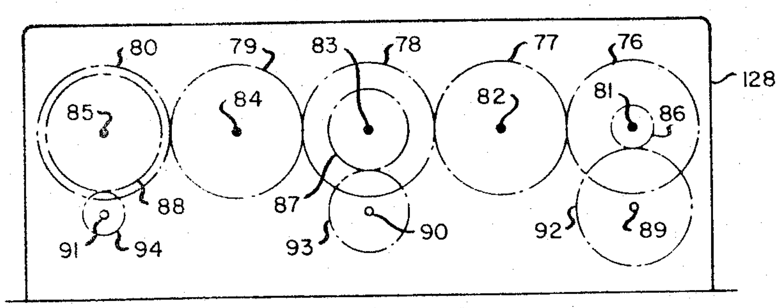

Fig. 7.

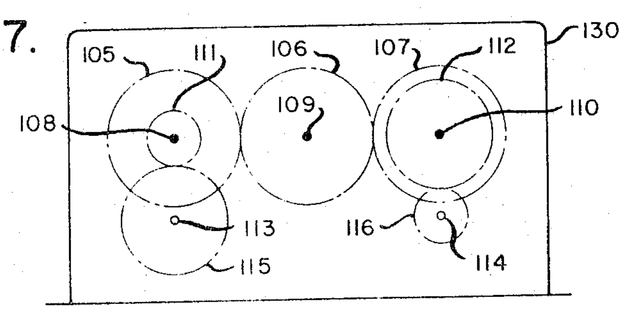

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Fig. 8.

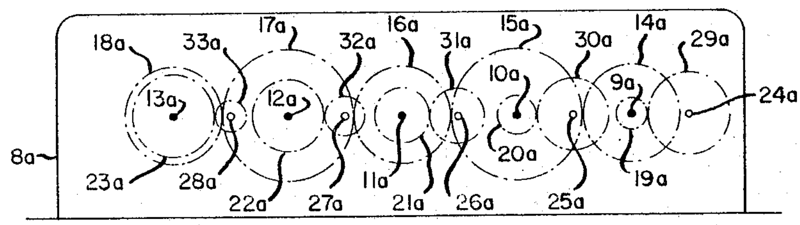


Fig. 9.

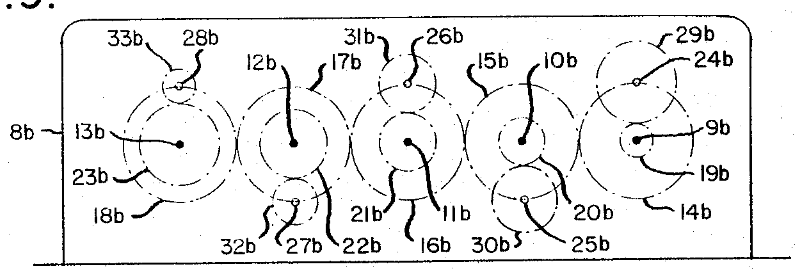


Fig. 10.

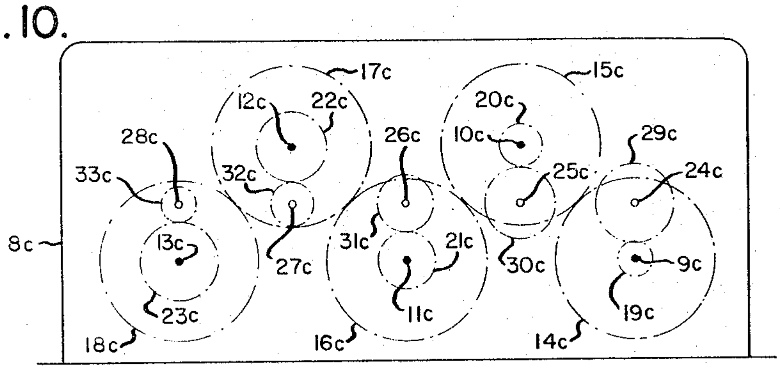
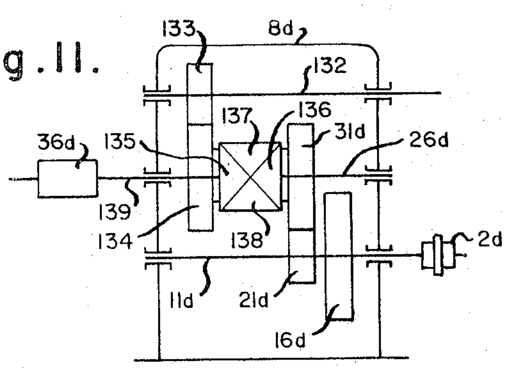


Fig. 11.



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United States Patent Office

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3,299,685

DRIVE FOR A MULTIPLE-STAND ROLLING MILL

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Claims priority, application Germany, Mar. 26, 1963, K 49,298
5 Claims. (Cl. 72—249)

This invention concerns a drive for a multiple-stand rolling mill such for example as a multiple-stand universal mill for rolling rods or tubular material. Our drive has advantages hereinafter explained over drives heretofore proposed for mills of similar type.

For purposes of explanation and illustration the invention will be described as embodied in a number of drives for multiple-stand universal mills for rolling rods. Such mills have heretofore been driven by a mechanical drive disposed alongside the mill, the rolls being driven at progressively increasing speeds in the direction of advance of work through the mill corresponding with the progressive elongation of the work caused by reduction of its cross section as it advances through the mill. The direction of rotation of the roll-driving shafts must be the same for all stands in mills with two-roll passes; in mills having three rolls forming a pass with the rolls of each successive stand disposed in position turned about the mill axis 60° relatively to those of the preceding stand the direction of rotation of the roll-driving shafts may be reversed from stand to stand.

It is known to drive such mills from a shaft disposed longitudinally of the mill. The longitudinal shaft is driven, as by an electric motor drive, at a mean speed. From the longitudinal shaft the rolls of each stand are driven through bevel gears by either a speed reducing drive or a speed increasing drive as the occasion requires. Operating speeds of bevel gear drives are quite limited as known to those skilled in the art.

Drives utilizing planar gears, such as spur gears may operate at higher speeds than bevel gear drives. Spur gear drives for mills of the type in question are known. In such known drives each succeeding stand is driven from the preceding stand so each pair of adjacent stands are connected mechanically with each other and driven in opposite directions of rotation. Because the center-to-center distance between drives for the rolls of adjacent stands is established by the stand interval and cannot be less than the roll diameter the rolling speed is limited by the maximum permissible peripheral speed of the gears employed.

Our drive obviates the disadvantages inherent in previous drives for mills of the type referred to. Bevel gears are eliminated in favor of planar gears. We mount a planar gear drive in a gear box or casing. The drive may be operated by an electric motor or any other suitable source of power. Through suitable driving connections the planar gear drive drives the mill rolls. The term "planar gear" as used herein means a gear generally in the shape of a wheel with the teeth at the peripheral face, either perpendicular or non-perpendicular to the general planes of the sides of the gear; the term includes gears which are generally described as "spur gears" and "helical gears" in contradistinction to bevel gears.

We provide a drive for a multiple-stand rolling mill comprising generally parallel shafts driving the mill rolls, a number of planar gears arranged in sequence along the mill, separate generally parallel shafts on which the planar gears are respectively mounted, the planar gears being sequentially in mesh with one another so as to form a continuous gear train along the mill, means for driving such continuous gear train, of the planar gears numbered consecutively along the mill all the odd numbered gears having the same number of teeth and all the even numbered gears having the same number of teeth, and separate planar gear drives from the shafts on which the first mentioned planar gears are respectively mounted to the shafts driving the mill rolls, the transmission ratios of the separate planar gear drives being such that the speeds of rotation of the mill rolls increase in the direction of passage through the mill of material being rolled.

The planar gears are preferably of approximately the same diameter; they may all have the same number of teeth. All of the odd numbered planar gears may have the same number of teeth and all of the even numbered planar gears may have the same number of teeth but a different number of teeth than the odd numbered planar gears.

The axes of the generally parallel shafts driving the mill rolls may be disposed in one plane with the axes of the generally parallel shafts on which the planar gears are respectively mounted disposed in another plane, or the axes of the generally parallel shafts driving the mill rolls and the axes of the generally parallel shafts on which the planar gears are respectively mounted may all be disposed in the same plane.

The axes of the generally parallel shafts driving the mill rolls may be arranged on a zigzag line with the axes of the generally parallel shafts on which the planar gears are respectively mounted coplanar, or the axes of the generally parallel shafts driving the mill rolls may be coplanar with the axes of the generally parallel shafts on which the planar gears are respectively mounted arranged on a zigzag line. Alternatively, the axes of the generally parallel shafts driving the mill rolls may be arranged on a zigzag line with the axes of the generally parallel shafts on which the planar gears are respectively mounted arranged on another zigzag line, which zigzag lines intersect each other with their apices spaced apart a distance equal to the longitudinal spacing between the generally parallel shafts driving the mill rolls.

Our drive in a modified form may comprise generally parallel shafts driving the mill rolls, a number of planar gears arranged in sequence along the mill, separate generally parallel shafts on which such planar gears are respectively mounted, such planar gears being sequentially in mesh with one another so as to form a continuous gear train along the mill, means for driving such continuous gear train, of the planar gears numbered consecutively along the mill all of the odd numbered gears having the same number of teeth and all of the even numbered gears having the same number of teeth, and separate planar gear drives from the shafts on which the first mentioned planar gears are respectively mounted to the shafts driving the mill rolls, each of such separate planar gear drives comprising two planar gears, one mounted on a shaft driving a mill roll of a roll stand and the other mounted on a shaft carrying one of the first mentioned planar gears, the transmission ratios of the separate planar gear drives being such that the speeds of rotation of the mill rolls increase in the direction of passage through the mill of material being rolled.

The axes of the shafts of at least one of the groups of generally parallel shafts (a) driving the mill rolls and (b) on which the planar gears arranged in sequence along the mill are respectively mounted may be arranged on a zigzag line and, in addition, the axes of those of the shafts driving the mill rolls and of the shafts on which the planar gears are respectively mounted which are directly drivingly connected with one another by the separate planar gear drives may be disposed perpendicular to a plane containing the mill pass.

We further provide a drive for a multiple-stand rolling mill having shafts driving the mill rolls, the shafts being arranged in a plurality of groups with the axes of the shafts of each group parallel, with a drive for the shafts of each group comprising a number of planar gears arranged in sequence along the mill, separate generally parallel shafts on which the planar gears are respectively mounted, the planar gears being sequentially in mesh with one another so as to form a continuous gear train along the mill, means for driving such continuous gear train, of the planar gears numbered consecutively along the mill all the odd numbered gears having the same number of teeth and all the even numbered gears having the same number of teeth, and separate planar gear drives from the shafts on which the first mentioned planar gears are respectively mounted to the shafts driving the mill rolls, the transmission ratios of the separate planar gear drives being such that the speeds of rotation of the mill rolls increase in the direction of passage through the mill of material being rolled.

A differential gear may be connected with a second drive interposed between each shaft driving a mill roll and the mill roll driven thereby.

Our drive preferably has either exactly or approximately a 1 to 1 speed ratio in all stages from which the rolls are driven. The direction of rotation of the planar gears alternates. This is advantageous for driving mills having three-roll passes, as will be demonstrated.

The train of planar gears, preferably of approximately the same diameter, disposed along the mill may be arranged in a straight line with the axes of all of the gears in the same plane. The axes of the driving shafts are preferably offset from the axes of the gears of the train of planar gears either longitudinally of the mill or in a direction at right angles to the length of the mill. The axes of the driving shafts on the one hand and the axes of the gears of the train of planar gears on the other hand may, as above indicated, lie in zigzag lines which cross each other and are relatively displaced longitudinally of the mill a distance equal to the longitudinal distance between the centers of adjacent roll stands.

We preferably provide means for driving the train of planar gears operatively connected with one of the gears intermediate the ends of the train of gears and in that case the gear drives for the rolls toward the entrance end of the mill are speed reducing gear drives and the gear drives for the rolls toward the exit end of the mill are speed increasing gear drives. A pinion is preferably fixed to each roll driving shaft and separate gear drives may operatively connect individual gears of the train of planar gears to the pinions to drive the rolls of the mill at progressively increasing speeds in the direction of advance of work through the mill.

When the stands of rolls of the mill have coacting rolls rotatable about parallel axes separate gear drives may operatively connect individual gears of the train of planar gears to the driving shafts of such coacting rolls which are rotatable about parallel axes to drive both such rolls.

When the axes of some rolls of the mill are non-parallel to the axes of other rolls a plurality of trains of planar gears as above referred to, constituting independent drives, may be utilized, each of such independent drives driving rolls whose axes extend in the same direction so that there are as many such independent drives as there are roll axis directions. When the axes of rolls in the same stand are non-parallel a plurality of such independent drives may be employed, such rolls of the same stand being driven respectively by different independent drives. In mills having two coacting rolls rotatable about parallel axes forming a pass with the rolls of each successive stand disposed in position turned about the mill axis 90° relatively to those of the preceding stand two independent drives each comprising a train of planar gears as above referred to may be employed, each such drive driving the rolls of alternate stands. In mills in which the axes of rolls in the same stand are non-parallel a plurality of independent drives may be utilized for respectively driving such rolls. In mills having three coacting rolls rotatable about non-parallel axes forming a pass with the rolls of each successive stand disposed in position turned about the mill axis 60° relatively to those of the preceding stand three independent drives each comprising a train of planar gears as above referred to may be employed, each such drive driving one roll of each stand.

In a train of planar gears as above referred to the number of teeth in the gears is preferably approximately but not necessarily exactly the same. For example, alternate gears may have a slightly greater number of teeth than the alternate gears in between them; one such set of alternate gears may have 43 teeth in each gear and the other such set of alternate gears may have 44 teeth in each gear. Such an arrangement may have advantages to the designer of the mill. For example, the spacing of the roll passes of the mill may be such that two planar gears having an equal number of teeth will not fit properly. In certain cases slight variation in the number of teeth in the train of driving gears may facilitate the obtaining of desired speed ratios between roll passes.

A drive from a planar gear of a train of planar gears as above referred to to a roll may be constructed and arranged to drive the driving shaft driven thereby selectively at a plurality of speeds. For example, a plurality of pairs of coacting gears of different ratios may be employed together with clutch or equivalent means for selectively rendering such pairs of coacting gears operative. By proper design of the drives for the respective passes of the mill provision can be made through the use of selective gear ratios for varying the reduction of the work as it progresses through the mill while driving each pass at the proper speed for the desired reduction.

Other details, objects and advantages of the invention will become apparent as the following description of certain present preferred embodiments thereof proceeds.

In the accompanying drawings we have illustrated diagrammatically certain present preferred embodiments of the invention, in which

FIGURE 1 is a plan diagram of a drive for a multiple-stand rolling mill;

FIGURE 2 is a gear diagram of the drive of FIGURE 1;

FIGURE 3 is an elevational or cross-sectional diagram as though taken on the line III—III of FIGURE 4 of a drive for a multiple-stand rolling mill having three-roll passes with the rolls of each successive stand disposed in position turned about the mill axis 60° relatively to those of the preceding stand;

FIGURE 4 is a gear diagram of the drive of FIGURE 3;

FIGURE 5 is a plan diagram of a drive for a multiple-stand rolling mill having two-roll passes with the rolls of each successive stand disposed in position turned about the mill axis 90° relatively to those of the preceding stand;

FIGURE 6 is a gear diagram of part of the drive of FIGURE 5 looking in the direction VI of FIGURE 5;

FIGURE 7 is a gear diagram of part of the drive of FIGURE 5 looking in the direction VII of FIGURE 5;

FIGURE 8 is a gear diagram of a drive for a multiple-stand rolling mill similar to the drive of FIGURES 1 and 2 but modified in that of the planar gears numbered consecutively along the mill all the odd numbered gears have the same number of teeth and all the even numbered gears have the same number of teeth but a different number of teeth than the odd numbered gears;

FIGURE 9 is a gear diagram of a drive for a multiple-stand rolling mill in which the axes of the generally parallel shafts driving the mill rolls are arranged on a zigzag line and the axes of the generally parallel shafts on which the planar gears are respectively mounted are coplanar;

FIGURE 10 is a gear diagram of a drive for a multiple-stand rolling mill in which the axes of the generally parallel shafts driving the mill rolls are coplanar and the axes of the generally parallel shafts on which the planar gears are respectively mounted are arranged on a zigzag line; and

FIGURE 11 is an elevational or cross-sectional diagram of a drive for a multiple-stand rolling mill with differential gearing connected with a second drive interposed between each shaft driving a mill roll and the mill roll driven thereby.

Referring now more particularly to the drawings and first to FIGURES 1 and 2, there is shown a multiple-stand rolling mill designated generally by reference numeral **1** having five equally spaced stands of rolls, each stand of rolls comprising two coacting rolls with their axes parallel and horizontal. The five stands of rolls are illustrated diagrammatically in FIGURE 1 and designated **3**, **4**, **5**, **6** and **7**, respectively, in the direction from the entrance end to the exit end of the mill.

Disposed alongside the mill **1** is a gear box or housing **8** in which are journaled five shafts **9**, **10**, **11**, **12** and **13**, respectively, spaced apart as shown, such shafts being coplanar, parallel and horizontal and offset horizontally from the stands of rolls **3**, **4**, **5**, **6** and **7**. Spur gears **14**, **15**, **16**, **17** and **18**, respectively, are fixed to shafts **9**, **10**, **11**, **12** and **13**. The spur gears **14**, **15**, **16**, **17** and **18** are of substantially the same diameter and mesh with each other. They may all have the same number of teeth, or they may have approximately but not exactly the same number of teeth. For example, the gears **14**, **16** and **18** may each have 43 teeth while the gears **15** and **17** may each have 44 teeth. The reasons for such slight variation in the number of teeth in the train of driving gears under certain circumstances have been explained above.

The shaft **11** is driven by any suitable source of power, such, for example, as an electric motor, through a coupling **2**. Fixed to shafts **9**, **10**, **11**, **12** and **13** are spur gears **19**, **20**, **21**, **22** and **23**, respectively. Journaled in the gear box or casing **8** are shafts **24**, **25**, **26**, **27** and **28**, respectively. These shafts are coplanar, parallel and horizontal and also coplanar and parallel with the shafts **9**, **10**, **11**, **12** and **13**. They are offset horizontally from the shafts **9**, **10**, **11**, **12** and **13** and are disposed in line with the respective stands of rolls **3**, **4**, **5**, **6** and **7**. Spur pinions **29**, **30**, **31**, **32** and **33** are fixed to the shafts **24**, **25**, **26**, **27** and **28**, respectively, and mesh with the gears **19**, **20**, **21**, **22** and **23** respectively.

Thus the means for driving the train of gears **14**, **15**, **16**, **17** and **18** are operatively connected with the central gear of that train and through the gears **19**, **20**, **21**, **22** and **23** and the pinions **29**, **30**, **31**, **32** and **33** the gears **14**, **15**, **16**, **17** and **18** drive the shafts **24**, **25**, **26**, **27** and **28**. The gears **19**, **20**, **21**, **22** and **23** are of progressively increasing diameter in the direction of rolling and the pinions **29**, **30**, **31**, **32** and **33** are of progressively decreasing diameter in the direction of rolling and the gear drives toward the entrance end of the mill are speed reducing gear drives while the gear drives toward the exit end of the mill are speed increasing gear drives, the gear drives being constructed and arranged through means now to be described to drive the rolls of the mill at progressively increasing speeds in the direction of advance of the work through the mill corresponding with the progressive elongation of the work caused by reduction of its cross section as it advances through the mill.

The respective shafts **24**, **25**, **26**, **27** and **28** which as above stated are disposed in line with the respective stands of rolls **3**, **4**, **5**, **6** and **7** are operatively connected with the rolls of such respective stands of rolls through couplings designated generally by reference numerals **34**, **35**, **36**, **37** and **38**, respectively. Since alternate shafts **24**, **25**, **26**, **27** and **28** rotate in opposite directions and since the rolls of the mill must all be driven in a direction to advance the work through the mill the couplings **34**, **35**, **36**, **37** and **38** are aternately connected to drive the upper and lower rolls of the stands **3**, **4**, **5**, **6** and **7**, respectively. For example, depending upon the direction in which the shaft **11** is driven through the coupling **2**, the shaft **24** may be directly coupled to the upper roll of the stand **3** by the coupling **34**, the shaft **25** may be directly coupled to the lower roll of the stand **4** by the coupling **35**, the shaft **26** may be directly coupled to the upper roll of the stand **5** by the coupling **36**, the shaft **27** may be directly coupled to the lower roll of the stand **6** by the coupling **37** and the shaft **28** may be directly coupled to the upper roll of the stand **7** by the coupling **38**. In the case of each stand of rolls the two rolls may be geared together so that the driven roll drives the roll coacting therewith.

FIGURES 3 and 4 show my invention applied to a mill in which each roll pass is formed by three rolls with the rolls of each successive stand disposed in position turned about the mill axis 60° relatively to those of the preceding stand. In FIGURE 3 the rolls of one stand are illustrated in solid lines and designated **39** and the rolls of the succeeding stand are illustrated in dotted lines and designated **40**. There may be five stands of rolls, and the mill may be driven by a train of five spur gears of substantially the same diameter mounted on parallel shafts and meshing with each other, although the train of spur gears in the form of FIGURES 3 and 4 differs from that in the form of FIGURES 1 and 2 in that the shafts on which such gears are mounted are staggered rather than being coplanar. The gears are mounted in a gear box or housing **127**. In FIGURE 4 the train of spur gears of substantially the same diameter is illustrated as comprising gears **41**, **42**, **43**, **44** and **45**. The shafts of the gears **41**, **43** and **45** are coplanar and disposed in an upper horizontal plane viewing FIGURE 4 while the shafts of gears **42** and **44** are coplanar and are disposed in a lower horizontal plane viewing that figure. Analogously to FIGURES 1 and 2 the gear **41** drives through a gear **48** fixed to the shaft **49** carrying the gear **41** a pinion **50** fixed to a shaft **51**, the gear **42** drives through a gear **52** fixed to the shaft **53** carrying the gear **42** a pinion **54** fixed to a shaft **55**, the gear **43** drives through a gear **56** fixed to the shaft **57** carrying the gear **43** a pinion **58** fixed to a shaft **59**, the gear **44** drives through a gear **60** fixed to the shaft **61** carrying the gear **44** a pinion **62** fixed to a shaft **63** and the gear **45** drives through a gear **64** fixed to the shaft **65** carrying the gear **45** a pinion **66** fixed to a shaft **67**. The shaft **57** upon which the gear **43** is mounted is driven by an electric motor or other suitable driving mechanism **46** through a coupling **47**. Since the shafts **49**, **57** and **65** are coplanar the coupling **47** appears in FIGURE 3 to be in line with the shaft **65** but actually it is in line with and drives the shaft **57**.

As is apparent from FIGURE 4 the shafts **51**, **55**, **59**, **63** and **67** are staggered in an interfitting pattern with the staggered shafts **49**, **53**, **57**, **61** and **65**, i.e., the axes of the driving shafts **51**, **55**, **59**, **63** and **67** on the one hand and the axes of the shafts **49**, **53**, **57**, **61** and **65** carrying the gears of the train of driving gears on the other hand lie in zigzag lines which cross each other and are relatively displaced longitudinally of the mill a distance equal to the longitudinal distance between the centers of adjacent roll stands.

The sizes of the gears and pinions are determined analogously to the sizes of the gears and pinions of FIGURES 1 and 2 to drive the shafts **51**, **55**, **59**, **63** and and **67** at progressively increasing speeds. The shafts **51**, **59** and **67** turn in one direction while the shafts **55** and **63** turn in the opposite direction. FIGURE 3 shows the shaft **67** connected through a coupling **68** with the lower roll **39** of one of the stands of rolls of the mill. The shafts **51** and **59** are coupled to the lower rolls of similarly oriented stands of rolls. The shafts **55** and

63 are coupled through couplings such as that shown in dotted lines and designated **69** in FIGURE 3 with the upper rolls **40** of similarly oriented stands of rolls in between the stands of rolls **39**. In this case there may be a direct drive for each roll mentioned since the lower rolls **39** turn in one direction while the upper rolls **40** turn in the opposite direction and the shafts which drive those rolls are driven in the correct direction of rotation for direct drive.

There may be three drives for the mill illustrated in FIGURE 3, the other two drives substantially duplicating the drives shown in FIGURES 3 and 4 but being arranged to drive respectively the other two sets of rolls **39** and **40** disposed in common planes in the mill.

FIGURES 5, 6 and 7 illustrate the application of two drives somewhat like but specifically different from the drive of FIGURES 1 and 2 to a mill having two directly opposed rolls in each pass with the planes of the rolls of successive passes disposed in position turned about the mill axis 90° as shown in FIGURE 5. Rolls oriented like the rolls **70** and **71** are driven by a drive **72** and rolls oriented like the rolls **73** and **74** are driven by a drive **75**.

The drive **72** comprises a train of spur gears of substantially the same diamter **76, 77, 78, 79** and **80** respectively fixed to shafts **81, 82, 83, 84** and **85** which are parallel and coplanar. The gears are mounted in a gear box or housing **128**. A gear **86** is fixed to shaft **81**, a gear **87** is fixed to shaft **83** and a gear **88** is fixed to shaft **85**. The gears **86, 87** and **88** are of progressively increasing diameter.

Three roll driving shafts **89, 90** and **91** are disposed respectively opposite the shafts **81, 83** and **85**. A pinion **92** is fixed to the shaft **89** and meshes with the gear **86**. A pinion **93** is fixed to the shaft **90** and meshes with the gear **87**. A pinion **94** is fixed to the shaft **91** and meshes with the gear **88**.

The shaft **83** may be driven by any suitable source of power through a coupling **95**. Since the shafts **81, 83** and **85** are coplanar the coupling **95** appears in FIGURE 5 to be in line with the shaft **85** but actually it is in line with and drives the shaft **83**. FIGURE 5 shows at the left-hand side the spur gear **80**, the shaft **85**, the spur gear **88**, the pinion **94** and the shaft **91** which through a coupling **96**, a shaft **97**, a coupling **98** and a shaft **99** drives the roll **71**. Fixed to the shaft **97** is a gear **100** which meshes with the similar gear **101** fixed to a shaft **102** driving the gear **70** through a coupling **103** and a shaft **104**. The gears **100** and **101** are mounted in a housing **129**. The other stands of rolls coplanar with the rolls **70** and **71** are similarly driven by the shafts **89** and **90**. Since the drives for the rolls are taken off of alternate gears of the train of driving gears all of the rolls **70** and **71** are driven in the proper direction.

The drive **75** comprises a train of spur gears of substantially the same diameter **105, 106** and **107** respectively fixed to shafts **108, 109** and **110** which are parallel and coplanar. The gears are mounted in a gear box or housing **130**. A gear **111** is fixed to shaft **108** and a gear **112** is fixed to shaft **110**. The gear **112** is of greater diameter than the gear **111**.

Two roll driving shafts **113** and **114** are disposed respectively opposite the shafts **108** and **110**. A pinion **115** is fixed to the shaft **113** and meshes with the gear **111**. A pinion **116** is fixed to the shaft **114** and meshes with the gear **112**.

Any of the shafts **108, 109** and **110** may be driven by any suitable source of power. That source of power may be transmitted through a coupling **117** to, for example, the shaft **109**. Since the shafts **108, 109** and **110** are coplanar the coupling **117** appears in FIGURE 5 to be in line with the shaft **110** but actually it is in line with and drives the shaft **109**. FIGURE 5 shows at the right-hand side the spur gear **107**, the shaft **110**, the spur gear **112**, the pinion **116** and the shaft **114** which through a coupling **118**, a shaft **119**, a coupling **120** and a shaft **121** drives the roll **74**. Fixed to the shaft **119** is a gear **122** which meshes with a similar gear **123** fixed to a shaft **124** driving the gear **73** through a coupling **125** and a shaft **126**. The gears **122** and **123** are mounted in a housing **131**. The other stand of rolls coplanar with the rolls **73** and **74** is similarly driven by the shaft **108**. Since the drives for the rolls are taken off of alternate gears of the train of driving gears all of the rolls **73** and **74** are driven in the proper direction.

FIGURE 8 illustrates a drive for a multiple-stand rolling mill similar to the drive of FIGURES 1 and 2 but modified in that of the planar gears numbered consecutively along the mill all the odd numbered gears have the same number of teeth and all the even numbered gears have the same number of teeth but a different number of teeth than the odd numbered gears. The parts shown in FIGURE 8 are respectively analogous to those shown in FIGURE 2 and corresponding parts in the respective figures bear the same reference numerals except that the letter "*a*" is added to each numeral in FIGURE 8. In FIGURE 8 the gears **14***a*, **16***a* and **18***a* have the same number of teeth and the gears **15***a* and **17***a* have the same number of teeth, but the gears **15***a* and **17***a* have more teeth than the gears **14***a*, **16***a* and **18***a*. Otherwise the drive of FIGURE 8 is like that of FIGURES 1 and 2.

FIGURE 9 illustrates a drive for a multiple-stand rolling mill similar to the drive of FIGURES 1 and 2 but modified in that the axes of the generally parallel shafts driving the mill rolls are arranged on a zigzag line and the axes of the generally parallel shafts on which the planar gears are respectively mounted are coplanar. The parts shown in FIGURE 9 are respectively analogous to those shown in FIGURE 2 and corresponding parts in the respective figures bear the same reference numerals except that the letter "*b*" is added to each numeral in FIGURE 9. In FIGURE 9 the shafts **24***b*, **25***b*, **26***b*, **27***b* and **28***b* are arranged on a zigzag line and the shafts **9***b*, **10***b*, **11***b*, **12***b* and **13***b* are coplanar. Otherwise the drive of FIGURE 9 is like that of FIGURES 1 and 2.

FIGURE 10 illustrates a drive for a multiple-stand rolling mill similar to the drive of FIGURES 1 and 2 but modified in that the axes of the generally parallel shafts driving the mill rolls are coplanar and the axes of the generally parallel shafts on which the planar gears are respectively mounted are arranged on a zigzag line. The parts shown in FIGURE 10 are respectively analogous to those shown in FIGURE 2 and corresponding parts in the respective figures bear the same reference numerals except that the letter "*c*" is added to each numeral in FIGURE 10. In FIGURE 10 the shafts **24***c*, **25***c*, **26***c*, **27***c* and **28***c* are coplanar and the shafts **9***c*, **10***c*, **11***c*, **12***c* and **13***c* are arranged on a zigzag line. Otherwise the drive of FIGURE 10 is like that of FIGURES 1 and 2.

FIGURE 11 illustrates a drive for a multiple-stand rolling mill similar to the drive of FIGURES 1 and 2 but modified in that differential gearing connected with a second drive is interposed between each shaft driving a mill roll and the mill roll driven thereby. The parts **2***d*, **8***d*, **11***d*, **16***d*, **21***d*, **26***d*, **31***d* and **36***d* are respectively analogous to the parts **2, 8, 16, 11, 21, 26, 31** and **36** shown in FIGURE 1. An auxiliary shaft **132** driven separately from the shaft **11***d* is journaled in the gear box or housing **8***d* and has a spur gear **133** fixed thereto. The spur gear **133** meshes with a spur gear **134** integral or connected with a bevel gear **135**. Similarly the spur gear **31***d* is integral or connected with a bevel gear **136**. Bevel gears **137** and **138** are journaled upon mounting elements connected with a shaft **139** and projecting laterally therefrom, which shaft **139** extends to the coupling **36***d*. The bevel gears **137** and **138** mesh with the bevel gears **135** and **136** to constitute differential gearing whereby the speed of rotation of the shaft **139** is affected by the speed of rotation of the auxiliary shaft **132**. Otherwise the drive of FIGURE 11 is like that of FIGURES 1 and 2.

While we have shown and described certain present preferred embodiments of the invention it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied within the scope of the following claims.

We claim:

1. A drive for a multiple-stand rolling mill comprising generally parallel shafts driving the mill rolls, a number of planar gears arranged in sequence along the mill, separate generally parallel shafts on which the planar gears are respectively mounted, the planar gears being sequentially in mesh with one another so as to form a continuous gear train along the mill, means for driving such continuous gear train, of the planar gears numbered consecutively along the mill all the odd numbered gears having the same number of teeth and all the even numbered gears having the same number of teeth, and separate planar gear drives from the shafts on which the first mentioned planar gears are respectively mounted to the shafts driving the mill rolls, the transmission ratios of the separate planar gear drives being such that the speeds of rotation of the mill rolls increase in the direction of passage through the mill of material being rolled, the axes of the generally parallel shafts driving the mill rolls and the axes of the generally parallel shafts on which the planar gears are respectively mounted being all disposed in the same plane.

2. A drive for a multiple-stand rolling mill comprising generally parallel shafts driving the mill rolls, a number of planar gears arranged in sequence along the mill, separate generally parallel shafts on which the planar gears are respectively mounted, the planar gears being sequentially in mesh with one another so as to form a continuous gear train along the mill, means for driving such continuous gear train, of the planar gears numbered consecutively along the mill all the odd numbered gears having the same number of teeth and all the even numbered gears having the same number of teeth, and separate planar gear drives from the shafts on which the first mentioned planar gears are respectively mounted to the shafts driving the mill rolls, the transmission ratios of the separate planar gear drives being such that the speeds of rotation of the mill rolls increase in the direction of passage through the mill of material being rolled, the axes of the generally parallel shafts driving the mill rolls being arranged on a zigzag line and the axes of the generally parallel shafts on which the planar gears are respectively mounted being coplanar.

3. A drive for a multiple-stand rolling mill comprising generally parallel shafts driving the mill rolls, a number of planar gears arranged in sequence along the mill, separate generally parallel shafts on which the planar gears are respectively mounted, the planar gears being sequentially in mesh with one another so as to form a continuous gear train along the mill, means for driving such continuous gear train, of the planar gears numbered consecutively along the mill all the odd numbered gears having the same number of teeth and all the even numbered gears having the same number of teeth, and separate planar gear drives from the shafts on which the first mentioned planar gears are respectively mounted to the shafts driving the mill rolls, the transmission ratios of the separate planar gear drives being such that the

speeds of rotation of the mill rolls increase in the direction of passage through the mill of material being rolled, the axes of the generally parallel shafts driving the mill rolls being coplanar and the axes of the generally parallel shafts on which the planar gears are respectively mounted being arranged on a zigzag line.

4. A drive for a multiple-stand rolling mill comprising generally parallel shafts driving the mill rolls, a number of planar gears arranged in sequence along the mill, separate generally parallel shafts on which the planar gears are respectively mounted, the planar gears being sequentially in mesh with one another so as to form a continuous gear train along the mill, means for driving such continuous gear train, of the planar gears numbered consecutively along the mill all the odd numbered gears having the same number of teeth and all the even numbered gears having the same number of teeth, and separate planar gear drives from the shafts on which the first mentioned planar gears are respectively mounted to the shafts driving the mill rolls, the transmission ratios of the separate planar gear drives being such that the speeds of rotation of the mill rolls increase in the direction of passage through the mill of material being rolled, the axes of the generally parallel shafts driving the mill rolls being arranged on a zigzag line and the axes of the generally parallel shafts on which the planar gears are respectively mounted being arranged on another zigzag line, which zigzag lines intersect each other with their apices spaced apart a distance equal to the longitudinal spacing between the generally parallel shafts driving the mill rolls.

5. A drive for a multiple-stand rolling mill comprising generally parallel shafts driving the mill rolls, a number of planar gears arranged in sequence along the mill, separate generally parallel shafts on which the planar gears are respectively mounted, the planar gears being sequentially in mesh with one another so as to form a continuous gear train along the mill, means for driving such continuous gear train, of the planar gears numbered consecutively along the mill all the odd numbered gears having the same number of teeth and all the even numbered gears having the same number of teeth, and separate planar gear drives from the shafts on which the first mentioned planar gears are respectively mounted to the shafts driving the mill rolls, the transmission ratios of the separate planar gear drives being such that the speeds of rotation of the mill rolls increase in the direction of passage through the mill of material being rolled, the axes of the shafts of at least one of the groups of generally parallel shafts (a) driving the mill rolls and (b) on which the planar gears are respectively mounted being arranged on a zigzag line and, in addition, the axes of those of the shafts driving the mill rolls and of the shafts on which the planar gears are respectively mounted which are directly drivingly connected with one another by the separate planar gear drives being disposed perpendicular to a plane containing the mill pass.

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