United States Patent

Guddal et al.

[15] **3,682,575**

[45] **Aug. 8, 1972**

[54] **CONCRETE PUMP**

[72] Inventors: **Karl Guddal,** 6221-27th N.E., Seattle, Wash. 98115; **Gunnar Guddal,** 6711 5th N.W., Seattle, Wash. 98107

[22] Filed: **Dec. 10, 1970**

[21] Appl. No.: **96,861**

[52] **U.S. Cl.** **417/517,** 417/900, 137/625.48

[51] **Int. Cl.**........**F04b 7/00,** F04b 15/02, F16k 11/20

[58] **Field of Search**.............417/517, 900, 516, 518; 137/625.33, 625.34, 625.48

[56] **References Cited**

UNITED STATES PATENTS

2,125,283 8/1938 Campbell...............417/517 X

FOREIGN PATENTS OR APPLICATIONS

T 83,831 2/1956 Germany...................417/900

1,803,819 10/1968 Germany...................417/517

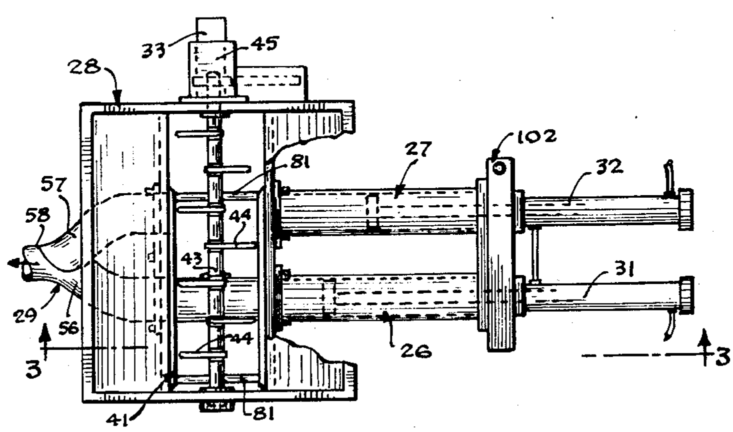
Primary Examiner—Robert M. Walker

Attorney—Lloyd L. Zickert

[57] **ABSTRACT**

A concrete pump comprising a pair of hydraulically actuated concrete pumping cylinders, a hopper for receiving a supply of concrete to be pumped, a Y-shaped fitting including a pair of inlets and a single outlet, and a valve coacting with the concrete pumping cylinders, the hopper and the Y-shaped fitting to control the flow of concrete through the pump. The valve includes a valve body and a valve spool shiftable by a single hydraulic cylinder to alternately connect the concrete pumping cylinders to the inlets of the Y-fitting and to the hopper.

19 Claims, 25 Drawing Figures



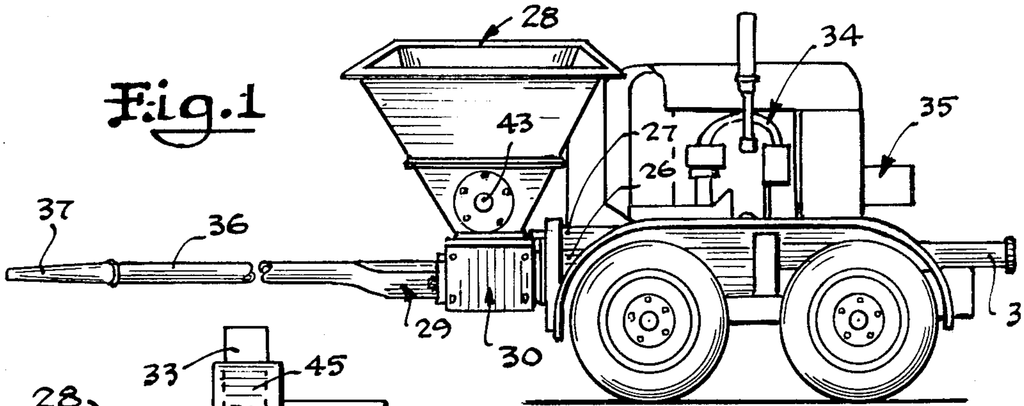


Fig.1

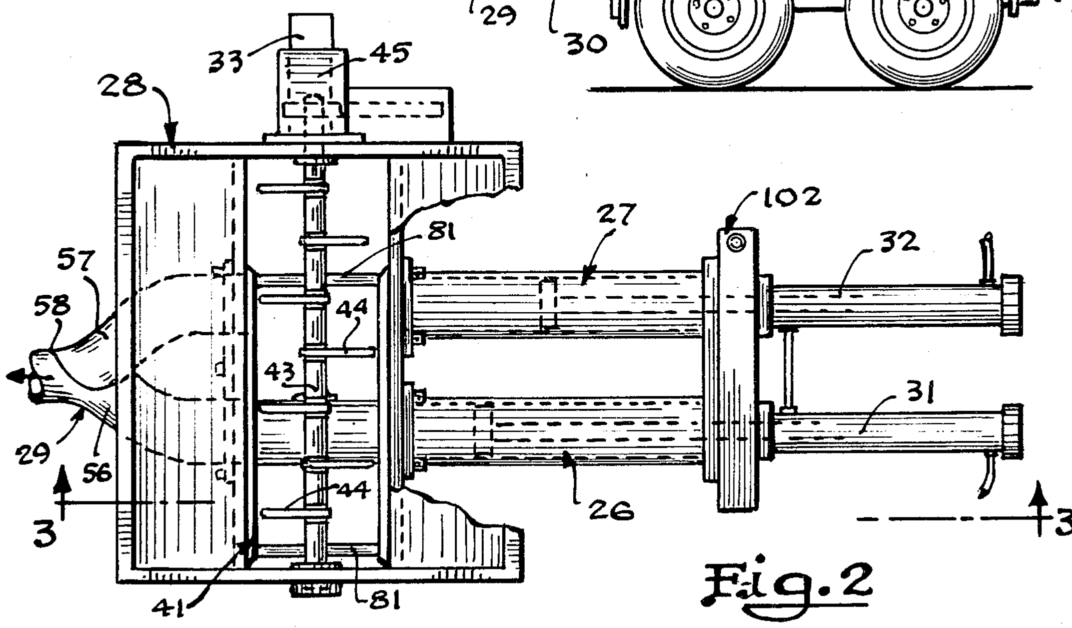


Fig.2

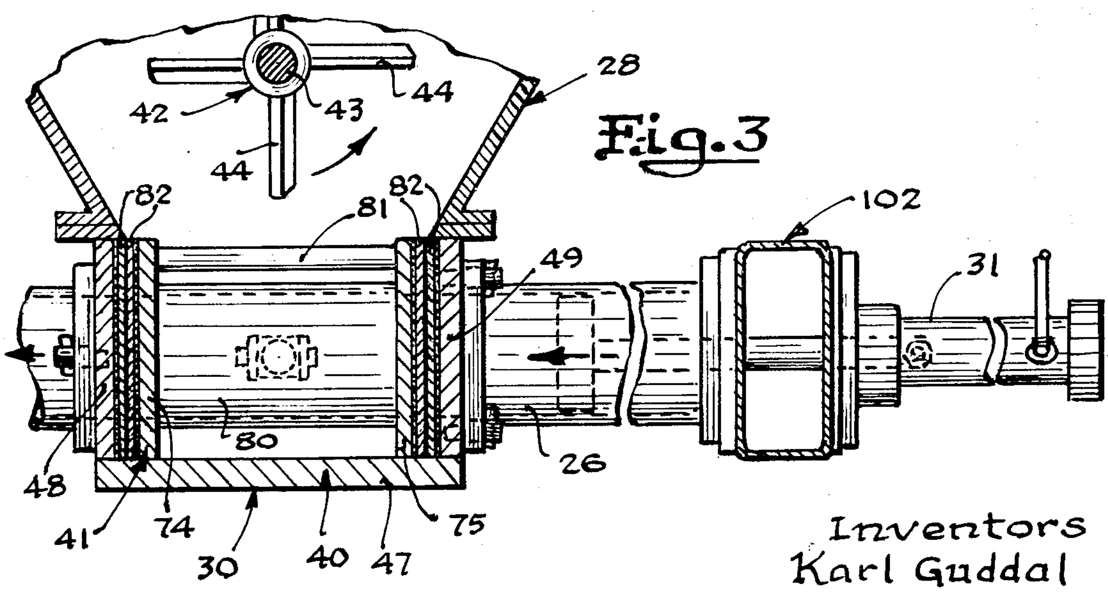


Fig.3

Inventors
Karl Guddal
Gunnar Guddal
By Kinzer, Dorn & Zickert
Attorneys

Fig.4

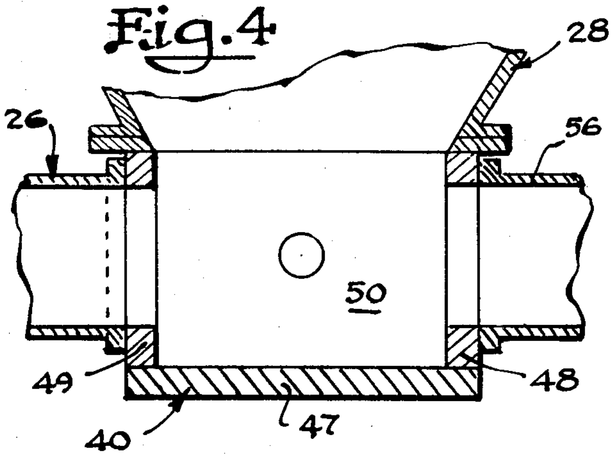
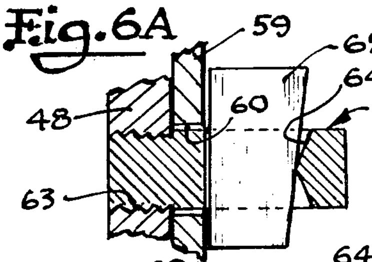


Fig.6A



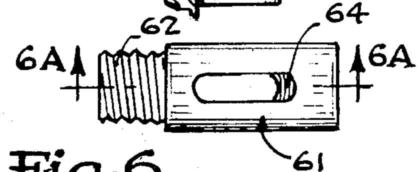
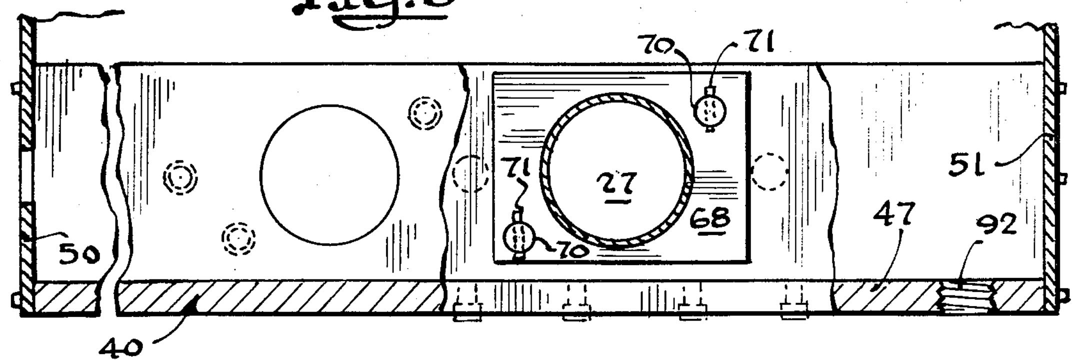


Fig.6

Fig.5



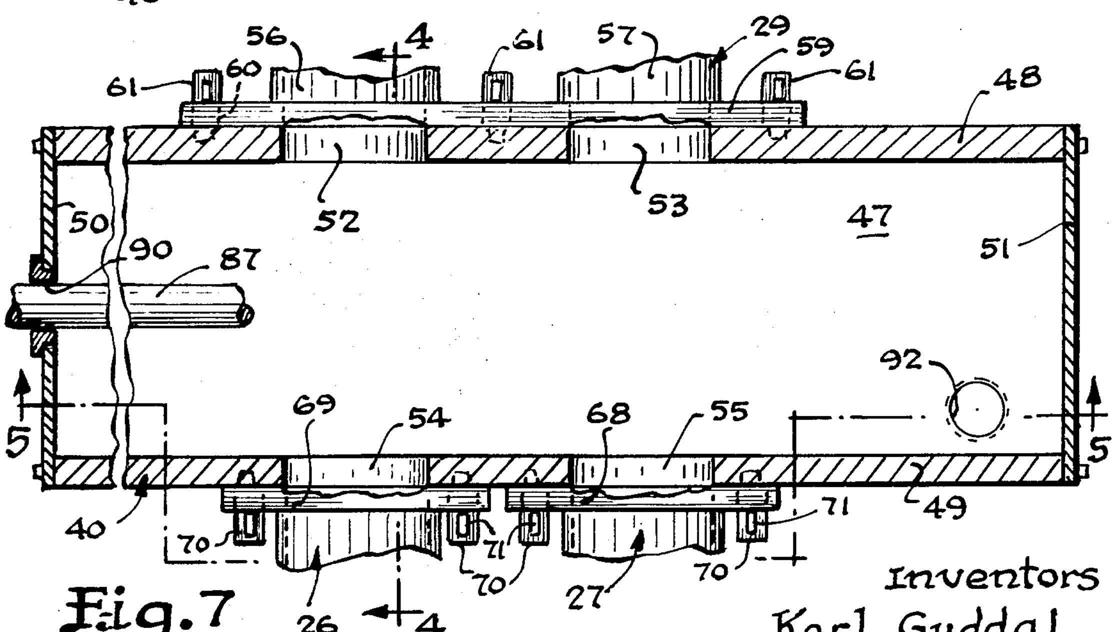
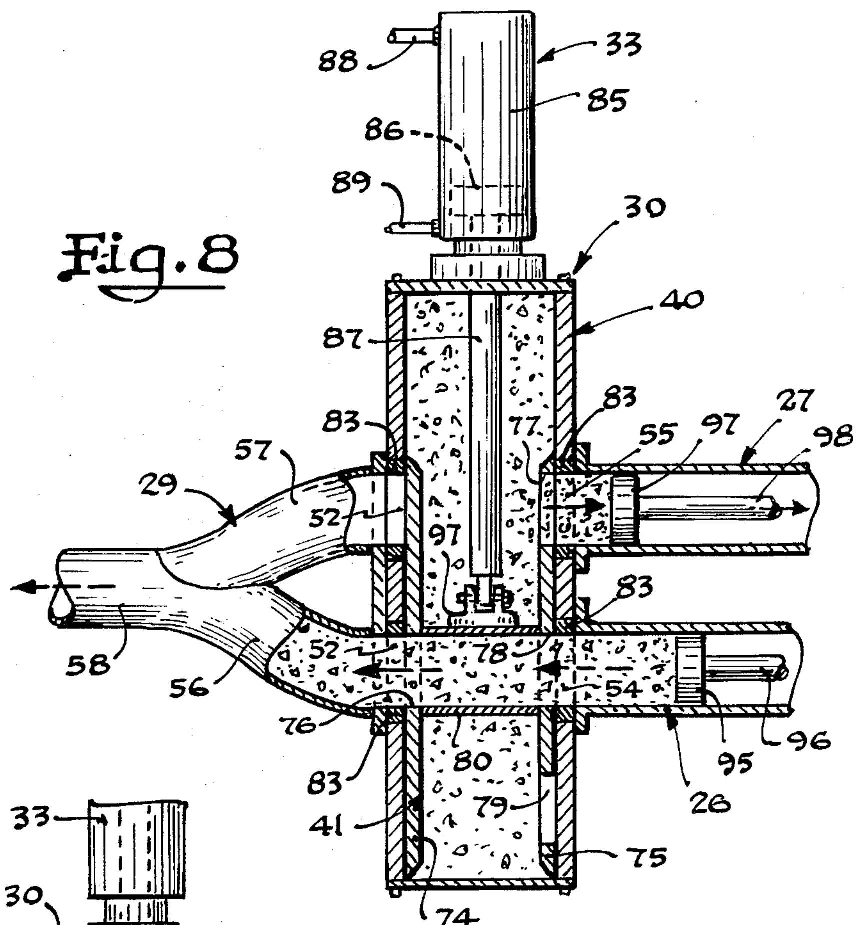


Fig.7

Inventors
Karl Guddal
Gunnar Guddal
By Kinzer, Dorn & Zickert
Attorneys

Fig. 8



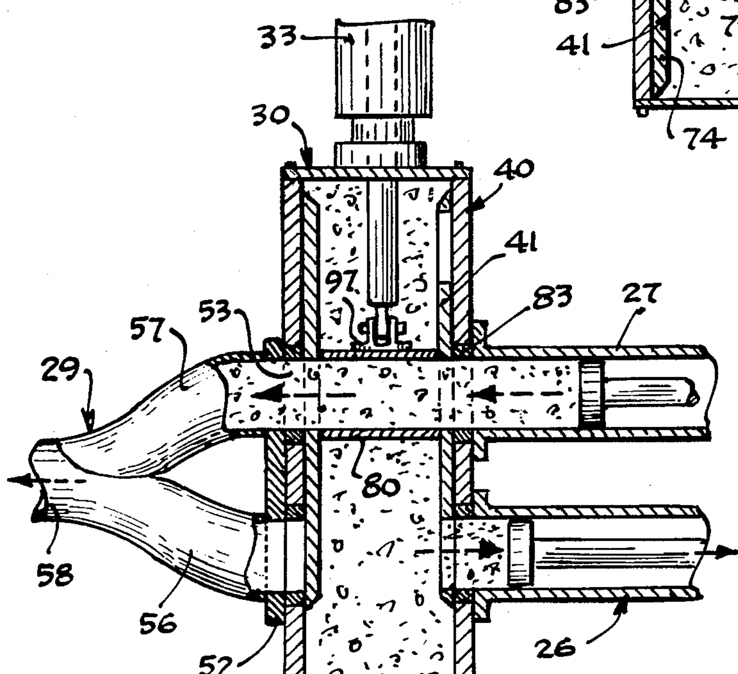
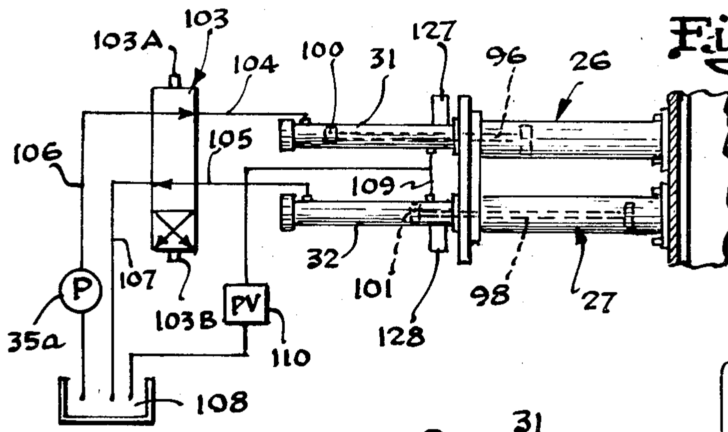


Fig. 9

Inventors
Karl Guddal
Gunnar Guddal
By Kinzer, Dorn & Zickert
Attorneys

Fig. 10



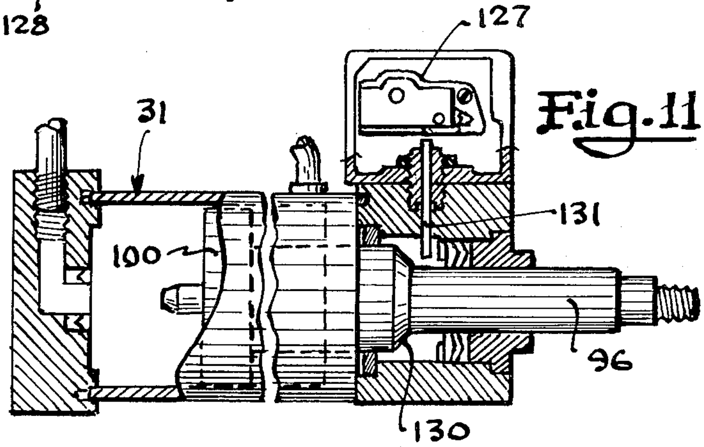
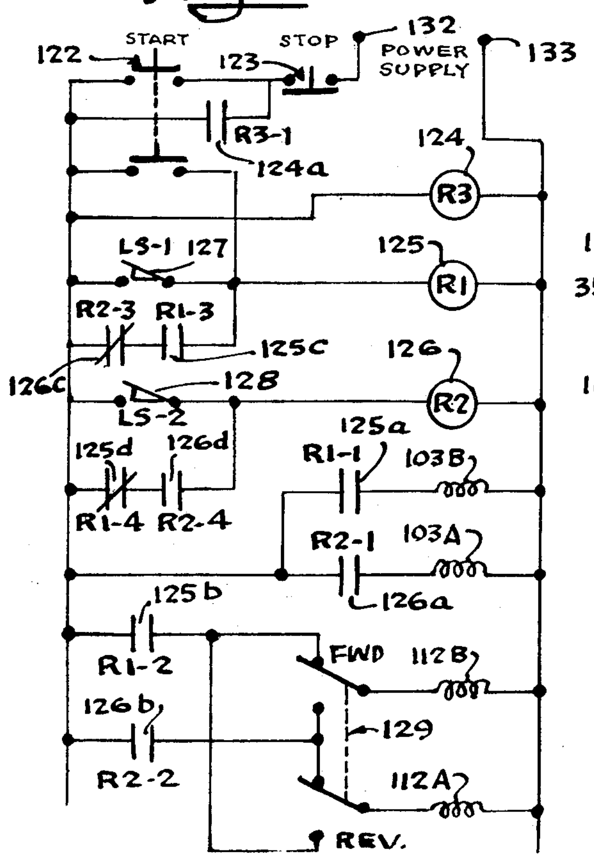


Fig. 11

Fig. 13



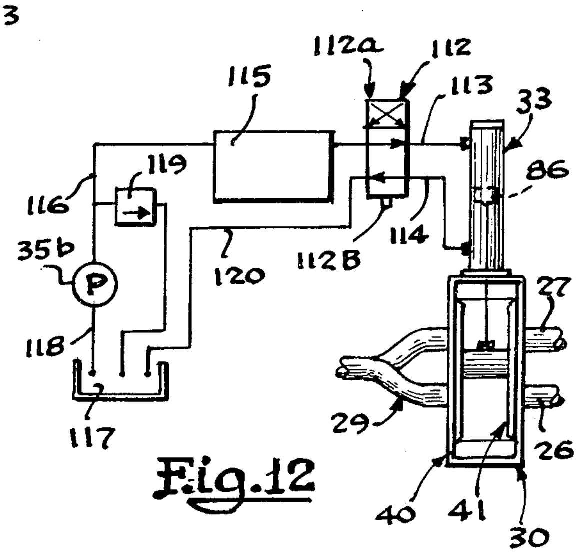


Fig. 12

Inventors
Karl Guddal
Gunnar Guddal
By Kinzer, Dorn & Zickert
Attorneys

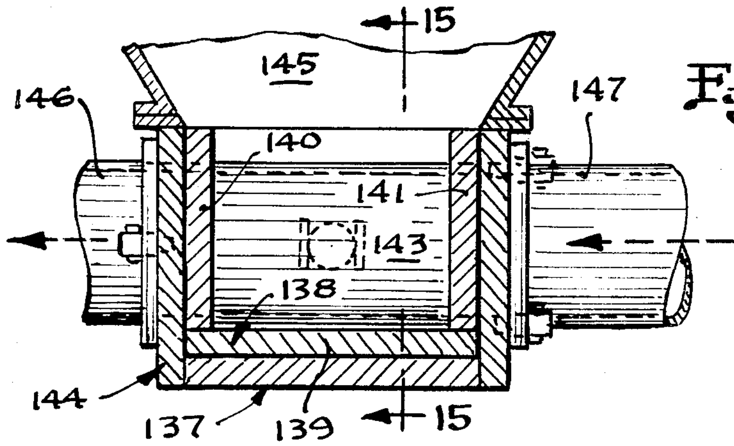
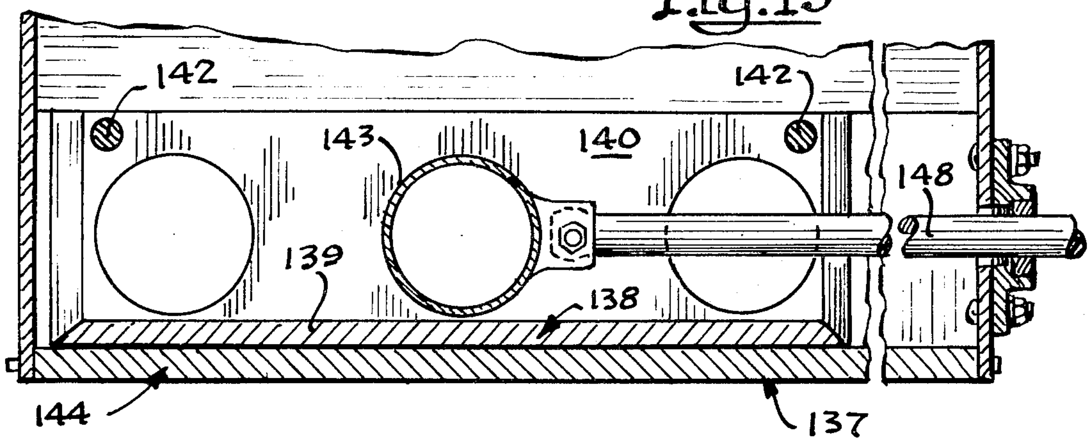


Fig.14

Fig.15



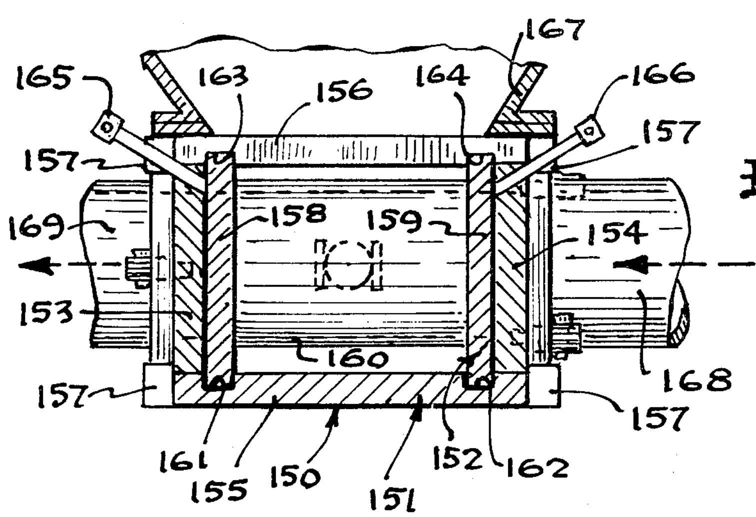


Fig.16

Inventors
Karl Guddal
Gunnar Guddal
By Kinzer, Dorn & Zickert
Attorneys

Fig.17

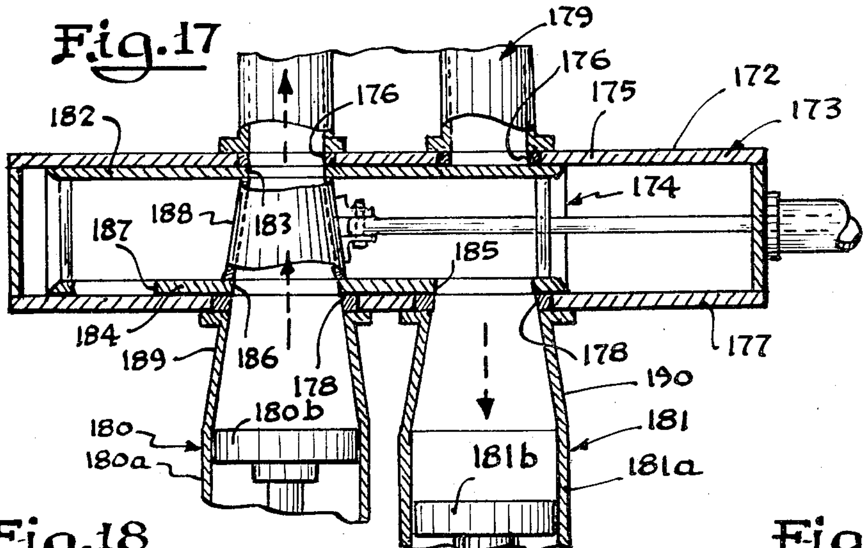


Fig.18

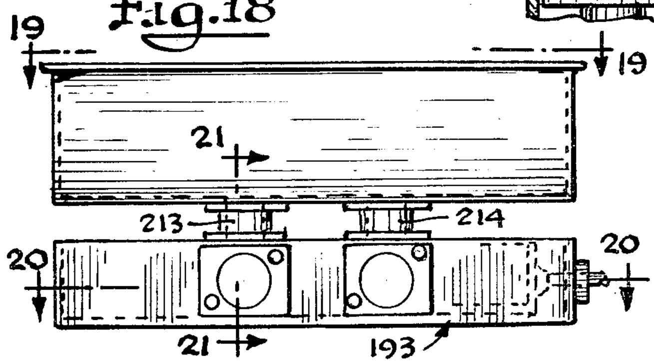


Fig.21

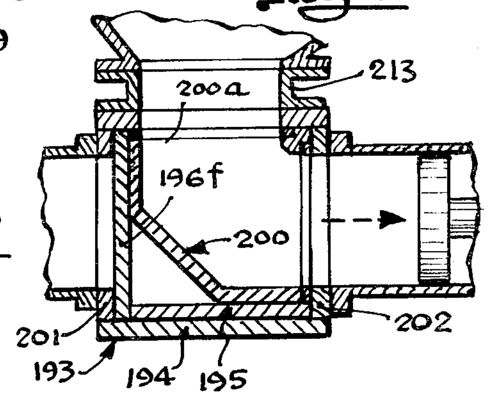
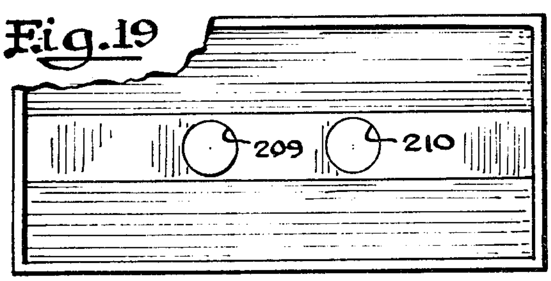


Fig.19



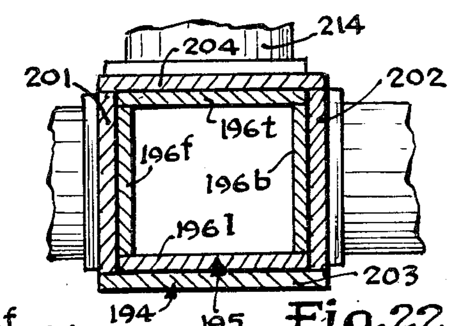
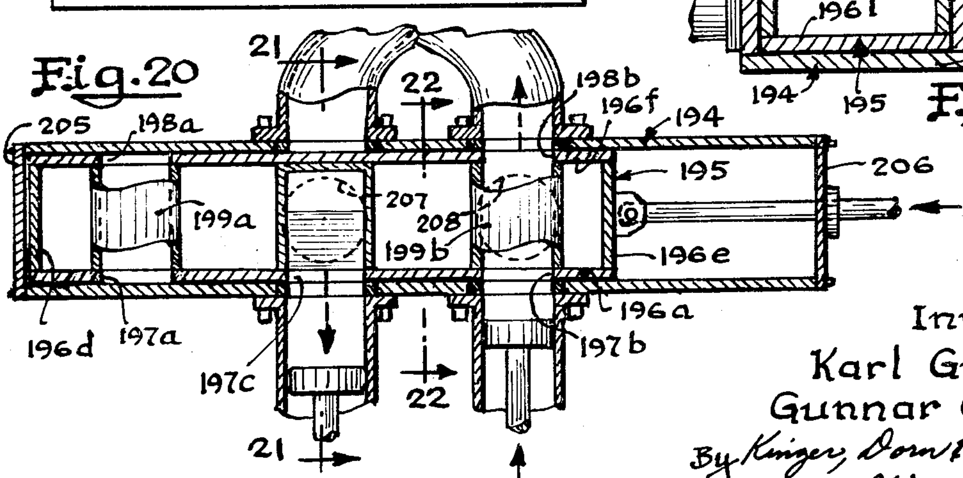


Fig.22

Fig.20



Inventors
Karl Guddal
Gunnar Guddal
By Kinzer, Dorn & Zickert
Attorneys

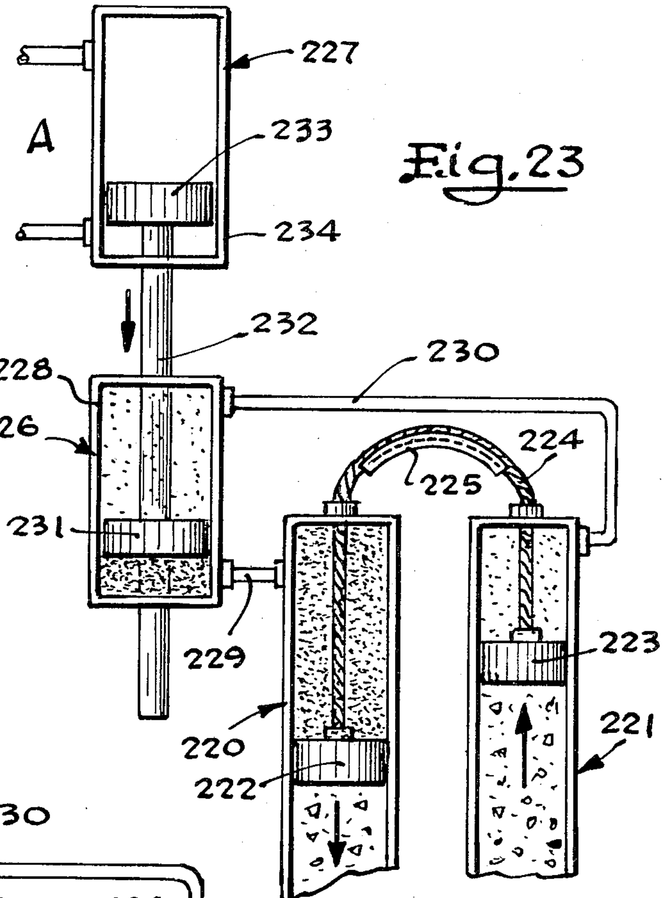


Fig.23

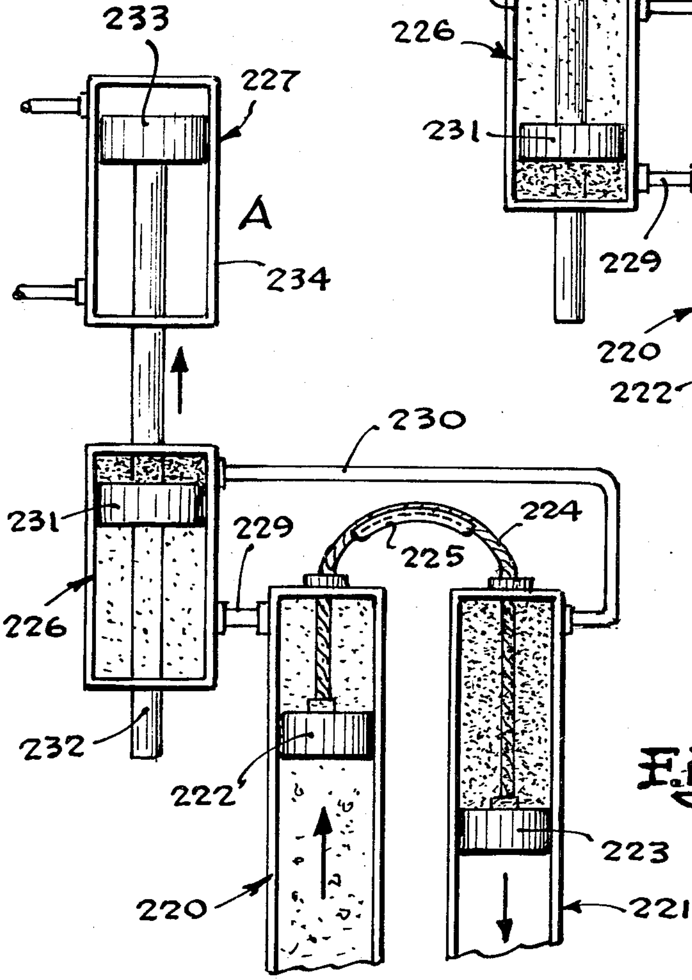


Fig.24

Inventors
Karl Guddal
Gunnar Guddal
By Kinzer, Dorn & Zickert
Attorneys

CONCRETE PUMP

This invention relates in general to a concrete pump for pumping concrete from a source to a nozzle, or for pumping concrete to transport the concrete from one location to another, and more particularly to a concrete pump capable of pumping both wet and dry concrete, and still more particularly to a concrete pump having a single movable valve spool for controlling concrete flow therethrough, although the pump may also be used to pump other dense and difficult to move fluid materials.

Heretofore, there have been several concrete pumps developed, none of which could pump anything but wet concrete. For example, it has only been possible to pump concrete having a 3 to 4 inch slump with pumps heretofore known, while the pump of the invention can pump concrete having a 1 inch slump, this being much drier. It should also be recognized that the pump of the present invention can pump wetter concrete with more efficiency than heretofore known pumps. One of the problems of pumps already known lies in the fact that the concrete must move through sharp angles and narrow openings to enter the inlet side of the pump. Another problem with heretofore known pumps is the need to use a plurality of valving members and hydraulic cylinders for operating the valving members in order to accomplish pumping action. For example, one known pump utilizes four independent valves each independently powered by a hydraulic cylinder in order to accomplish the desired flow of concrete through the pump. Another known pump utilizes a flipper valve arrangement which necessitates bending the concrete around sharp corners to flow through the pump. It is not possible for dry concrete to easily bend around sharp corners.

The pump of the present invention obviates the heretofore known difficulties and enables relatively dry concrete to be pumped, such as concrete having as low as one inch slump. The pump of the invention includes a valve having a valve body and a valve spool shiftable therein and powered by a hydraulic cylinder. The valve body includes a pair of inlet ports to which are connected concrete pumping cylinders, a pair of outlet ports aligned with the inlet ports and having a Y-fitting connected thereto, wherein the Y-fitting includes a pair of inlets and a single outlet. The valve spool is movable within the valve body to coact with the inlet and outlet ports and thereby control movement of concrete therethrough. The valve spool includes a pair of opposed plates, one coacting with the inlet ports of the valve body and the other coacting with the outlet ports. The plate coacting with the inlet ports includes three openings, while the plate coacting with the outlet port includes a single opening. The tubular member extends between the single opening of the one plate and the center opening of the other plate. One of the openings in the plate having three openings, and the center opening is aligned with the inlet ports of the valve body during each of the two positions into which the valve spool may move. Accordingly, the opening in the other plate and common to the tubular member extending between the plates is alternately in communication with one or the other of the inlets to the Y-fitting, and therefore one of the outlet ports to the valve body is always closed to the hopper and valve spool, while the other is always open to the tubular member. With respect to the plate having three openings, the opening on either side of the center opening is either connected to a pumping cylinder and a hopper or is not being used. It can therefore be recognized that a single movable valve is arranged in a valve body for effecting flow control of concrete into the Y-fitting. Suitable hydraulic and electrical controls are provided for synchronously operating the concrete pumping cylinders and the valve spool. The capacity of the pump may be easily changed by changing the capacity of the concrete pumping cylinders.

It is therefore an object of the present invention to provide a new and improved concrete pump.

Another object of the invention is in the provision of a concrete pump that is simple in construction in that it has a low number of parts, and which is easily convertible for changing its capacity, and which is constructed to minimize leakage of concrete.

Another object of the present invention is in the provision of a concrete pump capable of pumping relatively dry concrete, such as concrete having as low as one inch slump.

Other objects, features, and advantages of the invention will be apparent from the following detailed disclosure, taken in conjunction with the accompanying sheets of drawings, wherein like reference numerals refer to like parts, in which:

FIG. 1 is a perspective view of the concrete pump according to the invention mounted on a trailer;

FIG. 2 is a top plan view of the essentially mechanical components of the concrete pump, with some parts broken away and other parts shown in dotted lines for purposes of clarity;

FIG. 3 is an enlarged partially fragmentary and broken view taken substantially along line 3—3 of FIG. 2 showing some parts in vertical section and other parts in side elevation;

FIG. 4 is an enlarged fragmentary sectional view taken substantially along line 4—4 of FIG. 7 through the valve with the valve spool omitted;

FIG. 5 is a broken, partly sectional and partly side elevational view taken substantially along line 5—5 of FIG. 7;

FIG. 6 is a top plan view of a stud or pin employed for providing quick detachable coupling of the pumping cylinders and Y-fitting;

FIG. 6*a* is a vertical sectional view taken through one of the studs mounted on the valve and illustrating a part anchored by a pin in phantom, and taken substantially along line 6A—6A of FIG. 6;

FIG. 7 is a broken horizontal sectional view taken through the valve body of the valve embodiment shown in FIG. 3;

FIG. 8 is a partly diagrammatic, partly horizontal sectional view taken through the valve of FIG. 3 and illustrating the position of the movable parts when the valve spool is in one position;

FIG. 9 is a view similar to FIG. 8 but illustrating the valve spool in the other position and also showing the movable parts as they are moved to the corresponding position;

FIG. 10 is a schematic diagram of a hydraulic circuit for actuating the concrete pumping cylinders;

FIG. **11** is a broken and partly sectional view of a hydraulic cylinder employed for powering a concrete pumping cylinder, and illustrating the limit switch arrangement;

FIG. **12** is a schematic diagram of the hydraulic circuit for operating the valve spool of the valve;

FIG. **13** is an electrical schematic diagram for the solenoid actuated hydraulic valves that drive the concrete pump of the invention;

FIG. **14** is a transverse sectional view taken through a modified valve wherein the spool includes a bottom wall;

FIG. **15** is a longitudinal vertical sectional view, partly broken, and of the valve embodiment of FIG. **10**, and taken substantially along line **15—15** of FIG. **14**;

FIG. **16** is a transverse sectional view taken through a still further modified valve according to the invention;

FIG. **17** is a horizontal sectional view taken through a further modification of the invention and illustrating a tapered tube in the valve spool;

FIG. **18** is a front elevational view of a further modification of the invention illustrating the hopper and valve arrangement;

FIG. **19** is a top plan view of the hopper taken substantially along line **20—20** of FIG. **18**;

FIG. **20** is a fragmentary enlarged sectional view taken substantially along line **20—20** of FIG. **18**, showing the valve spool in one position;

FIG. **21** is a fragmentary enlarged sectional view taken substantially along line **21—21** of FIGS. **18** and **20**;

FIG. **22** is a fragmentary enlarged sectional view taken substantially along line **22—22** of FIG. **20**;

FIG. **23** is a generally diagrammatic and somewhat sectional view of a further modified concrete pumping cylinder drive arrangement and illustrating the parts in one position; and

FIG. **24** is a view similar to FIG. **22** but illustrating the parts in another position.

Referring now to the drawings, the concrete pump of the invention is preferably mobilized to facilitate movement from one location to another, and it therefore may be mounted on a trailer or on a truck chassis. Mounting of the pump on a trailer is illustrated in FIG. **1**. The pump generally includes a pair of concrete pumping cylinders **26** and **27**, a hopper **28**, a Y-fitting **29**, and a valve **30**. The concrete pumping cylinders **26** and **27** are respectively driven by reciprocating hydraulic motors **31** and **32** in the form of hydraulic cylinders, while the valve **30** is controlled by a hydraulic motor **33** in the form of a hydraulic cylinder. An engine **34** drives one or more hydraulic pumps **35** which supplies fluid power to the hydraulic cylinders **31, 32** and **33**.

Concrete is suitably supplied to the hopper **28**, and operation of the concrete pumping cylinders **26** and **27** and the valve **30** causes the concrete pumping cylinders to be alternately charged with concrete and to discharge concrete. Discharge of concrete is alternately made to one of the sides of the Y-fitting **29** which is suitably connected to a flexible or rigid pipe **36**, that may terminate in a nozzle **37** for the pneumatic application of concrete in a wall system or the like. Compressed air may also be supplied to the nozzle for facilitating discharge of concrete therefrom. It should be appreciated that the concrete pump may merely be used to transport concrete from one location to another. More specific operation of the pump will be hereinafter set forth in connection with the hydraulic circuits which control the hydraulic cylinders, as seen in FIGS. **10** and **12**, and the synchronization of the cylinders by means of a suitable electrical circuit and switching arrangement as seen in FIG. **13**.

The valve **30**, details of which are illustrated in FIGS. **3, 4, 5** and **7** to **9**, includes generally a valve body **40** and a valve spool **41**. The valve is positioned below the hopper **28**, so that concrete is fed to the valve and the valve controls the flow of concrete to the Y-fitting **29**. In order to facilitate the movement of concrete from the hopper into the valve, since the hopper is tapered toward the bottom, an agitator **42** is positioned just above the valve **30** within the lower end of the hopper, and it is defined by a shaft **43** extending cross-wise of the hopper and bearingly supported in opposed hopper walls, and a plurality of fingers or tines **44** which extend from the shaft, and which are capable of moving through the concrete to maintain it in mixed form and flowable at the inlet to the valve **30**. A suitable rotatable fluid motor **45**, FIG. **2**, may be mounted on one end of the hopper and drivingly connected to the agitator shaft **43** to provide rotating power to the agitator. The fluid motor **45** may be driven from the source of the pressurized and hydraulic fluid developed by the pump **35**.

The valve body **40** of the valve **30** includes a bottom wall **47**, front and back walls **48** and **49**, and opposite end walls **50** and **51**, all arranged together to define a rectangularly shaped chamber in which the valve spool **41** is received. As seen particularly in FIG. **7**, the front wall of the valve body is provided with a pair of outlet ports **52** and **53**, while the back wall **49** is provided with inlet ports **54** and **55**, it being appreciated that the outlet port **52** and the inlet port **54** are aligned, while the outlet port **53** and the inlet port **55** are aligned.

The outlet ports **52** and **53** are connected to the Y-fitting **29**, wherein the Y-fitting includes a pair of legs or inlets **56** and **57** merging into a single leg or outlet **58**. Thus, the legs **56** and **57** become inlet members to the leg **58**, the latter of which becomes an outlet or discharge member. A single flange **59** provided at the inlet ends of legs **56** and **57** defines a mounting flange for mounting the Y-fitting to the valve front wall **48**, and in this connection, the flange **59** is provided with a plurality of stud holes **60** which are received on studs **61** carried by the front wall **48**.

As seen in detail in FIGS. **6** and **6*a***, each stud **61** is provided with a threaded portion **62** at one end which is adapted to be received in a threaded hole **63** of the valve body front wall **48**. Each stud is provided with a pin opening **64** that is adapted to receive a removable pin **65** which serves to lock the flange **59** in place tightly against the valve body wall **48**. Any suitable gasket may be provided between the Y-fitting flange and wall if desired to eliminate leakage and enhance the sealing relation between the flange and valve body. The pin and stud arrangement enables quick disconnect and quick connect of the Y-fitting to the valve **30**. During disconnection, the pins would be driven free and removed from the pin openings so that the flange and Y-fitting could easily be pulled from the studs. Similarly, when mounting the Y-fitting and flange onto the valve body, following the positioning of the flange onto the studs, the pins are inserted into the pin openings and driven into tight engagement to firmly fix the Y-fitting in place on the valve body. Accordingly, Y-fittings of various sizes can be easily substituted, and in the event of any clogging problems, the Y-fitting may be quickly and easily removed to enable cleaning and unclogging.

The concrete pumping cylinders **26** and **27** are similarly detachably fastened to the valve body **40**, wherein the pumping cylinders are respectively provided with mounting flanges **68** and **69**. Each pumping cylinder mounting flange includes a plurality of stud holes for receiving studs **70** that are secured to the back wall **49** of the valve body. Removable pins **71** are received in pin openings in the studs, which pins are hammered into position or removed as the case may be when mounting or demounting of the pumping cylinders to the valve body. Accordingly, the pumping cylinders may easily be exchanged for replacements or cylinders of different capacity. Again, suitable gaskets may be provided between the valve wall and mounting flanges to seal against leakage. The pumping cylinders **26** and **27** will of course be in alignment with the inlet ports **54** and **55**, while the legs **56** and **57** of the Y-fitting **29** will be in alignment with the outlet ports **52** and **53**. Moreover, in the event of maintenance requirements for the pumping cylinders, they may easily be disengaged from the valve body.

The valve spool **41** may take many forms, but in the embodiment of FIGS. **1** to **9**, includes front and back plates **74** and **75** of about the same height as the front and back walls of the main valve body, but of much shorter length in order to facilitate movement within the valve body. The front plate **74** includes a single opening **76**, while the back plate **75** includes three openings **77**, **78** and **79**. The centers of the openings are at the same level as the centers of the inlet and outlet ports of the valve body. The central opening **78** in the back plate **75** is aligned with the opening **76** in the front plate **74**, and a tubular member **80** extends between these openings and is suitably secured to the front and back plates, such as by welding, so that the front opening **76** and the rear central opening **78** are always in communication with each other. The outside rear openings **77** and **79** are spaced from the central opening **78** a distance equal to the spacing between the inlet ports **54** and **55** of the valve body, whereby alignment of the rear central opening **78** with one or the other of the inlet ports will cause the alignment of one or the other of the rear openings **77** and **79** with the other inlet port.

The front and rear plates **74** and **75** of the valve spool **41**, are of the same length and aligned with each other, and maintained in alignment by the tubular member **80**, and a plurality of connecting cross bars **81**, FIGS. **2** and **3**, so that the front and back plates maintain their proper position in slidable relation against the front and back walls of the valve body and move together upon being shifted from one position to the other as illustrated in FIGS. **8** and **9**.

Wear plates **82** of hardened steel, FIG. **3**, are epoxy glued to the engaging faces of the spool and valve body to provide long wear. They may be replaced by melting the glue and installing new plates.

In order to facilitate maintenance and to enable changing capacity of the valve, wear rings **83**, FIGS. **8** and **9**, may be provided for the inlet and outlet ports of the valve body, which wear rings may easily be replaced when necessary, or may be exchanged for wear rings of different size to change the inlet and outlet port size. The wear rings are merely held in place by the flanges of the pumping cylinders and Y-fittings, and the front and back plates of the valve spool. When changing the capacity of the valve, a sleeve may be inserted in the tubular member **80** to coact with the size of the wear rings. Therefore, to change the capacity, it is only necessary to change the size of the rear rings, utilize a sleeve in the tubular member **80**, and change the size of the concrete pumping cylinders.

The valve spool **41** is shifted between two positions shown in FIGS. **8** and **9** by the reciprocating fluid motor **33** in the form of a hydraulic cylinder which includes a cylinder **85** having a piston **86** therein and secured to a piston rod **87**. The hydraulic cylinder **33** is double acting and may be operated by alternately connecting pressure and exhaust lines to the fluid lines **88** and **89** at opposite ends of the cylinder **85**. The piston rod **87** is movable through a sealed opening **90** in end wall **50** of the valve body, and is connected at its terminal end to a fitting **91**, FIGS. **8** and **9**, which is in turn suitably connected to the tubular member **80** of the valve spool. Thus, actuation of the hydraulic cylinder **33** will produce shifting of the valve spool **41** between the positions shown in FIGS. **8** and **9**, wherein the concrete pumping cylinders are alternately connected to the hopper so they can be charged with concrete and to one of the Y-fitting legs so that the charge can be pumped through the Y-fitting **29**. As seen in FIG. **8**, the pumping cylinder **26** is in its pumping or discharge stroke, and therefore in communication with the inlet leg **56** of the Y-fitting **29** through the alignment of the inlet port **54**, the rear opening **78** in the valve spool, the tubular member **80**, the front opening **76**, the outlet port **52**, and the Y-fitting leg inlet **56**, while the other pumping cylinder **27** is in communication with the hopper and during it suction stroke will draw concrete into the cylinder through the rear opening **77** in the valve spool and the inlet port **55** of the valve body. Conversely, when the concrete pumping cylinders are making the opposite stroke, the pumping cylinder **26** is sucking concrete and being charged, while the pumping cylinder **27** is pumping concrete through the tubular member **80** of the valve spool and into the Y-fitting inlet leg **57**, and during this cycle, the outlet port **52** is closed to the hopper. Similarly, during the previous cycle as shown in FIG. **8**, the outlet port **52** is closed to the hopper by the front plate **74** of the valve spool. Therefore, it can be appreciated that while the outlet ports **52** and **53** of the valve body are alternately connected to the concrete pumping cylinders, they are likewise alternately closed by the valve spool.

In order to facilitate cleaning of the valve **30**, following the use of the pump, which may be accomplished by feeding water to the hopper and pumping it through the pumping cylinders and the Y-fitting, a drain and clean out plug **92** may be provided in the bottom wall **47** of the valve body. While not necessary, the Y-fitting **29** may also be removed during cleaning. Further, as will be hereinafter explained, the pump may be placed in reverse to draw water through the Y-fitting and back into the valve and hopper in order to expedite cleaning.

The pumping cylinders **26** and **27** operate opposite to each other, that is, when one of the pumping cylinders is in the pumping cycle, the other is in the suction cycle. The pumping cylinder **26** includes a piston **95** slidable therein and connected to a piston rod **96**, while the pumping cylinder **27** includes a piston **97** connected to a piston rod **98**.

The hydraulic circuitry employed for operating the hydraulic cylinders **31** and **32** which in turn power the concrete pumping cylinders **26** and **27** is illustrated in FIG. **10**. The piston rod **96** of the pumping cylinder **26** is connected directly to the piston **100** operable in the hydraulic cylinder **31**, while the piston rod **98** of the pumping rod **27** is connected directly to the piston **101** operable in the hydraulic cylinder **32**. Suitable seals will be provided for the piston rods **96** and **98** to prevent leakage from the concrete pumping cylinders or from the hydraulic drive cylinders, and a lubrication box **102**, FIGS. **2** and **3**, may be provided between the hydraulic drive cylinders and the concrete pumping cylinders to provide lubrication for the piston rods.

A four-way solenoid operated hydraulic control valve **103** alternately connects the blind ends of the hydraulic cylinders **31** and **32** to pressure and exhaust to alternately cause the concrete pumping cylinders to move through charge and discharge cycles. Lines **104** and **105** respectively connect the blind ends of the hydraulic cylinders **31** and **32** to control valve **103** which is also connected to pressure and exhaust or drain lines **106** and **107**. The pump **35** in reality includes two stages, one of which is used to handle the hydraulic circuitry for the concrete pumping cylinders, and is designated **35*a*** and the other of which is used for hydraulic circuitry handling the shifting of the valve spool **41** and which is designated **35*b***. The inlet end of the pump **35*a*** is connected to the reservoir or tank **108**, while the outlet or pressure side is connected to the pressure line **106**. The rod ends of the hydraulic cylinders **31** and **32** are connected in common by line **109**, which line is also connected through a pressure responsive valve **110** to tank **108**. Accordingly, the hydraulic fluid on the rod ends of the pistons in the hydraulic cylinders **31** and **32** is forced back and forth between the hydraulic cylinders by the pressure applied to the blind end sides of the pistons. Inasmuch as leakage will be experienced, the excess fluid at the rod ends of the pistons can be returned to tank through opening of the pressure responsive or overload valve **110** when the pressure in the common line **109** exceeds the set point of the valve **110**.

The hydraulic circuitry for controlling the shifting of the valve spool **41** is illustrated in FIG. **12**, wherein a four-way solenoid operated hydraulic control valve **112** alternately connects the rod and blind side of the piston **86** to pressure and tank. Lines **113** and **114** connect the control valve **112** to the valve spool hydraulic cylinder **33**. Inasmuch as a quick and positive shifting of the spool **41** is desired, an accumulator **115** is provided for feeding pressurized fluid through the control valve **112** to the hydraulic cylinder **33**. The accumulator is charged by a pump **35** through a pressure line **116**. The suction side of the pump is connected to tank **117** through suction line **118**. When the desired pressure is reached in the accumulator, an unloading valve **119** will be actuated to connect the pressure line **116** back to tank while maintaining the pressure in the accumulator. A tank line **120** is connected to the control valve **112**. Thus, operation of the control valve **112** will cause shifting of the valve spool **41** through the operation of the hydraulic valve cylinder **33**.

Electrical circuitry for synchronizing the operation of the pumping cylinders and the valve spool is illustrated in FIG. **13**. It should be appreciated that any type of electrical circuitry may be provided, and further that any type of hydraulic circuitry may be employed, and that what is illustrated is typical. Each of the solenoid actuated control valves **103** and **112** include a pair of solenoids designated respectively as **103A**, **103B**, **112A** and **112B**. The circuitry of FIG. **13** includes a start switch **122**, a stop switch **123**, relays **124**, **125** and **126**, normally open limit switches **127** and **128**, and a forward-reverse switch **129**. The limit switches **127** and **128** are mounted on the hydraulic cylinders **31** and **32** which power the concrete pumping cylinders **26** and **27**. A typical mounting arrangement is shown in FIG. **11** in connection with hydraulic cylinder **31**, wherein a collar **130** is provided on the common piston rod **96** to engage and drive a movable pin **131** and actuate the limit switch **127**. A similar arrangement would be provided for the hydraulic cylinder **132** to actuate the limit switch **128** at the end of the pumping cycle for the respective concrete cylinder.

Power is supplied to the circuitry through terminal points **132** and **133**. The stop switch **123** is normally closed while the start switch **122** is normally in open position. Momentary pressing of start switch **122** energizes relay **124** to close contacts **124*a*** and thereby bypass the start switch **122** and hold relay **124** in energized condition. Depressing of the start switch **122** also bypasses limit switch **127** to energize relay **125** and cause closing of contacts **125*a***, **125*b***, **125*c*** and opening of contacts **125*d***. Closing of the contacts **125*a*** causes shifting of the control valve **103** to cause actuation of the cylinder **32** and concrete pumping cylinder **27** through its pumping cycle. The forward-reverse switch **129** is in the forward position as illustrated. Closing of contacts **125*b*** causes a shifting of the valve spool **41** to the position whereby the pumping cylinder **27** is in communication with one side of the Y-fitting to pump concrete therethrough. Closing of contacts **125*c*** causes holding of relay **125** through normally closed contacts **126*c***, while opening of normally closed contacts **125*d*** prevents any possible actuation of relay **126** until the limit switch **128** is closed. Upon closing of limit switch **128** by the piston rod in cylinder **32**, relay **126** is energized causing opening of normally closed contacts **126*c*** and deenergization of relay **125**. Further, energization of the relay **126** causes closing of contacts **126*a*** to operate the control valve **103** and apply pressure to the blind end of the hydraulic cylinder **31** while connecting the blind end of the hydraulic cylinder **32** to tank thereby causing the pumping cylinder **26** to move through a pumping stroke while the pumping cylinder **27** will move through a suction stroke. At the same time, contacts **126*b*** are closed to operate control valve **112** and shift the valve spool **41** so that the pumping cylinder **26** is placed in communication with the Y-fitting while the pumping cylinder **27** is placed in communication with the hopper. When the hydraulic cylinder **31** reaches the end of its forward travel, it will close limit switch **127** to energize relay **125** and cause deenergization of relay **126** and reverse the hydraulic control valves to cause reversal of the spool valve position and reverse movement of the concrete pumping cylinders. The cycling continues as the limit switches are alternately closed. Pumping is stopped upon opening the stop switch **123** and deenergizing relay **124** and the other one of the relays that is energized. By actuating the forward-reverse switch **129** to take the position opposite from that of FIG. **13**, the relative cycling of the valve spool **41** and the pumping cylinders **26** and **27** are reversed to cause the pumping action from the Y-fitting back into the hopper.

The valve for controlling the flow of concrete between the hopper, the concrete pumping cylinders and the Y-fitting may take other forms than that shown in the embodiment of FIGS. **1** to **9** without changing the concrete flow path. It should be appreciated that the valve of the embodiment of FIGS. **1** to **9** is such that it is open at the top directly to and in communication with the lower end of the hopper so as to facilitate movement of concrete into the valve. In this respect, the valve defines the hopper bottom. Once the concrete is in the valve, it need only be sucked into one of the concrete pumping cylinders, and thereafter discharged along a straight path from the concrete cylinder through the valve spool tubular member **80** and into the Y-fitting. It should be appreciated that the concrete does not have to flow around corners in passing between the hopper and pumping cylinders, for it first gravitationally flows directly into the valve spool and then is drawn directly into one of the concrete pumping cylinders. This feature enhances the efficiency of the concrete pump and enables it to easily pump concrete of low slump.

The valve illustrated in FIGS. **14** and **15**, and generally designated **137** differs from that shown in FIGS. **1** to **9** only in that the valve spool **138** includes a bottom plate **139** arranged between the front and back plates **140** and **141** so that the valve spool is further reinforced. Cross bars **142** additionally hold the front and back walls in spaced apart relation, as will the tubular member **143**. The valve spool is slidably received in the valve body **144**, the latter of which is of the same construction as the valve body **40** in the embodiment of FIGS. **1** to **9**. Similarly, the hopper **145** together with the Y-fitting **146** and the pump cylinders **147** are the same as in the first embodiment. Likewise, the piston rod **148** is connected at one end to the tubular member **143** and associated with a reciprocating fluid motor for shifting the valve spool within the valve body. The front and back plates **140** and **141**, as well as front and back walls of the valve body are provided with the same openings as in the first embodiment. Similarly, the end edges of the front and back plates as well as the bottom plate of the valve spool are tapered to facilitate movement through the concrete received in the valve. The operation of a concrete pump having the valve of this construction is identical to that of the embodiment of FIGS. **1** to **9**.

The embodiment of FIG. **16** illustrates a variation in valve construction, wherein the valve is designated by the numeral **150** and includes a valve body **151** within which is slidably arranged a valve spool **152**. The valve body includes front and back walls **153** and **154**, and a bottom wall **155**. The front and back walls are on the outer edges of the bottom wall. A plurality of cross bars **156** extends across the front and back walls at the upper end. Both the bottom wall and the cross bars are held in place by elongated fastening bars **157**. The valve spool **152** includes front and back plates **158** and **159**, separated by a tubular member **160**. As in the other embodiments, the front and back walls of the valve body, and the front and back plates of the valve spool include ports and openings in the same positions. The lower edges of the front and back plates of the valve spool are slidably received in longitudinally extending tracks or grooves **161** and **162** formed in the bottom wall **155** of the valve body, while the upper ends of the plates are slidably received in tracks or grooves **163** and **164** formed in the cross bars **156**, thereby guidably arranging the valve spool within the valve body. Normally, the cement of the concrete provides sufficient lubrication for the engaging surfaces of the valve spool and the valve body. However, when the pump is being cleaned, it may be necessary to provide further lubrication, and in that event, grease or the like may be introduced to the engaging surfaces of the valve spool and valve body by means of grease fittings **165** and **166**. Any number of grease fittings may be provided along the valve body for admitting grease to the areas needing lubrication. The operation of the valve shown in FIG. **16**, relative to the flow of concrete from the hopper **167** into the pumping cylinders **168** and out the Y-fitting **169** is the same as in the embodiment of FIGS. **1** to **9**.

Another form of valve and pumping cylinder variation is illustrated in FIG. **17**, wherein the structure is intended to permit greater pumping capacity, while at the same time maintaining compactness of the pump by maintaining a relatively short stroke on the pumping cylinders and maintaining a relatively short length on the valve, this being important from the standpoint of providing a concrete pump that can be easily transported. The valve of this embodiment is generally designated as **172**, and includes a valve body **173** within which a valve spool **174** is respectably arranged. The valve body includes a front wall **175** having outlet ports **176**, and a back wall **177** having inlet ports **178**. A Y-fitting **179** is secured to the front wall **172** in the same fashion as before mentioned, while pumping cylinders **180** and **181** are secured to the back wall in the same fashion as heretofore mentioned. The valve spool **174** includes a front plate **182** having a single opening **183**, and a back plate **184** having openings **185**, **186** and **187**. The inlet and outlet ports of the valve body are sized differently as illustrated in FIG. **17** wherein the inlet ports **178** are larger than the outlet ports **176**. Similarly, the valve spool openings **185**, **186** and **187** in the back plate are larger than the valve spool openings **183** in the front plate. Accordingly, the velocity of concrete flow into the pumping cylinders is lower than the velocity of concrete flow into the fitting **179**.

The tubular member **188** extending between the front and back plates of the valve spools is frusto-conical in shape wherein it has a larger inlet end than outlet end, the inlet end being at the back plate of the spool.

Further, the pumping cylinders include cylinder walls **180***a* and **181***a* within which the pistons **180***b* and **181***b* reciprocate, and the outlet ends of the cylinders are connected to the valve body by frusto-conically shaped pipe sections **189** and **190**, wherein the inlet ends of the sections are larger than the outlet ends.

This embodiment is important where it is desired to increase the capacity of the concrete pump wherein the tapered tubular member **188** and the tapered pipe sections **189** and **190** permit larger pumping cylinders to be used without increasing the length of the pumping cylinders as would be necessary if the same size pumping cylinders would be employed. Further, the length of the valve need not be as long as it would have to be if the openings and ports were of a size equal to that of the pumping cylinders. It is important that the distance between the adjacent edges of the inlet ports **178** of the valve body be such that the discharge end of the tubular member **188** at the front plate of the valve spool be closed prior to the inlet end of the tubular member at the back plate but opened to the next pumping cylinder to prevent backflow of concrete from the Y-fitting into hoppers.

The embodiment of FIGS. **18–22** illustrates another form of the invention wherein the valve spool of the valve is not open directly to the hopper throughout its length, but communicates with the hopper through pipe sections. The valve, generally designated by numeral **193**, includes a valve body **194** within which the valve spool **195** is reciprocably positioned. The valve spool **195** includes a front plate **196***f* in spaced relation from a back plate **196***b*, top and bottom plates **196***t* and **196***l*, and end plates **196***d* and **196***e*. Three openings **197***a*, **197***b* and **197***c* are provided in the back plate **196***b*, and two openings **198***a* and **198***b* are provided in the front wall **196***f*. Openings **197***a* and **197***b* in the back plate align with openings **198***a* and **198***b*, and tubular members **199***a* and **199***b* respectively extend therebetween. The center opening **197***c* communicates with an elbow **200** that also communicates with an opening **200***a* in the top plate **196***t*.

The valve body **193** includes front and back walls **201** and **202**, a bottom wall **203**, and a top wall **204**, all arranged in box form, and closed at opposite ends by end walls **205** and **206**. Inlet openings to the valve **193** are provided in the top wall by openings **207** and **208**, FIG. **20**, which are in communication with outlet openings **209** and **210** formed in the bottom wall **211** of the hopper **212**, by means of connecting pipes **213** and **214**. The inlet openings **207** and **208** in the valve are aligned with the inlet and outlet ports of the valve body, whereby charging of the concrete pumping cylinders is facilitated. The operation of the pump of this embodiment is essentially the same as that of the other embodiments, wherein the pumping cylinders are alternately charged with concrete and then discharge the concrete through a tubular member of the valve spool and the outlet Y-fitting **216**.

A variation for driving the concrete pumping cylinders is illustrated in the embodiment of FIGS. **23** and **24**, wherein the pumping cylinders **220** and **221** have their pistons **222** and **223** interconnected by a flexible cable **224** which extends through the rod ends of the cylinders and over a guide **225**. Hydraulic fluid is pumped from a power cylinder **226** into one or the other of the pumping cylinders **220** and **221** against the cable sides of the pistons, and the power cylinder is actuated by a further hydraulic cylinder **227**. The power cylinder **226** includes a cylinder **228**, one end of which is in communication with the pressure chamber of concrete pumping cylinder **220** by means of a line **229**, and the other end of which is in communication with the pressure chamber of the concrete pumping cylinder **221** through a line **230**. A piston **231** is slidable within the cylinder **228** and provided with a piston rod **232** that is connected to the piston **233** of the hydraulic drive cylinder **227**. The piston **233** of the drive cylinder **227** is slidably received within a cylinder **234** which is in a suitable hydraulic circuit for causing synchronized operation of the pumping cylinders. The hydraulic circuitry for the drive cylinder **227** is completely independent from the hydraulic circuitry for the power cylinder **226** and the concrete pumping cylinders, whereby the hydraulic fluid operating the drive cylinder **227** will not mix with that operating the power cylinder **226**. Therefore, any possible leakage across the pistons of the concrete pumping cylinders, while going into the hydraulic fluid of the circuitry driving the pumping cylinders, will not affect the hydraulic circuitry for the drive cylinder **227**.

In operation, as seen in FIG. **23**, where the power cylinder piston **231** is driven downwardly, it pressurizes the fluid in the lower end of the cylinder and drives it into the pumping cylinder **220** to force the piston **222** downwardly to pump the concrete therefrom. Forcing the piston **222** through the pumping cycle will cause the piston **223** and the pumping cylinder **221** to go through the return stroke by the cable connection between the pistons and cause the pumping cylinder **221** to be charged with concrete. However, it should be appreciated that the vacuum created at the head end of each piston during operation of power cylinder **226** will retract the piston. Yet the connection of the pistons by cable **224** provides a more positive retraction. The low pressure fluid in the pumping cylinder **221** will be driven back into the power cylinder **226** on the low pressure side of the piston **231**. The opposite movements of the pumping cylinder are effected upon driving the piston **231** of the power cylinder in the upward direction as illustrated in FIG. **24**. The size of the power cylinder **226** may be relatively large so that it has a short stroke, thereby making it more compact.

This embodiment illustrates how the overall length of the concrete pumping cylinder can be reduced by directly driving the pumping cylinders rather than driving same with hydraulic cylinders as in the other embodiments.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention, but it is understood that this application is to be limited only by the scope of the appended claims.

This invention is hereby claimed as follows:

1. A concrete pump comprising a hopper for receiving concrete, a pair of concrete pumping cylinders synchronously operated to be alternately charged with concrete and to alternately discharge concrete therefrom, a Y-shaped discharge fitting having a pair of inlets and a single outlet adapted to be connected to a hose, a valve arranged between said cylinders and the inlets of said fitting for alternately connecting each of the cylinders to said hopper to be charged and to said inlets of said fitting to be discharged, said valve including a valve body having a pair of inlet ports, one communicating with each cylinder, and a pair of outlet ports axially aligned with the inlet ports, one outlet port communicating with each inlet of said fitting, and a valve spool (slidably received) reciprocably movable in said valve body between first and second positions alternately connecting one of the inlet ports with one of said outlet ports and the other of the inlet ports with the hopper and closing the other of the outlet ports.

2. A concrete pump as defined in claim **1**, and means for driving said concrete pumping cylinders and said valve spool in synchronism to cause pumping of concrete from the hopper to and through the Y-shaped discharge fitting.

3. A concrete pump as defined in claim **1**, and means for driving said concrete pumping cylinders and said valve spool in synchronism to cause pumping of concrete from the Y-shaped discharge fitting to and into the hopper.

4. A concrete pump as defined in claim **1**, wherein said valve body includes front and back opposed walls, the inlet ports being in the back wall, and the outlet ports being in the front wall, and said valve spool including spaced front and back plates interconnected to move together and respectively sliding against the front and back walls of the valve body, a single opening in the front plate adapted to be alternately in alignment with an outlet port, three openings in the back plate, the center opening being aligned with the opening in the front plate and the outside openings being spaced from the center opening a distance equal to the spacing of the valve body inlet ports, and a tubular member extending between the plates and interconnecting the opening in the front plate with the center opening in the rear plate.

5. A concrete pump as defined in claim **4**, wherein the openings in the spool plates are the same size as the valve body ports.

6. A concrete pump as defined in claim **4**, wherein the inlet ports and openings in the back spool plate are larger than the outlet ports and the opening in the front spool plate, and the tubular member is frusto-conical with the large end at the back plate.

7. A concrete pump as defined in claim **6**, wherein the concrete pumping cylinders have a larger outlet diameter than the valve inlet ports, and a frustoconically shaped connecting pipe extends between each cylinder and inlet port.

8. A concrete pump as defined in claim **1**, wherein said valve is positioned horizontally below the hopper and effectively defines the bottom of the hopper, and said valve is fully open to the hopper throughout its length.

9. A concrete pump as defined in claim **8**, wherein the valve body includes front and back opposed walls and end walls all connected to the bottom end of the hopper and a bottom wall, the inlet ports being in the back wall, and the outlet ports being in the front wall, and said valve spool including spaced front and back plates of about the same height as the front and back walls of the valve body and interconnected to move together in sliding relation along the bottom wall and respectively against the front and back walls of the valve body, a single opening in the front plate adapted to be alternately in alignment with an outlet port, three openings in the back plate, the center opening being aligned with the opening in the front plate and the outside openings being spaced from the center opening a distance equal to the spacing of the valve body inlet ports, and a tubular member extending between the plates and interconnecting the opening in the front plate with the center opening in the rear plate.

10. A concrete pump as defined in claim **9**, wherein a bottom plate is provided for the spool extending between and connected to the front and back plates.

11. A concrete pump as defined in claim **9**, wherein tracks are provided in the bottom wall of the valve body in which are guidably received the lower edge portions of the front and back spool plates.

12. A concrete pump as defined in claim **11**, and cross bars extending between and connected to the front and back valve body walls at the upper ends, said cross bars having tracks for guidably receiving the upper edge portions of the front and back spool plates.

13. A concrete pump as defined in claim **1**, wherein quick disconnect means is provided between the valve body and the concrete pumping cylinders, and between the valve body and the Y-fitting.

14. A concrete pump as defined in claim **1**, wherein means is provided to lubricate the engaging surfaces of the valve spool and valve body.

15. A concrete pump as defined in claim **1**, wherein said valve is positioned horizontally below the hopper, said valve body including front and back opposed walls and top and bottom walls and end walls all connected together to define a chamber in which the valve spool operates in coaction therewith, the inlet ports being in the back wall, the outlet ports being in the front wall, a pair of concrete supply ports in the top wall aligned with the inlet and outlet ports, said hopper including a bottom wall having a pair of discharge ports, and connecting pipes between the discharge ports and the supply ports.

16. A concrete pump as defined in claim **1**, wherein each of said concrete pumping cylinders includes a cylindrical casing having a piston slidable therein between opposite ends thereof and connected to a piston rod, and means for driving the pistons of said concrete pumping cylinders including hydraulic cylinders axially aligned therewith, each of said hydraulic cylinders including a cylindrical casing having a piston slidable therein between opposite ends and connected to a piston rod of said concrete pumping cylinder.

17. A concrete pump as defined in claim **1**, wherein each of said concrete pumping cylinders includes a cylindrical casing having a piston slidable therein between opposite ends thereof, means for driving the pistons of said concrete pumping cylinders including a driving hydraulic cylinder including a cylindrical casing having a piston slidable therein between opposite ends thereof and connected to a piston rod, a power cylinder including a cylindrical casing having a piston slidable therein and connected to the piston rod of said driving hydraulic cylinder, a fluid connection from each end of said power cylinder, one to each of said concrete pumping cylinders, means connecting the pistons of the concrete pumping cylinders so they move in opposite directions, and hydraulic fluid in the power cylinder and concrete pumping cylinders, whereby operation of the power cylinder causes alternate movement of the pistons in the concrete pumping cylinders.

18. A concrete pump as defined in claim **1**, wherein wear plates are provided on the engaging surfaces of the spool and valve body.

19. A concrete pump as defined in claim **1**, wherein wear rings are provided at the inlet and outlet ports of the valve body.

* * * * *