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Piston and Piston Diaphragm Pumps for Long-Distance Hydraulic Conveying

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Kolben- und Kolbenmembranpumpen für den hydraulischen Ferntransport
Pompes à pistons et pompes à diaphragme à pistons pour le transport hydraulique de grande distance
Bombas de pistón y de pistón a diafragma para el transporte hidráulico a larga distancia

長距離水力コンベア運搬用ピストンおよびピストン膜ポンプ

长距离液压输送的活塞与活塞隔膜或泵

الكباس ورق الكباس المفرغ باستمرار المستخدمين في عمليات النقل الهيدروليكي لمسافة طويلة

Kolben- und Kolbenmembranpumpen für den hydraulischen Femtransport

Direkt beaufschlagte Kolbenpumpen als vierfachwirkende Duplexpumpen und einfachwirkende Triplexpumpen mit offenen Zylindern lassen als langsam laufende Pumpen (max. 60 Kolbenhübe/Min.) für den hydraulischen Transport von Feststoffgemischen mittlerer Abrasivität, wie Kohle, Kreideschlamm, Bohrschlamm, Klärschlämme, Dickstoffe, optimale Betriebsergebnisse erwarten.

Kolbenmembranpumpen stellen die optimale Lösung dar, für den hydraulischen Transport von Feststoffgemischen höchster Abrasivität wie Eisenerz, Kupfererz, Pyrite, Sande, Asche etc.

Um hohe störungsfreie Durchlaufzeiten der Pumpen zu erreichen, sollten die Förderdrücke in der Regel 100 bar nicht überschreiten.Eine Ausnahme sind hier Bohrschlammpumpen die mit Dauerbetriebsdrücken von über 200 bar arbeiten. Hier werden gute Standzeiten der Verschleißteile wie Kolben und Ventile durch eine Entsandung des Bohrschlamms auf unter 0,5 % erreicht.

Die Korngröße des Feststoffes sollte 3 mm nicht überschreiten. Der Grund hierfür sind die selbsttätig arbeitenden Pumpenventile. Membran-Stoßdämpfer ermöglichen einen nahezu pulsationsfreien Förderstrom.

Bombas de pistón y de pistón a diafragma para el transporte hidráulico a larga distancia

Bombas de pistón accionadas directamente, como bombas duplex de efecto cuádruple y bombas triplex de efecto simple con cilindros abiertos, permiten esperar resultados óptimos de servicio, como bombas de marcha lenta (max. 60 carreras de pistón/min.) para el transporte hidráulico de mezclas de sólidos de media abrasión, como carbón, fango de creta, fango de sondeos, cienos, y fluidos espesos.

Las bombas de pistón a diafragma ofrecen la solución óptima para el transporte hidráulico de mezclas de sólidos de máxima abrasión, como mineral de hierro, mineral de cobre, pirita, arena, cenizas, etc.

A fines de conseguir largos tiempos de paso de las bombas, exentos de perturbaciones, las presiones de transporte normalmente no deberían exceder de 100 bar. Sin embargo, hay una excepción en cuanto a las bombas de fango de sondeos que trabajan con presiones de servicio permanentes de más de 200 bar. Aquí se consiguen buenas duraciones de las piezas de desgaste, como pistones y válvulas, desarenando el fango de sondeos a menos de un 0,5 %.

El tamaño de grano de los sólidos no debería exceder de 3 mm. La razón es que las válvulas de bomba trabajan automáticamente.

Amortiguadores a diafragma permiten un flujo casi exento de vibraciones.

Pompes à pistons et pompes à diaphragme à pistons pour le transport hydraulique de grande distance.

Des pompes à pistons actionnées directement comme pompes duplex à quadruple effet et pompes triplex à simple effet avec des vérins ouverts font espérer des résultats de service optimum — en leur qualité de pompes à faible vitesse (60 courses de pistons/min. au maximum) — pour le transport hydraulique des mélanges de matières solides de moyenne abrasivité, comme le charbon, la boue de craie, boue de forage, boues de curage, liquides épais.

Des pompes à diaphragme à pistons représentent la solution optimale pour le transport hydraulique des mélanges de matières solides d'une abrasivité maximale comme le minerai, minerai de cuivre, pyrites, sables, cendres, etc.

Afin d'obtenir de longs temps de passage sans trouble aux pompes, les pressions de refoulement ne devraient pas dépasser 100 bar en règle générale. Les pompes à boue de forage opérant avec des pressions de service continues de plus que 200 bar font exception. Grâce à un dessablage à moins que 0,5 % on atteint de longues durées de service des pièces de rechange comme les pistons et soupapes.

La grosseur de grain de la matière solide ne devrait pas dépasser 3 mm en raison des soupapes de pompe opérant indépendamment.

Des amortisseurs de chocs à diaphragme permettent un débit presque sans vibrations.

1. Introduction

For the hydraulic long-distance conveyance of solids, principally piston and piston diaphragm pumps are employed. The selection criteria for the economic employment of piston and piston diaphragm pumps are essentially the abrasiveness of the solids, the conveying pressure and the solids particle grain size.

In order to achieve a disturbance-free flow, maximum operating safety and minimum operating costs, the three above mentioned criteria must be investigated as thoroughly as possible.

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Due to the high margin of investment between the various pump types, it is recommended in particular when planning a solids pipeline, to establish a close cooperation between the processing engineers and the pump experts.

2. Piston Pumps

There is a large field of employment for piston pumps; they can be economically employed for conveying media of slight and medium abrasiveness, flotation media, chalk slurries, muds, settling muds, etc.

These pumps are directly actuated pumps, i.e., the conveying piston, and the gaskets are in direct contact with the medium.

Fig. 1 shows a double-effect 2-cylinder piston pump, and duplex piston pump, resp., with a driving power of 920 kW, a

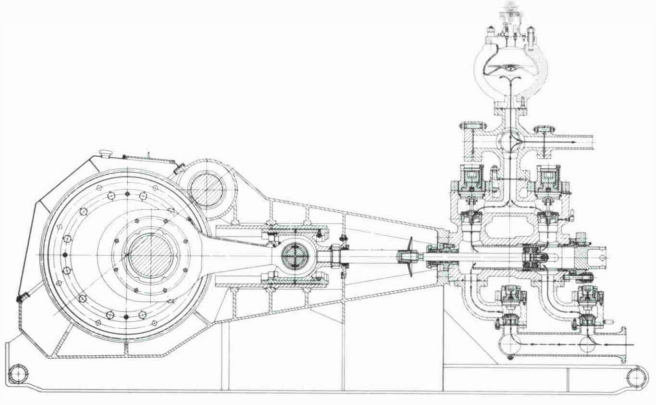


Fig. 1: Sectional drawing of a 2-cylinder double effect piston pump

max. conveying pressure of 250 bar, and a max. delivery of 3,350 l/min (200 m³/h).

Duplex piston pumps are nowadays designed up to a driving power of 1,350 kW. In the case of the Black Mesa coal slurry pipeline, 13 pumps in total of this type convey 4.8 million tons of coal per year, over a distance of 440 km.

The power produced by the drive is converted into an oscillating movement over drive shaft, drive wheel, crankshaft and connecting rod, up to the cross-head, and passed to the fluid end over cross-head rod, and piston rod.

So, the fluid end is equipped with 4 suction valves, and 4 pressure valves, which make the medium to be conveyed pass round the piston at both sides, thus making possible the double effect.

Fig. 2 shows a duplex pump. Fig. 3 shows a duplex piston pump with piston flushing, and water receiver before the piston rod packings. Thus, the disturbance-free flow time is essentially increased.

Fig. 4 shows a pump station, commissioned in 1964, comprising 5 duplex piston pumps, with open cylinders for pumping 500 m³/h of chalk slurry, over a distance of 7 km.

Fig. 5 shows a 3-cylinder piston pump, and triplex piston pump, respectively, with a driving power of 960 kW, a maximum conveying pressure of 362 bar, and a maximum delivery of 2840 l/min (170 m³).

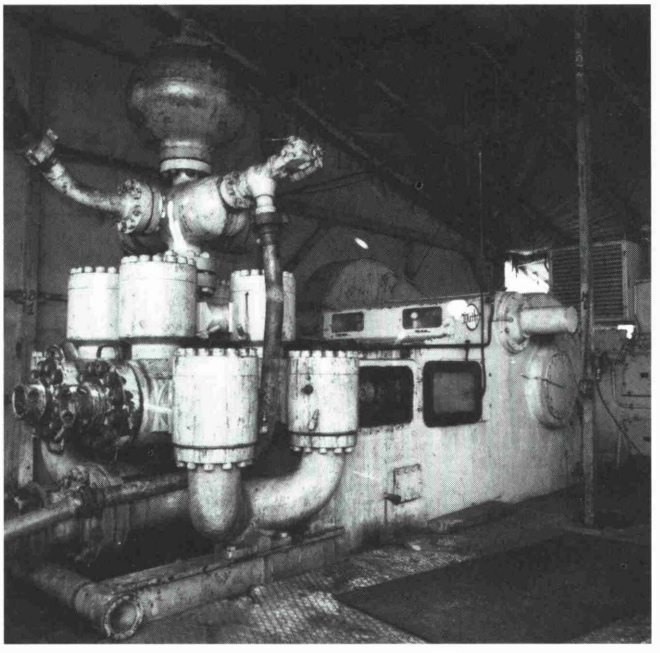


Fig. 2: 2-cylinder double effect piston pump

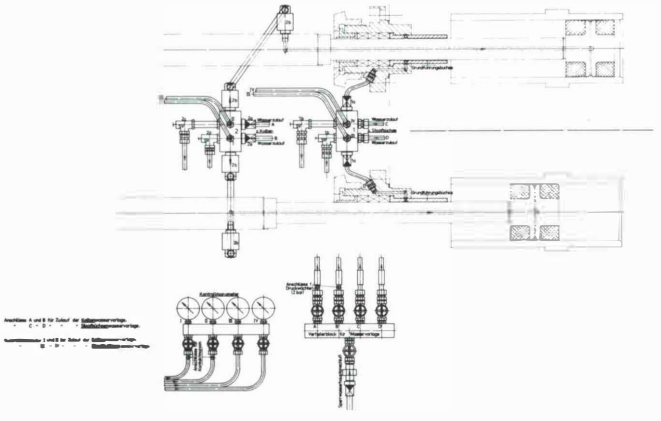


Fig. 3: Scheme of the piston flushing system and shut-off water receiver before piston rod packing, for double acting piston pumps

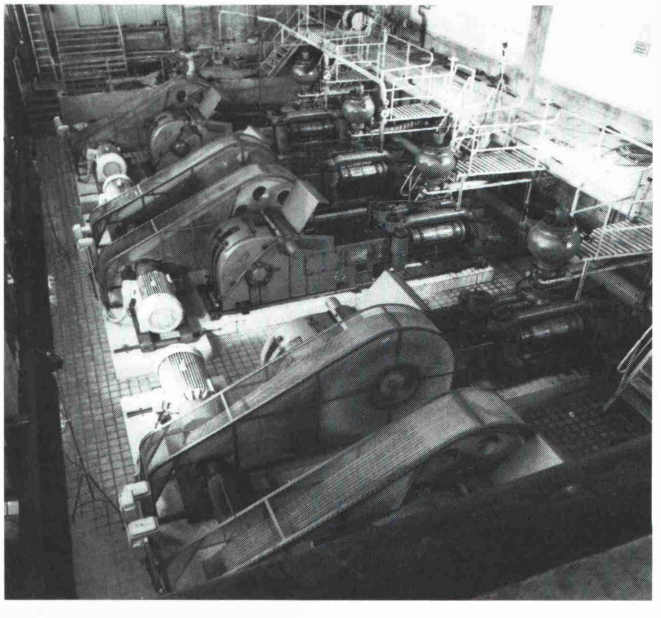


Fig. 4: Pump station with 5 piston pumps for the conveyance of chalk slurry

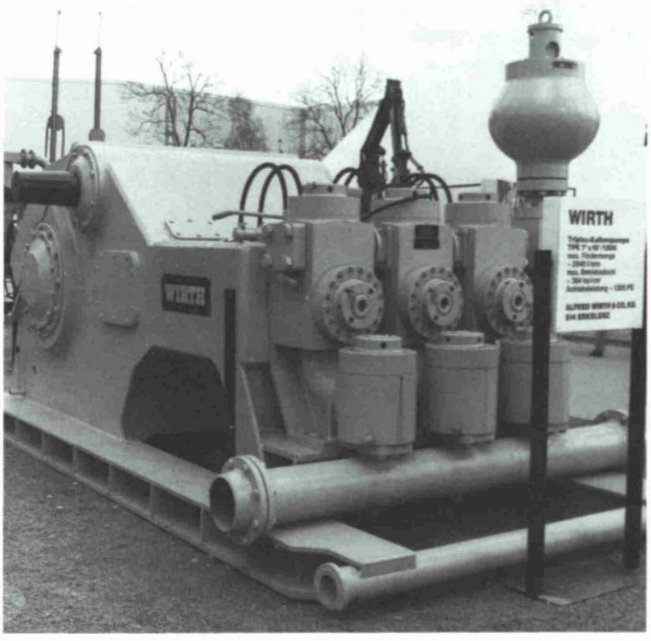


Fig. 5: 3-cylinder piston pumps with open cylinders

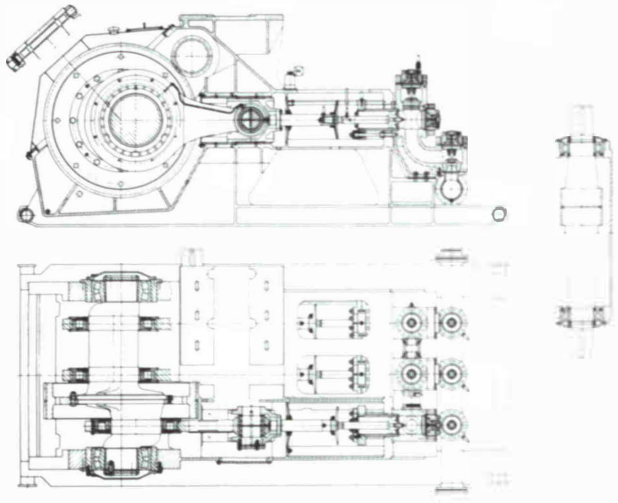


Fig. 6: Sectional drawing of a 3-cylinder piston pump with open cylinders

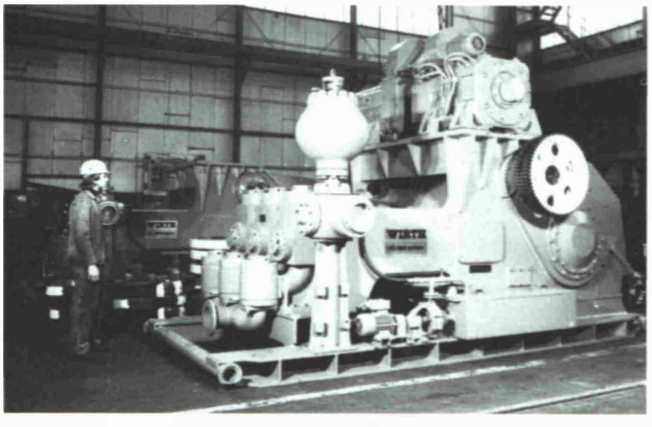


Fig. 7: 3-cylinder piston pumps with open cylinders

The triplex piston pumps are an improvement of the duplex pumps. As single-acting pump with so-called open cylinders, the advantage of this pump type is in the cylinder liner flushing system, with simultaneous lubrication of the piston packing, and dissipation of friction heat.

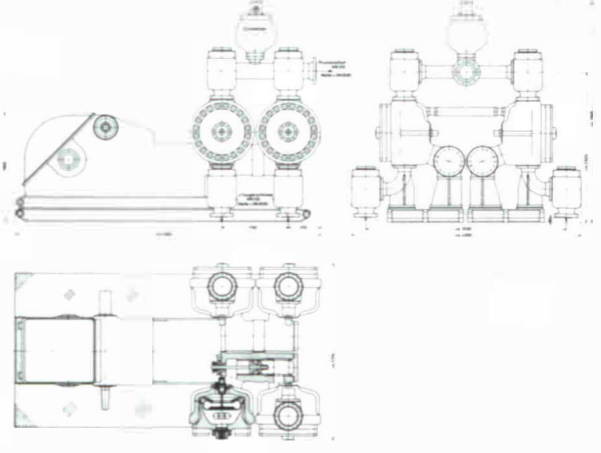
Due to this type of construction, slightest leakages indicate that piston collars must be necessarily exchanged. Thus, lifetime of cylinder liners and pistons is considerably increased, in comparison with the above mentioned duplex piston pumps. Furthermore, reduction of wear parts offers an additional advantage (piston rods and corresponding packings).

Fig. 6 shows the construction of a triplex piston pump. The drive side can be compared with the duplex piston pumps. Only the fluid ends are designed in such a way that the medium to be conveyed passes round the piston by one side only, the rear side of the piston being available for the advantages which have been indicated above.

In order to reduce to a minimum the number of pump stations for a coal slurry pipeline, pumps are employed which can produce conveying pressures of at least 50—100 bar. Solids grain sizes of 3 to 4 mm, and approx. 10 % excessive grain size up to 6 mm are possible. Recently, triplex piston pumps with deliveries of 700 m³/h have been proposed and projected. One of these pumps is in a position to convey 350 t/h of coal. The driving power amounts to approx. 1030 kW. Due to the respective delivery, a pump station is equipped with 3 to 6 pumps. One of these pumps is intended as reserve. By installing several pump stations one after the other, it is possible to bridge large distances.

Fig. 7 shows the largest triplex pump in the world at present, with a driving power of 1180 kW, and an intermittent power of 1470 kW.

Fig. 8 shows a duplex piston diaphragm pump of horizontal design, for conveyance of red mud, and bauxite suspension, resp., with a delivery of 200 m³/h. The drive side is again



Performance Data

Delivery	200 m³/h, 3,340 dm³/min
Stroke number	40 strokes/min
Operating pressure	50 kp/cm² (max)
Power required	495 HP

Conveying Media

Red mud
Bauxite suspension

Fig. 8: Sectional drawing of a 2-cylinder double acting diaphragm pump

comparable with the duplex piston pumps. The piston, however, is not surrounded by the media to be pumped, but by a hydraulic fluid. Due to the oscillating piston movement, the hydraulic fluid is submitted to pressure, transmitting this pressure subsequently over a diaphragm to the medium to be pumped.

When pumping bauxite suspensions at a delivery pressure of 80 bar, and temperatures of 80 °C, for example, lifetimes of the diaphragm of more than 6000 operating hours have been reached.

Fig. 9 shows a piston diaphragm pump as triplex pump.

Fig. 10 shows a duplex piston diaphragm pump for pumping sand. By means of this pump type, a quartz sand/water mixture of 375 g sand (up to 3 mm grain size) per ltr. mixture was pumped, at a delivery pressure of 100—120 bar. The test time amounted — under the above-mentioned conditions — to 1000 hours, without exchange of wear parts, such as valves, diaphragms, etc. At a subsequent long-duration test of approx. 2000 hours for bauxite suspension pumping at a delivery pressure 150—170 bar, the good test stand results were confirmed, with respect to the high lifetime of valves and diaphragms. After termination of the long-duration test, these decisive components continued being available for use.

For pumping ore pulp, multiple-cylinder plunger pumps with shut-off medium have been frequently employed in the past.

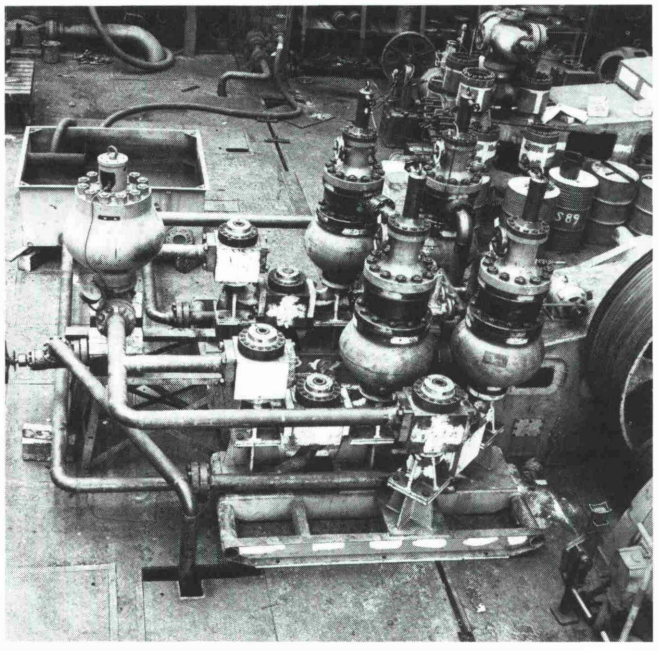


Fig. 9: Sectional drawing of a 3-cylinder single acting piston pump

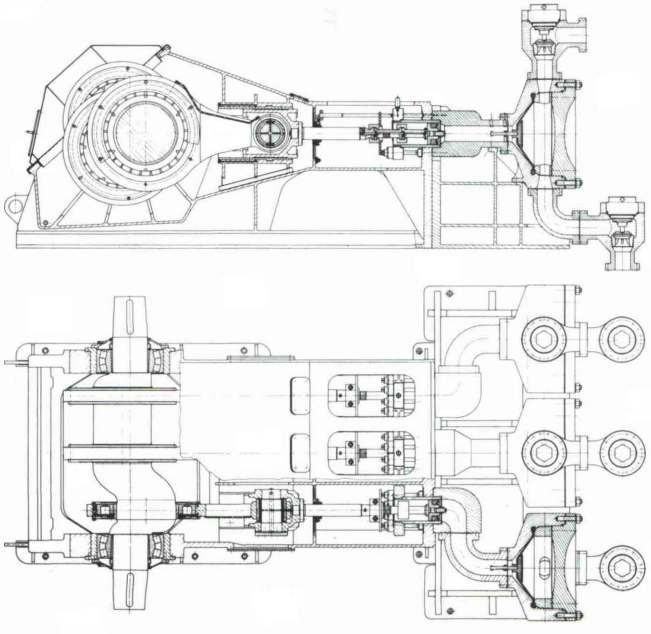


Fig. 10: 2-cylinder double acting piston pump (special design for pumping sand)

3. Piston Diaphragm Pumps

Piston diaphragm pumps are employed for highly abrasive media, such as iron ore, copper ore, bauxite, red mud, sand, etc.

In the case of these pumps, the medium to be conveyed is not in direct contact with the conveying piston and the packings, but is mechanically separated over a diaphragm and an intermediate medium. Due to this type of construction, pistons, piston rods, and cylinder liners as main wear parts do not exist.

Fig. 11 shows such a pump which is constructed in vertical and horizontal design, being comparable with the triplex piston pumps. Instead of the piston, however, a plunger is installed. The shut-off medium is intended to prevent destruction of the plunger packing and the plunger by solid particles. Concrete and reliable operating results are not available. Fig. 12 shows a schematic of the plunger with shut-off medium.

Fig. 13 shows a double-acting 2-cylinder piston pump, system Mars. As far as this system is concerned, the medium to be conveyed is over an oil receiver hydrostatically separated from the piston. These pumps are employed for

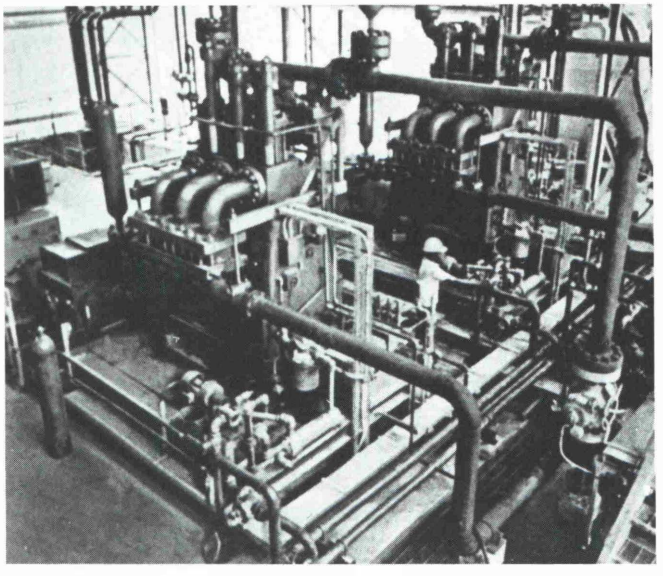


Fig. 11: 3-cylinder plunger pump with shut-off medium

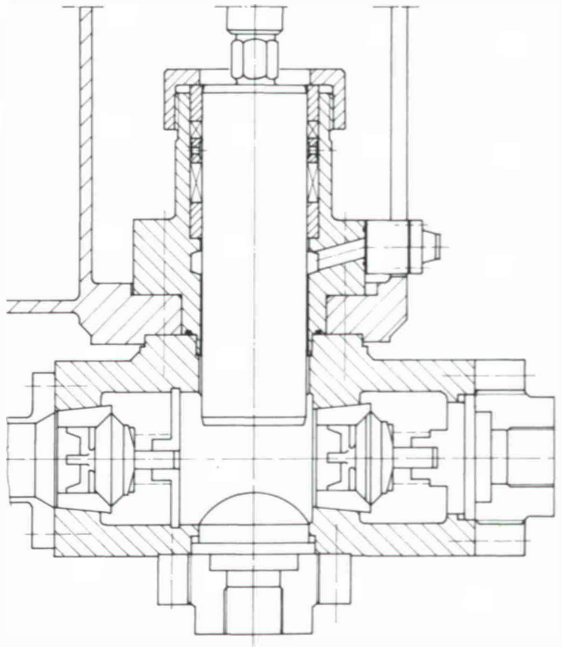


Fig. 12: Schematic drawing of a plunger with shut-off medium

gold sand conveyance in South Africa. Unfortunately, also in that case, reliable operating results are not available. From the corresponding literature, modifications of this pump type are known, which indicate mixture of the abrasive material with the oil.

4. Shock Absorbers

In order to achieve for all the above described pumps a pulsation-free flow, so-called diaphragm pulsation dampers

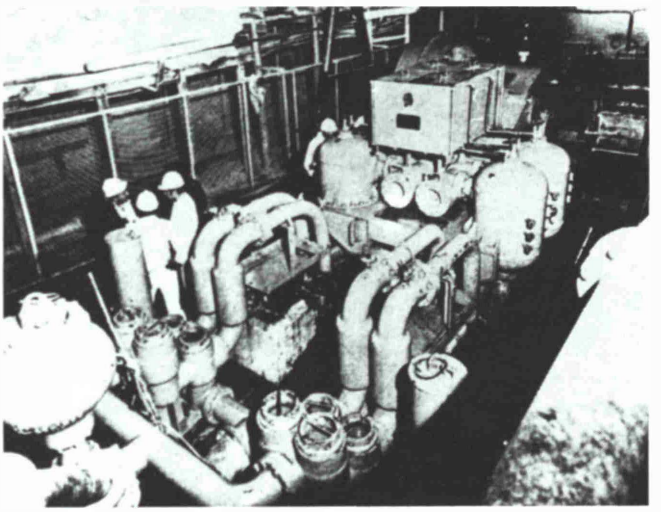


Fig. 13: Double acting 2-cylinder piston pump with oil as shut-off medium

are installed in the pressure lines, and partly also in the suction lines. These shock absorbers help obtain a damping degree of approximately 98 % (see Fig. 1).

5. Drive

The drive of all above-mentioned pumps is normally effected by a three-phase current motor, controllable fluid clutch, and torque converter. This driving method allows for slow starting, and disconnection of the unit. This is required for preventing pressure surges, and vacuum surges, in case of acceleration and deceleration of the fluid column. The variety of driving methods cannot be treated here.

Hydraulical auxiliary tools in connection with hydraulically actuated valve and cylinder closures allow for quick and easy exchange of wear parts.