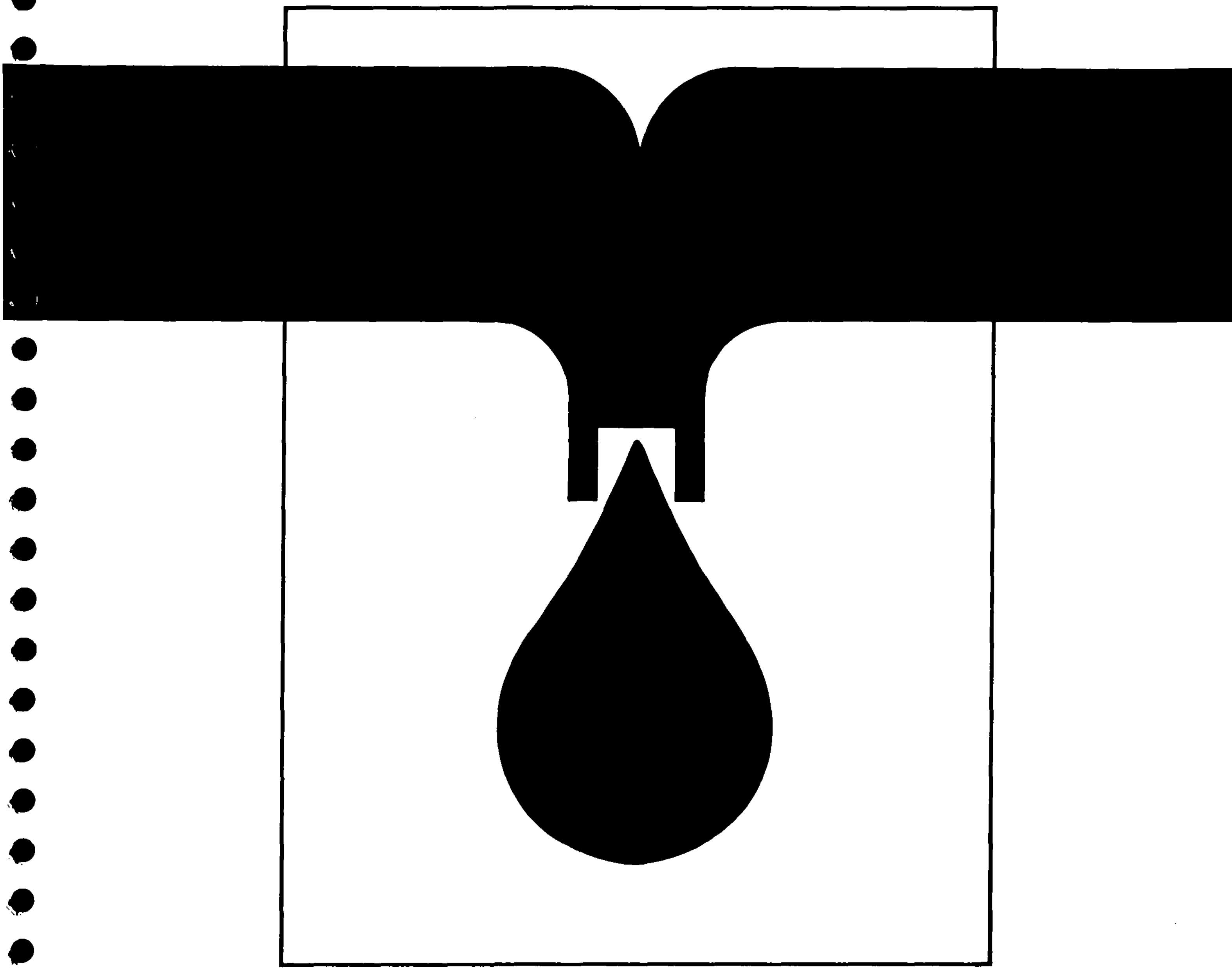
TRAINING MODULES FOR WATERWORKS PERSONNEL



Special Knowledge

2.3 d

Design, functioning, operation, maintenance and repair of power transmission mechanisms

Foreword

Even the greatest optimists are no longer sure that the goals of the UN "International Drinking Water Supply and Sanitation Decade", set in 1977 in Mar del Plata, can be achieved by 1990. High population growth in the Third World combined with stagnating financial and personnel resources have led to modifications to the strategies in cooperation with developing countries. A reorientation process has commenced which can be characterized by the following catchwords:

- use of appropriate, simple and – if possible – low-cost technologies,
- lowering of excessively high water-supply and disposal standards,
- priority to optimal operation and maintenance, rather than new investments,
- emphasis on institution-building and human resources development.

Our training modules are an effort to translate the last two strategies into practice. Experience has shown that a standardized training system for waterworks personnel in developing countries does not meet our partners' varying individual needs. But to prepare specific documents for each new project or compile them anew from existing materials on hand cannot be justified from the economic viewpoint. We have therefore opted for a flexible system of training modules which can be combined to suit the situation and needs of the target group in each case, and thus put existing personnel in a position to optimally maintain and operate the plant.

The modules will primarily be used as guidelines and basic training aids by GTZ staff and GTZ consultants in institution-building and operation and maintenance projects. In the medium term, however, they could be used by local instructors, trainers, plant managers and operating personnel in their daily work, as check lists and working instructions.

45 modules are presently available, each covering subject-specific knowledge and skills required in individual areas of waterworks operations, preventive maintenance and repair. Different combinations of modules will be required for classroom work, exercises, and practical application, to suit in each case the type of project, size of plant and the previous qualifications and practical experience of potential users.

Practical day-to-day use will of course generate hints on how to supplement or modify the texts. In other words: this edition is by no means a finalized version. We hope to receive your critical comments on the modules so that they can be optimized over the course of time.

Our grateful thanks are due to

Prof. Dr.-Ing. H. P. Haug
and
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for their committed coordination work and also to the following co-authors for preparing the modules:

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It is my sincere wish that these training modules will be put to successful use and will thus support world-wide efforts in improving water supply and raising living standards.

Dr. Ing. Klaus Erbel
Head of Division
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Eschborn, May 1987

Title: Design, functioning, operation, maintenance and repair of power transmission mechanisms

Contents:

1. Introduction and use

A wide variety of power transmission mechanisms are used in waterworks and pumping stations.

Valves and fittings are equipped with crank mechanisms, basic gear mechanisms, bevel gear mechanisms etc. The mechanisms are operated manually or by means of a motor depending on the purpose for which they are used.

Piston pumps, for example, are operated by slider-crank mechanisms. The flywheel is operated via a belt drive, which is itself driven by an electric motor or a turbine shaft.

In the case of turbine-operated centrifugal pumps, the rotational speed is increased, for example, with the aid of planetary gear mechanisms.

Variable-speed drive mechanisms are used for adjustable-speed feed devices such as proportioning systems.

A wide variety of mechanisms, from deflection pulleys to planetary gear units, are also used on hoisting gear (see Module 2.3.h).

2. Examples of actuating systems for valves and fittings

The function of actuating (or drive) systems is to move the shutoff devices of valves and fittings through the introduction of a force. They must be designed such that during the opening and closing procedure they can overcome the forces and torques occurring at the spindle or shaft with full pressure on one side.

An adequately dimensioned actuating system is particularly important in the case of valves or fittings which remain in the same position for months at a time. The type of system chosen, and its design, are determined by the nature of the valve or fitting and its size.

The simplest means of actuating gate valves with a fairly small nominal diameter is a pull rod with handle (Fig. 1). In the case of large nominal diameters and high back pressures, the rod is supplemented by a leverage system and thus corresponds to a crank mechanism (Fig. 2).

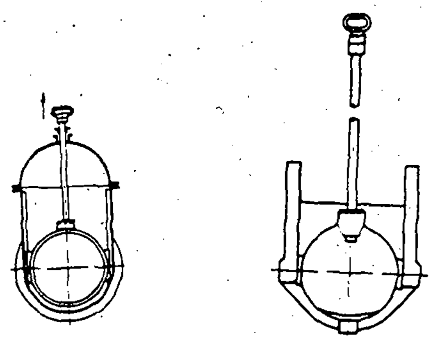


Fig. 1 Pull rod with handle

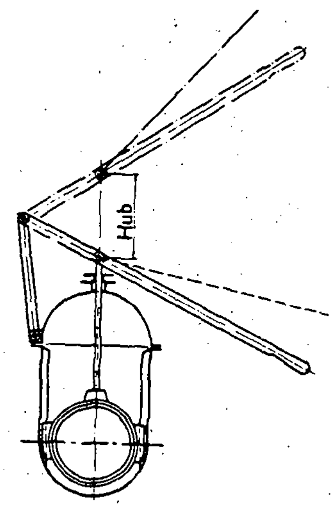


Fig. 2 Pull rod with leverage system

The most common actuating system for valves and fittings is the screw spindle with handwheel. Valves and fittings of any nominal diameter can be operated in this way depending on the handwheel diameter, thread pitch and transmission mechanism used. Figs. 3 - 10 show examples of various types of gate-valve actuating systems.

Fig. 3 shows a standard actuator with handwheel and screw spindle. The spindle mounting takes the form of a friction bearing. A better mounting and greater ease of operation are afforded by the ball-bearing version shown in Fig. 4.

Fig. 5 shows a bevel gear mechanism which can be used to change the direction of actuation.

Fig. 6 shows a cylindrical gear mechanism, used primarily to increase the actuating force.

Figs. 7 and 8 show the two above-mentioned types of mechanism with ball bearings.

Figs. 9 and 10 show a combined bevel/cylindrical gear mechanism, with and without ball bearings. This design can be used to transmit high torques.

If intermediate gears are fitted, the number of hand turns per stroke is multiplied in proportion to the transmission ratio by comparison with that required if the spindle is actuated directly.

This results in longer closing times, particularly for pipe fittings with a large nominal diameter. The mechanisms used for standard valves are similar to those used for gate valves.

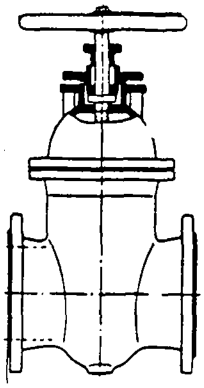


Fig. 3

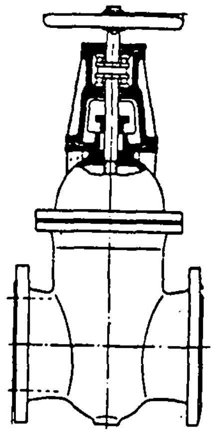


Fig. 4

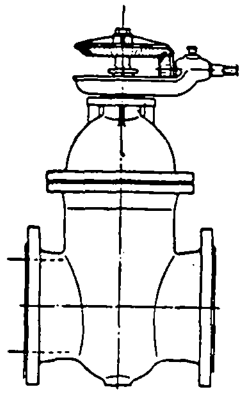


Fig. 5

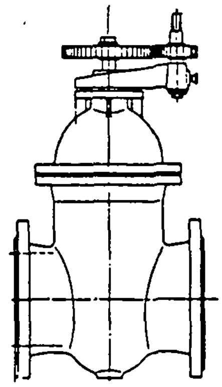


Fig. 6

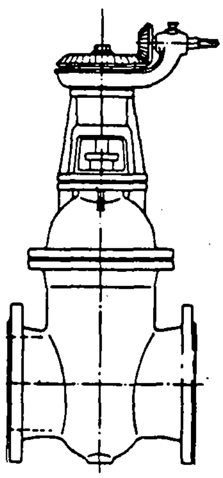


Fig. 7

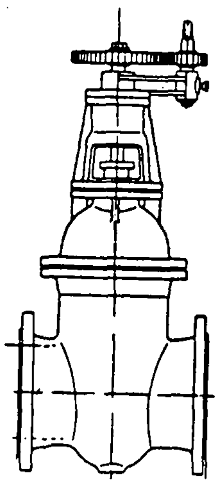


Fig. 8

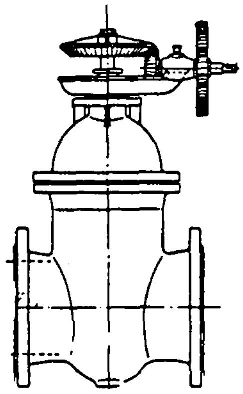


Fig. 9

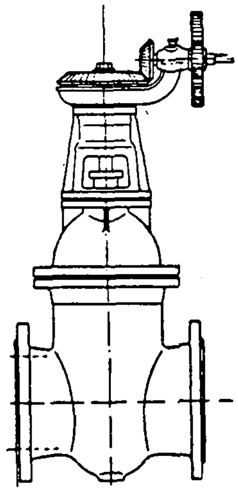
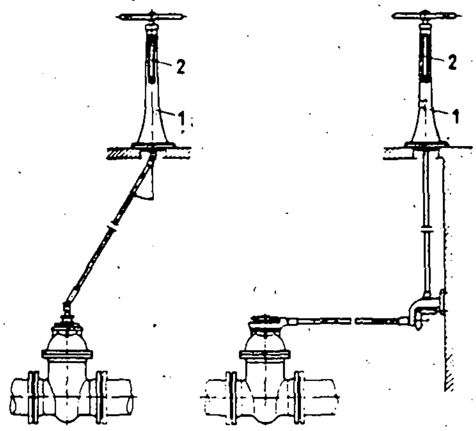


Fig. 10

Fig. 3 Screw spindle
Fig. 4 Screw spindle with ball bearing
Fig. 5 With bevel gear mechanism without ball bearing
Fig. 6 With cylindrical gear mechanism without ball bearing
Fig. 7 Bevel gear mechanism with ball bearing
Fig. 8 Cylindrical gear mechanism with ball bearing
Fig. 9 Combined bevel/cylindrical gear mechanism
Fig. 10 Combined bevel/cylindrical gear mechanism with ball bearing

In machinery houses it is often necessary to locate the handwheels some way away from the valve or fitting involved, e.g. using ball joints, bevel gear mechanisms etc. There are numerous possibilities of this nature.

Fig. 11 shows two examples. The pillar (1) permits easy operation, while the position indicator (2) shows the degree of opening.



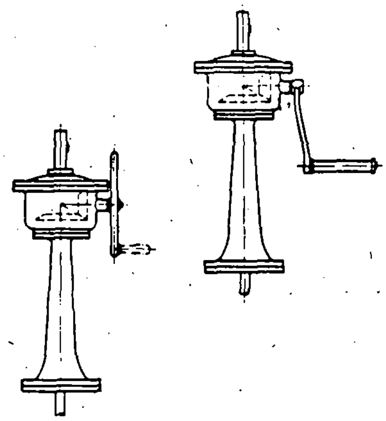


Fig. 11 Extension of actuating mechanism

Fig. 12 Enclosed bevel gear mechanism

Fig. 12 shows an enclosed bevel gear mechanism operated by means of a handwheel or crank. This system permits easy operation of pipe fittings from the machinery house floor above the pipe gallery.

Figs. 13 and 14 show actuating systems for flap valves involving an electric motor or a piston. Position switches, torque cut-off facilities and limit switches are possible with such systems (see Module 3.3.d).

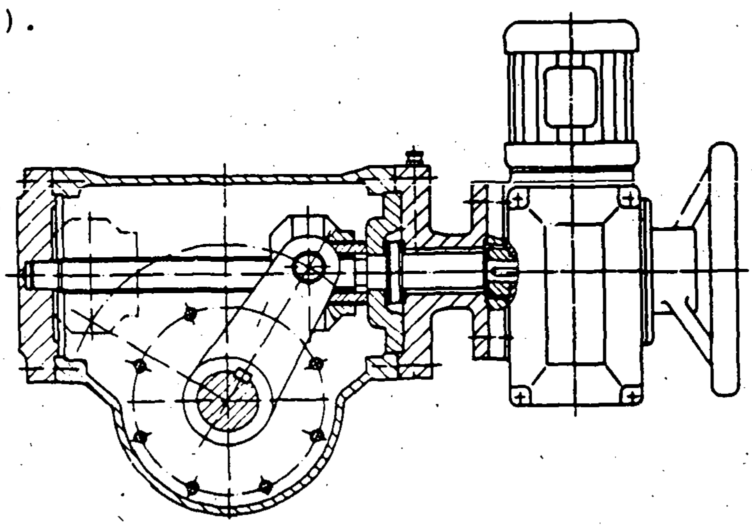


Fig. 13 Flap valve actuated by electric motor

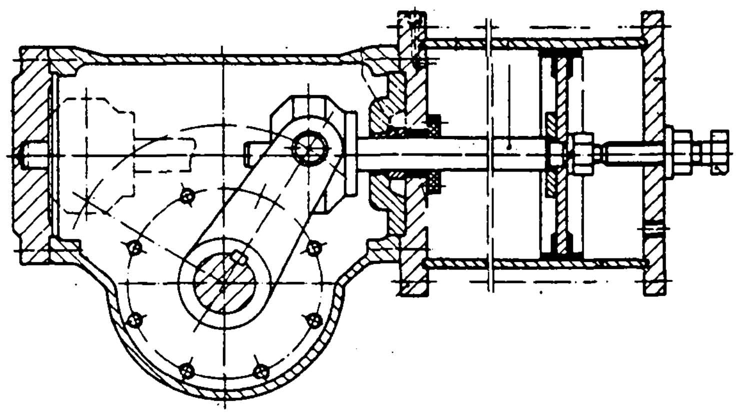


Fig. 14 Flap valve with piston actuation

3. Crank mechanisms and slider-crank mechanisms

These are used in water systems primarily for piston pumps. Fig. 15 shows a piston pump with three cylinders which is driven via a slider-crank mechanism; rotary motion is transformed into linear motion.

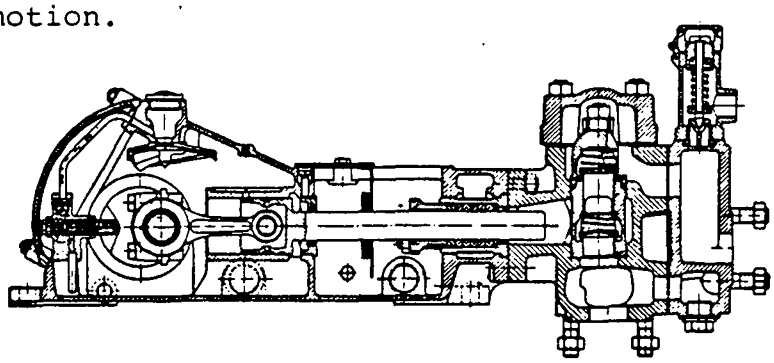


Fig. 15 Slider-crank mechanism for a piston pump

4. Belt drives

Belt drives can be used to handle wide transmission ratios. In water supply systems, belt drives are used primarily for reciprocating machines, e.g. for driving a piston pump via an electric motor or turbine. A simple belt drive is shown in Fig. 16. Conversion of the motor speed to the machine input speed is effected according to the ratio $d_1 : d_2$.

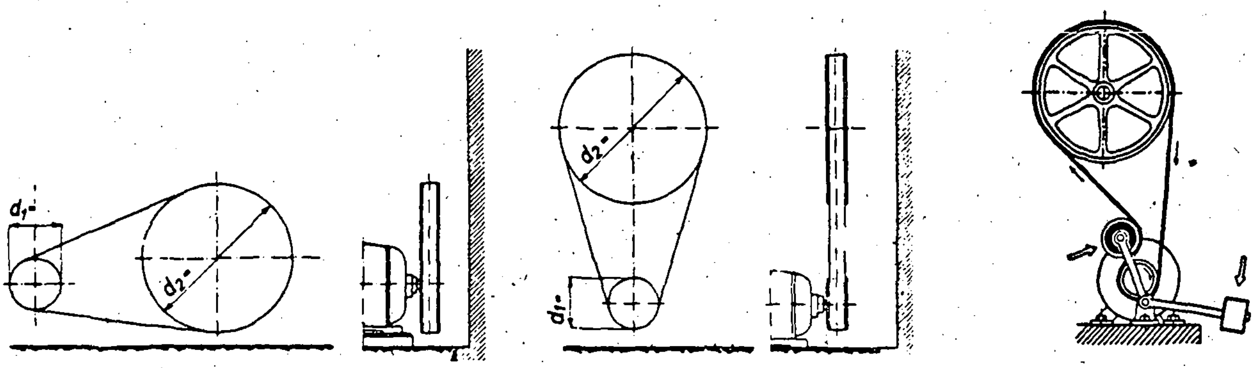


Fig. 16 Belt drive

With tensioning roller

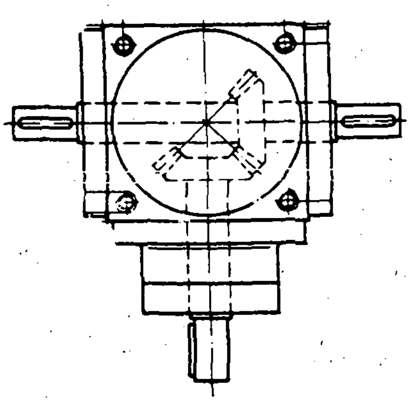
In order to minimize frictional losses, the belts are routed over appropriate tensioning devices, which prevent belt slip (a major cause of frictional losses) and protect the belt against excessive wear.

A wide variety of belt designs, such as flat belts and vee belts, are used in belt drives.

5. Basic gear mechanisms, bevel gear mechanisms and cylindrical gear mechanisms

Bevel gear mechanisms have a long service life and are relatively insensitive to elastic deformation of gears, shafts and bearings. They are also suitable for high-speed drive systems.

Fig. 17 shows some of the many possible configurations for a bevel gear mechanism.



Arrows of the same type indicate the relationship between the directions of rotation

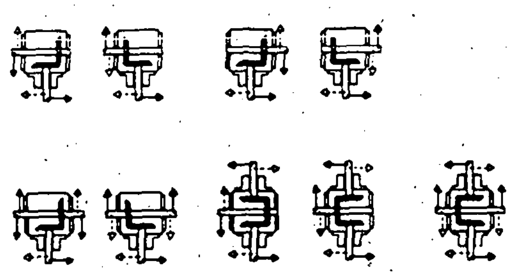


Fig. 17 Bevel gear mechanism

Bevel gear mechanisms are today fitted with curved-tooth bevel gears.

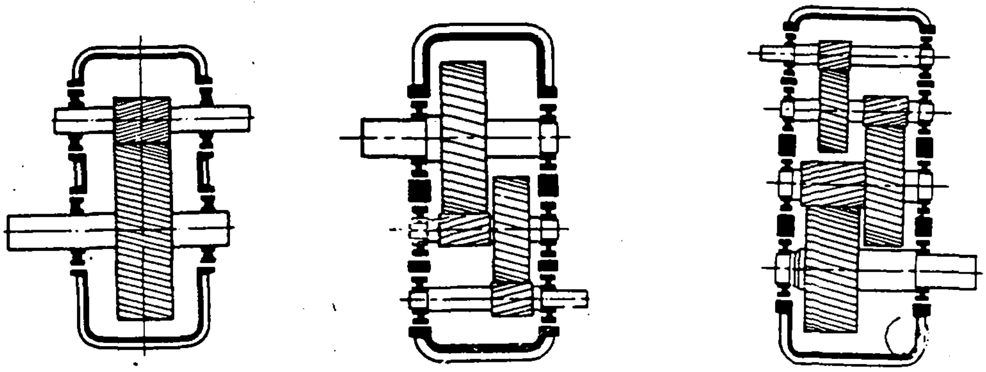


Fig. 18 Cylindrical gear mechanisms

Fig. 18 shows a single-stage cylindrical gear mechanism with single involute helical gearing, made of high-grade special steels and with rolling bearings, for transmission ratios from 1.2 : 1 to 8 : 1.
The two-stage cylindrical gear mechanism with shafts located one behind the other and single involute helical gearing is suitable for transmission ratios from 7.1 : 1 to 56 : 1.
Transmission ratios of 40 : 1 to 180 : 1 are possible with the three-stage cylindrical gear mechanism.

6. Accessories - clutches and couplings

The majority of actuators and mechanisms are linked to the part of the pipe fitting or pump etc. to be actuated by means of a clutch or coupling.
A distinction is made between couplings and clutches, as well as between friction clutches and centrifugal clutches. They are subject to severe impact loads, particularly when used with reciprocating machines. The use of flexible couplings is also advisable in drive systems for centrifugal pumps. Fig. 19 shows sections through a friction clutch, a centrifugal clutch and a flexible coupling.

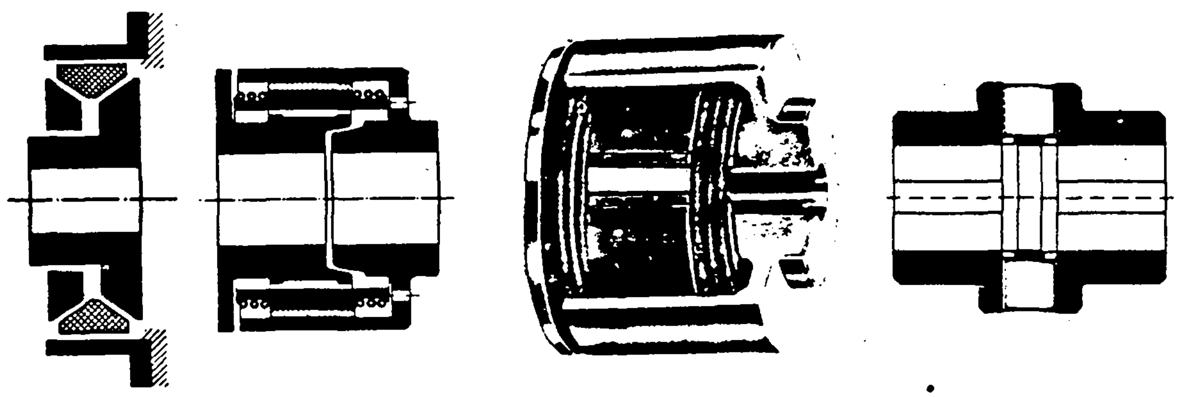


Fig. 19

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The government-owned GTZ operates in the field of Technical Cooperation. Some 4,500 German experts are working together with partners from some 100 countries in Africa, Asia and Latin America in projects covering practically every sector of agriculture, forestry, economic development, social services and institutional and physical infrastructure. – The GTZ is commissioned to do this work by the Government of the Federal Republic of Germany and by other national and international organizations.

GTZ activities encompass:

- appraisal, technical planning, control and supervision of technical cooperation projects commissioned by the Government of the Federal Republic of Germany or by other authorities
- advisory services to other agencies implementing development projects
- the recruitment, selection, briefing and assignment of expert personnel and assuring their welfare and technical backstopping during their period of assignment
- provision of materials and equipment for projects, planning work, selection, purchasing and shipment to the developing countries
- management of all financial obligations to the partnercountry.

The series **"Sonderpublikationen der GTZ"** includes more than 190 publications. A list detailing the subjects covered can be obtained from the GTZ-Unit 02: Press and Public Relations, or from the TZ-Verlagsgesellschaft mbH, Postfach 36, D 6101 Roßdorf 1, Federal Republic of Germany.

TRAINING MODULES FOR WATERWORKS PERSONNEL

List of training modules:

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