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MOVABLE BRIDGES AFFILIATE

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SESSION
WORKSHOP NOTES

Session (4-11)
"Ship-lifting-devices; An Explanation of Types", Ernst Herz, Mannesmann Rexroth, Lohr, Germany

SHIP LIFTS

by Ernst HERZ

1. Introduction

Ship lifts, like river and canal locks, are employed in order to overcome gradients in navigable waterways.

This solution is particularly suitable in navigation canals in which, owing to excessive gradients and the associated high water consumption, or because of unsuitable subsoil conditions, the installation of locks would be impractical or too expensive.

The ship lift option may also be more attractive as compared with a locking system (single lock or staircase system) because of the intensity of shipping traffic involved or because it represents lower construction and maintenance costs.

Modern ship lifts, generally speaking, are able to transfer vessels upstream and downstream at a faster rate and within a shorter horizontal distance than is the case with lock systems.

The water loss involved is also considerably lower, as it is normally restricted to the relatively small outflow volume which occurs during vessel entry/exit cycles and general see page through worn or damaged seals.

As a result, transfer operations between the lift system and the adjacent water channels result in only minimal swell and turbulence.

2. Ship lift designs

The most important ship lift designs are indicated in the table in *Fig. 1*.

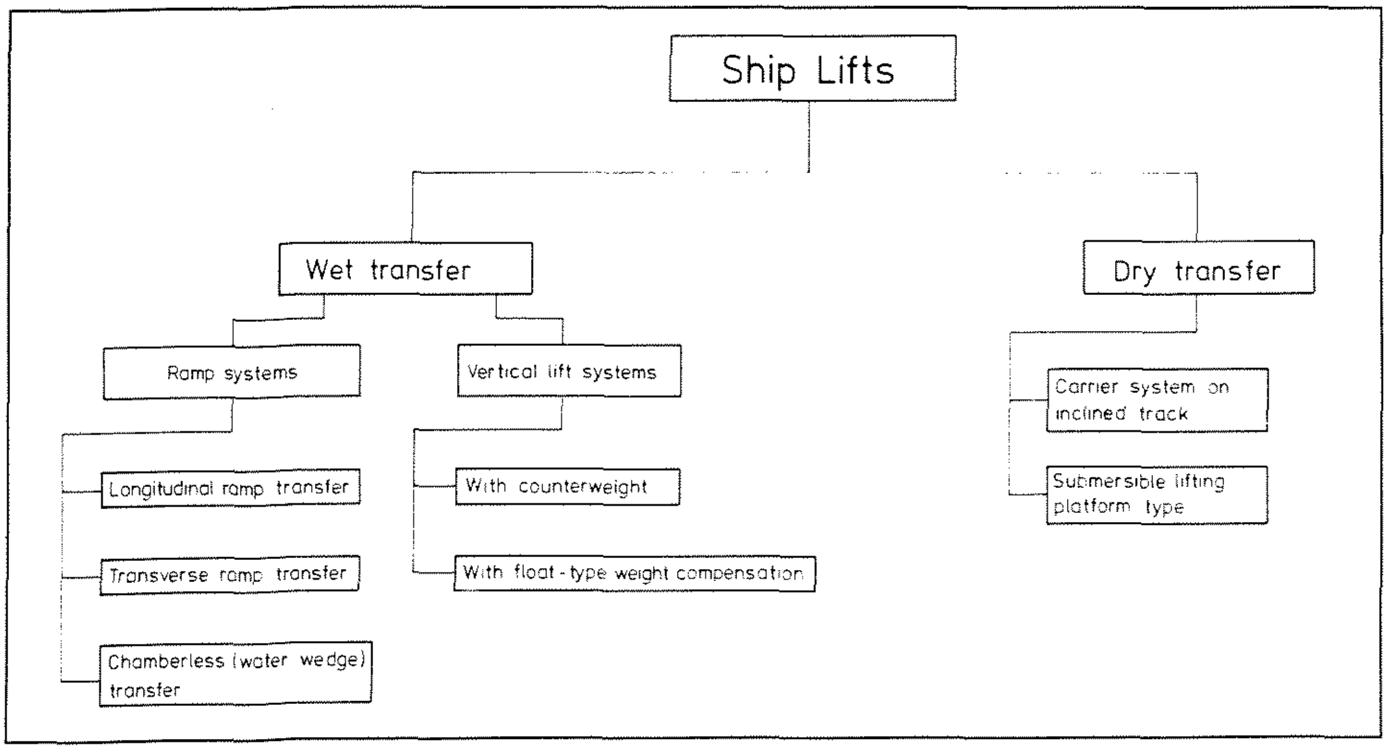


Fig. 1

2.1 Dry transfer

The dry transfer mode is based on the principle of placing the vessel on a carrier (transfer carriage, or a transfer platform), which is then transported to the upper or lower channel.

This method has the considerable disadvantage that the supports for the vessel on the carrier have to be adjusted to suit the specific dimensions of each individual load.
This problem alone is sufficient to discount the dry transfer option in any application involving regular shipping traffic.

The various types of dry transfer ship lift are as follows:

2.1.1 Transfer carriage with sloping travel path

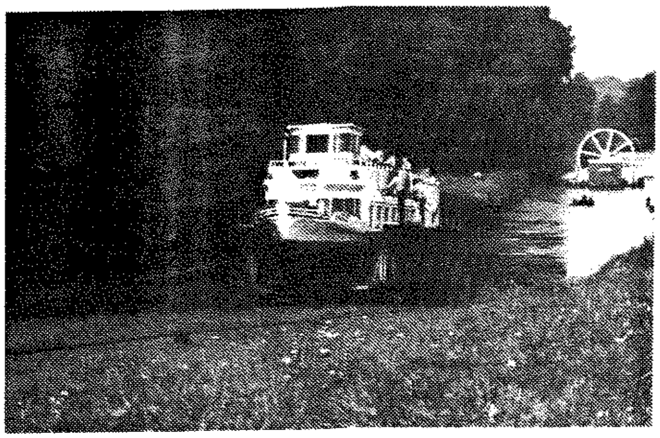


Fig. 2

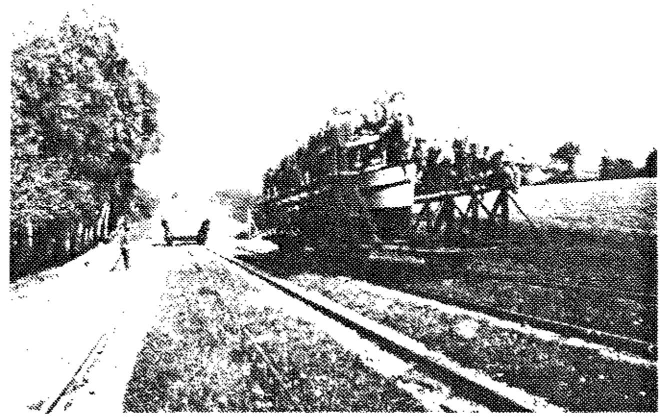


Fig. 3

The above figures show a dry lift for motor boats.

Two transfer carriages are attached to an endless rope so that they operate simultaneously in opposite directions.

They enter both the upper and lower channels to allow the boats to float into transfer position.

2.2.2 Platform lift with horizontal travel path

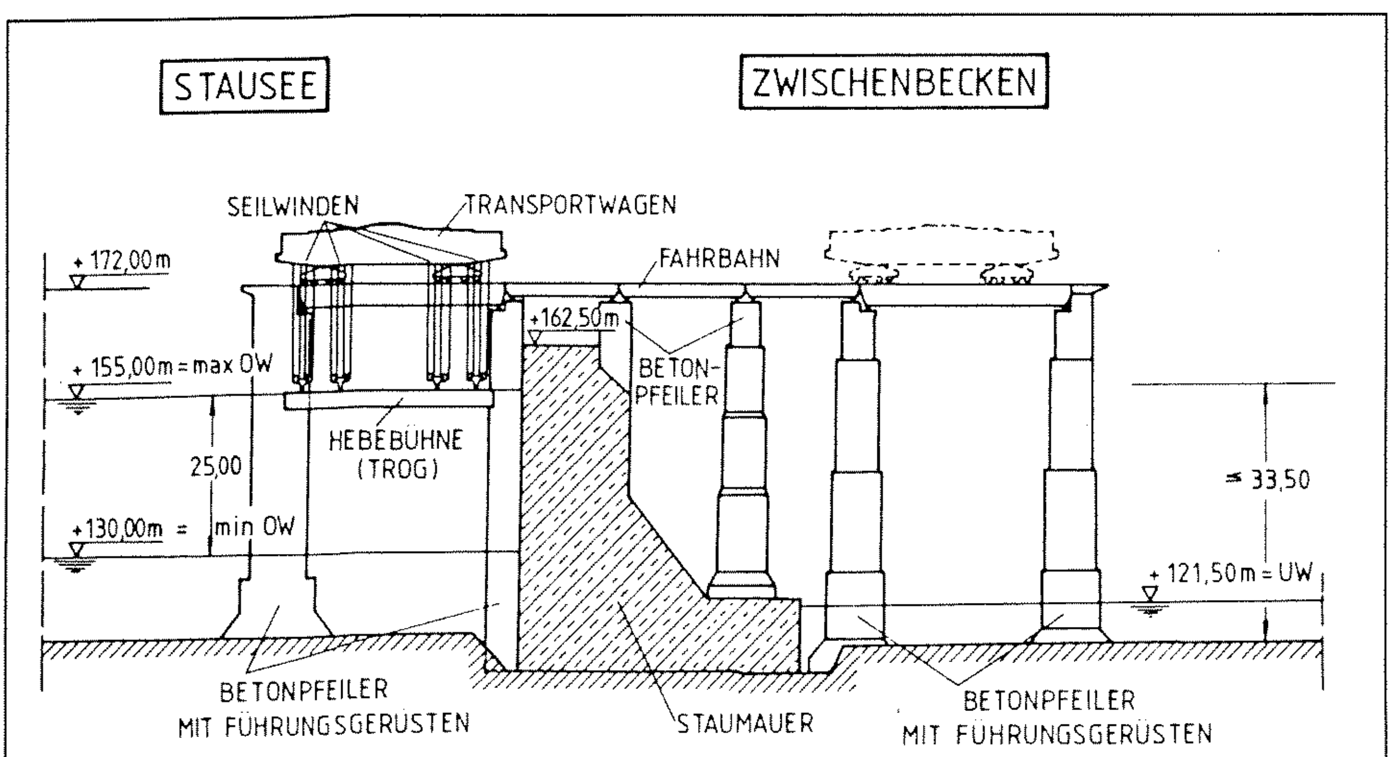


Fig. 4

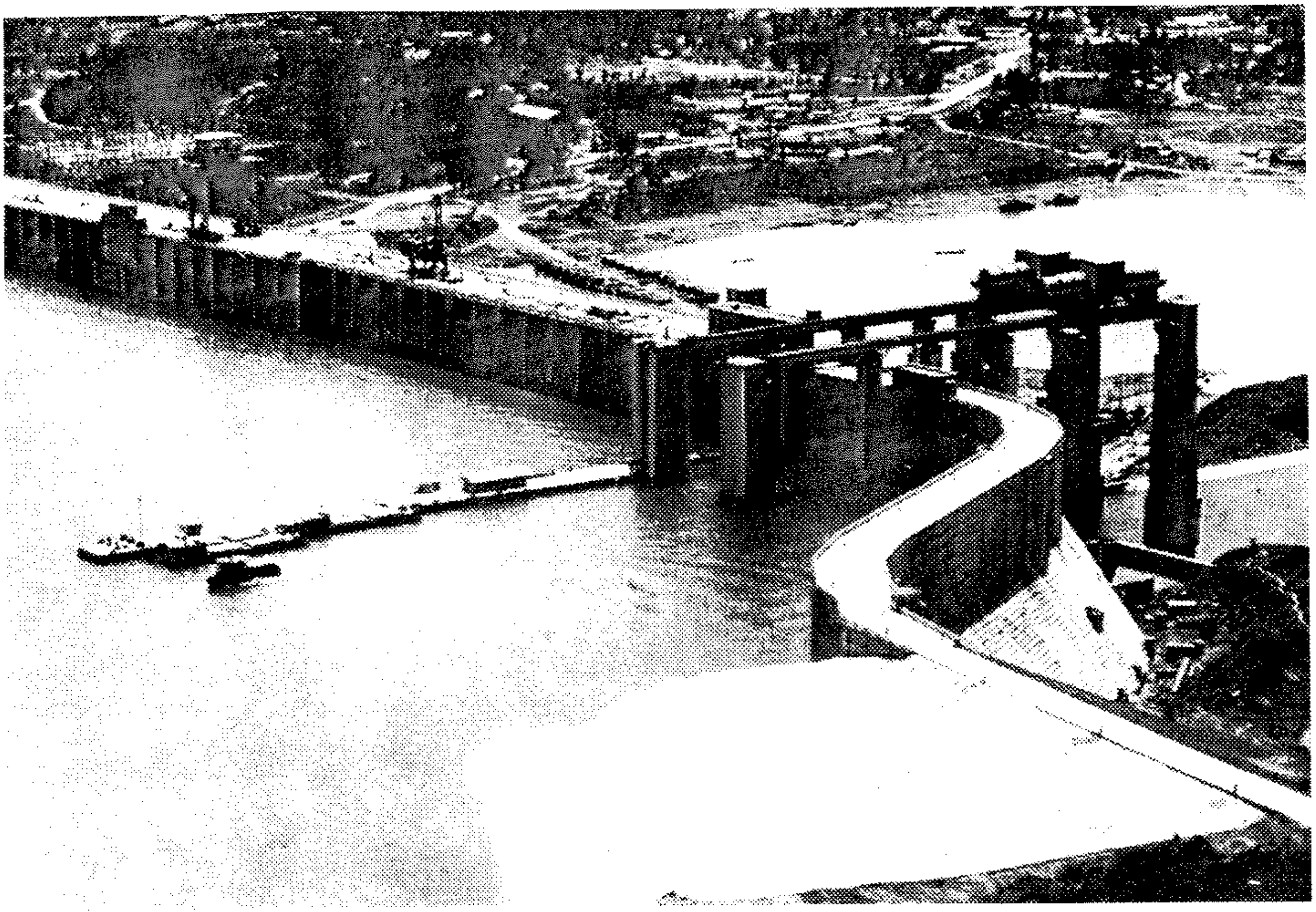


Fig. 5.1

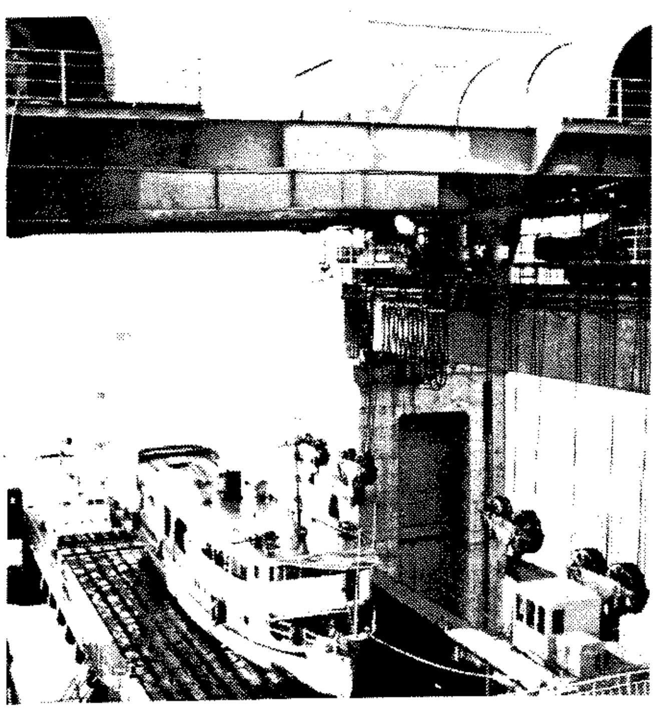


Fig. 5.2

This system entails an overhead track on which a carrier is horizontally transferred by means of hoist trolleys. Suspended from the hoists is a lifting platform.

The platform is submerged in the upper or lower channel in order to pick up or set down the vessel.

Owing to the relatively lengthy process of securing the vessel to the platform, this system is again not particularly suitable for waterways which carry regular shipping traffic.

A number of these systems have been installed in China, although the application in these cases involved only occasional transfer operations between the two levels either side of a dam.

The vessels involved are also not particularly large.

2.1.3 General

In view of the fact that dry transfer methods have failed to make any significant breakthrough, tending as they do to be employed only in canals handling minimal traffic volumes or for applications in which vessels are transferred only occasionally, this alternative will not be dealt with in any further detail.

2.2 Wet transfer

The term „wet transfer" refers to methods in which the vessel enters a water-filled lifting chamber which is then raised or lowered to the adjacent upstream or downstream channel.

Wet transfer methods have the advantage that vessels of differing size can be transported quickly and efficiently without the need for elaborate support or securing means. Moreover, the weight of the water-filled lifting chamber remains virtually the same with or without the vessel load.

The obvious advantage as compared with dry transfer methods is that the operating cycle is considerably shortened.

The two basic wet transfer systems are as follows:

2.3 Ramp transfer

Ramp transfer systems fall into the following categories:

2.3.1 Longitudinal lifting chamber transfer

Here the lifting chamber is transferred up or down the ramp along its longitudinal axis.

2.3.2 Transverse lifting chamber transfer

In this system the tracks are arranged transverse to the lifting chamber longitudinal axis.
Both the longitudinal and transverse transfer systems are further subcategorized into systems with or without a counterweight/weight balancing system.

Counterweight/weight balancing systems have the advantage that the deadweight of the water-filled lifting chamber is largely, compensated out, so that, broadly speaking, the installed capacity of the drive system can be limited to that required to overcome the frictional forces and the horizontal forces derived from the inclination of the transfer track.

2.3.3 Transferable water „wedge" systems (chamberless)

This third alternative involves moving the vessel together with a „wedge" of water on which it floats along the inclined channel by means of a lowerable obturating plate. This seals the channel and then is moved in a longitudinal direction by means of the two cars between which it is pivot-mounted.

2.4 Vertical lift systems

In vertical transfer ship lifts, the deadweight of the water-filled lifting chamber is largely balanced - to between 95% and 98% - by means of an appropriate auxiliary arrangement.

Again, there are two basic system types:

2.4.1 Ship lifts with conventional counterweight

2.4.2 Ship lifts with float type weight compensation

In the following, each of the 5 types of wet transfer system is described in greater detail on the basis of pratical examples.

3. The Ronquières ramp type ship lift

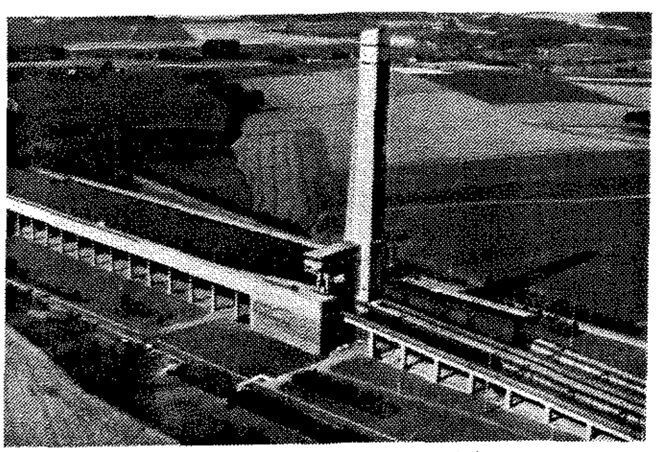


Fig. 6: *Longitudinal transfer with counterweight*

The Ronquières twin lift system was designed on the basis of the following specifications:

Lifting height	68.0 m
Track inclination	1 : 20
Track length	1430 m
Designed as a twin lift system with two *individually operated lifting chambers*	
Total lifting chamber weight (depending on water level)	max. 5700 t
Counterweight	5200 t

Drive system: 8 ropes	
d =	55 mm
Vmax. =	1.2 m/sec.
Drive rating	6 x 125 kW
Acceleration ta =	3 min
Deceleration tb =	3 min

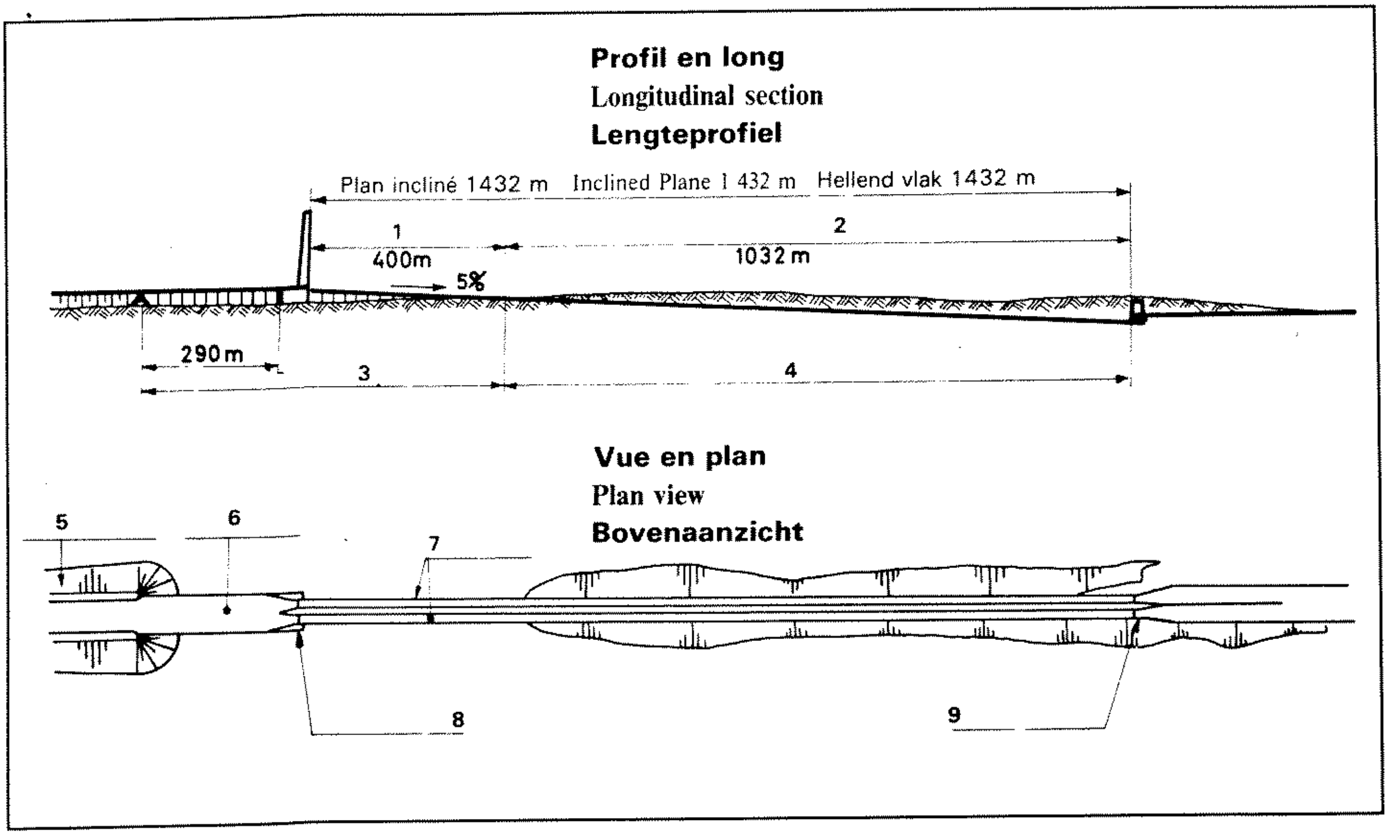


Fig. 7: *The inclined plane and environs*

General description:

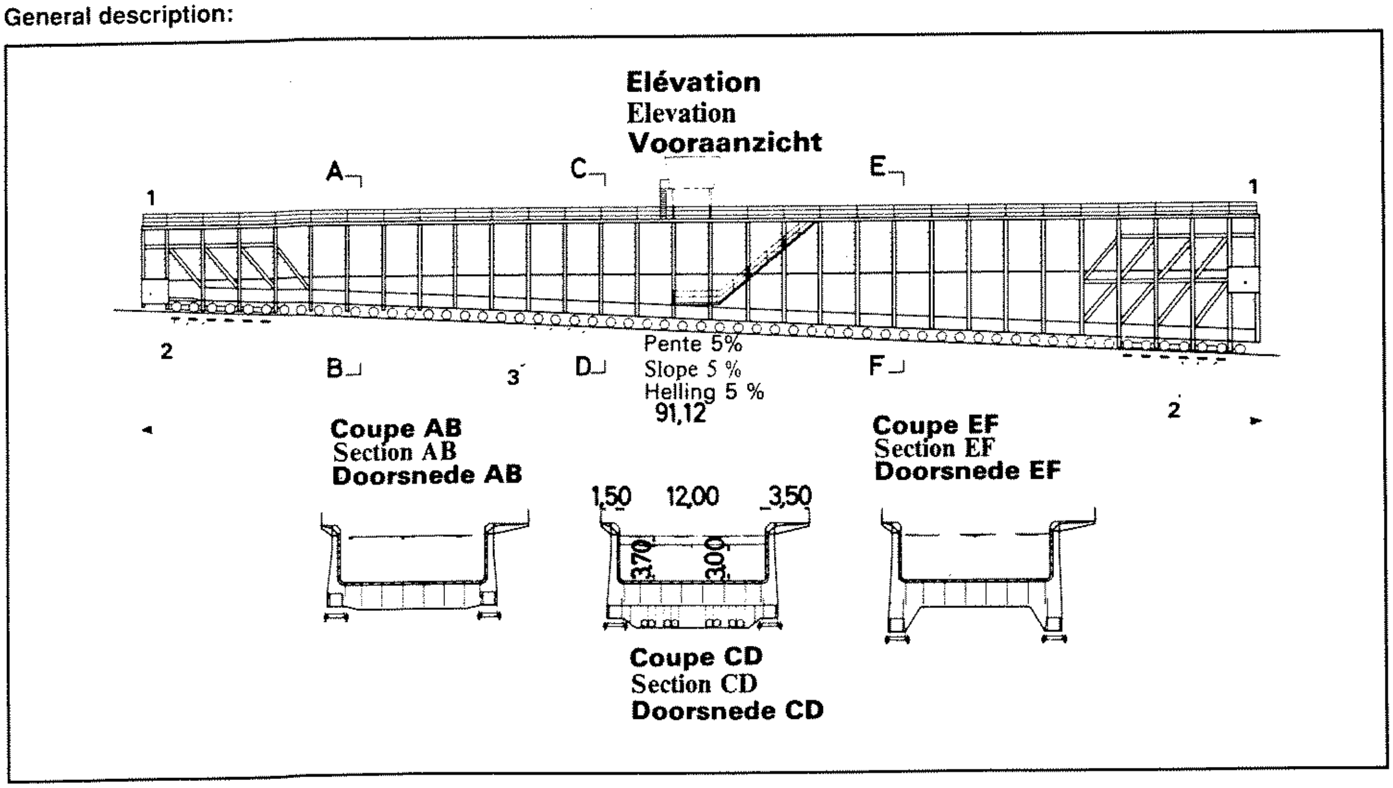


Fig. 8: *Cage*

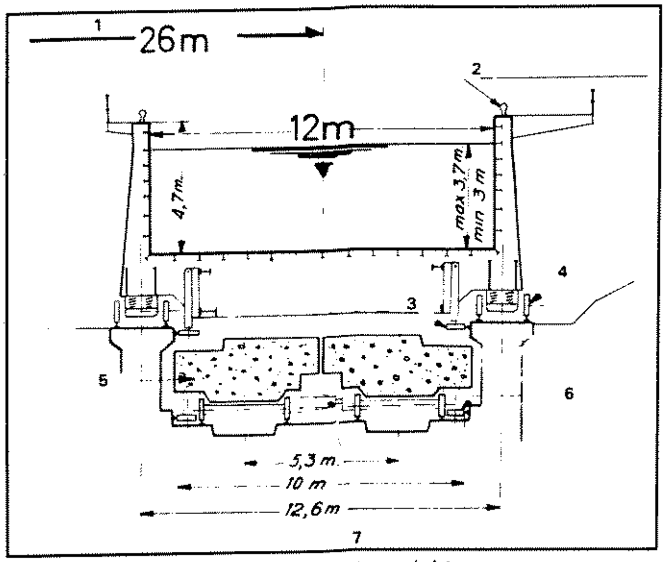


Fig. 9: *Section of cage and counterweight*

Each lifting chamber runs on two tracks with a track gauge of 1700 mm.

Arranged under the lifting chamber is a total of 58 wheel pairs.

The system also features a spring suspension system in order to ensure even load distribution.

The counterweight travels in the opposite direction at a level beneath the lifting chamber.

The counterweight runs on 48 spring-mounted wheel pairs along an appropriately designed track.

The 8 hoist ropes are connected via hydraulic cylinders to the counterweight in order to ensure even rope tension.
The power unit with the Koepe type driving pulleys (5.5 m diameter) is located in the machine house on the upper channel gate structure. See *Fig. 10.*

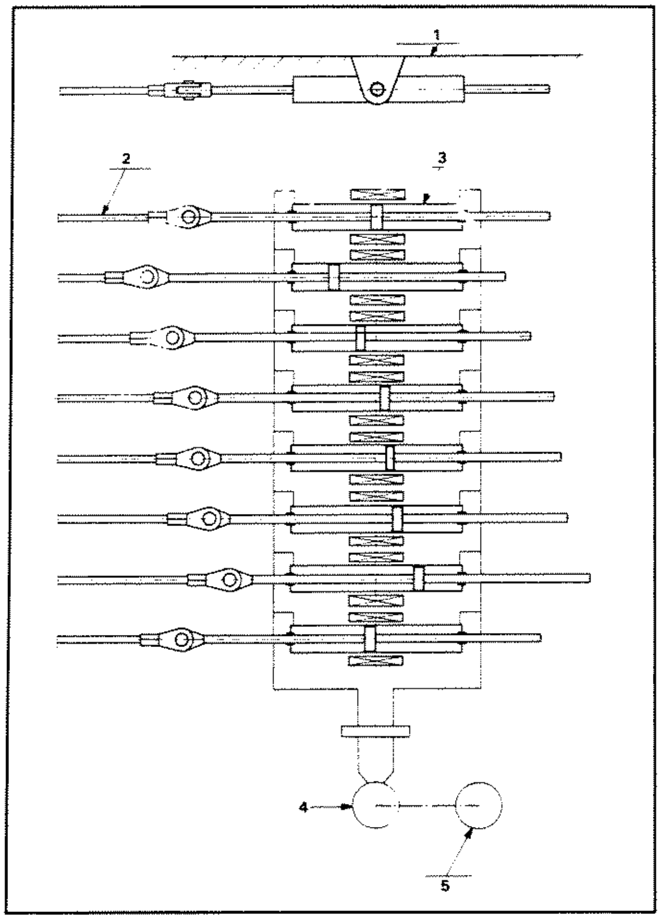


Fig. 10: *Cage coupling*

The pure transfer time for the 68 m height differential, i.e. a ramp travel of 1430 m, is 22 minutes. Allowing for the vessel entry and exit time into and out of the lifting chamber, the cycle rate can be expected to average approx. one upstream and one downstream transfer per hour.

With the twin arrangement, therefore, this means that two vessels can be transferred up and two down per hour.

The overall performance capabilities of the system can be estimated on the basis of the above values.

4. The Krasnoyarsk longitudinal transfer ramp type lift without counterweight

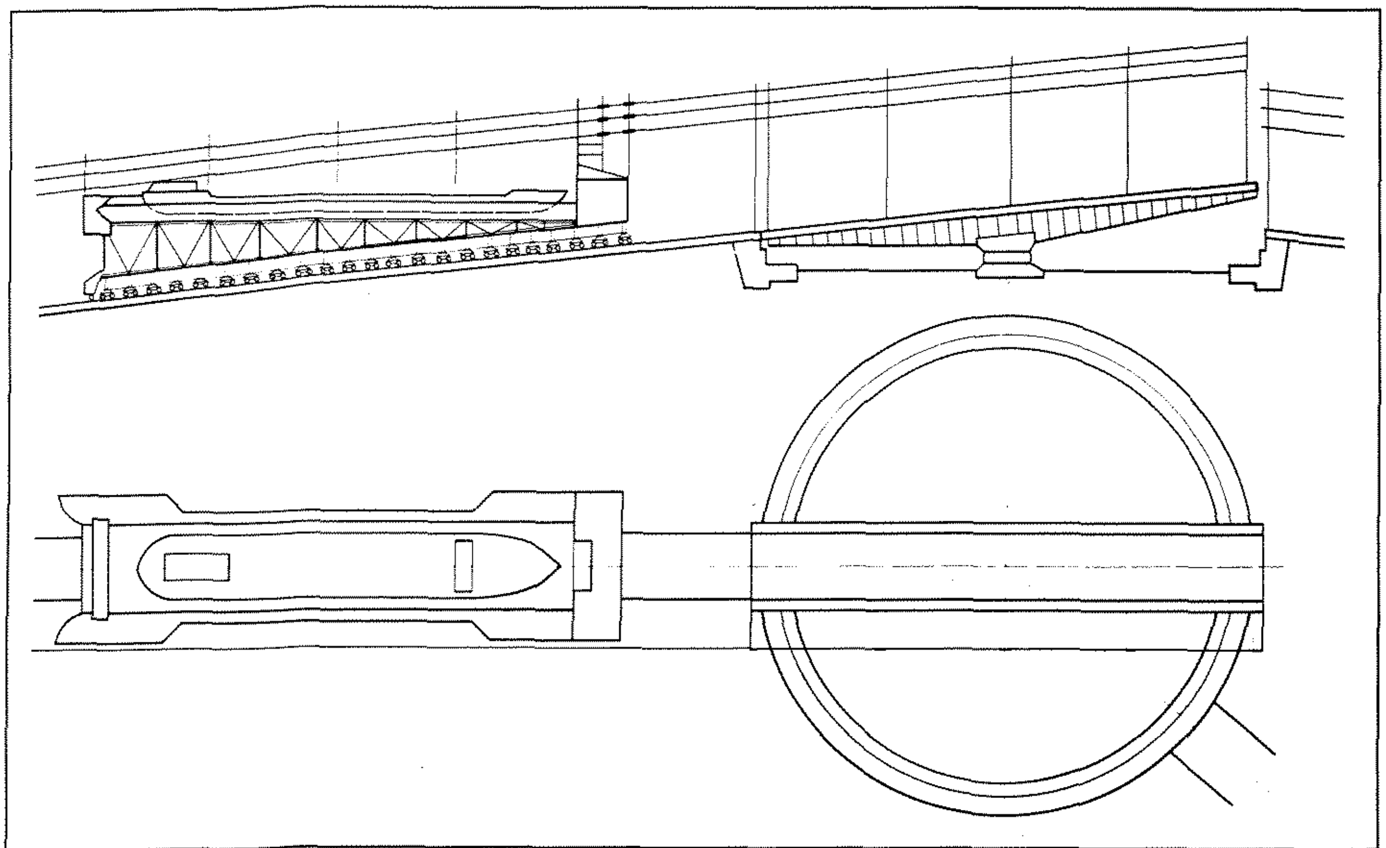


Fig. 11

Another longitudinal ramp ship lift was installed in the USSR near Krasnoyarsk.

The project involved maintaining navigation along the river Yenisei in Siberia during work on the dams and power plant which were being built on the river in order to enhance its potential for hydroelectric power generation.

Completion of the Krasnoyarsk dam resulted in a hydraulic head of max. 100.1 m, subject to seasonal pondage fluctuations of up to 13 m.

Here again, a longitudinal ramp lift was chosen as the means for overcoming the ensuing height differential, the track inclination this time being 1:10.

As the undercarriage of the longitudinal transfer lifting chambers are matched to the angle of inclination of the track, it was necessary in this case to rotate the carriage approx. 180° on the dam crest in order to enable it to travel downslope by the aforementioned 13 m to the reservoir water level during the dry season.

This rotation of the complete chamber carrier system meant that the installation had to be designed without a counterweight.

The system is shown in *Fig. 11*.

Specifications:

Useful lifting chamber length	90 m
Lifting chamber width	18 m
Depth of water	3.3 m
Max. vessel deadweight	2000 t
Total weight of water-filled lifting chamber	6700 t
Tare weight of the complete chamber carrier	3160 t
Travel speed	1.2 m/sec.
Total installed drive power	9936 kW
Upstream/downstream cycle time	60 min.
Bridge rotation time	5 min.

The lifting chamber support structure consists of two horizontally arranged lattice assemblies with an inclined lower chord. These then transfer the weight of the chamber via the 78-wheel undercarriage onto the track installation.

Load per wheel:	45 t
Track gauge:	9 m

Either side of the track rails are the racks for the drive pinions which are arranged on a vertical shaft.

The shafts are driven by hydromotor in order to ensure even force distribution along the rack.

This also results in excellent uniformity of loading between the various pinions.

5. Arzviller ship lift, France

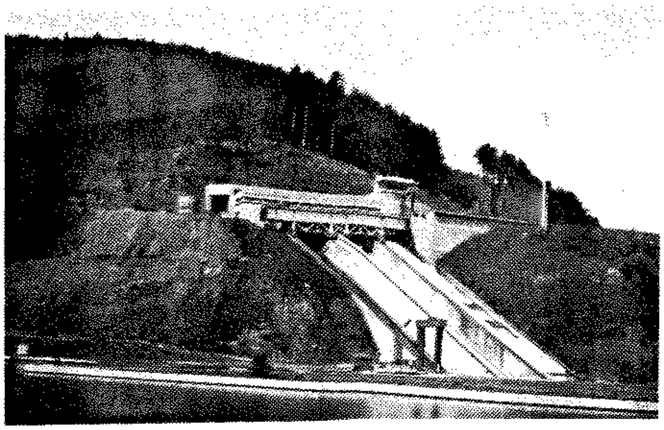


Fig. 12

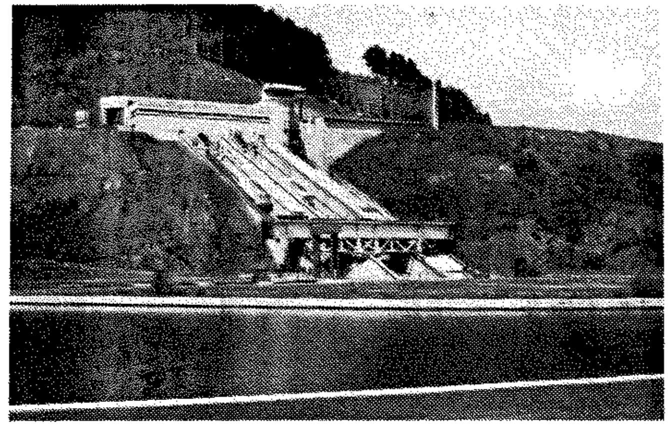


Fig. 13

Transverse ramp lift with counterweight

In 1976, as part of the modernization work carried out on the Rhine-Marne canal, a staircase lock system was replaced by a ramp type ship lift.

The lifting chamber carriage runs on a transverse ramp with a 41% inclination.

Specifications:

Lifting height:	44.5 m
Max. vessel deadweight	350 t
Useful lifting chamber length	44.5 m
Lifting chamber width	6.0 m
Depth of water in lifting chamber	2.7 m
Travel speed	0.23 m/min.
Lifting chamber weight	270 t
Weight of water in chamber	625 t
Total chamber weight	895 t
Counterweight	895 t
Drive rating	165 kW
Chamber carriage track gauge	25.75 m
Counterweight carriage track gauge	10.4 m

Figs. 12, 13 and 14 show the lifting chamber as it moves between the upper and lower channels.

General description:

Lifting chamber supported by eight bogies, each with four wheels of 700 mm dia.

Chamber drive system in the form of a rope winch with a drum diameter of 3300 mm, arranged on the upper channel gate structure in a machine house.

Winch driven by two motors of 100 kW each.

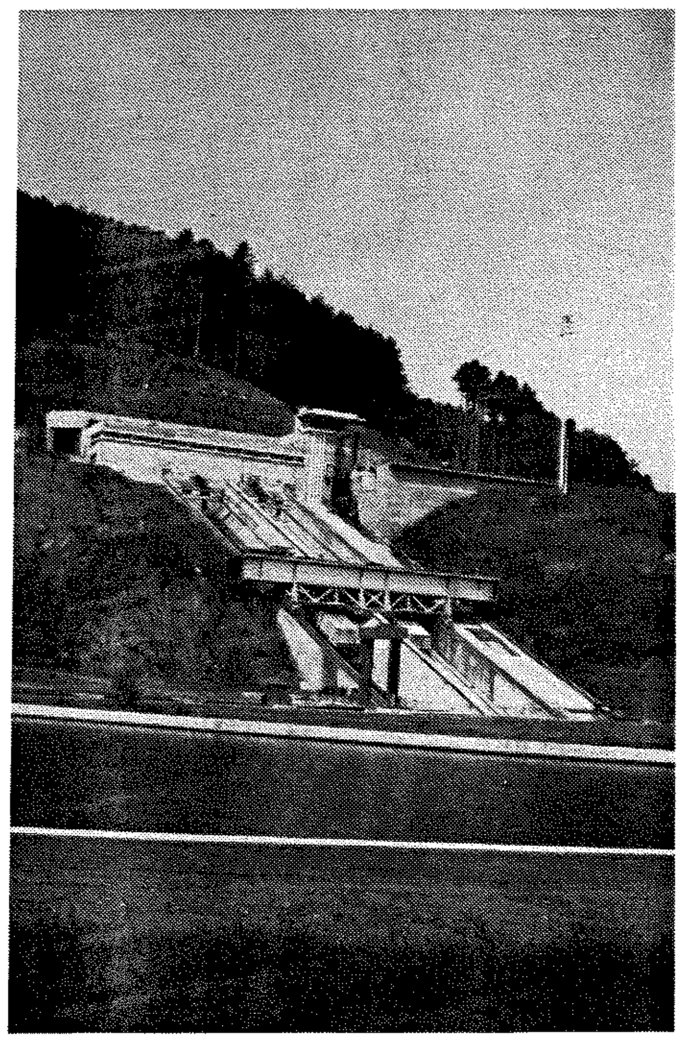


Fig. 14

6. The Montech ship lift

6.1 Chamberless („water wedge") system

The water wedge system constitutes a particularly interesting modification of the longitudinal ramp type ship lift design, as the vessels are still transferred with a supporting body of water but without a self-contained lifting chamber.

So far, this system has been employed for two installations, both of which handle only relatively small vessels.

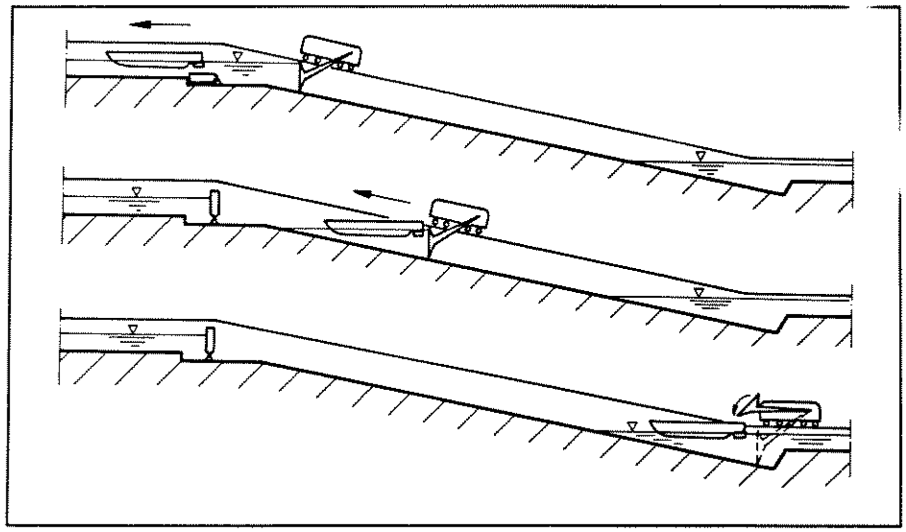


Fig. 15

Description:

In the case of the water wedge type ship lift, the height differential between the upper and lower channels is overcome by means of an inclined channel with vertical walls in which the vessel floats on a cushion of water (the wedge) during the transfer operation.
The water wedge is pushed along the inclined channel by means of a lowerable sliding plate similar in design to a radial lock gate which is sealed against the channel walls and bottom.

For upstream transfer operations, the vessel initially enters the bottom channel section. The wedge of water on which it rests is then sealed off by lowering the sliding plate.

The plate is then moved forward by the drive carriages, causing the water wedge and vessel to move up the inclined channel. The same operation is then carried out in reverse for downstream transfers.

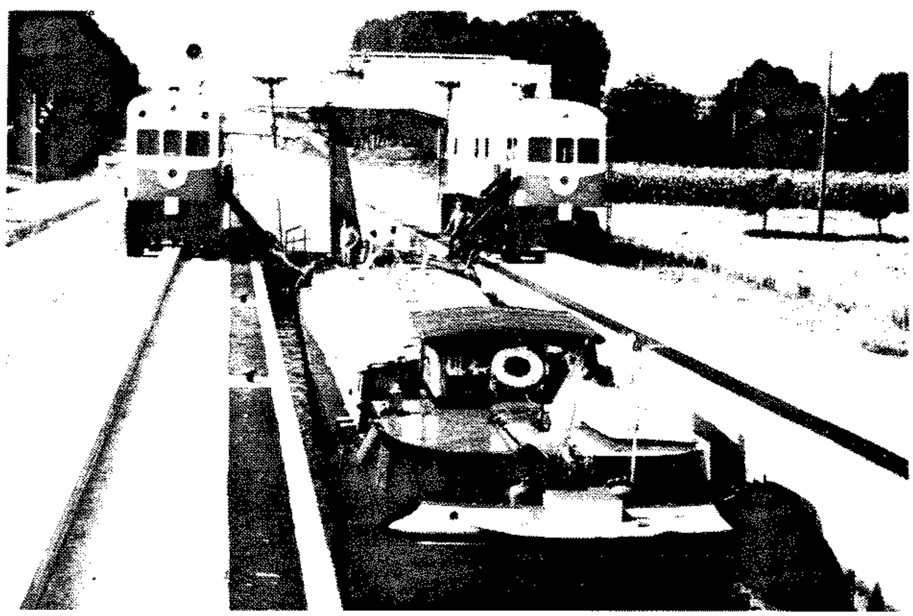


Fig. 16

Specifications:

Lifting height	13.3 m
Max. vessel deadweight	400 t
Max. vessel length	40 m
Max. vessel width	5.5 m
Min. depth of water	2.5 m
Channel inclination	3 %
Channel length	433 m
Channel width	6.0 m
Installed car power	2 x 735 kW
Max. sliding plate travel speed	1.4 m/sec.
Resultant average vessel lifting rate	2.8 m/min.

7. The Rothensee ship lift

Vertical lift system, float type weight compensation

The Rothensee ship lift was installed in order to provide a link between the Mittellandkanal and the river Elbe.

The lift features a float type weight compensation system, i.e. the deadweight of the water-filled lifting chamber is countered by means of two floats located in water-filled shafts.

Specifications:

Lifting height	18.67 m
Useful lifting chamber length	85 m
Clear width of the lifting chamber	12.2 m
Max. vessel deadweight	1000 t
Weight of the filled chamber with a water level of 2.5 m	4000 t
Total moving assembly weight incl. floats	5400 t
Max. chamber lifting or lowering time	90 sec.
Diameter of floats	10 m
No. of floats	2
Height of floats	36 m
Diameter of float shafts	11 m
Depth of float shafts	70 m
Chamber lifting speed	0.15 m/sec.

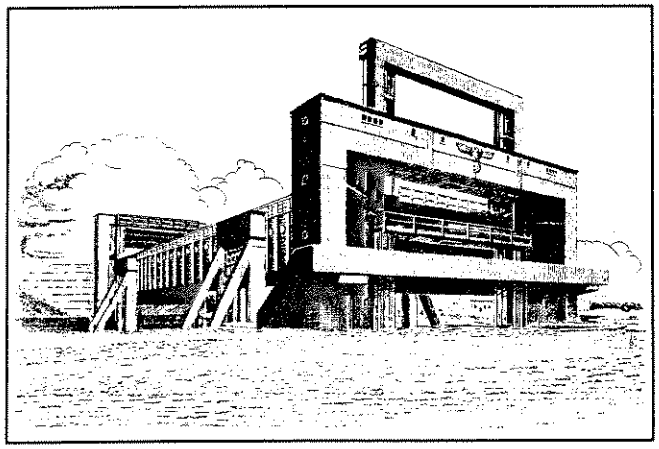


Fig. 17

The lift drive transmission takes the form of four spindles which are mounted in the guideway turrets.

The spindles remain stationary, and the lifting and lowering operations are effected by means of rotating spindle nuts, as indicated in *Fig. 20*.

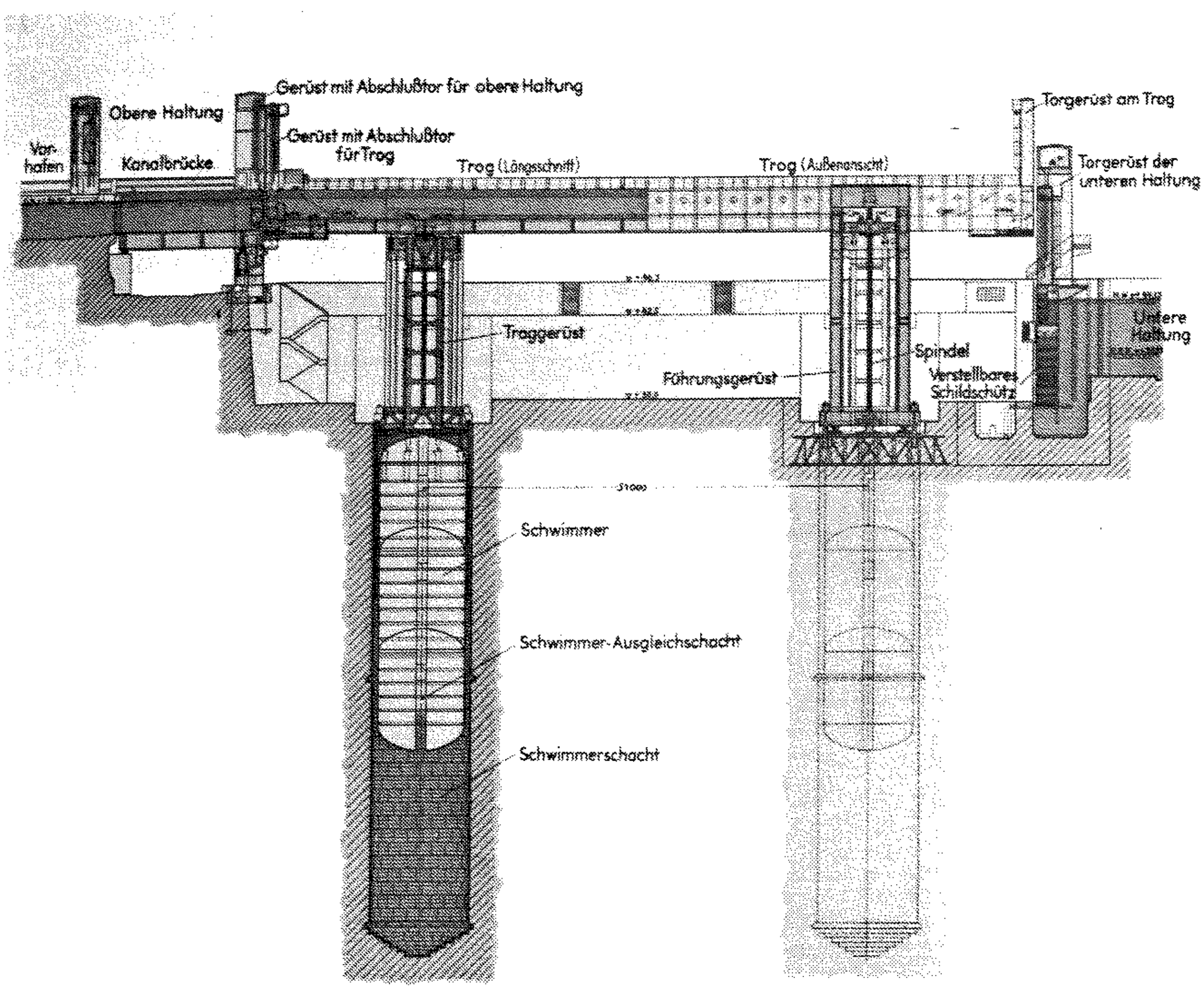


Fig. 18

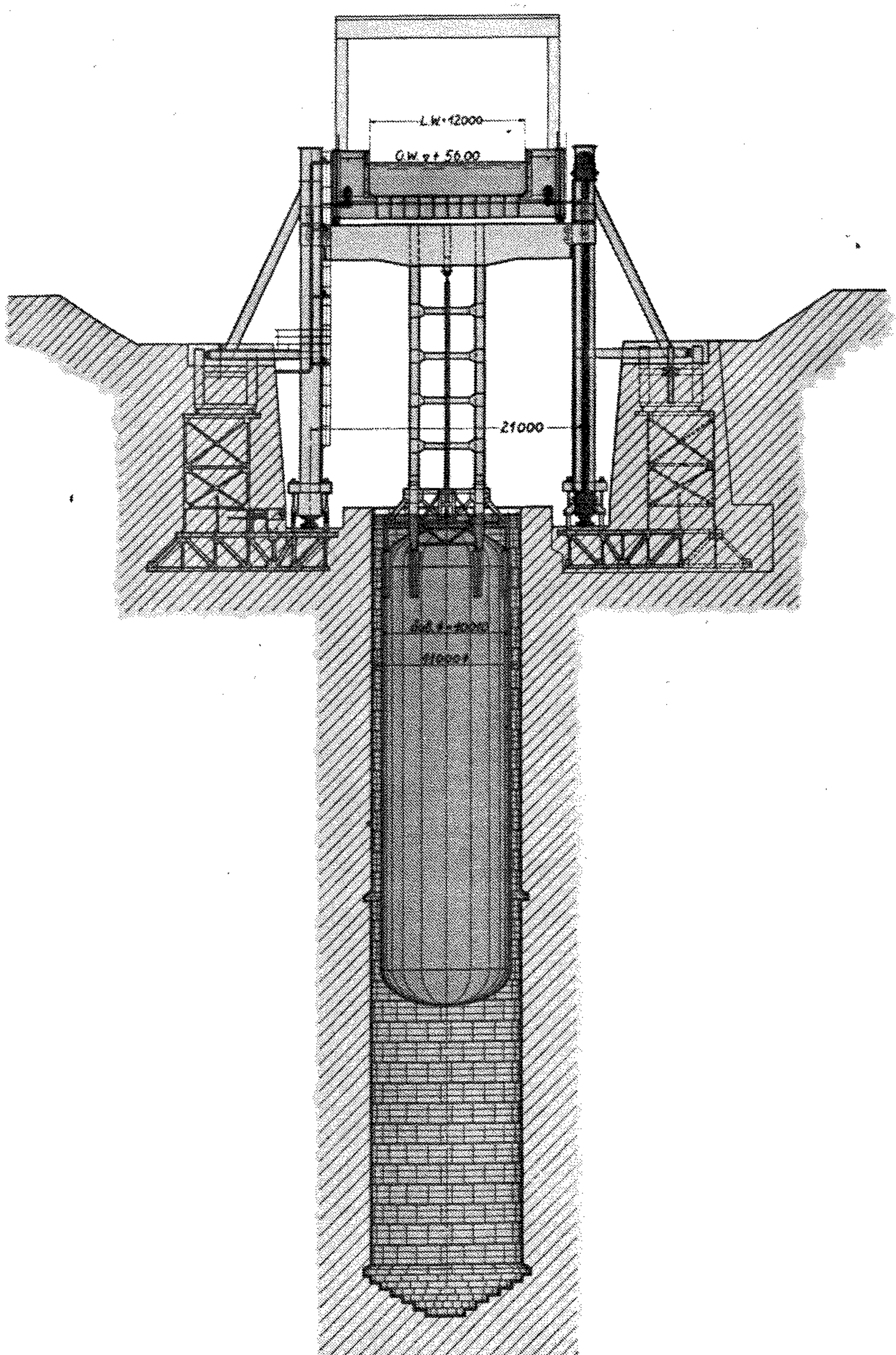


Fig. 19

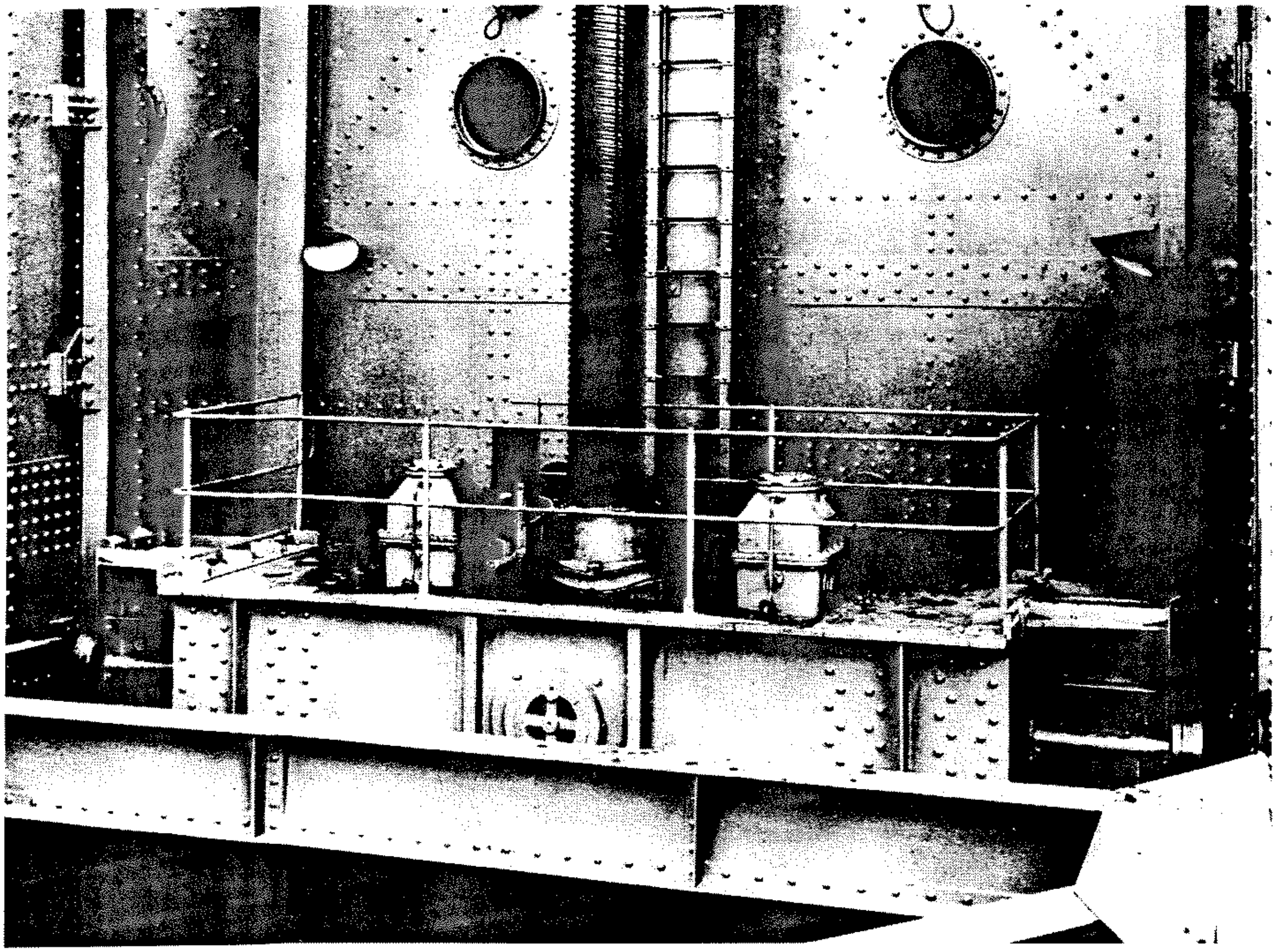


Fig. 20

The four nut drives are mechanically linked to one another.

The spindle threads are self-locking and dimensioned such that they can absorb worst-case emergency loads resulting from

a) a sudden loss of water from the lifting chamber
b) a rapid upward surge from the floats.

The two ends of the lifting chamber are fitted with lifting gates:

- The upstream side lifting gate and an additional safety gate at the end of the channel.

- A shield gate with a built-in lifting gate at the bottom. As the downstream water level can fluctuate by approx. 6.30 m, depending on the water level of the Elbe, it was necessary to arrange the downstream channel gate in a vertically adjustable shield.

The height of this shield is vertically adjusted according to the water level of the Elbe, so that the lower channel gate is always in the right position. Needless to say, the vertical travel of the lifting chamber is also adjusted to the vertical position of the shield, i.e. the lower position of the chamber is adapted to the changing water levels of the lower channel.

8. Ship lifts at Henrichenburg

Vertical lift system, float type weight compensation

In 1898 the Dortmund-Ems canal was built as part of a project involving expansion of the canal network in western Germany.

This canal provides a link between the North Sea ports and the Ruhr district.

The Ruhr district constitutes Germany's main iron and steel production area.

In particular the canal serves as a cheap supply route for transporting the iron ore from abroad to the steel mills.

In order to provide a link to the industrial region around Dortmund, one of the main centres of the German iron and steel industry within the Ruhr district, a ship lift was also installed which, at the time, was regarded as an outstanding engineering achievement. It remained in service until 1970.

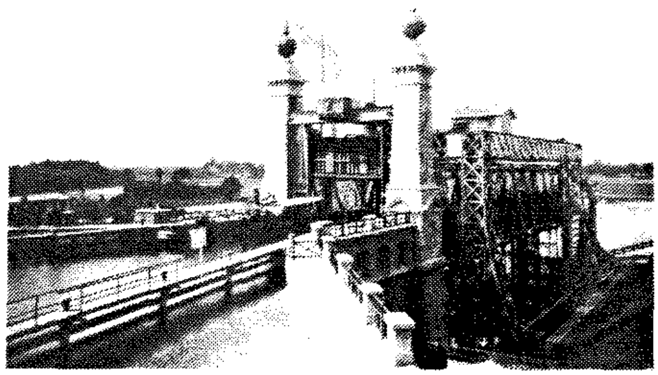


Fig. 21

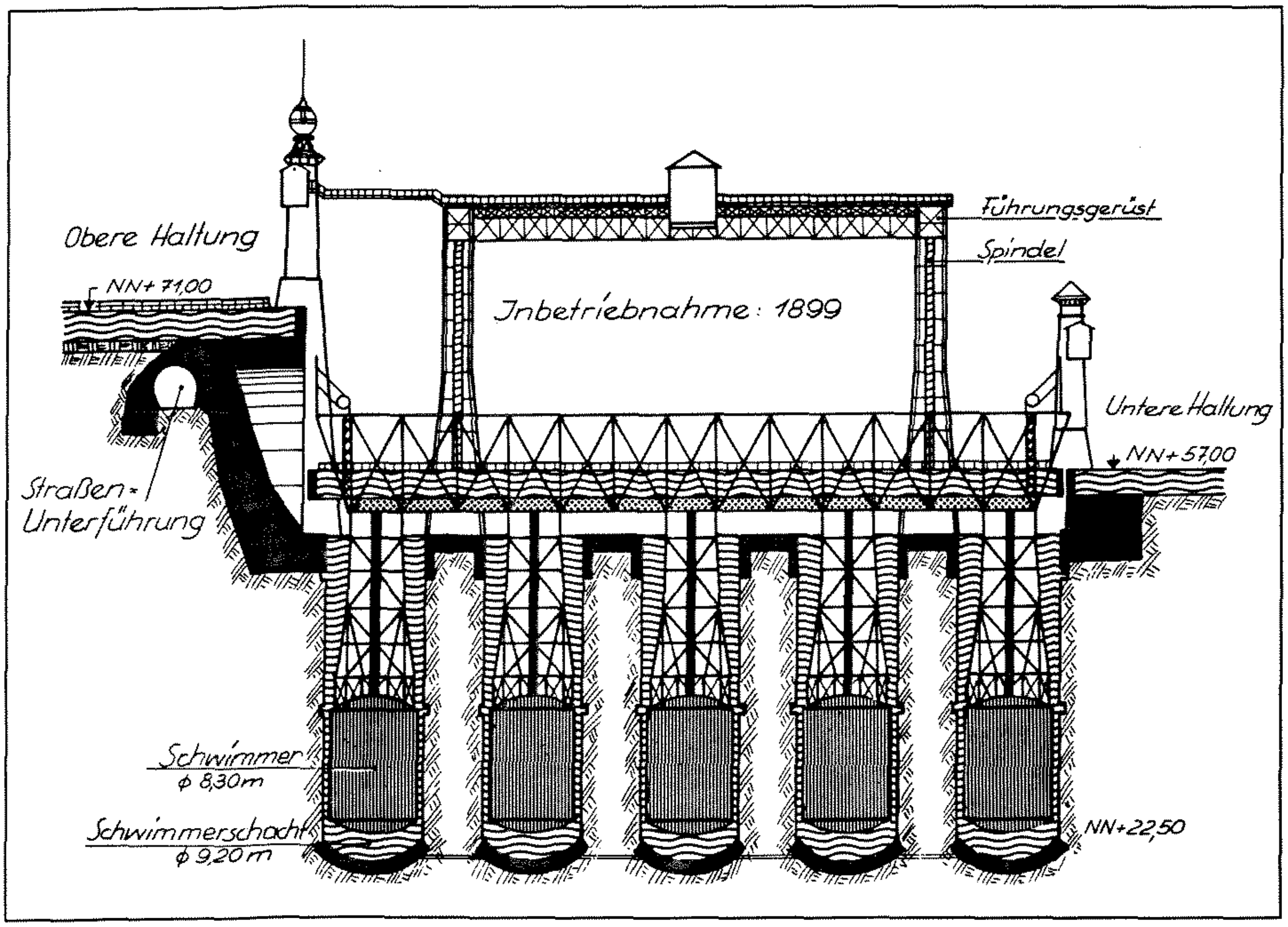


Fig. 22

It was designed with a float type weight compensating system, i.e. the deadweight of the lifting chamber was balanced by a system of floats located in water-filled shafts.

Figs. 21 and 22 show the old lift from two different aspects.

Because the old lift was unable to cope with the enormous growth in shipping traffic volumes which began towards the end of the 1950's and the general increase in vessel size, it was replaced in 1962 by a new system.

Specifications of the new ship lift:

Lifting height	13.75 m
Lifting chamber length	90 m
Lifting chamber width	12 m
Water depth in lifting chamber	3 m
Max. vessel deadweight	1350 t
Lifting chamber weight incl. support structure	870 t
Weight of water fill	3500 t
Chamber deadweight plus weight of water compensated by means of two floats	
Diameter of floats	10 m
Height of floats	35.3 m
Water displacement per float approx.	2500 cm^3

Dimensions of the float shafts:

Diameter	11.32 m
Depth	52.48 m

The lifting chamber is guided by four columns which also house the drive spindles.

The drive system in this case involves rotating spindles and stationary nuts.

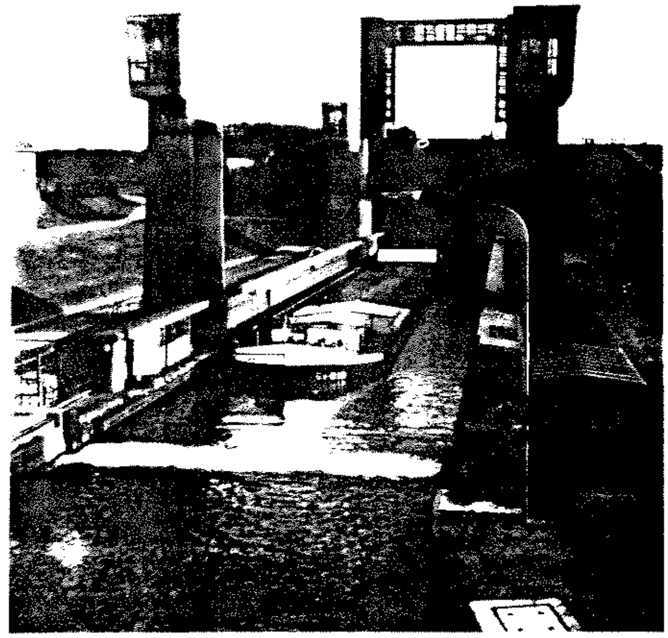


Fig. 23

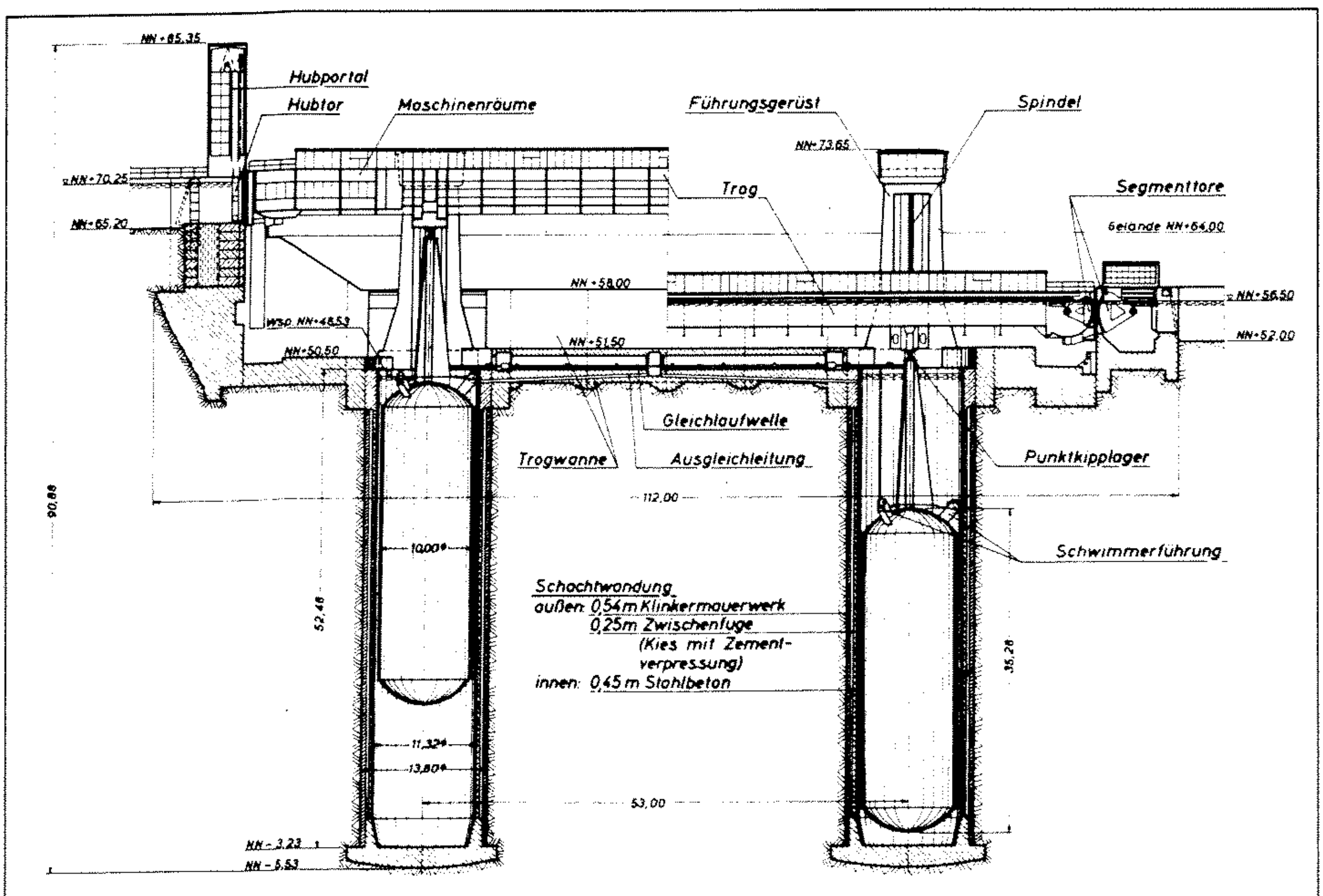


Fig. 24

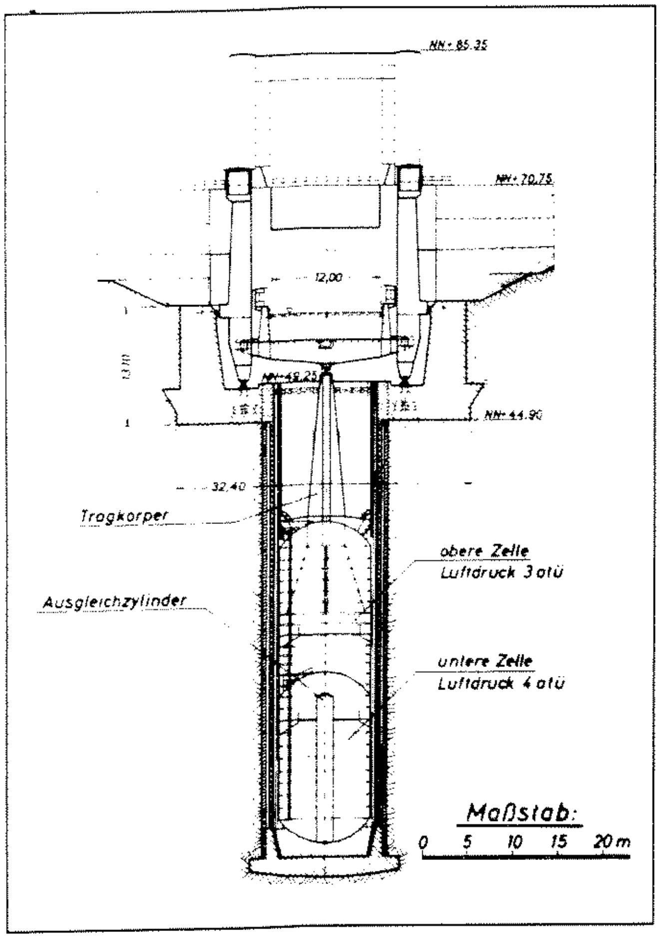


Fig. 25

The spindle nuts are mounted on the lifting chamber.

The spindles themselves are mounted in bearings so that they are always in tension. They are designed to absorb the full force of a worst-case emergency, i.e. sudden loss of water from the lifting chamber followed by a rapid upward surge of the floats.

Spindle length approx. 21.0 m
The spindle nuts are fixed to the lifting chamber by means of shock-absorbing rubber mounts. The nuts, which are replaceable, are manufactured in bronze and have a total length of 0.83 m.

The drive power is provided by four electric motors, each with a rating of 125 kW.

Lifting and lowering speed of the chamber: 0.15 m/sec.

The spindle rotary drives are located in the machine houses at the top of the guide columns.

The spindles are interconnected at the bottom of the structure by means of shafts to provide for mechanical operating synchronization.

Max. chamber lifting and lowering speed: 90 sec.

The chamber is sealed by means of radial gates featuring drives on both sides of the axle.

The upstream channel is equipped with a lifting gate, while the downstream channel is sealed by means of a radial gate with a single drive.

9. The Niederfinow ship lift

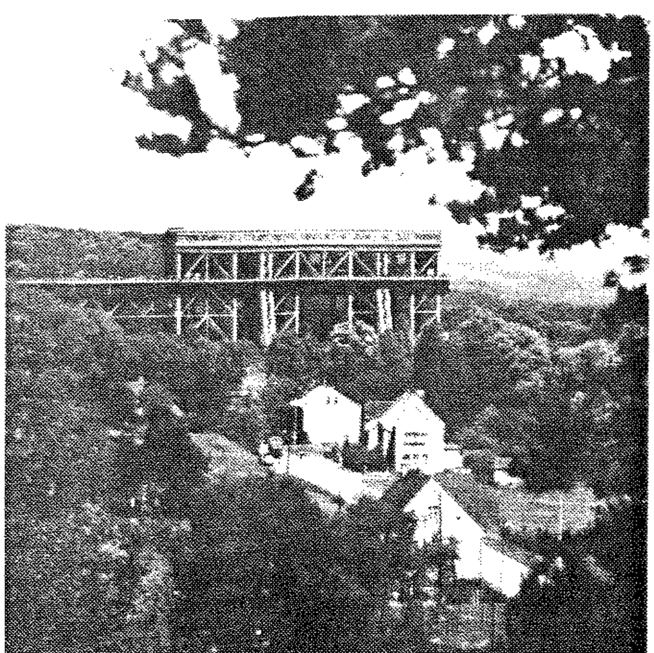


Fig. 26

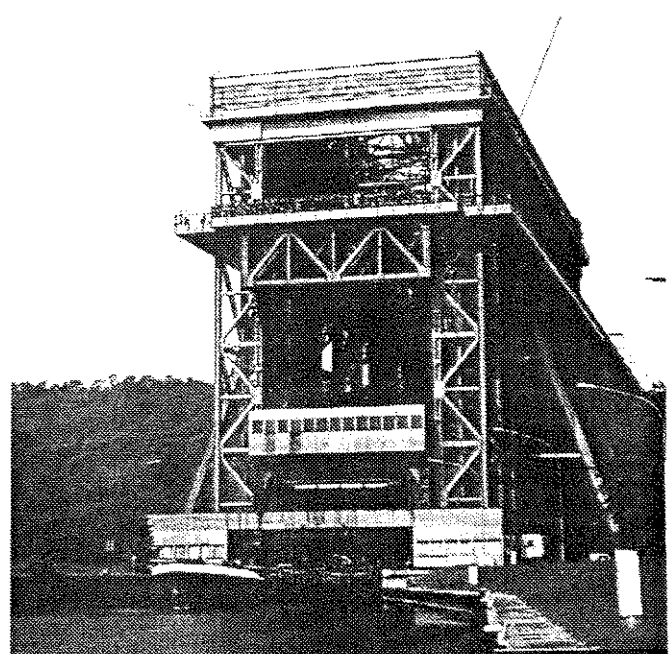


Fig. 27

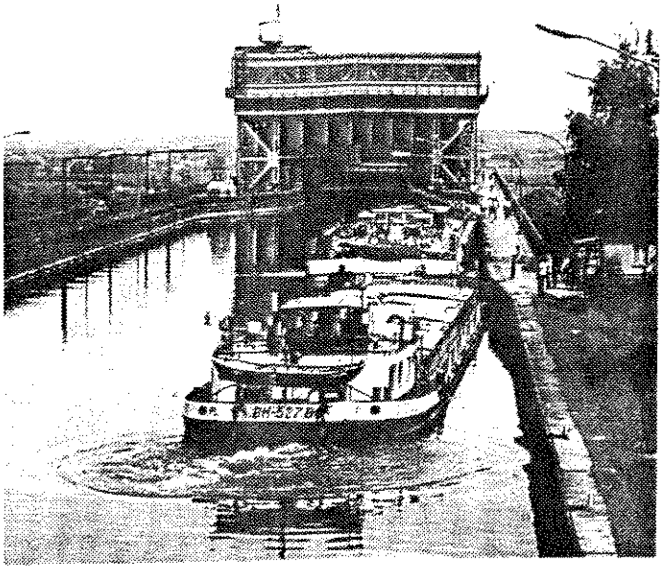


Fig. 28

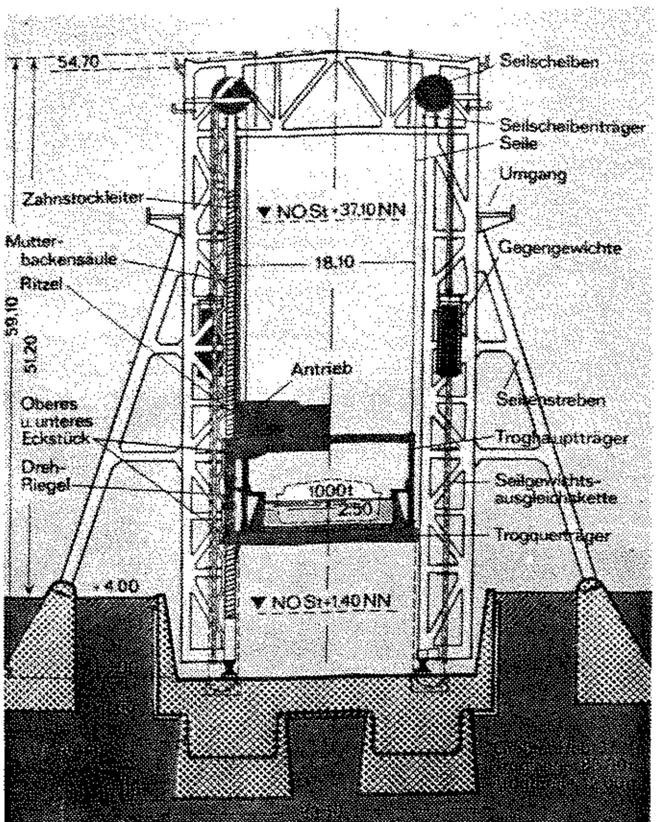


Fig. 29

9. The Niederfinow ship lift

The Niederfinow ship lift links the canal network in central Germany with the river Oder, thus providing a gateway between this canal system and the Baltic Sea ports.

The system is of the vertical lift type with counterweight balancing.

Specifications:

Useful length of the lifting chamber	85 m
Lifting chamber width	12 m
Depth of water in chamber	2.5 m
Max. vessel deadweight	1000 t
Deadweight of the lifting chamber with support structure	1600 t
Water fill	2690 t
Total weight of water-filled chamber	4290 t
Weight compensated by counterweights	
Lifting height	35.7 m

System description:

The lifting chamber is permanently supported by a latticework bridge; it is, therefore, not self-supporting.

The counterweight ropes are attached to this bridge. The counterweights run in a gantry-shaped steel structure.

Chamber lifting and lowering is effected by means of four rack-and-pinion drives.

The four racks are installed on the guide columns. The appurtenant pinions are mounted on the support frame (bridge structure) of the lifting chamber as indicated.

The drive rating of each of the four DC motors, which are connected in a Ward-Leonard circuit, is 60 kW.

The four drives are mechanically synchronized by means of a system of shafts and gear units.

The drive pinions themselves are each mounted on a rocker in order to ensure perfect engagement in the racks.

Four split-nut columns are mounted on the lifting chamber as a safety precaution in the event of a major system failure, e.g. a sudden loss of water from the chamber or rupture of a counterweight rope.

Located between the two halves of these split-nut columns is an approx. 1.40 m long threaded spindle with a core diameter of 87 mm. Under normal conditions, this rotates freely between the column nut halves by virtue of a clearance of 30 mm. For details, see *Fig. 30*.

The spindle is coupled to the appurtenant pinion drive and runs in synchronization with the motor.

In the event of a major failure, however, the spindles come into contact with, and engage in, the nuts, thus ensuring maximum safety.

The lifting chamber is sealed at both ends by a lifting gate, as are the upstream and downstream channels.

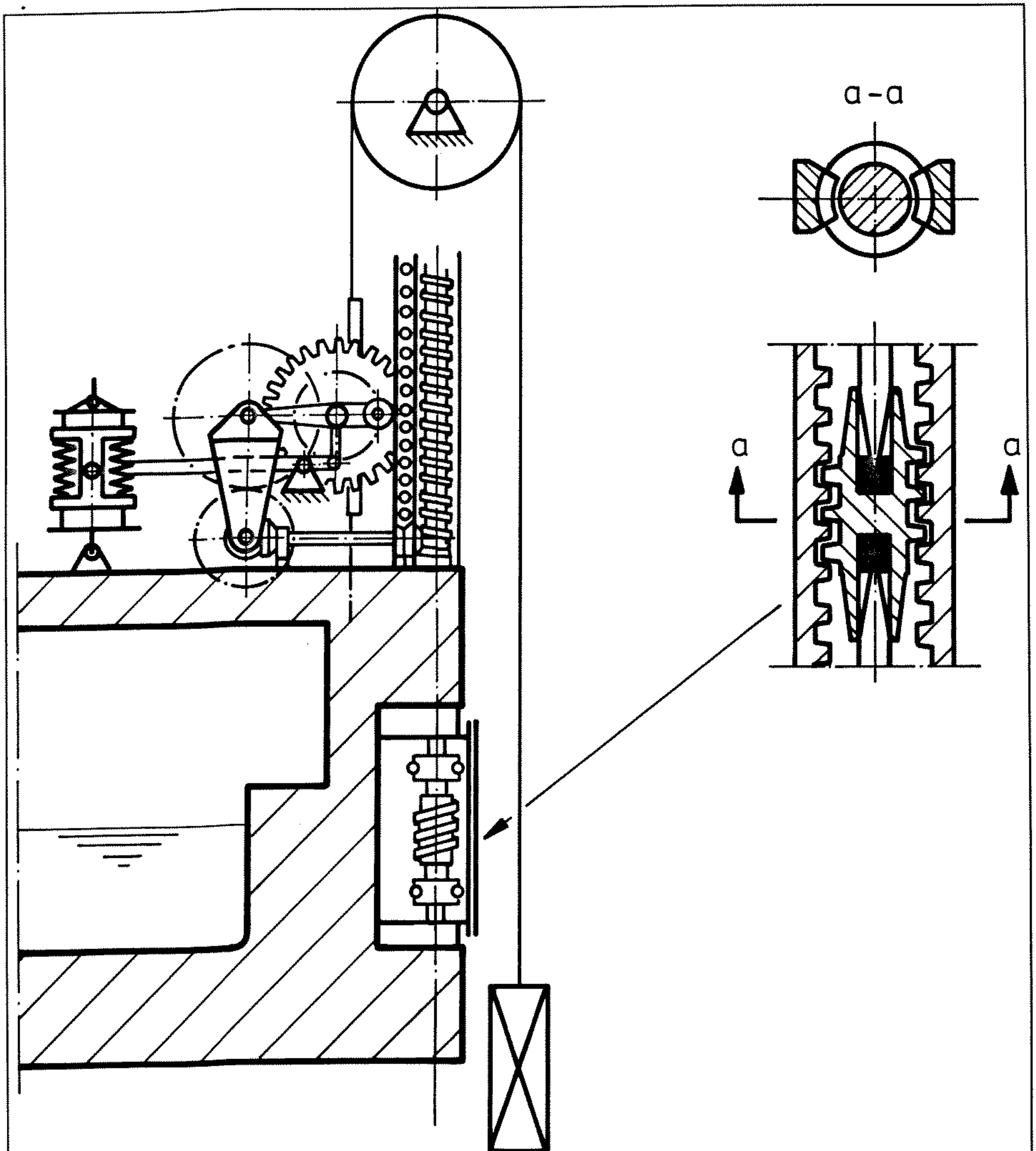


Fig. 30

10. Summary

The paper describes a number of actual ship lift installations which constitute examples of the various ramp and vertical lift systems employed for „wet transfer“ applications.

A comparison of the performance data of the two main types clearly shows that the vertical lift systems are the more efficient - they offer the shortest cycle times and thus a higher number of transfer operations per unit of time.

Each application must, however, be considered on it own merits, and the final selection made on the basis of a thorough cost/performance analysis of each possible solution.
It is of particular importance in this field of engineering to pay due attention to the geological conditions involved in the project.

In the following you will find a separate, detailed description of the Scharnebeck ship lift installation (Germany).

The Scharnebeck Shiplift

The Elbe-Seitenkanal, a canal in the Federal Republic of Germany, connects the sea port of Hamburg with the internal canal network (and thus to the western German and Peine-Salzgitter industrial areas) for ships up to 1350 tonnes carrying capacity. As an auxiliary canal, to the Elbe, it also improves the connection to central Germany, Berlin, and Czechoslovakia, in addition to these wide-ranging duties, the Elbe-Seitenkanal is of importance in the economic development of the area of Lüneberg and Uelzen on the border of the Federal Republic of Germany, across which it passes. A connection with the sea port of Lübeck by extending the Elbe-Lübeck canal is also planned for the future.

The Elbe-Seitenkanal, which connects the Elbe above *Hamburg at Artlenburg* with the Mittellandkanal to the west and the lock group Sülfeld from Braunschweig in the north, has a height difference of 61 m to overcome in its *length of 115 km. To the foot of the Geesstrand in Schar*nebeck the rise is 38 m and to south of Uelzen at Esterholz, 23 m *(see Fig. 1).*

The long level stretches between the lock at Geesthacht on the Elbe, the two lifting devices of the Elbe-Seitenkanal and the locks at *Sülfeld or Anderten on the Mittelka*nal, and the increase in the section of the canal for Euro-barges, allows barge traffic to move swiftly along the Elbe Seitenkanal.

As the largest and most interesting engineering project on the Elbe-Seitenkanal, the project to transfer ships between two extreme levels, was put out to open tender. For this, there were 4 contenders, each of which was made up of a number of design offices and consortiums from the steel and machine building industries, both from Germany and overseas.

On the 28th November 1968, preliminaries for 5 types of installation (locks vertical lifts - longitudinal and sideways inclined lifts, and as an a special design, a water ramp) were submitted, each with a firm quotation.

After considering all the constructional, operational, and economic points, a decision was made on 30th June 1969 in favour of a double vertical shiplift with counterbalance weights and two independently operating lifting chambers.

This, of all the designs, exhibited the best performance, and also fulfills the requirements of the forecast for 8,4 *million tonnes* of goods per year moving "upstream", (with a maximum peak of 43000 tonnes per day), and 3,6 million tonnes moving "downstream" as forecast by Professor Dr. Berkenkopf in a paper on the development of the area.

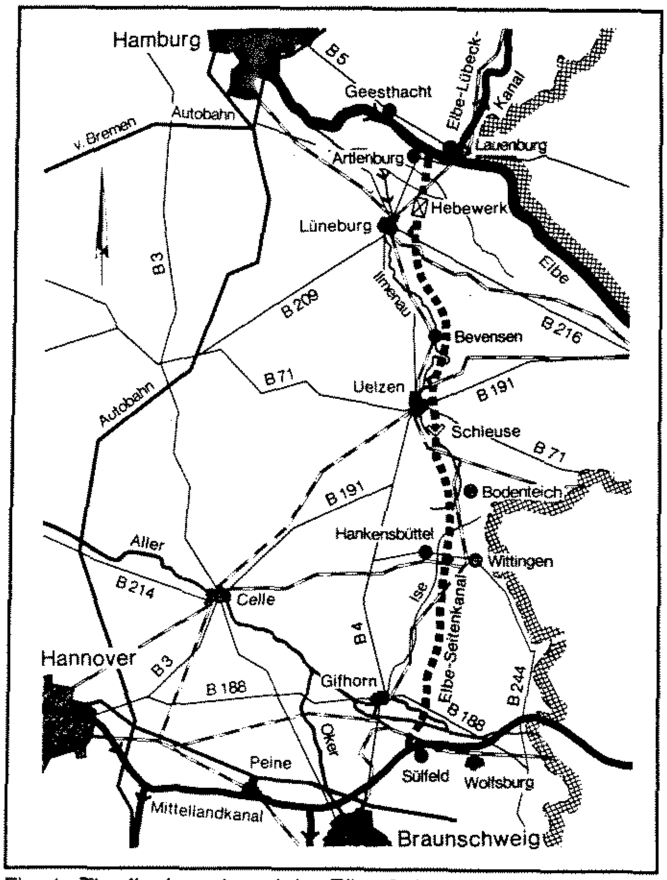


Fig. 1: *The final section of the Elbe-Seitenkanal*

The shiplift with its two chambers imparted an operational security to the Elbe-Seitenkanal and a particular usefulness as a connection between the sea port of Hamburg *and the inland area which largely depends on this link.* Furthermore, when compared with the other possibilities, it offered the lowest operating and maintenance costs, *particularly considering the lack of a natural supply of* sufficient water to operate the installation.

Site work started on the 15th September 1969, and the project completed in 1974/75.

The lifting chambers have a length of 100 m, a width of 12 m and a water depth of 3,5 m. They can accept an extended Euro-barge of 85 m length, or a split train of pusher-tug barges with a width of 9,50 m. or exceptionally, lighters with a beam of 11,4 m. The need to split a train of pusher-tug barges proved to be no disadvantage. Compared to transport via a 185 m long lock system with the necessity to fill the lock chambers, the time taken to couple and de-couple the train is regained by the increase in lifting speed of the shiplift.

Technical data of the shiplift

Normal lift height	38	m
Usable chamber length between shock absorbers	100	m
Chamber width between fenders	12	m
Water depth in chamber	3,50	m ± 0,10 m
O/all weight of chamber (including water)	5 700	tonnes
O/all weight of moving parts of one chamber with water	11 400	tonnes
Weight of individual counterweights (each) (6,8 x 3,4 x 0,32 m)	26,5	tonnes

Chamber drive

4 electric motors each of	150	kW
Chamber travel time approx.	3	mins.
average travel speed	0,21	m/sec
	or 12,6	m/min
max. travel speed	0,24	m/sec.
	or 14,4	m/min
Acceleration and deceleration	0,012	m/s^2

Performance of the shiplift

Lifting time including entry and exit	15	min
Lift capacity in one direction (16 hrs/day, 310 days/yrs (taking a mean ship size and rounding the usage of the load capacity)	10,10	mill. t

Dimensions of the canal bridges upstream

Length	42	m
Width between fenders	12	m

Dimensions of the entrance harbours

Length of moorings above and below lift, per side of the canal	525	m
Width of entrance harbours	90	m

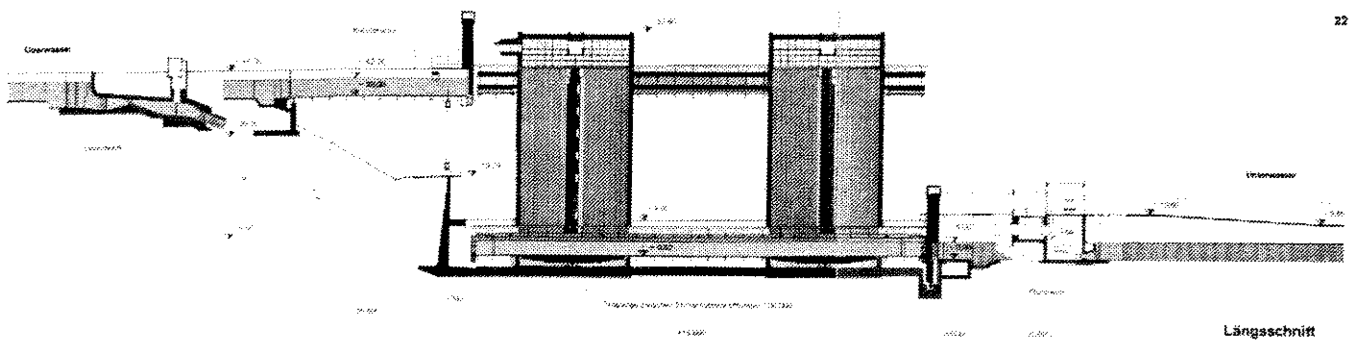


Fig. 2: *Shiplift Scharnebeck*

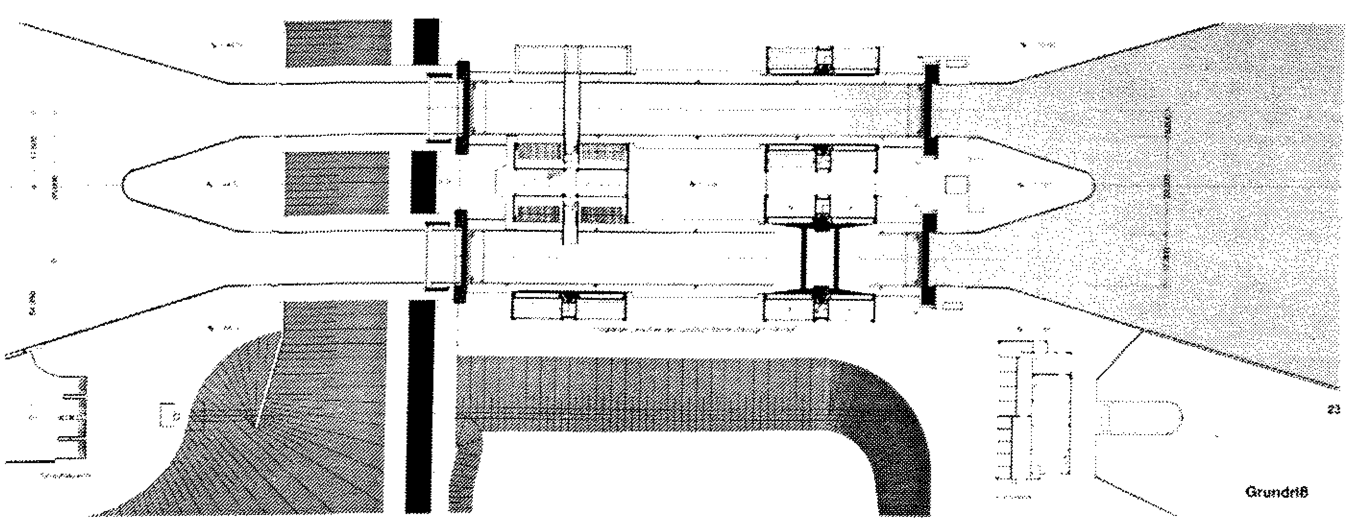


Fig. 3: *Shiplift Scharnebeck*

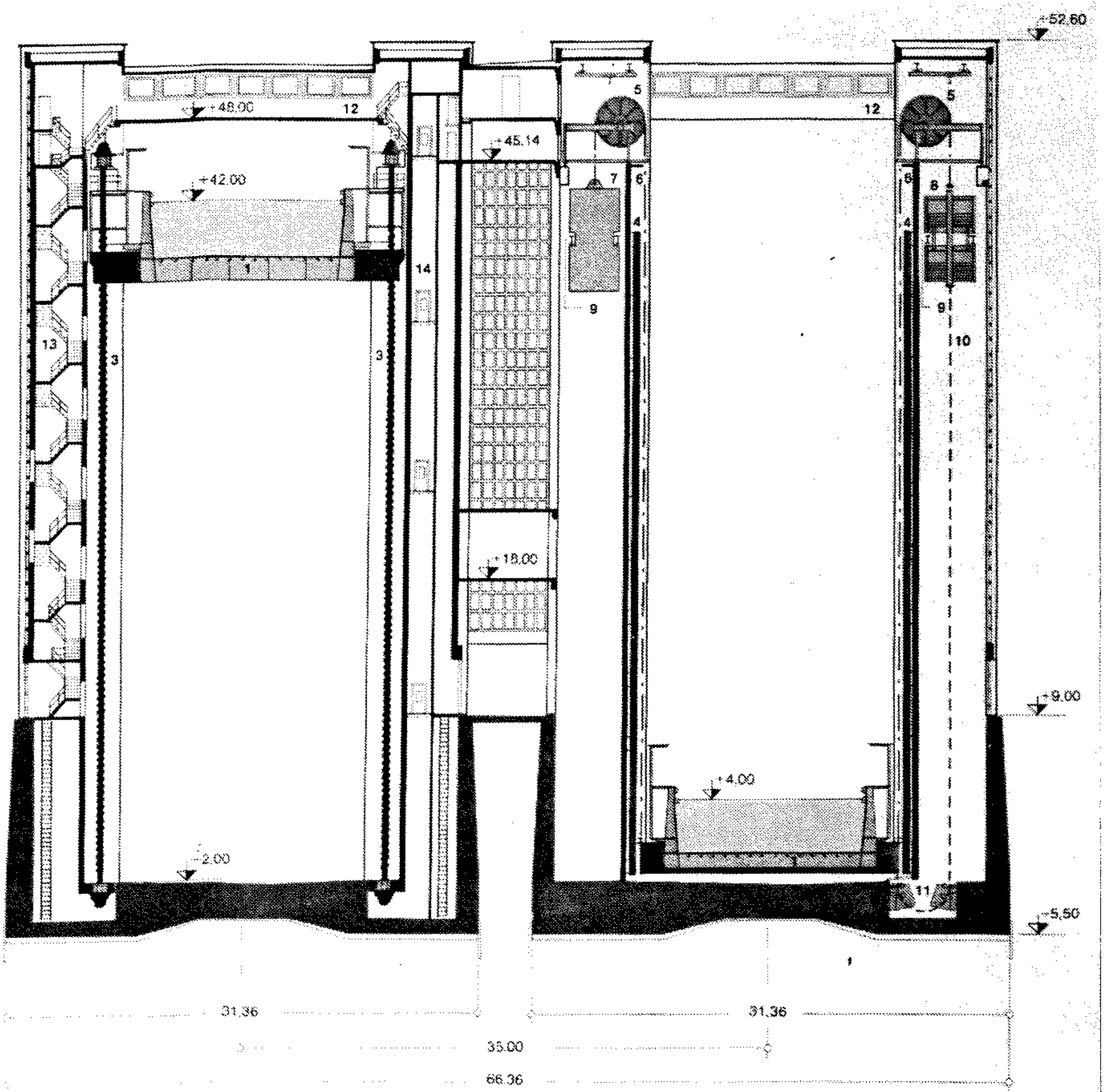


Fig. 4: *Shiplift Scharnebeck*

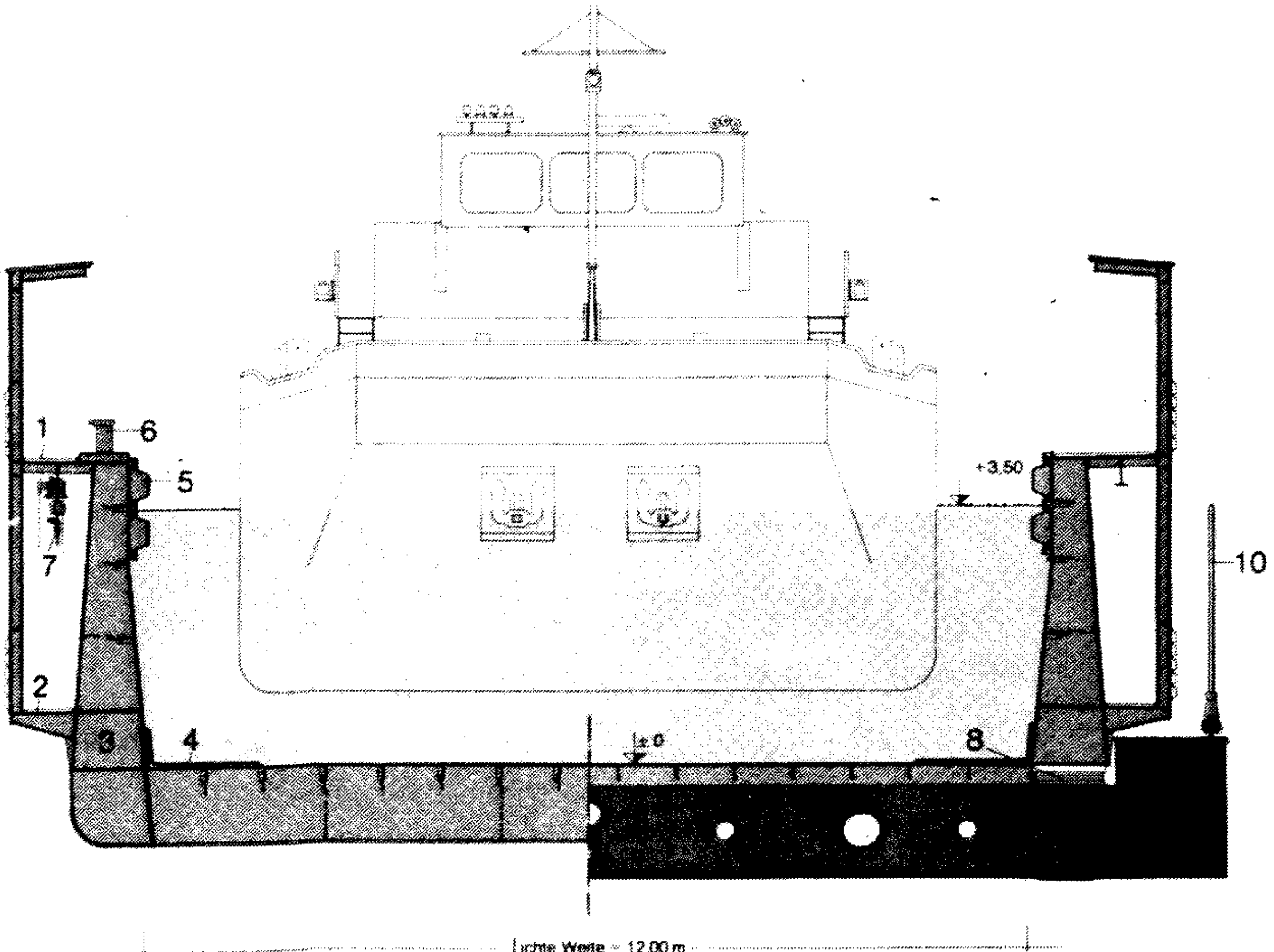


Fig. 5: *Shiplift Scharnebeck, section of lifting chamber*

1 Upper service access
2 Lower service access
3 Torsion box
4 Closing plate
5 Fender
6 Bollard
7 Travelling winch
8 Chamber bearings
9 Support frame
10 Counterweight rope

In the four guide and counterbalance towers, the water filled chamber with a weight of approximately 5700 tonnes is counterbalanced by 8 packages of 224 concrete plate like counterweights, each with a weight of about 26,5 tonnes, and also 8 extra balance weights made up of steel billets.

As each counter weight is connected to its own rope and the extra balance weights are connected to two steel cables, each chamber has 240 counterweight ropes. The 8 strand compensating cables are 54 mm diameter. These are connected to the chamber via the chamber support arms.

As the steel ropes are fitted close together, they are led around double grooved pulleys of 3,4 m dia., they thus have a diameter 65 times the rope diameter. The towers are not only used to support the rope pulleys, and thus to transfer the overall weight of 11400 tonnes to the foundations of the unit, but also to guide the chamber itself. In addition, the towers house the steps and passenger lifts.

The chambers are driven by four drives, which are mounted in the support frame in the vicinity of the towers. The rectifier drive of the fully controllable drives has a power of 150 kW. The motors drive the chambers via gearboxes, and pinions, which engage in racks fitted into the towers. These drives impart a speed of 14,4 m/minute to the chamber, allowing the lift height of the unit (38 m) to be covered in three minutes.

The four drives are connected together via a synchronising shaft system. Four nuts also run on spindles in synchronism with the main drives. These nuts run on spindles mounted in the towers and have an axial thread clearance with respect to the spindles of 30 mm in each direction. Should, catastrophically, heavy loads be applied to the main drive, and the drive pinions overloaded, the main drive motors will stop and the pinion rotate backwards to relieve the load in the direction of the excess load. The safety nuts then engage on the spindles to safely hold the chamber in position *(Figs. 6 and 7)*.

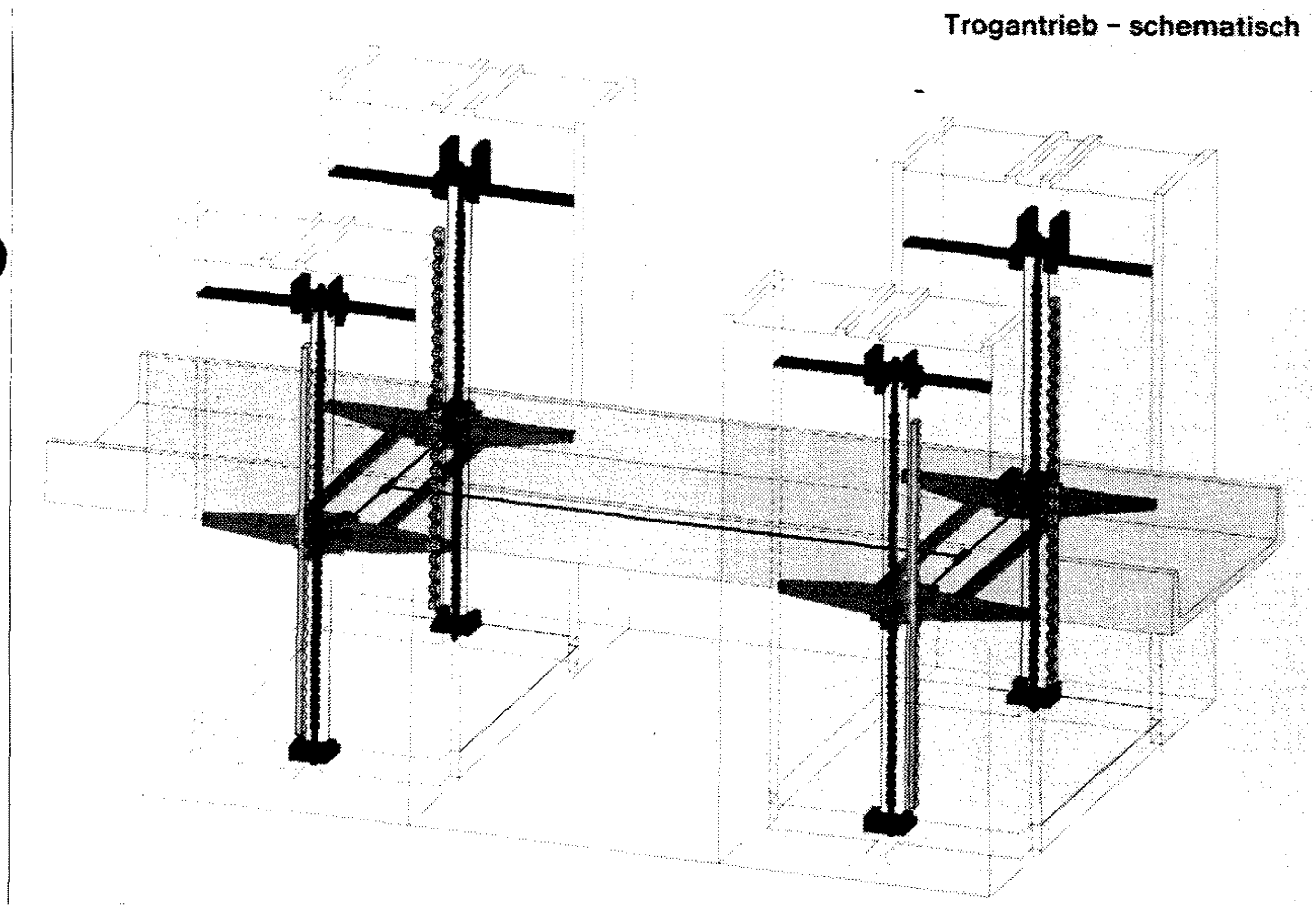


Fig. 6: *Shiplift Schranebeck, schematic of chamber drive*

Teleskoprahmen

1 Haltung	4 Reversierpumpe
2 Trog	5 Dichtung
3 Teleskoprahmen	6 Spaltwassertank

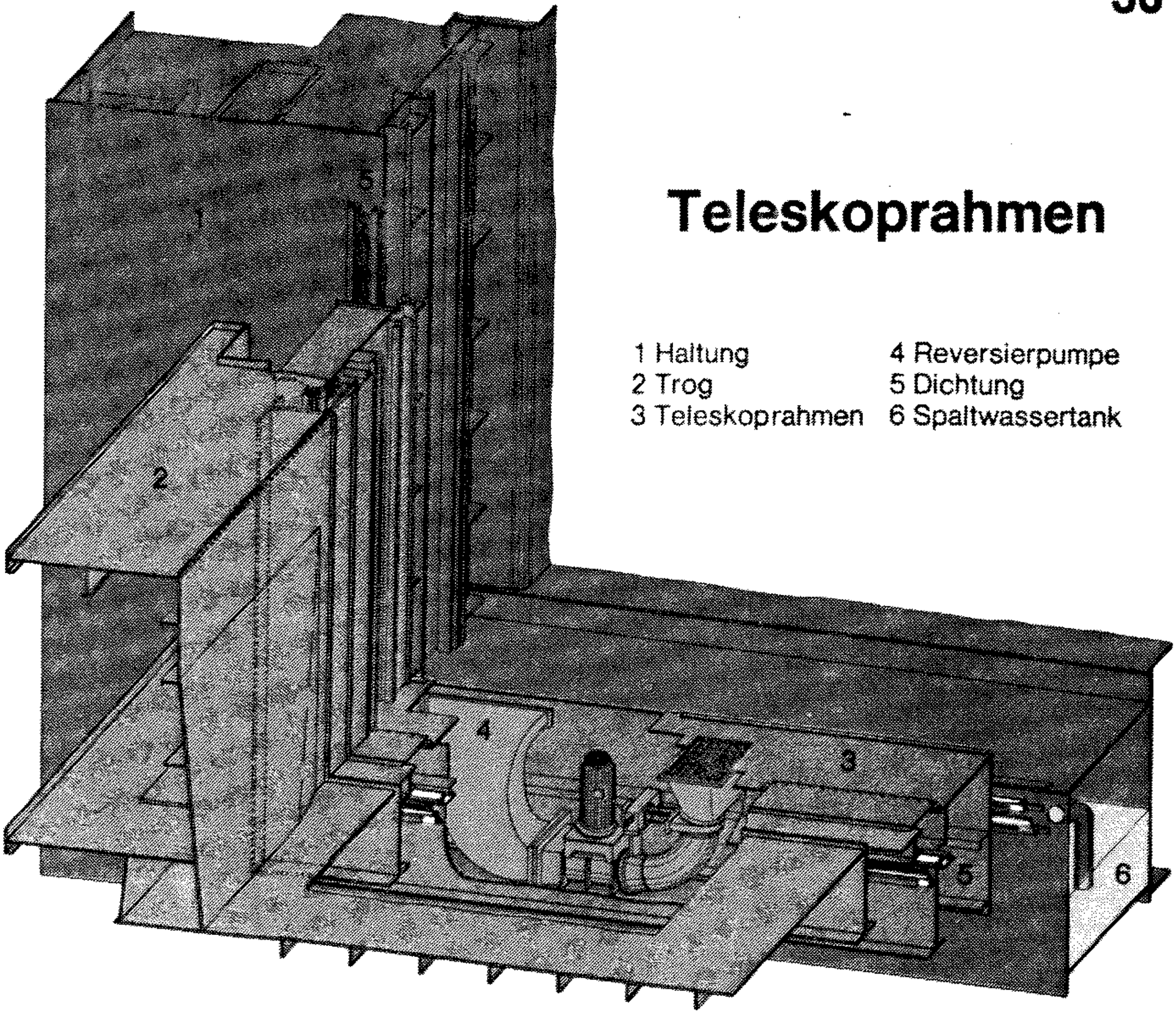
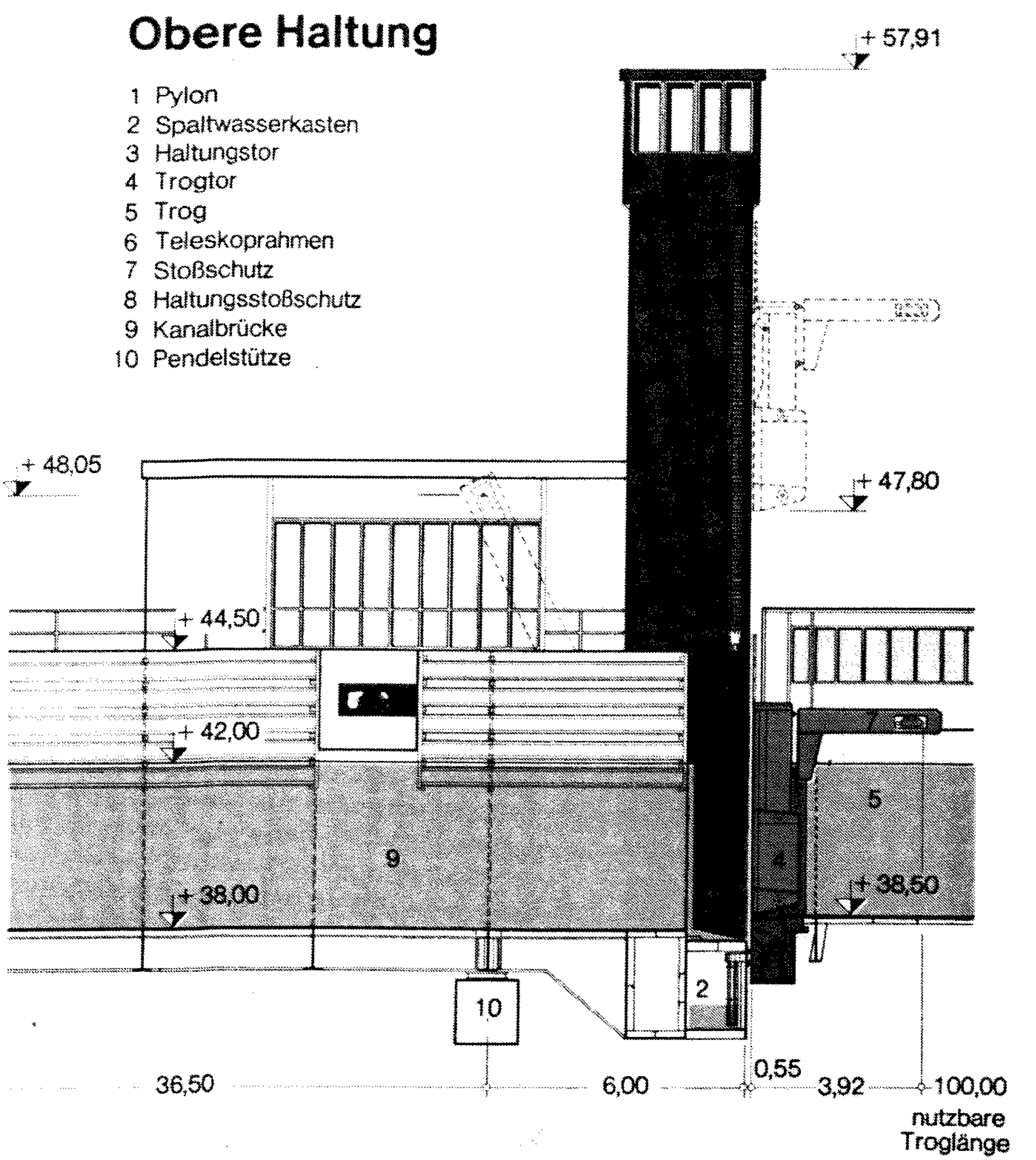


Fig. 7: *Shiplift Scharnebeck, telescopic chamber*

1 Sealing unit
2 Lifting chamber
3 Telescopic chamber
4 Reversing pump
5 Sealing
6 Intermediate water tank

The holding gates at the "upper" *(Fig. 8)* and "lower" channel gates and also the gates in the ends of the chambers are lifting gates. These chamber gates do not have their own drives, but are hooked onto the relevant channel gate and the whole, together with the crash barrier is then lifted and lowered as one. All drives, with the exception of the main drives are hydraulic. All together, a total of 28 hydraulic stations are installed.

Fig. 8: *Shiplift Scharnebeck, upper sealing unit*
1 Pylon
2 Intermediate water chamber
3 Holding gate
4 Chamber gate
5 Lifting chamber
6 Telescopic chamber
7 Arrester
8 Upper channel arrester
9 Aqueduct
10 Double sided arrester



When the water level of the electronically controlled chamber is at the same height as the water in the upper or lower channels, a telescopic connection is made between the chamber and the channel. When the sealing elements are locked, the gap can be filled with water and the holding door together with the chamber door opened as one. A shield gate at the low water end with a hanging holding door matches its position to the water level which can vary by up to 4 m *(Fig. 9)*.

The whole lifting operation can be controlled from a central control stand between the two centre towers at the upper water level, from where, ship movements and the entire lifting and lowering operations are signalled. All movements of the lifting installation including the opening and closing of the gates are then fully automatic. For repair and maintenance purposes, the individual motions can be controlled locally.

Set on the eastern side of the low water end, is a pumping station with 3 pumps, each with a capacity of 2250 L/sec. This pumping station is used to make up for leakage and evaporation, and also for irrigation purposes, to replace water in the upper channel.

The pump pipelines (each having an internal of 2,5 m) can allow flow in the opposite direction via two valves to allow flows of up to 25 m^3/sec to relieve flood water.

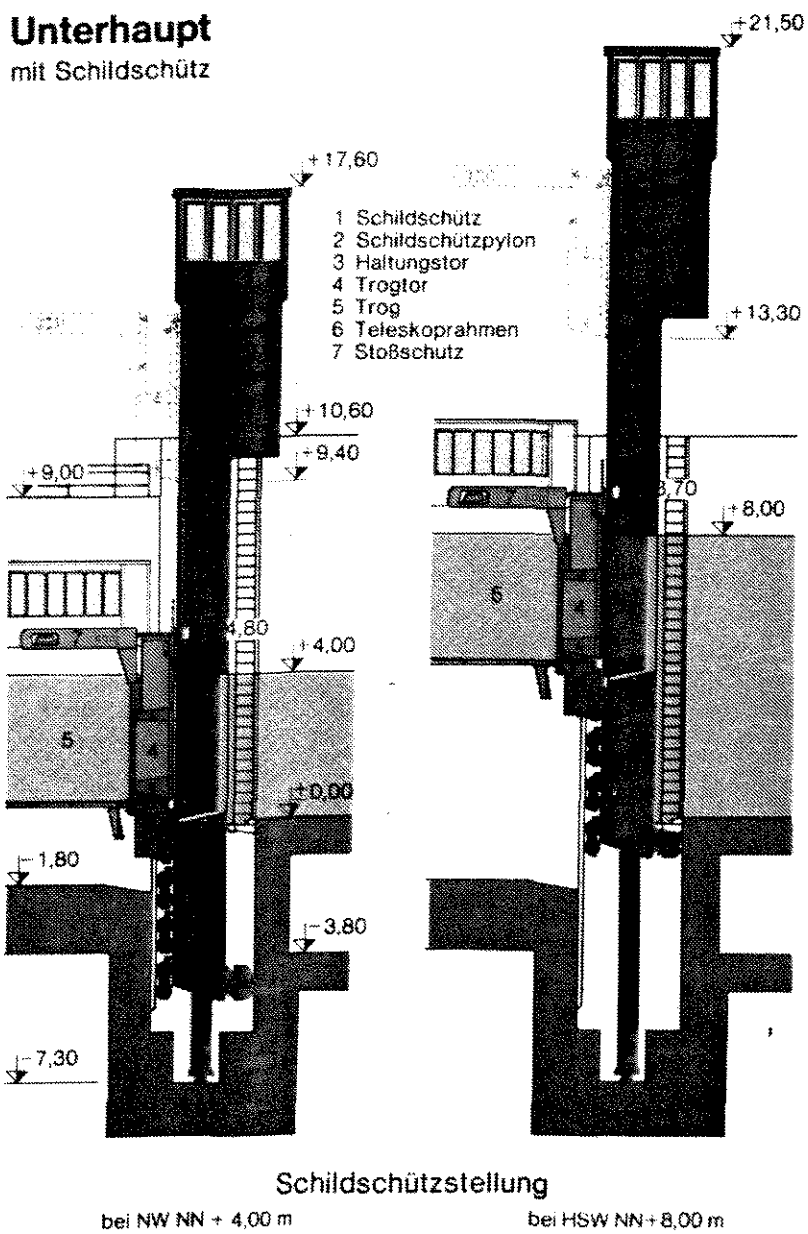


Fig. 9: *Shiplift Scharnebeck, Downstream side with shield gate*
1 Shield gate
2 Shield gate pylon
3 Holding gate
4 Chamber gate
5 Lifting chamber
6 Telescopic chamber
7 Arrester

Shiplifting Scharnebeck

Working group

Fried. Krupp GmbH
Maschinen- und Stahlbau Rheinhausen

Dinglerwerke Aktiengesellschaft

Gutehoffnungshütte Sterkrade AG

Aug. Klönne

M.A.N. Werk Gustavsburg

Rheinstahl Union Aktiengesellschaft

Christiani & Nielsen Ingenieurbau AG

Building owner

Wasser- und Schiffahrtsdirektion
Hamburg
Neubauabteilung für den Bau des
Elbeseitenkanals
Neubauamt Abstiegsbauwerke