AMERICAN CONSULTING ENGINEERS COUNCIL'S

HEAVY MOVABLE STRUCTURES
MOVABLE BRIDGES AFFILIATE

3RD BIENNIAL SYMPOSIUM

NOVEMBER 12TH - 15TH, 1990

ST. PETERSBURG HILTON & TOWERS
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SESSION
WORKSHOP NOTES

Session (4-7)
"..Centenarian ... Sea Lock/N.Baltic Sea Canal", Dieter Laging, Waterway Authority, Rendsburg. Germany

Near centenarian with new outfit and drives

Dieter Laging

(Nr. 1637.) Gesetz, betreffend die Herstellung des Nord-Ostseekanals. Vom 16. März 1886.

Wir Wilhelm, von Gottes Gnaden Deutscher Kaiser, König von Preußen ꝛc.

verordnen im Namen des Reichs, nach erfolgter Zustimmung des Bundesraths und des Reichstags, was folgt:

§. 1.

Es wird ein für die Benutzung durch die deutsche Kriegsflotte geeigneter Seeschiffahrtskanal von der Elbmündung über Rendsburg nach der Kieler Bucht unter der Voraussetzung hergestellt, daß Preußen zu den auf 156 000 000 Mark veranschlagten Gesammtherstellungskosten desselben den Betrag von 50 000 000 Mark im Voraus gewährt.

This law, published in the official German gazette of 16 March 1886, was needed to build the artificial water link between the Northsea and the Baltic planned for the various routes and wanted ever since the 16th century by many reigning princes and seatraders.

As on many other occasions in the past, military considerations prompted construction of today's most-travelled merchant shipping canal in the world.

Digging began straight away with as many as 9000 workers on a trench with a width of 67.0+m at water level and 9.0+m depth right across Schleswig-Holstein from Kiel to Brunsbüttel on the Elbe.

Since the water levels vary in Brunsbüttel (tidal region) and also in Kiel, double chamber locks with mitre gates and a usable chamber size of 127 x 22 m were built at each end of the canal.

Although the locks were put into service in the autumn of 1894, the canal was only opened when the keystone was laid by Emperor Wilhelm II on 21 June 1895. The cost of the opening ceremonies amounted to 1.7 million Marks.

But after only a short time, it was found that the Northsea-Baltic Canal, or the Kaiser Wilhelm Canal as it was known at the time, no longer satisfied the military needs because of the European armaments race and the consequent expansion in the number of naval units.

Between 1907 and 1915 the canal was therefore widened to 102.5 m and the water depth was increased to 11 m. At the same time, two additional new double chamber locks with sliding gates and a usable chamber size of 310 x 42 m were built in Kiel and in Brunsbüttel. This means that each end of the canal has 4 lock chambers.

Because of the tremendous increase in traffic to nearly 90 000 ships passing through in 1965 and the damage resulting from this, a maintenance and modernization programme was approved for the Northsea-Baltic Canal in 1966. Among other things, this programme allows for the second canal widening to a water level width of 162+m and the thorough repair and restoration of the old lock (called the "Alte Schleuse") at Brunsbüttel.

Repair and restoration of the old lock, which for budget reasons has been taking place in 4 stages of construction at various intervals since 1984, comprises extensive renewal of the chamber walls, *complete redesign* of the outer and inner gates in the region of the drive machinery rooms, replacement of all 8 pairs of mitre gates, and the renewal of the drives for the mitre gates, culvert leaves and drainage gates leaves including the *necessary* electrical supply and control.

An oil-hydraulic drive with differential cylinders was chosen for the drive system. The cylinders for the mitre gates are designed for a maximum load of 2000 KN, for the culvert leaves of up to 250 KN, for the drainage gate leaves for up to 140 KN and those for the mitre gate latching up to 220 KN.

Each drive unit is a separate pump set comprising electric motor with flanged-on *axial conical piston fixed-displacement* pump, type A2F, the drive power for a mitre gate being split up over two equally sized pump units in order to reduce the starting current and at the same time to increase operational dependability.

Since the culvert and drainage gate leaves cannot operate at the same time, one culvert and drainage gate leaf is operated from a common pump set.

The gates are controlled both in the direction of motion and with respect to acceleration and deceleration by proportional valves which are driven via electrical amplifier cards.

For good measure as far as electronics in *civil engineering is concerned, all* drives for the lock gates are controlled by two programmable controllers (PLCs). The programme sequence for a lock with interlocking of mitre gates and culvert leaves is provided by a higher-level PLC installed in the central cabinet.

A special feature of the old lock in Brunsbüttel is that pressure is applied to the mitre gates in the closed position until a water level difference of at least 0.5 m has been reached.

The measure was intended to avoid "knocking" of the mitre gates when high waves occur in the outer harbour. This is controlled via the operating level. The pressing force is monitored by a differential pressure circuit during the necessary period of time which cannot be defined *absolutely because of the influence of tide* and occasional tidal waves.

As a world premiere in civil engineering, a ceramic-coated (Ceramax) piston rod was used in the first stage of construction in a mitre gate cylinder as a test object. Clearly, only one flood gate cylinder on the outer gates, which is completely flooded by seawater if tidal waves occur, could be considered.

Quite apart from the fact that a small price reduction was allowed for the cylinder so as to make this test an interesting proposition, and that the author is of the opinion that experience with new kinds of materials can only be obtained in practice, the coating material was tested on a sample *before the final decision was made as to* the use of the Ceramax piston rod.

In this test, a 70 mm coated steel rod was mounted on two prisms spaced 480 mm apart and loaded with a hydraulic press.

No cracks or peeling was found up to a sag of 5 mm, the beginning of permanent deformation.

At a permanent deformation of 7 mm, peeling occurred on the loaded side, and this is most probably due to the very high surface pressure resulting from line contact. On the stretched side, no cracks appeared.

As the sag increased, peeling also occurred on the stretched side.

Following the positive experience made after 3 and 4 years of operation, the mitre gate cylinders in the second and third stages of construction are now being ordered only with Ceramax piston rods. In addition, the drainage gate leaf cylinders, the first of which were required in the 3 stages of construction, were fitted with Ceramax rods.

Finally, I think it is worth knowing that the old lock at Brunsbüttel is once again being equipped with hydraulic drives after only 20 years with electromechanical drives. Until 1964, the gate elements and even the warping winches were driven by a *"pressure water hydraulics" system.*

The operating pressure here was 50 bar, generated by 3 cylinder piston pumps in the central machinery house placed next to the locks and in part stored in accumulators. The working fluid was taken into the drive machinery rooms through 100 mm bore pipes laid on the locks in the form of a closed-circuit system.
There were two pressure water motors each with 26 HP at 60 rpm for each drive group in a set of gates which consisted of 2 mitre gates wings, 2 culvert leaves and 1 capstan. Like the pump, the pressure water motor was a horizontally arranged three-cylinder piston machine with a spool valve control. With a suitable countershaft arrangement and couplings, the *various gate drives could be switched in* and even the motors could be coupled together so that twice the drive power was available.

Even at that time, the pressure water motors were controlled by pilot-operated spool valves with a moving force of 18 KN. It was cleverly designed so that the drives for a set of gates could be operated centrally from the middle wall without being assisted by electrical means. It was also possible to operate the two pressure water motors for a mitre gate pair either in parallel or in series depending on the drive power required.

For series operation, a synchronising control was provided which only acted on the side wall pressure water motor, as this was the secondary motor and operated by hand. 2 valves were provided for this purpose through which additional pressure water was supplied into the secondary line or from which water could be drained.

In the course of the project work for pressure water hydraulics which began in 1890, the question was also investigated as to whether "pistons pushed by pressure water in cylinders" could be used to move the gate wings. However, the middle wall was not wide enough for this purpose and the anchoring of two cylinders arranged one above the other, which would be necessary on the middle wall, caused "exceptional difficulties" so that "no use could be made of this arrangement which would be most suitable considering the nature of pressure water operation".

Emergency hand operation was already provided for in this hydraulics system. By using the capstan bars, it was possible to move all drives via the warping winch.

This shows that the hydraulic drives designed around 1890 by the mechanical engineers of C. Hoppe in Berlin for the locks on the Northsea-Baltic Canal comply in many points with the present-day requirements for a hydraulic system.

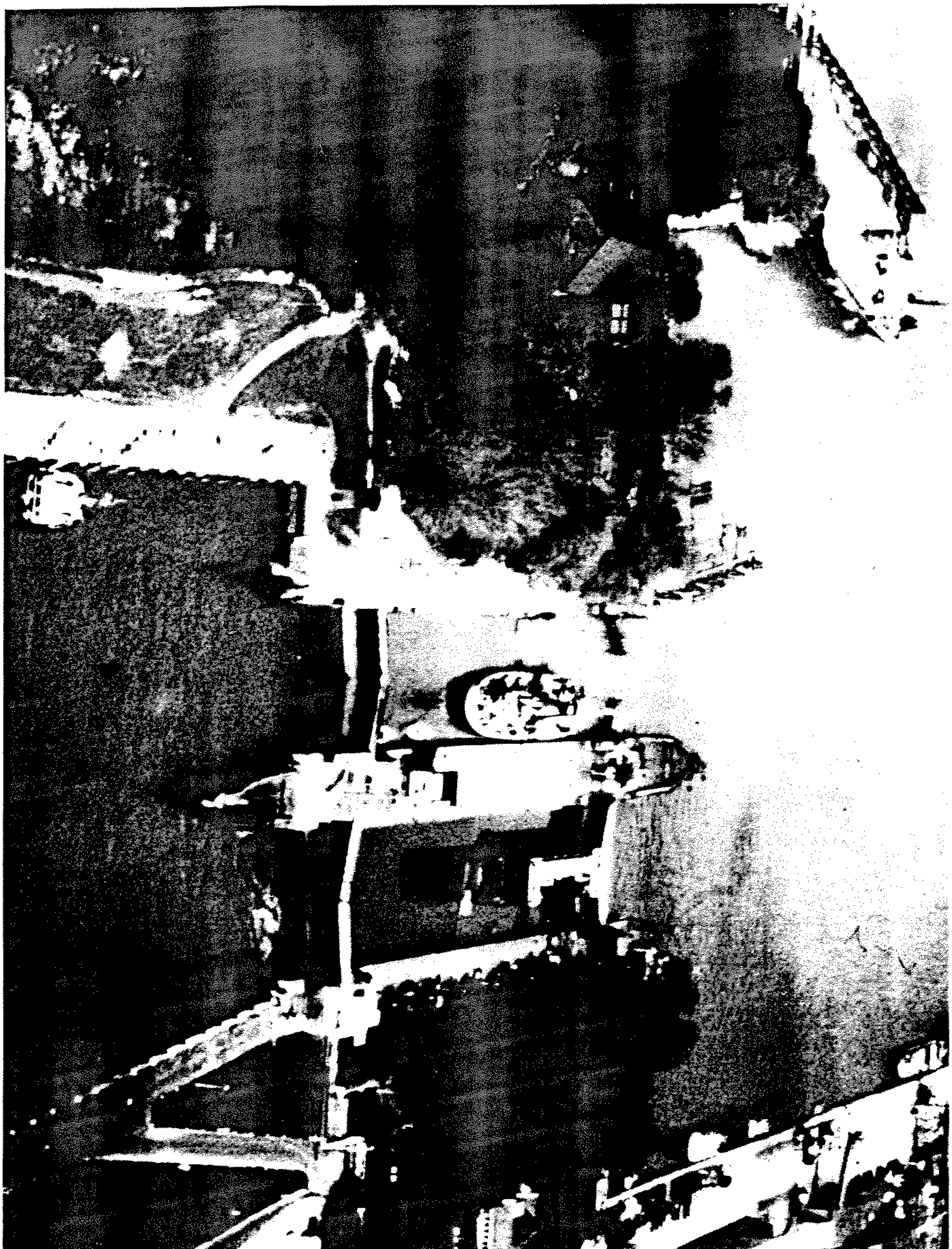

Fig. 1: Brunsbüttel lock

Fig. 2: Brunsbüttel lock • outer chamber with outer and inner gates

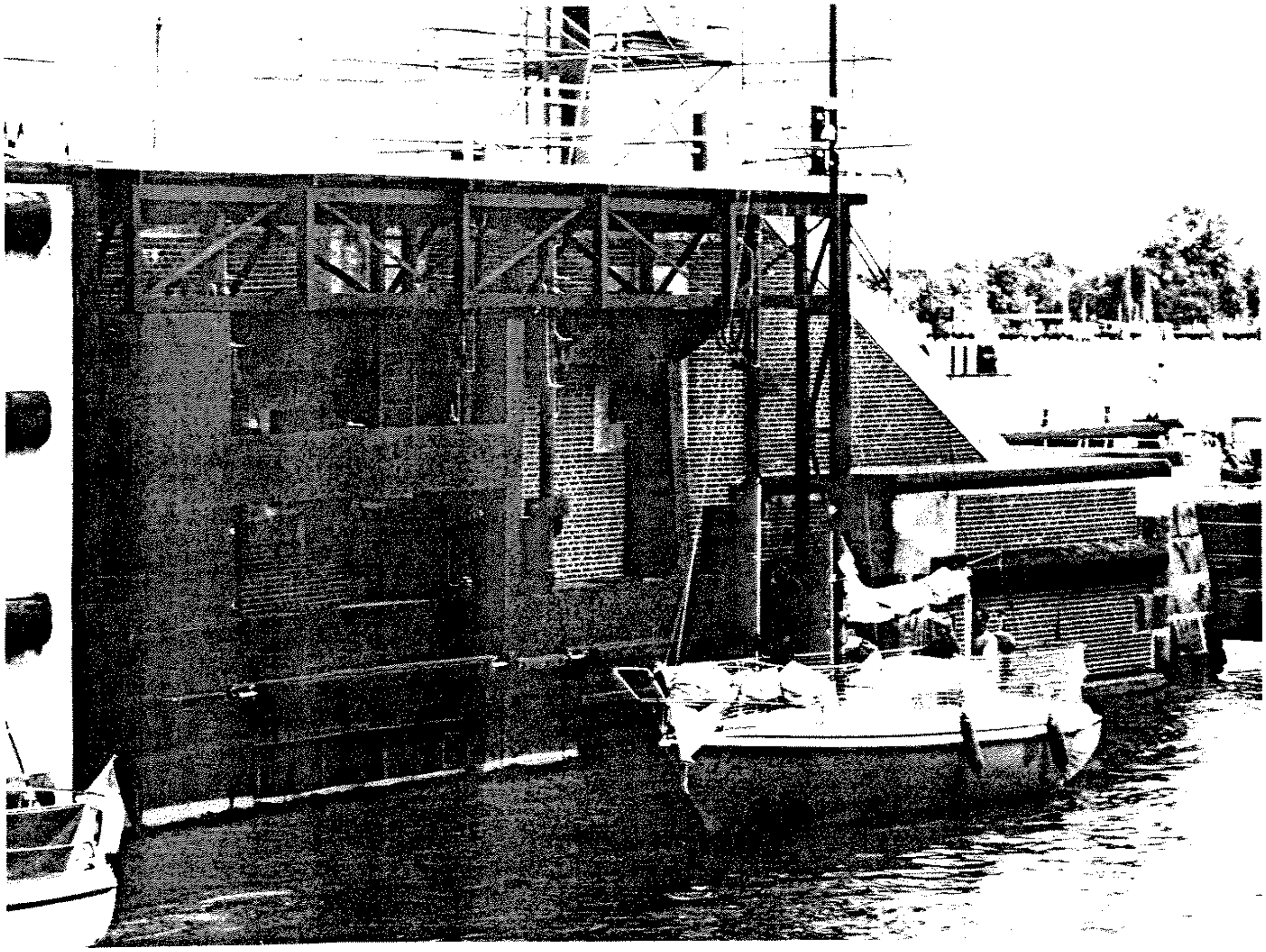

Fig. 3: Brunsbüttel lock • inner chamber, inner gate with drainage gates

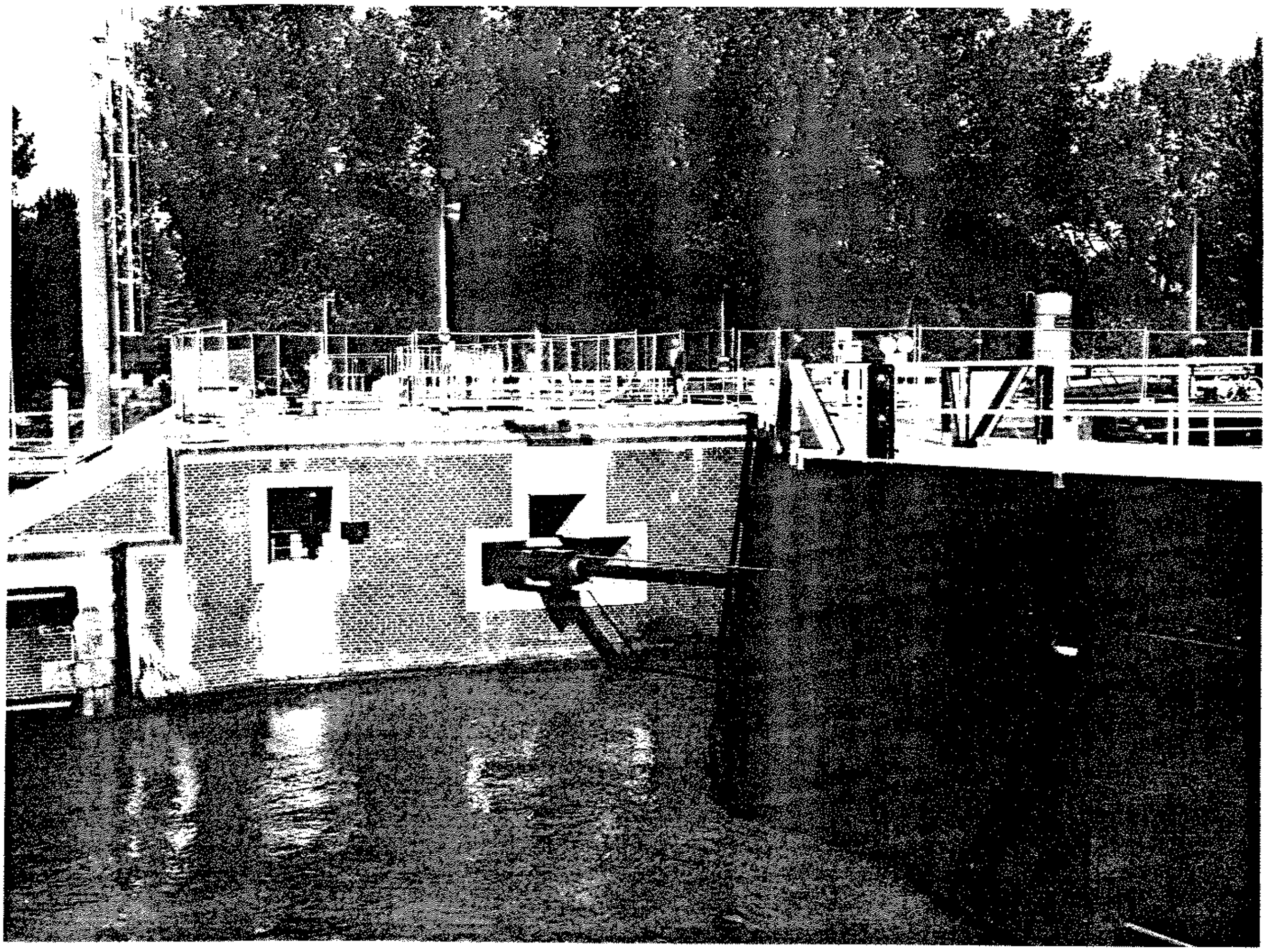

Fig. 4: Brunsbüttel lock • mitre gate with drive cylinder and locking system

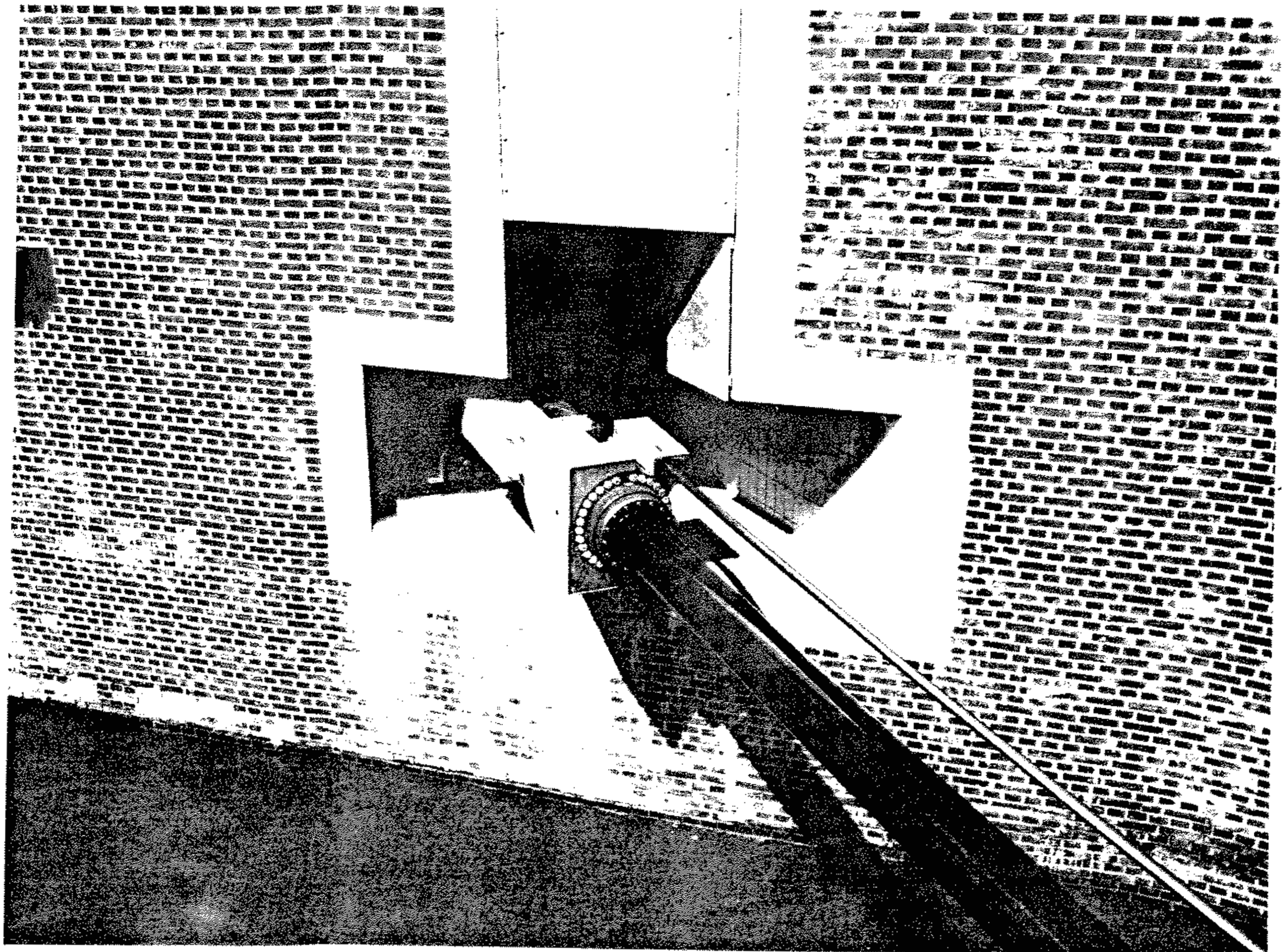

Fig. 5: Brunsbüttel lock • drive cylinder for mitre gate. piston rod with CERAMAX coating

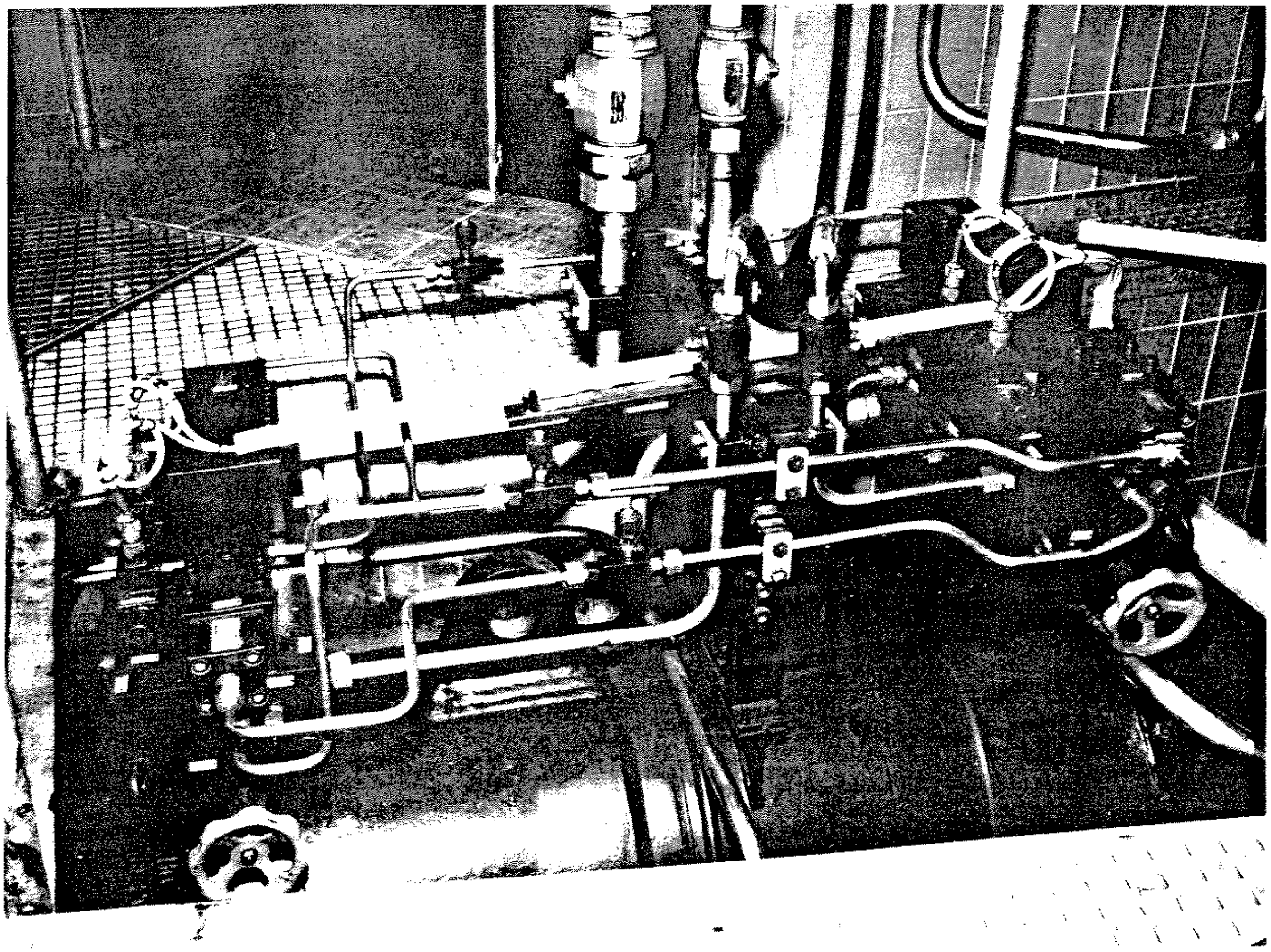

Fig. 6: Brunsbüttel lock • drive cylinder, mitre gate, control manifold flanged to cylinder

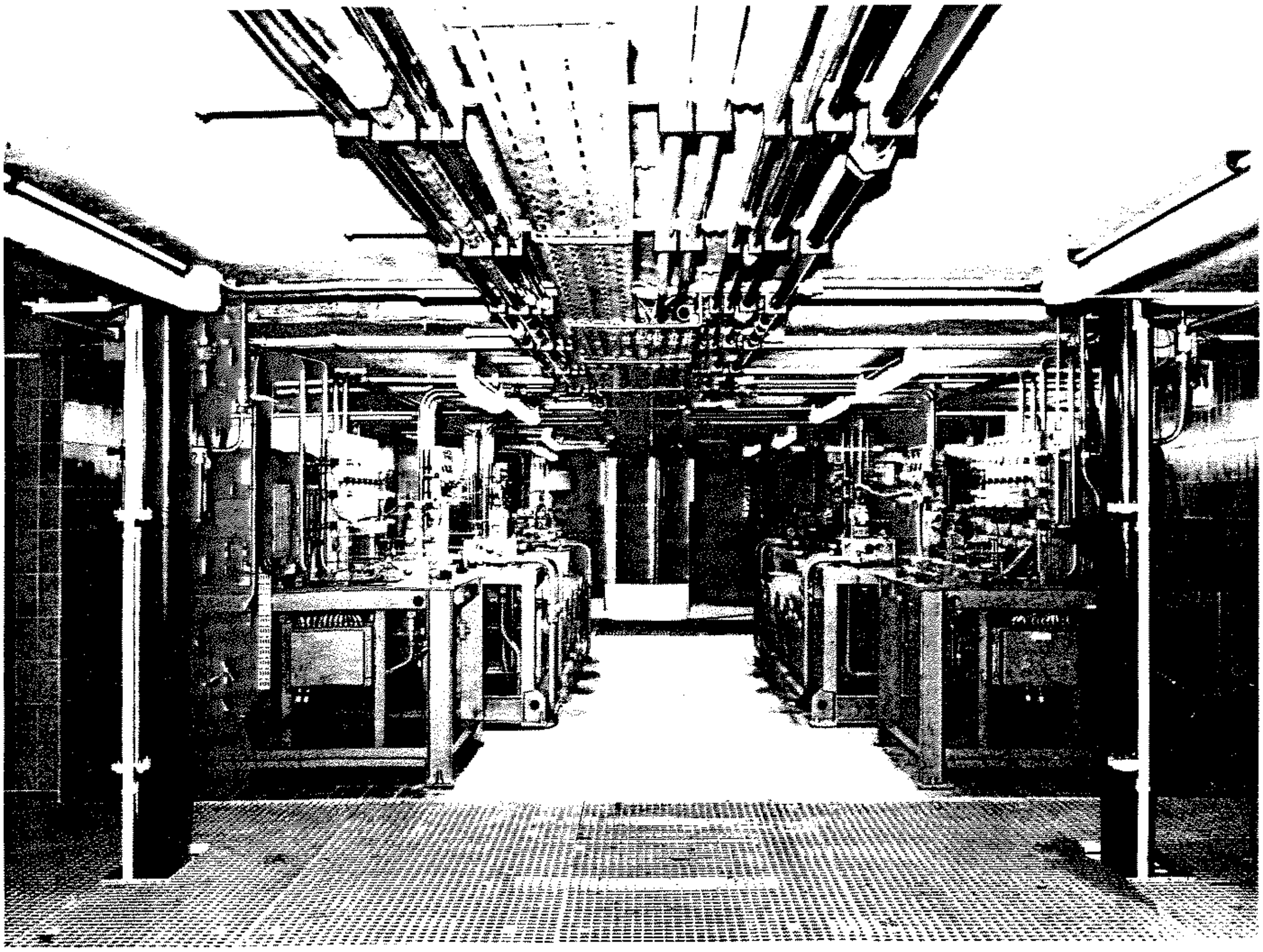

Fig. 7: Brunsbüttel lock • machine room middle wall

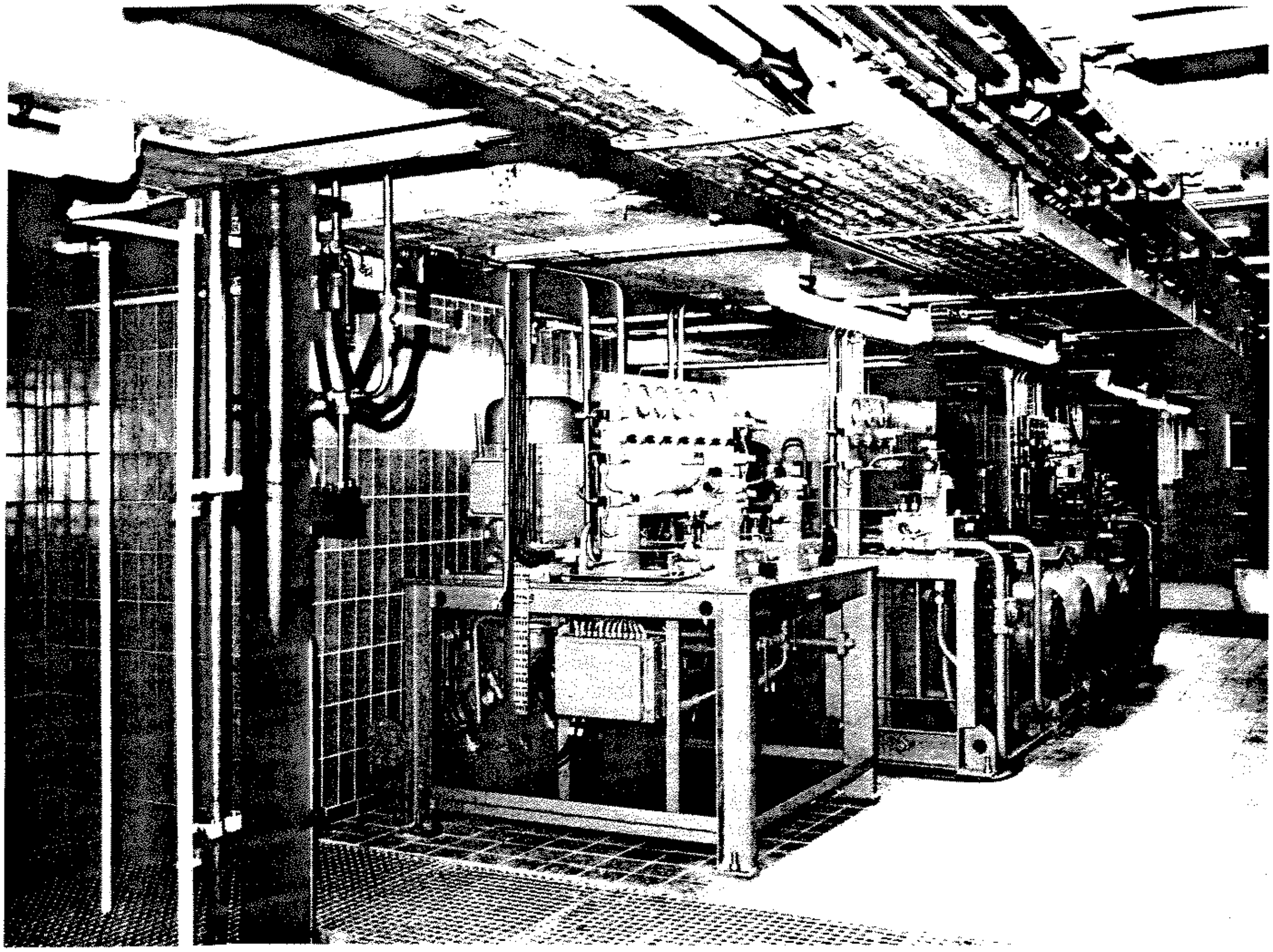

Fig. 8: Brunsbüttel lock • drive and control unit for 1 mitre gate leaf, 2 culvert and drainage gates, 1 latch assembly

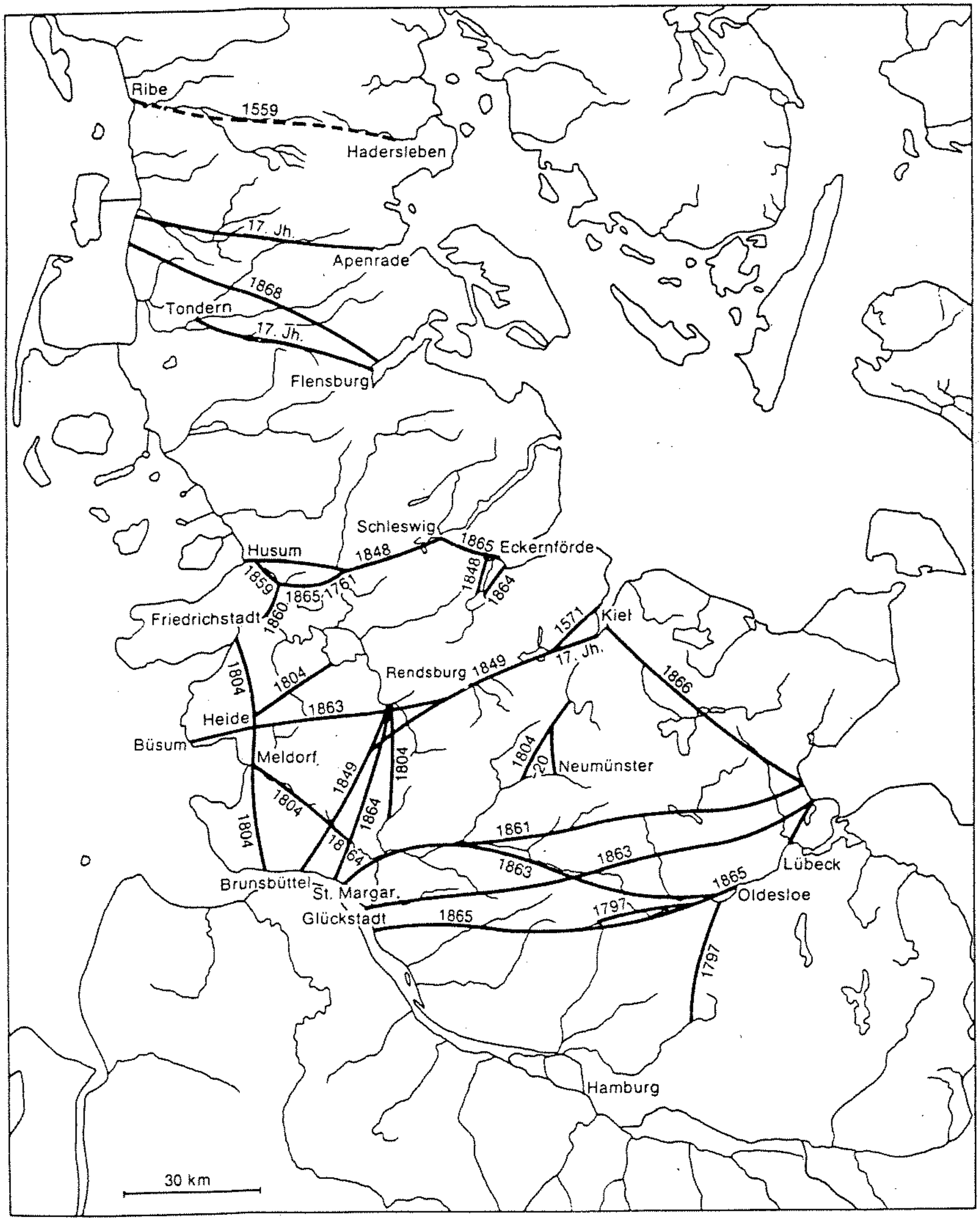

Fig. 9: canals in planning, but not yet built

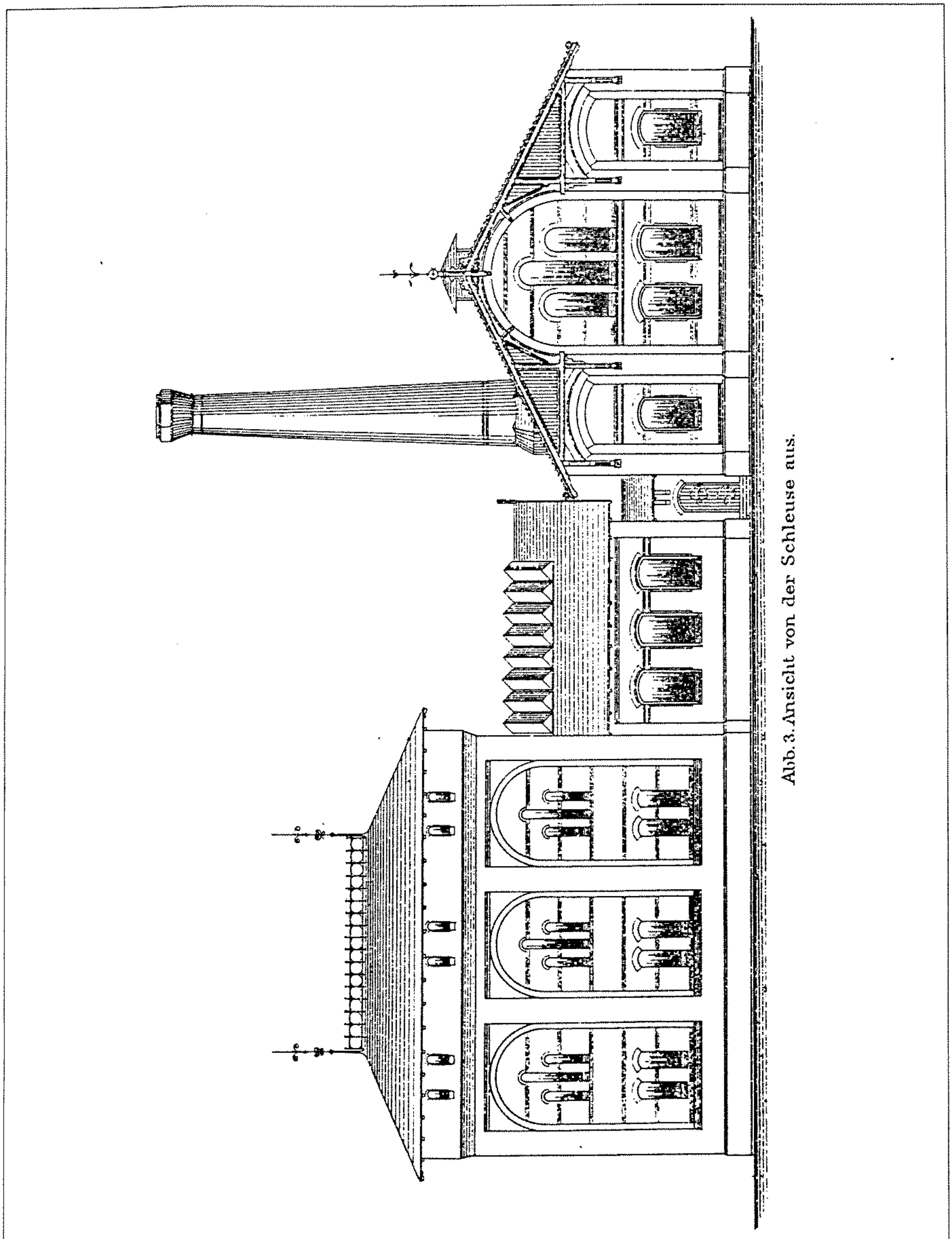

Fig. 10: view from the lock

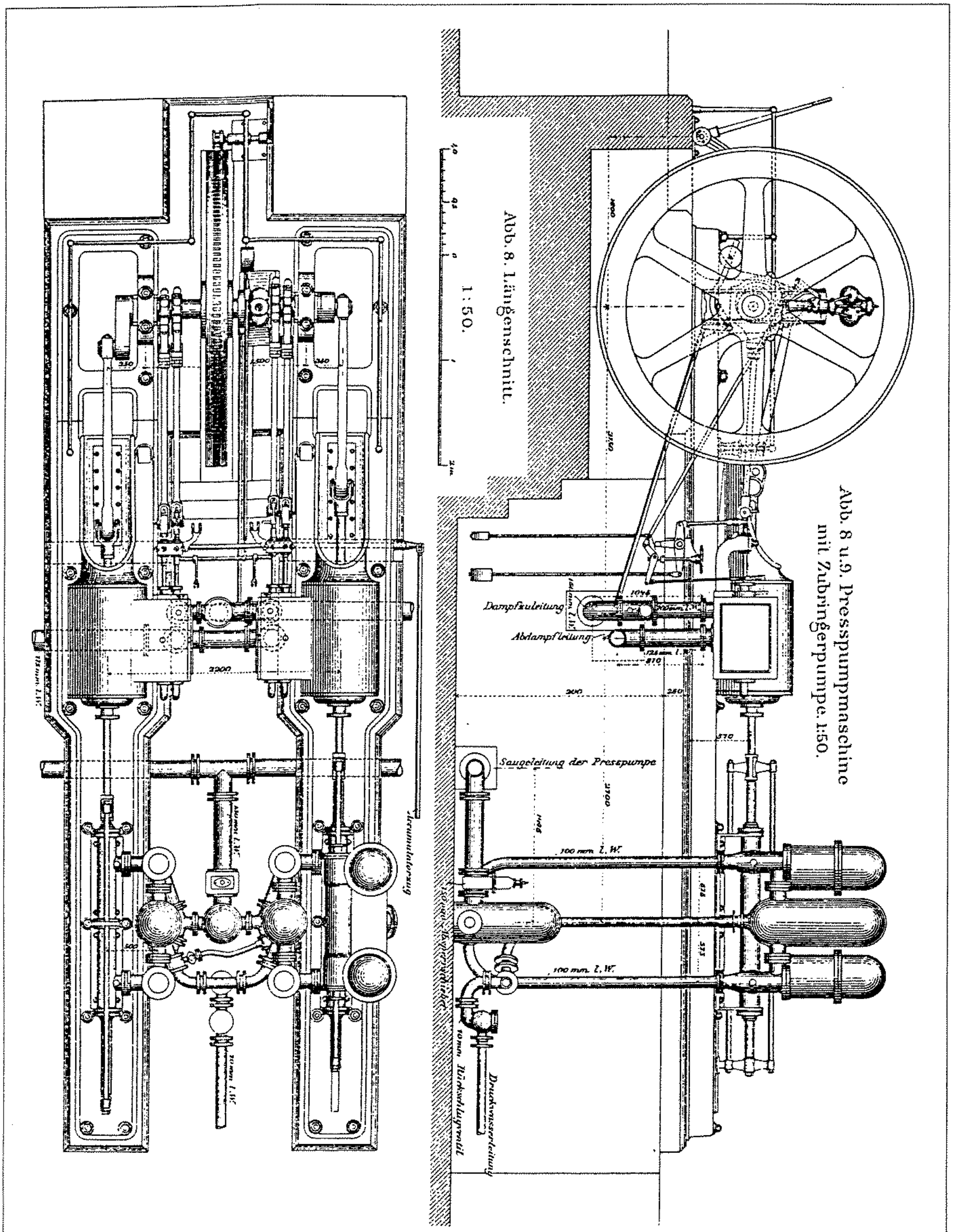

Fig. 11: pressure water motors with supply pump

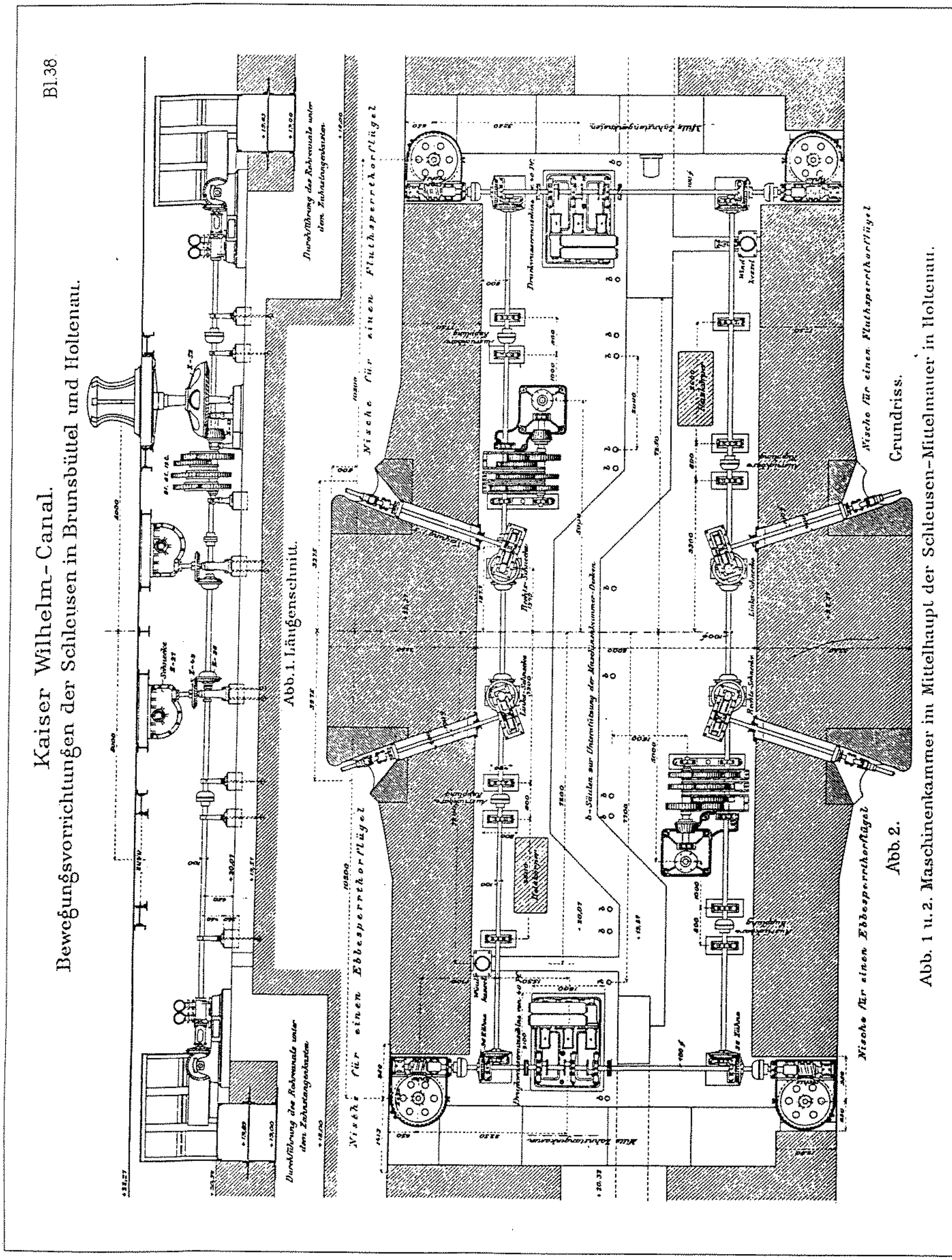

Fig. 12: Kaiser Wilhelm Canal • lock machinery for Brunsbüttel and Holtenau

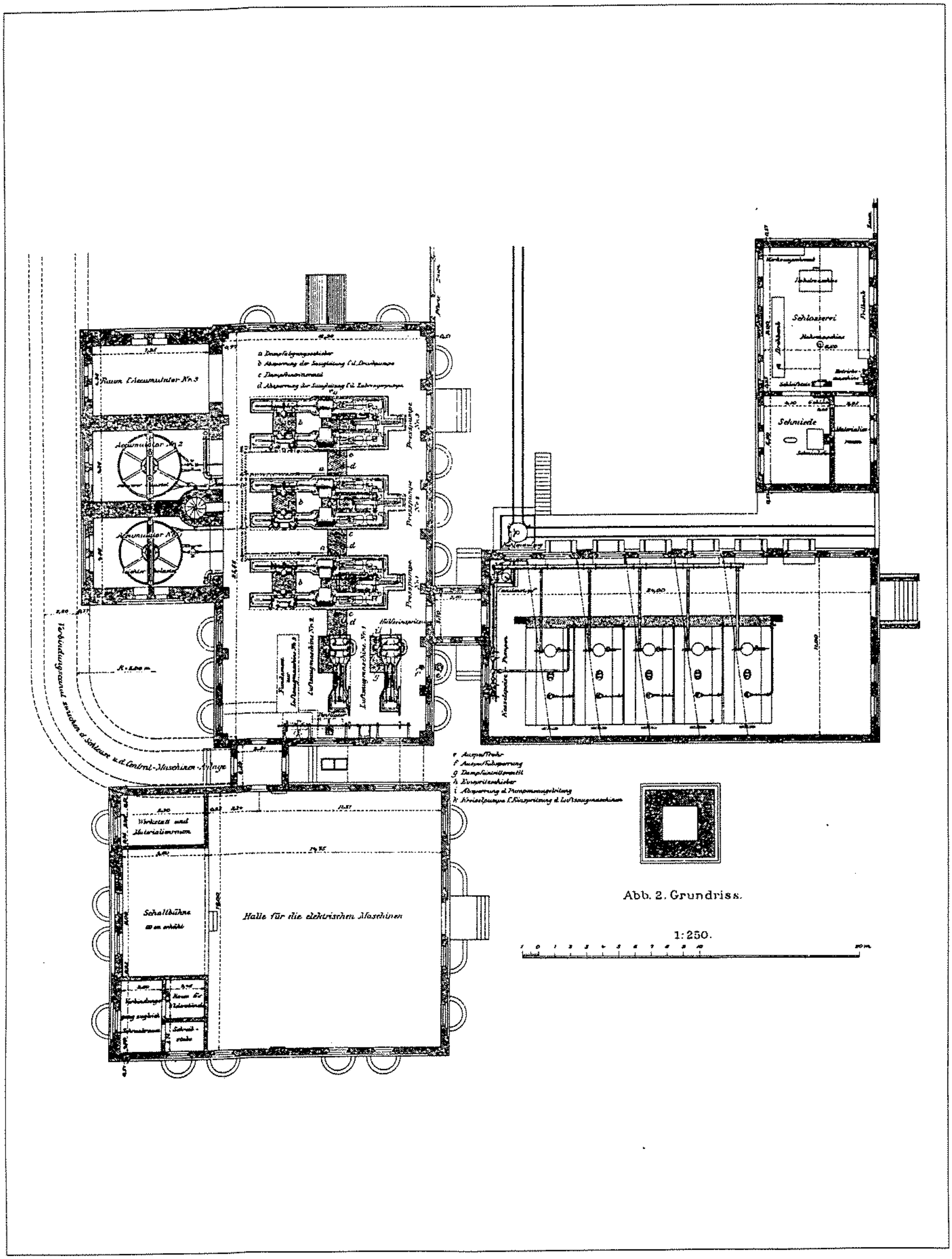

Fig. 13: layout