Special Print

Taprogge

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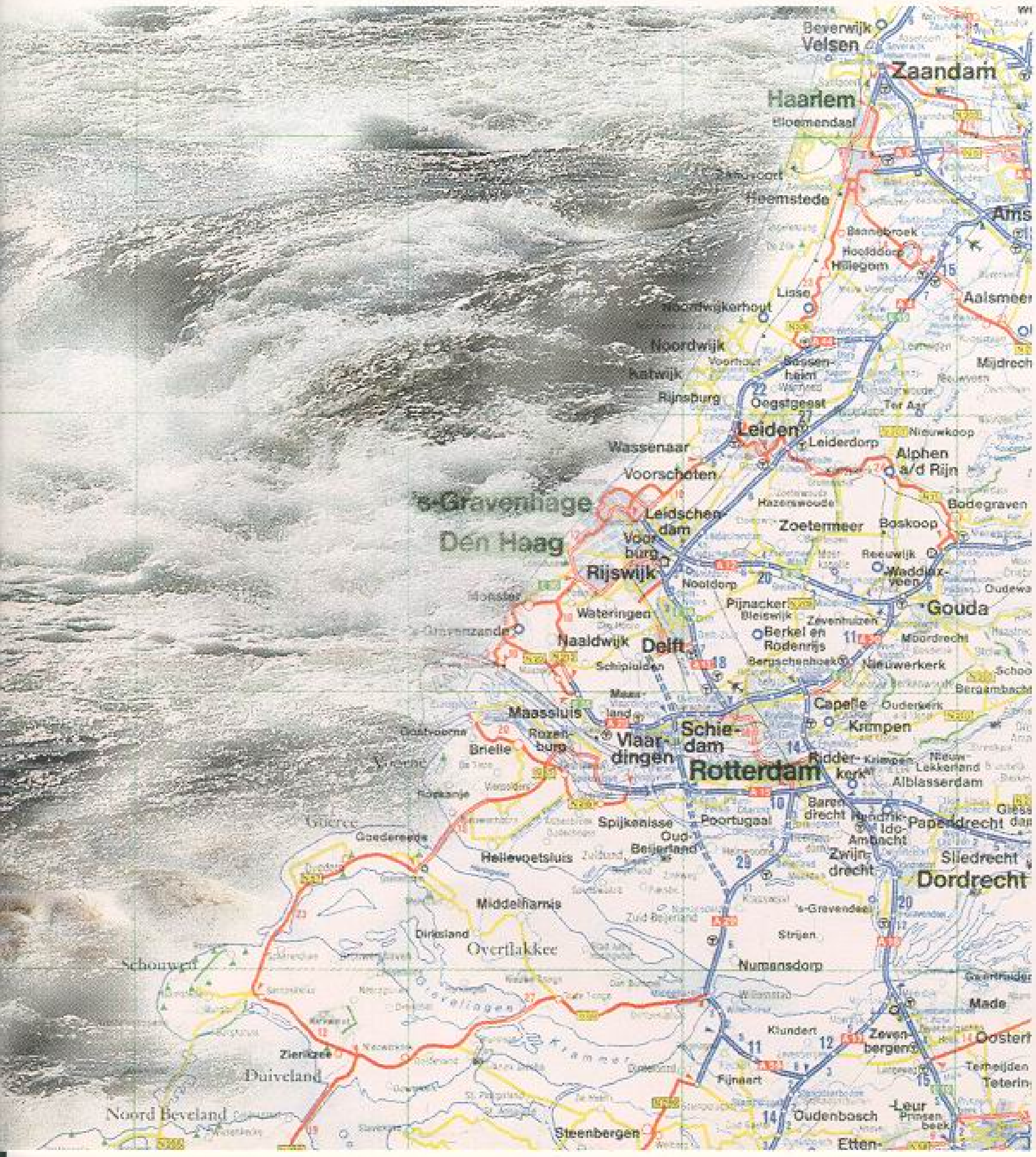
Avoidance of Macrofouling by Algae (Cordylophora caspia) in Cooling Water Systems by the Application of Automatic Backwash Filters

Ecology of the Hydroid, Cordylophora caspia

The colonial hydroid, Cordylophora caspia, has a world-wide distribution, from the cold boreal and antiboreal to the subtropical regions (Roch, 1924; Arndt, 1984). In general, C. caspia occurs in estuaries, lagoons and coastal lakes (Arndt, 1989), and rarely occurs in freshwater (Boreo, 1984). Well developed colonies of C. caspia are found in estuaries and grow at best at salinities of 16‰ (Schlichter, 1999) with relatively constant environmental conditions and considerable tidal influence (Arndt, 1989).

The occurence of C. caspia has also been reported from freshwater (Fulton, 1962) under favourable conditions, such as fast flow, higher oxygen availability, positive ion anomalities ($Ca2+$, $Mg+$, $Na1+$) and permanent twilight (Kinne, 1956; Arndt, 1989).



Hydroid C. caspia, for example, is the major fouling species in the cooling circuits of power stations on the coasts of the Netherlands. The environment inside cooling water circuits of industrial installations is very favourable for hydroid settlement and growth. High water flow within cooling circuits allows for greater oxygen and food supply around the hydroid colony and also diminishes the possibility of excessive sediment deposition on the colony (Boreo, 1984).

C. caspia normally appears between spring and autumn, with very different population sizes being observed over longer periods. Many different environmental influences, such as varying water quality and temperatures, result in strong annual quantity variations.

The increased settlement of hydroids on condenser tubes (e.g. in Velsen power station) affects heat transfer and requires repeated manual cleaning, even after intermittent chlorination (Jenner, 2000).

Not only the settlement of living and dead hydroids in apparatuses, but also their ingress into cooling water systems and deposition in the apparatuses leads to strongly reduced function.

The following article deals specifically with the present situation in the Netherlands. By some examples the fouling problems are demonstrated, and possible solutions suggested, which have proven their effectiveness for nearly 20 years.

Inhalt

Distribution of C. caspia (colloquial: "Apehaar" = monkey's hair) in the Netherlands

The known settlements are marked on the map of the coastal region of the Netherlands (**fig. 1**). It concerns the Noordzeekanaal, the river Maas and the Westerschelde. From the power stations and chemical plants located there, vast experience is available which shall be explained by some examples.

1. Chemical plant Pernis / Hoogvliet (Maas region)

Since the early nineties, a strong occurence of C. caspia has been observed in the entire cooling water circuit, however varying over the years and the seasons. Considerable trouble in the production process led to a search for a type of coarse filtration that could master this kind of fouling. Some filter types, all of them automatic backwash filters, were tested, and it turned out that the filter surfaces were clad by matting within very short time which led to the destruction of the filter surfaces within few hours. The major problem was to clean the filter surfaces, because fibrous debris has a tendency to get entangled behind the filter element, so that the entire surface of the filter element forms a densely knotted carpet (**see fig. 2 and 3**). By comprehensive test series we succeeded in finding an excellent solution consisting in a special execution of the filter element in conjunction with complete pressure relief. In the following chapters this technology will be described in detail. Since 1992, such filters with flow rates between 900 and 3,500 m³/h have been operated, and operational trouble has no longer occured since that time.

2. Rozenburg refuse incineration plant (Maas region)

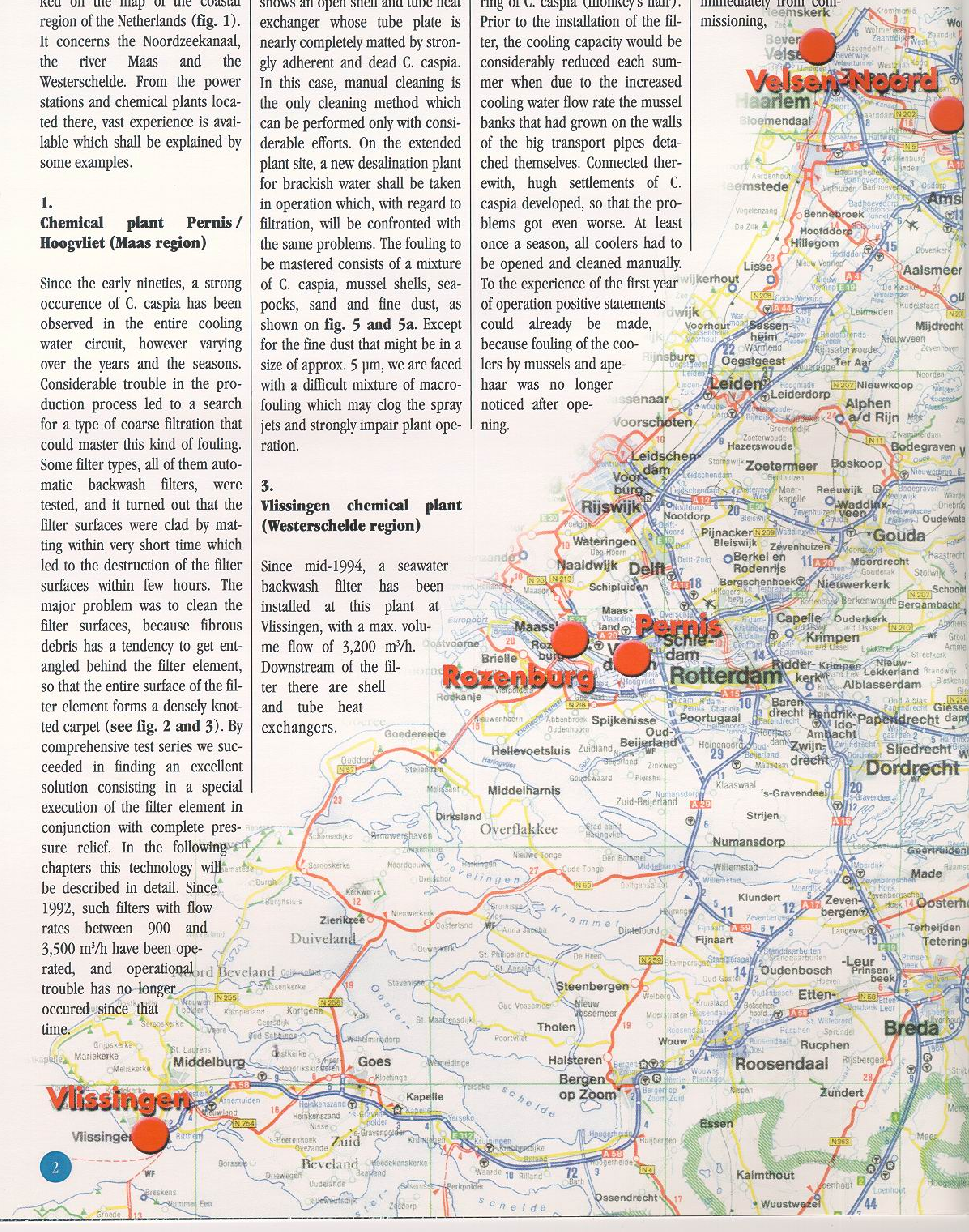
Rozenburg is situated approx. 10 km downstream of Pernis. **Fig. 4** shows an open shell and tube heat exchanger whose tube plate is nearly completely matted by strongly adherent and dead C. caspia. In this case, manual cleaning is the only cleaning method which can be performed only with considerable efforts. On the extended plant site, a new desalination plant for brackish water shall be taken in operation which, with regard to filtration, will be confronted with the same problems. The fouling to be mastered consists of a mixture of C. caspia, mussel shells, seapocks, sand and fine dust, as shown on **fig. 5 and 5a**. Except for the fine dust that might be in a size of approx. 5 µm, we are faced with a difficult mixture of macrofouling which may clog the spray jets and strongly impair plant operation.

3. Vlissingen chemical plant (Westerschelde region)

Since mid-1994, a seawater backwash filter has been installed at this plant at Vlissingen, with a max. volume flow of 3,200 m³/h. Downstream of the filter there are shell and tube heat exchangers.

From the seawater extraction point, seawater is pumped via the filter through the coolers. In addition to the regular mussel filter function, this filter is equipped with a special device for the filtering of C. caspia (monkey's hair). Prior to the installation of the filter, the cooling capacity would be considerably reduced each summer when due to the increased cooling water flow rate the mussel banks that had grown on the walls of the big transport pipes detached themselves. Connected therewith, hugh settlements of C. caspia developed, so that the problems got even worse. At least once a season, all coolers had to be opened and cleaned manually. To the experience of the first year of operation positive statements could already be made, because fouling of the coolers by mussels and apehaar was no longer noticed after opening.

After one year of continuous operation, the interior visual control and the functional check of the filter have shown that neither damage nor noticeable wear and tear have occured since then. Starting immediately from commissioning,



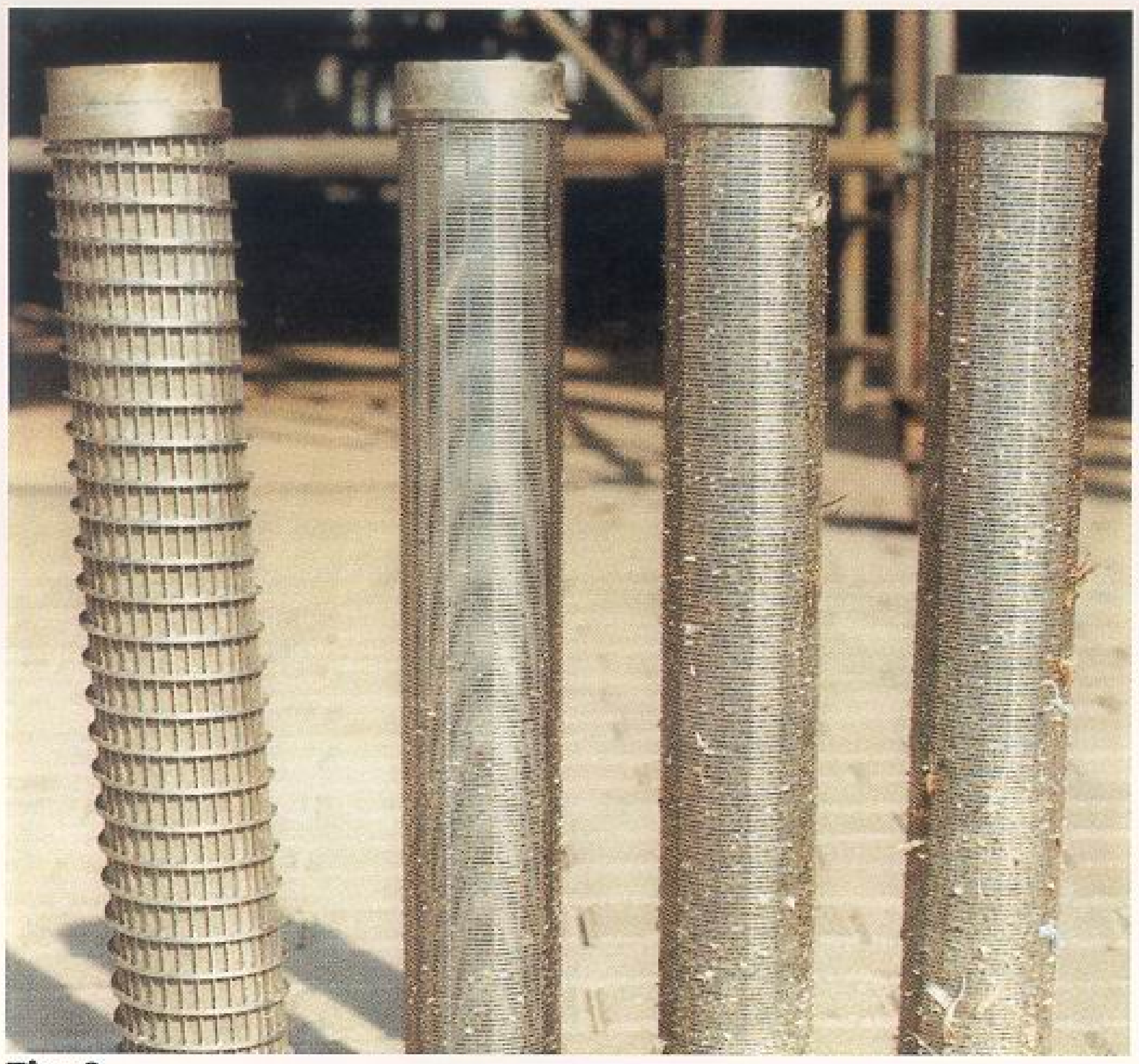


Fig. 2

Fig. 3

the filter has perfectly functioned for one year, without trouble and monitoring. Even with an extremely high seawater temperature of 23°C in summer 1994, the complete cooling capacity of the connected coolers was safeguarded.

4. Velsen Noord power station (Noordzee region)

The installed two-pass condenser had first been provided with tubes at the tube sheet that had protruded into the reversing chambers. At this place, apehaar of 50 cm length got entangled, and matting developed. In addition to clogging, corrosion came into being on the tubesheet. The supplier of the condenser was ordered to cut the tubes flush with the tubesheet to avoid the formation of corrosion. However, clogging by C. caspia had not yet been solved by this measure.

For the time being, production must be disrupted for 3 days twice or three times a year to perform manual cleaning – which must take place despite biochemical treatment of the "Riol" water (= sewage water). It can also be observed that by the reduced application of nitrates, phosphates and other pollutants used by agriculture, the water quality has clearly ameliorated.

A not foreseeable change of the water quality of the North Sea is being noticed every year, with the consequence that different charges are to be reckoned with in different periods, such as, mussels, sea pocks, "apehaare", etc.

In one power station in Amsterdam, mainly crab and mussels are to be found, less "apehaare".

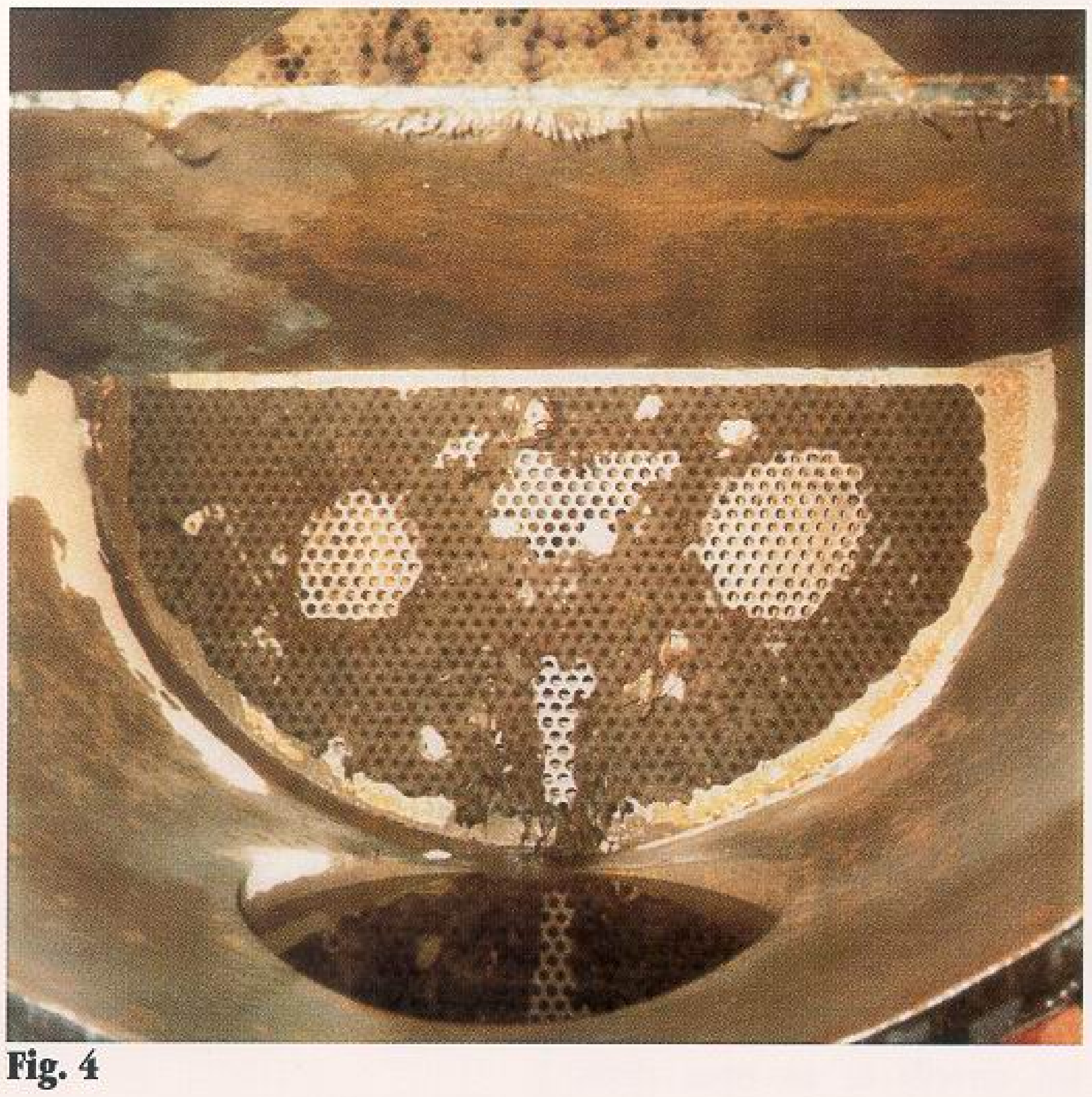


Fig. 4

Fig. 5

Fig. 5a

Solution to the problem of C. caspia by a specially developed automatic backwash filter

For problems as described above, a filter has been developed that is able to safeguard the complete cleaning of the filter surfaces after backwash. This filter may be considered a permanent solution due to its unrestricted availability. The installation of this type of filter guarantees trouble-free operation of production and considerably reduces costs for manual cleaning and maintenance. ☞

Description of the "Apehaar" Filter PR-BW 100-HP

Design

The filter consists of a spherical housing which is divided in the middle and connected by mating flanges (**fig. 6**). Between these flanges, the filter section (item 2) is installed – a perforated steel sheet. Gaps between clean and inlet water side are avoided, so that debris particles have no chance to pass by the filter screen.
The size of perforation depends on the type of debris. In special cases, such as with the filtration of "apehaar", its definition requires large-scale tests.

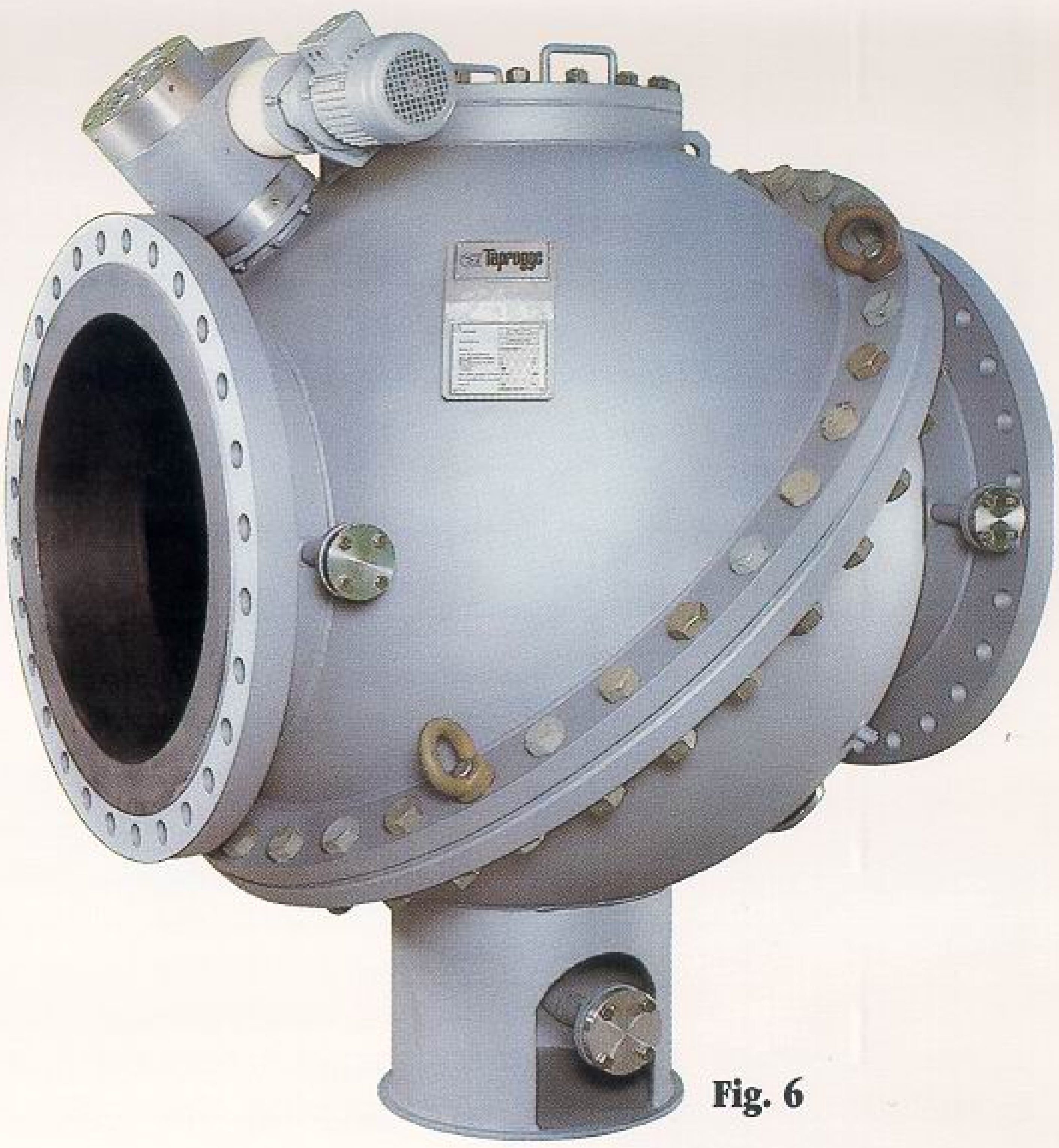


Fig. 6

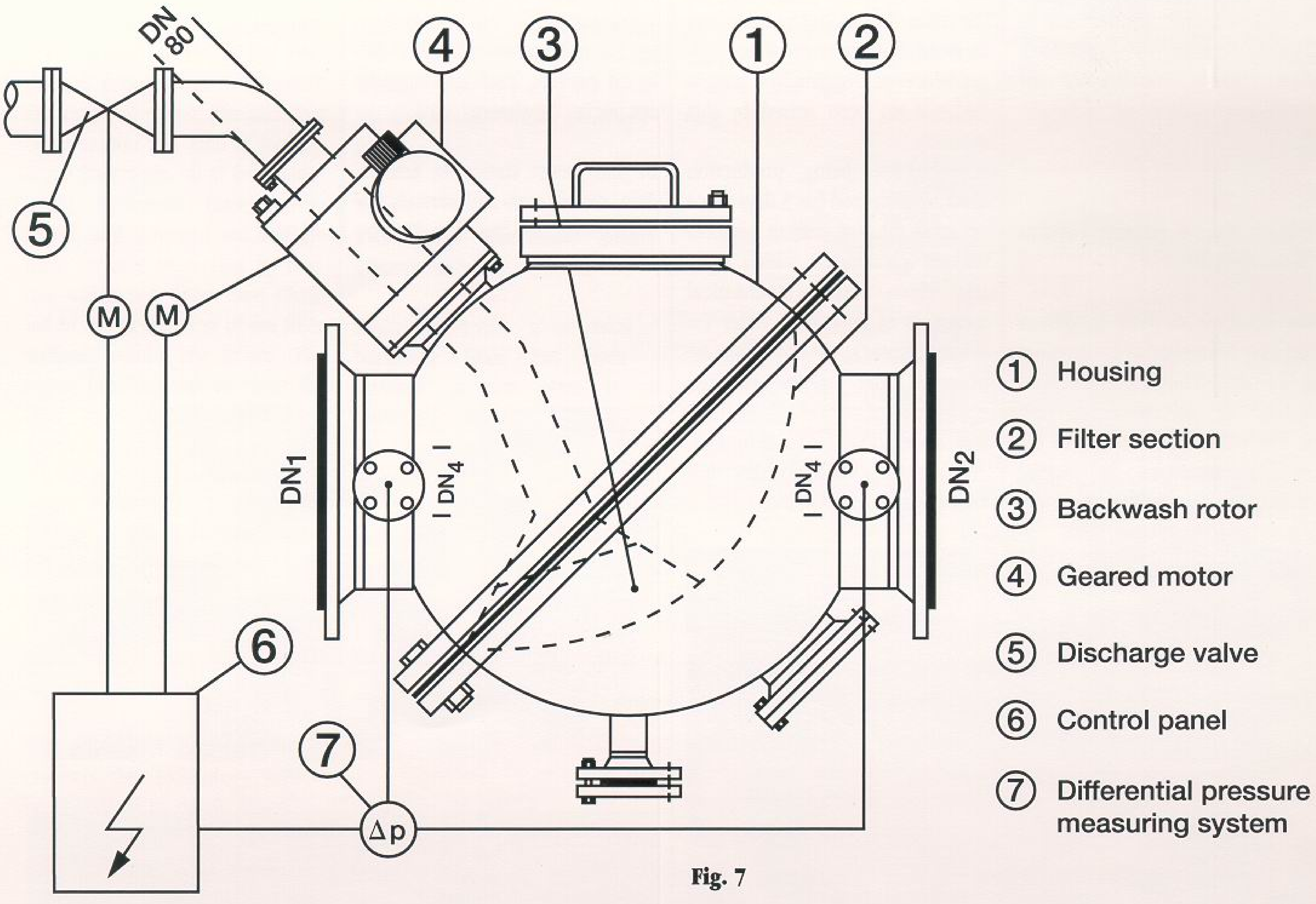


Fig. 7

On the inlet water side of the filter section, a backwash rotor (item 3) is arranged. The rotor is guided by two bearings and driven by a gear motor (item 4). The inlet opening of the backwash rotor is designed as a suction channel which partly covers the filter section. The channel inlet is provided with a flexible rubber sleeve and has a certain minimum distance to the filter section. A differential pressure measuring system (item 7) is connected to the nozzle DN 4.

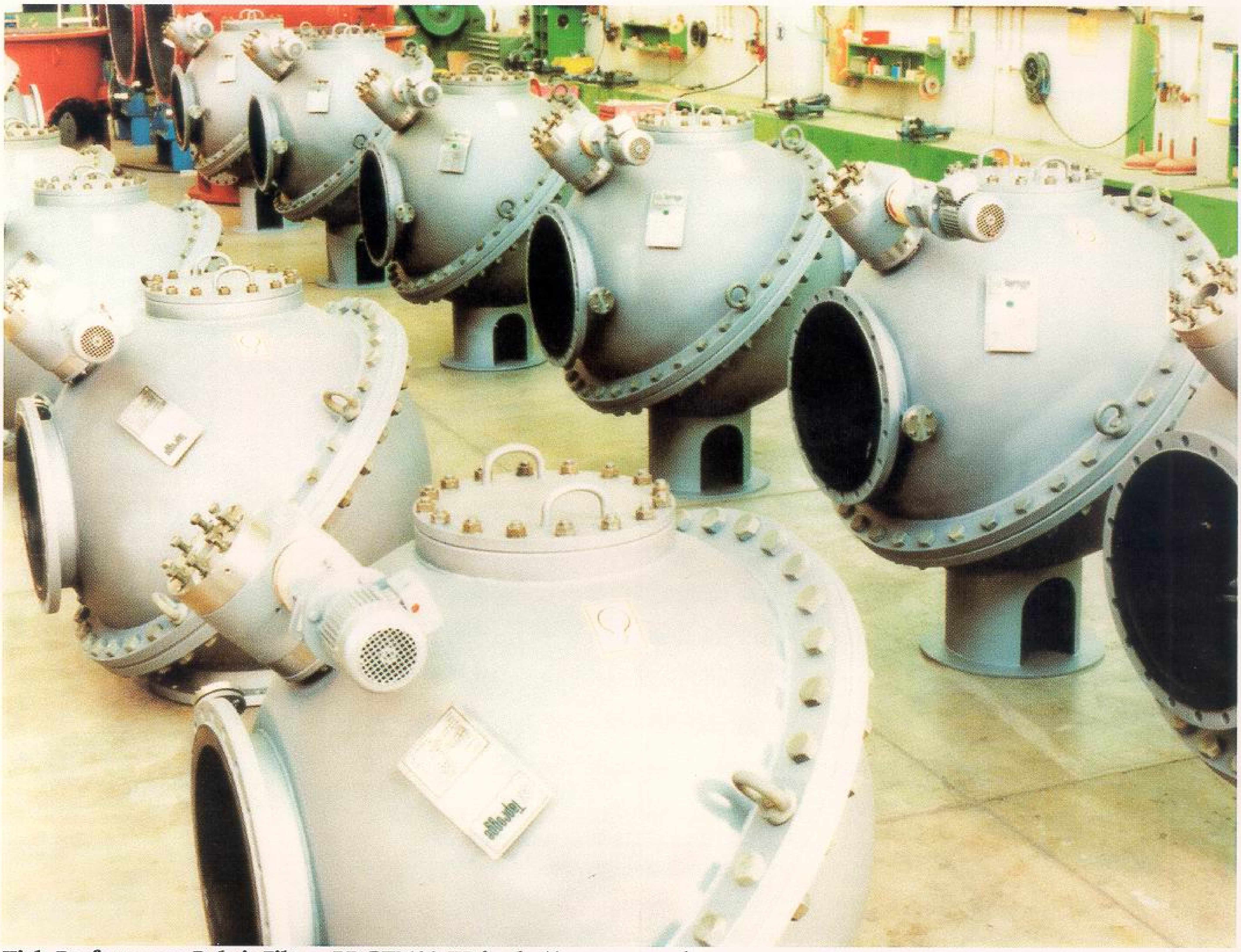
The discharge valve (item 5) may not cause a contraction of the cross-section and is equipped with an actuator. The discharge pipe is connected with pipes of lower operational pressure, or is led directly to an open drain.

Between the filter and the end of the discharge pipe, a pressure differential develops which must be sufficient to transport the debris out of the system (see sketch).

The special feature of the "Apehaar" Filter PR-BW 100-HP is a pressure-relieved chamber on the clean water side which travels with the backwash rotor with which it is connected.

Function

The cooling water enters the filter housing through the nozzle DN 1, passes through the section and leaves the filter through nozzle DN 2. All debris particles larger than the perforation size are retained on the filter section. The gear motor is actuated and the discharge valve is opened by the differential pressure measuring system or a timer.
The pressure difference between the operational pressure inside the filter and the pressure at the end of the discharge pipe produces a backwash at the filter section. By turning the rotor 360° the entire filter section is automatically pressure-relieved and backwashed with its self-medium. After 3 rotor revolutions within approx. 90 seconds the backwash procedure has been completed. The maximum debris discharge flow is not more than 5% of the total flow rate during the backwash cycle.
Backwashing is repeated until the value of the originally clean differential pressure has been reached again.



High-Performance Debris Filters PR-BW 100-HP in the Taprogge works

Installation

The PR-BW 100-HP filter can be installed in any position, horizontally or vertically, and in any angle, either in a straight pipe or instead of a pipe bend (**fig. 9**).

Fig. 9

Technical data

connection nozzles DN 1 and DN 2	150 to 800
filter surface area	6 to 8 x DN 1
pressure drop at 1.8 m/s	0.02 bar at > 3 mm perforation
debris discharge flow rate	< 5% of the total flow rate
drive power	0.1 to 0.5 kW

Special features and advantages of PR-BW 100 filter

- Fully automatic self-cleaning of the filter section and discharge of coarse particles
- No gaps between clean water and inlet water side and thus no by-pass of coarse particles to the clean water.
- In case of power failure back-washing of the filter section can easily be effected manually.
- Small backwash water quantity
- Short backwash time
- Large filter surface
- High debris storage capacity
- Very low pressure drop
- Low electric power consumption
- Low space requirement
- Optional nozzle positions
- Very effective for all kinds of debris, especially for fibrous kinds
- All wetted parts are rubberlined or made of stainless steels
- Easy control
- High efficiency/price ratio
- High operational and functional safety
- No counterflushing and no additional or seal water necessary

Worldwide Application of PR-BW 100-HP Filter

In addition to the Netherlands, "apehaar" algae filters are installed for the following applications:

Platform	Baltic Sea
Council Building	Chinese Sea
International Building	South China Sea
Heat pump power plant, Göteborg	Sewage
Nuclear power plant, Sweden	Baltic Sea
Chemical plant, Turkey	Mediterranean Sea
Chemical plant, India	Bay of Bengal
Hotel, Hong Kong	Chinese Sea
Chemical plant	Cattegat

As mere macrofouling filters, e.g. for mussels, sea pocks, fish, crab, jellyfish, leaves, twigs, grass, plastic foils, concrete parts, etc., 300 units of the filters have been operating the world over since 1982 under the name of PR-BW 100, i.e. without special pressure-relief chamber.

Conclusion

As long as it is possible to mechanically separate debris from waters by means of filters, which means in such a way that cleanliness of filter surfaces is always safeguarded and the filters thus perfectly master their task, the use of chlorine or other chemicals should be renounced on.
The continuous injection of chlorine, or intermittent chlorine dosage, do not avoid the growth of organisms in the water but only reduce them. Manual cleaning of apparatuses remains necessary at regular intervals and causes costs for devices and manpower, in addition to production losses. Also chlorine and other chemicals produce regular costs which are not to be neglected.
As has turned out in the course of recent years, the operation of automatic backwash filters and moderate chemical dosing provide the best treatment of cooling water – with regard to not only economic results, but also environmental burden.
The increased installation of automatic backwash filters in chemical plants confirms the success of this filter type which continues to be available as excellent solution.

QUESTIONNAIRE AUTOMATIC BACKWASH FILTER

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Customer: ______________________

User/Plant/Name: ______________________

Project No.: ______________________

FLUID

Seawater ☐ Brackish water ☐ Riverwater ☐

Wellwater ☐ Cooling pond ☐ Cooling tower ☐

Other fluids: ______________________

PRECLEANING

Coarse screen: ☐ (Meshsize mm–inch) ____ Fine screen: ☐ (Meshsize mm–inch) ____

Other precleaning: ______________________

POLLUTANTS

Sand ☐ Fibres ☐ Silt ☐ Mussels ☐

Other Pollutants: ______________________

Debris-load: (mg/l–ppm) ________ max. particle size: (mm–inch) ________

OPERATION DATA

Flowrate: (m^3/h–kg/s) ________ Required fliteration degree: (µm–mm) ________

Nominal diameter: DN/norm ________ Operation pressure: (bar) ________

Operation temperature: (°C–°F) ________ Voltage: ☐ Ex-Proof (Volt) ________

Purpose of filtration: ________ Location: ________

Arrangement drawing submitted: yes ☐ no ☐ Water analysis submitted: yes ☐ no ☐

Special remarks: ______________________

Prepared by: ________ Date: ________