ENEA-RT/VEL/84/4

R. Caponetti, M. Iacovelli (ENEA - Dipartimento Reattori Veloci, Casaccia)

EXPERIMENTATION WITH PEC CHANNEL PROTOTYPE: TESTS IN SODIUM, WASHING AND ASSESSMENT AFTER WASHING

Riassunto — Al Cre Casaccia sono attualmente in sperimentazione alcuni prototipi di componenti del PEC.
Questo rapporto riguarda i risultati del primo ciclo di prova del canale centrale, relativamente alla fase di lavaggio del componente dopo sperimentazioni in sodio.

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Summary — *Experimentation on prototypes of PEC components is presently being carried out at Casaccia Cre. This report shows the results of the first cycle of experimentation of the Central Channel, concerning the aspects of sodium removal after experimentation.*

COMITATO NAZIONALE PER LA RICERCA E PER LO SVILUPPO
DELL'ENERGIA NUCLEARE E DELLE ENERGIE ALTERNATIVE

R. CAPONETTI, M. IACOVELLI

EXPERIEMENTATION WITH PEC CHANNEL PROTOTYPE: TESTS IN SODIUM, WASHING AND ASSESSMENT AFTER WASHING

RT/VEL/84/4

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NOTE:

A work group consisting, in addition to the authors, of the following persons designed, prepared and conducted the experiments reported in this paper:

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G. Caminiti

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The alterations to the washing plant necessary for connection with the closing tube and channel were done by Mr. S. Barcaroli.

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1. SUBJECT OF THE PAPER

Reported in this paper are the description and the results of the washing process to which the CPC-2's closing tube and the prototype of PEC's Central Channel were subjected after being tested in sodium.

The closing tube is the component that forms the continuity of piping of the CPC-2, in substitution of the channel, during the plant's testing stages and which has made it possible to verify on a 1:1 scale the correspondence of the washing method established for the channel prototype after sodium tests. The substitution of the channel with the closing tube in the CPC-2 unit was impossible however since, for reasons of space, it was impossible to reproduce the hot shaft of the channel for its entire length.

Because of the sizes of both the tube and the channel, larger than that of tank SE 1, it has been necessary to establish a different washing procedure than those normally used, based on the installation of the component under test in the SE 1 washtank. As will be explained clearly later herein, the new procedure established for these components called for their connection in a position outside and parallel to tank SE 1 in order to obtain the circulation of the washing liquid to their interior from tank SE 1 itself.

For a more complete description of all the activities carried out, also the steps taken to prepare the

system for the procedure are discussed briefly in this paper and a short introductory paragraph treats the experimentation of the two components in sodium. In addition, a schematic list is given of the various steps making up a complete testing cycle of the two components.

2. BRIEF DESCRIPTIONS OF THE OVERALL ACTIVITY INVOLVING THE CLOSING TUBE AND THE PROTOTYPE OF THE PEC CHANNEL

Notwithstanding the experimentation steps in sodium of the closing tube and of the channel were very different (the former served to test the system and has therefore only been subjected to a number of test shocks, whereas the complete first step of the experimental activity previously scheduled was carried out with the latter), from a general point of view, the complete testing cycles for the two components turned out to consist of the same successive steps. They are:

a) testing in sodium

b) removal of the component from the CPC-2 unit

c) removal of the outer insulating material and of the heating cables from the component

d) transfer to the washing plant

e) washing

f) inspection after washing.

The operational procedures and results of the experimental test cycle relative to steps (e) and (f)

are reported in this paper. All the other steps are reported in papers VT-BC-00013 and VT-BC-00019.

3. IN-SODIUM TESTING

The closing tube and the prototype of the PEC channel have been subjected to a cycle of thermal shocks in the Component Testing Circuit (CPC-2), the first to a total of twenty-two shocks, of which twenty from 650° to 450°C and two from 650° to 390°C, and the second to a total of 120 shocks with Δ T of 200°C (sodium temperature exactly equal to 650 and 450°C) and to twenty with Δ T of 260°C (sodium temperature exactly equal to 650° and 390°C).

During testing, by means of continuous purification for consecutive periods of 8 to 10 hours, the sodium was kept very pure and the plugging temperature was always under 130°C, corresponding to around 1 ppm of oxygen in the sodium.

Figures 1 and 2 respectively illustrate the longitudinal section of PEC's central channel and the graph of the thermalshocks to which the latter was subjected over time.

4. WASHING

Before proceeding with the description of the successive steps of the washing procedure it is pointed out that they were the same for both components, with the same operating times and with the same results, inasmuch as the only difference between the two washing procedures was that the first was a test (of the closing tube) and the second (of the channel) was programmatic. Thus mention will hereinafter be made only of the washing of the component, with the reference being to both the testing operations carried out in a first instance on the closing tube and the washing of the channel effected in a second instance.

4.1 Preparations for the washing process

Upon termination of the in-sodium test the component was transferred, after removal of the outer insulation and disassembly of the electrical lines and wires for sodium leak detection, to the washing plant. The complete description of these operations is reported in paper VT-BC-00005. As has already been pointed out, due to the size of the component, it was previously to establish an operational procedure based on the installation of the same in an outside and parallel position to the SE 1 washing tank, as shown in the diagram of Figure 3. For greater clarity relative to the connection techniques detailed illustrations of the connection of the upper part of the closing tube and of the channel

to tank SE 1 are given in Figures 4 and 5.

The circulation of the washing liquid from tank SE 1 to the component was ensured by means of a 2" connector pipe and the inclusion of control valves, with input being from the lower part of the component.

Figures 6, 7 and 8 show respectively:

- the connection of the upper part of the channel to tank SE 1 with flow-rate control valves V_1 and V_2;
- the connection of the lower part of the channel to the manifold of the sprayheads in the washing unit;
- detail view of the connection of the lower part of the channel to the manifold of the sprayheads in the washing unit.

4.2 Washing procedure

Due to the component's very plain shape, the washing procedure was easy to establish and to carry out in practice. For removal of the sodium, which remained mostly in the form of a film on the inner surfaces of the two components and for the final rinsing respectively, butylcellosolve (ethylene glycol monobutyl ether) and demineralized water were used. The successive steps of the operations were the following:

- Inertization:

  tank SE 1, the component and the relative connections were made inert by repeated creation of partial vacuum in them and then filling with nitrogen until obtaining an oxygen concentration of less than 500 ppm. Five

complete cycles of vacuuming and pressurization were necessary to achieve this result.

- Flooding with solvent:

  Tank SE 1 was filled to slightly more than one tenth of its volume with butylcellosolve at room temperature.

  Its circulation and heating was then started, up to a temperature of 50°C, by opening the component's 2" lower connection valve to the tank. One (the one at the side) of the two upper connection valves to SE 1 was kept partially closed at this stage and the other (installed at the headend of the channel) open. This arrangement ensured circulation within the component under optimal conditions.

  The process parameters (hydrogen concentration, temperature, etc.) were controlled, as previously reported[1, 2 and 3], using the plant's instrumentation.

4.3 Rinsing

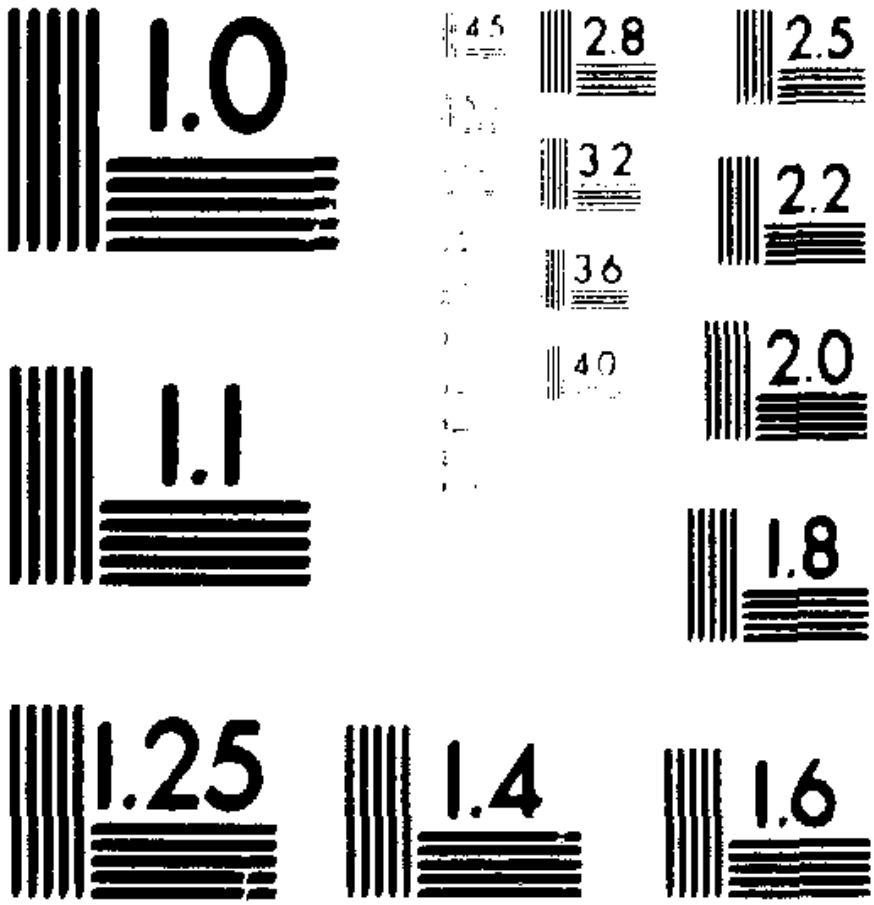
After hydrogen development (very slight given the small quantity of sodium deposited) ceased, the component was rinsed with demineralized water. The same circulation techniques were used for the water as already described for the solvent. The rinsewater temperature was kept at around 70°C and the component was rinsed seven times.

4.4 Drying

Drying of the component, of tank SE 1 and of the connection piping was carried out by repetition of successive cycles of vacuuming, filling with nitrogen and heating of the same with the external heaters installed on the component for the purpose (partially visible in Figure 7).

Nine cycles were necessary to complete the drying process.

Table one indicates the complete process (washing, rinsing and drying).



Process steps				
Process parameters	Before washing begun	Washing	Rinsing	Drying
Butylcello-solve temp.	20-30°C	30-50°C	-	-
Demineral-ized water temp.	-	-	70°C	-
Nitrogen temp.	20°C	20°C	-	80°C
Hydrogen con-centration	-	0-3%	-	-
Oxygen con-centration	<500 ppm	<100 ppm	-	-
H_2O concen-tration in nitrogen	-	-	-	<30 ppm
Vacuum	1 mbar	-	-	1 mbar
Pressure	1030 mbar	1030 mbar	-	1030 mbar

5. OPERATIONS AFTER WASHING, RESULTS AND CONCLUSIONS

After having washed the closing tube and the channel prototype they were disconnected and sectioned. The inspection of the various parts constituting these components revealed no trace of sodium, not even the most minute quantity. The washing and forced solvent circulation method has therefore been judged to be adequate.

The simple form of the components has, moreover, made possible very short operation times, since only twelve days were necessary for the complete process.

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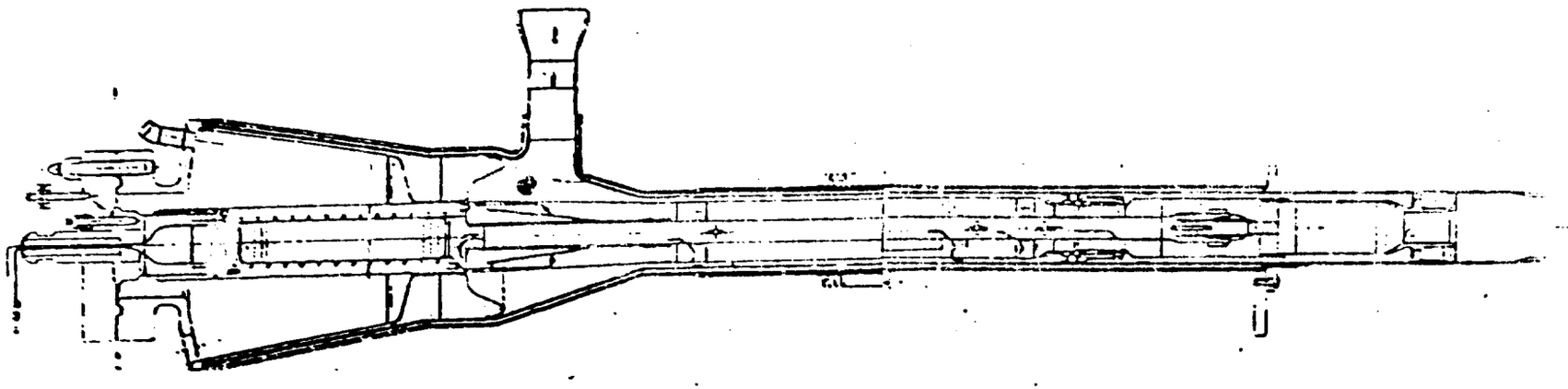


Fig. 1 - Longitudinal section of PEC's Central channel

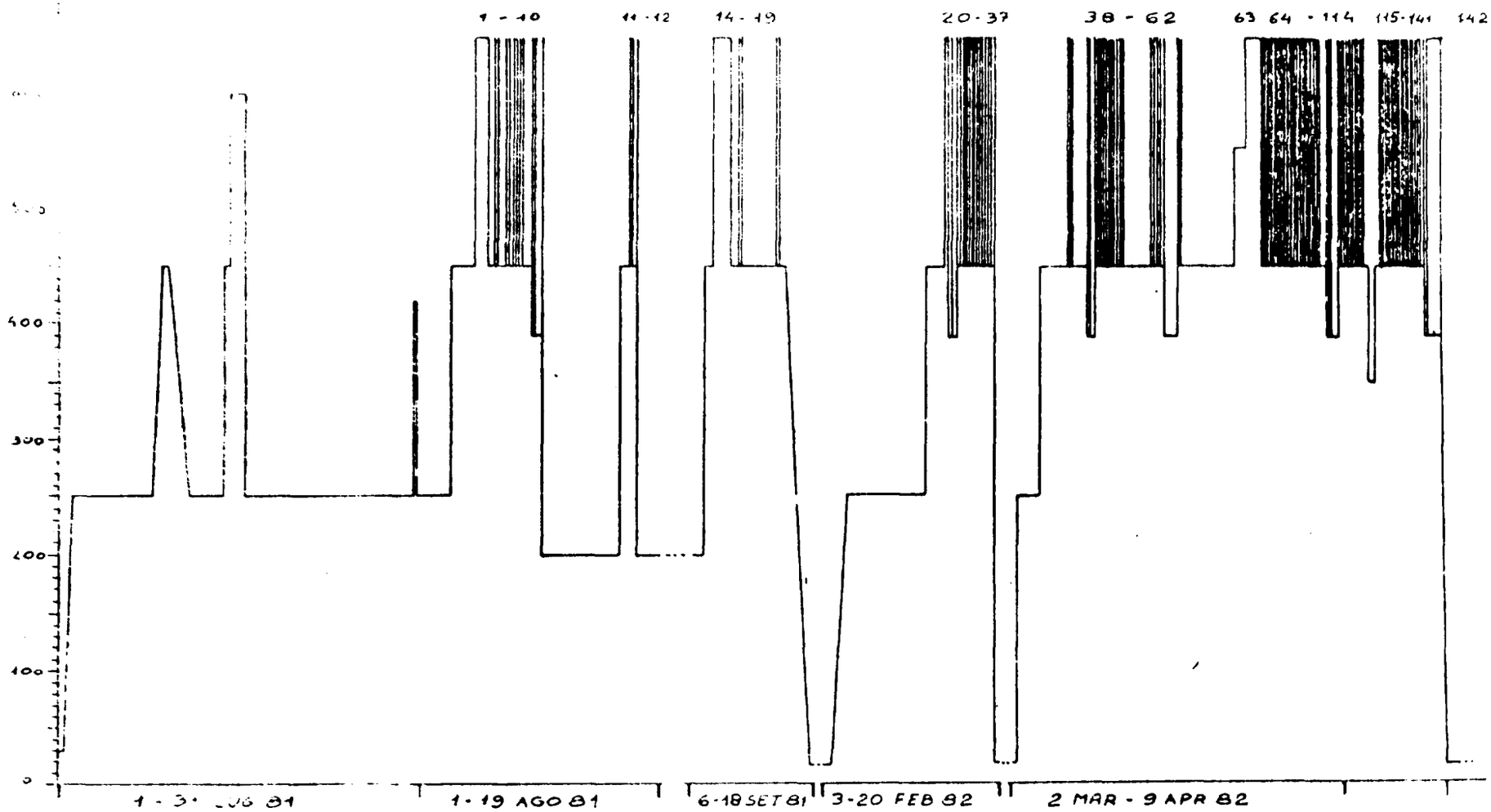


Fig. 2 - Graph showing thermal shocks to wich PEC's central channel was subjected.

Fig. 3 - Diagram showing connection of channel with washing plant components

L E G E N D

P = solvent circulation pump

R = solvent heater

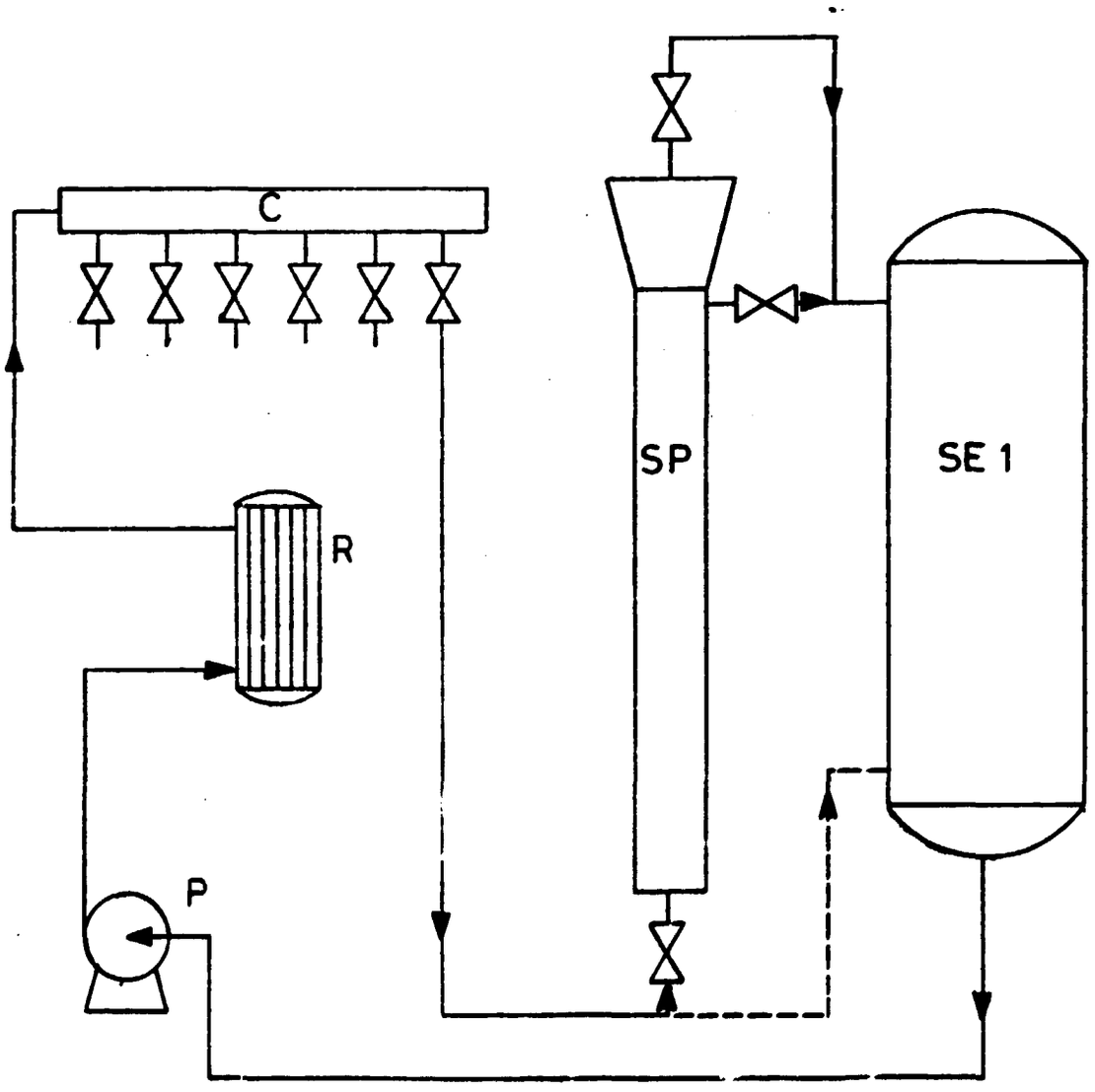
C = spray-head manifold

SP = test section

SE 1 = washing container

--- = SE 1 filling line

—— = heated solvent circulation line



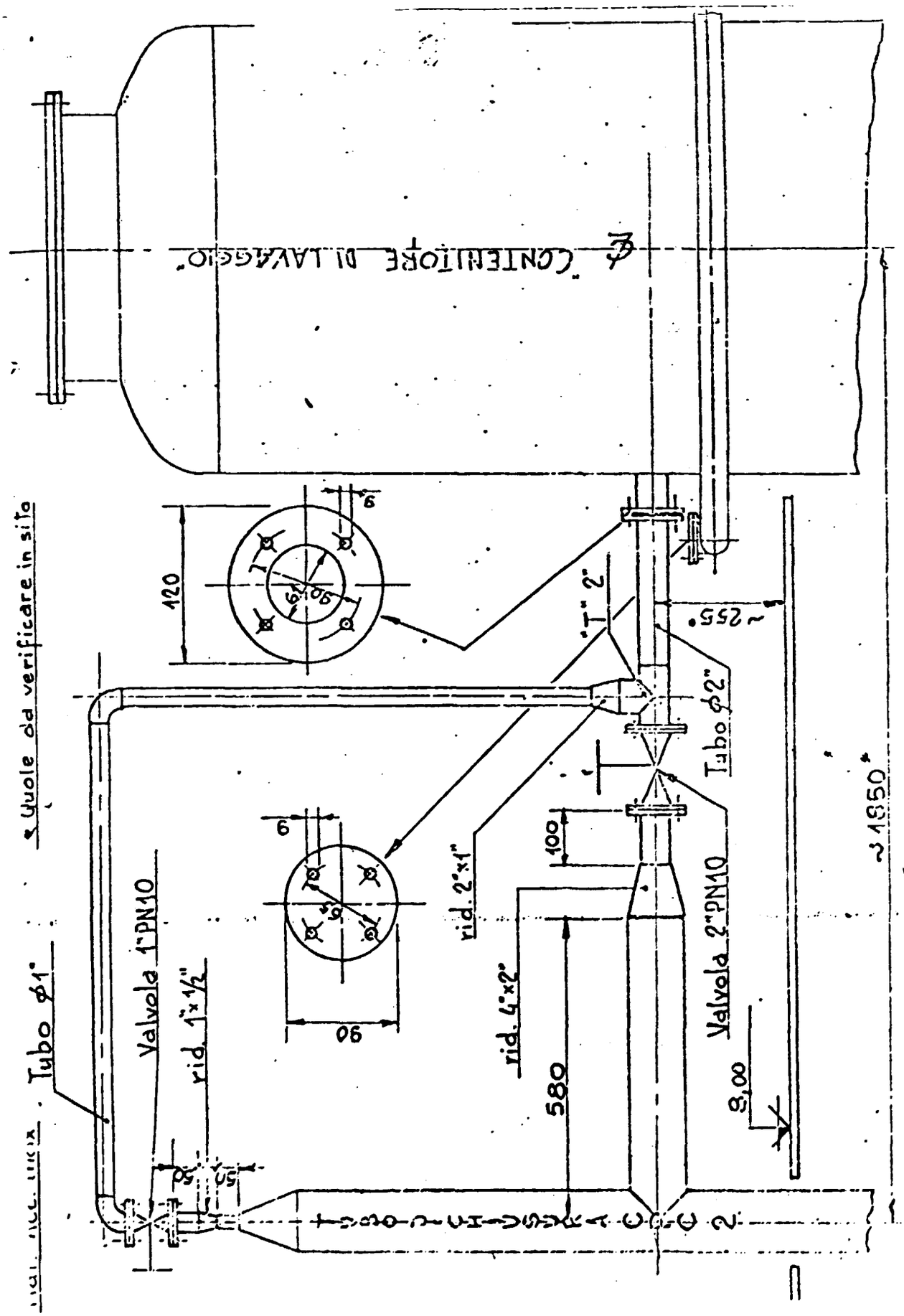


Fig. 4 - Detail of the connection of the upper part of the closing tube with tank SE-1

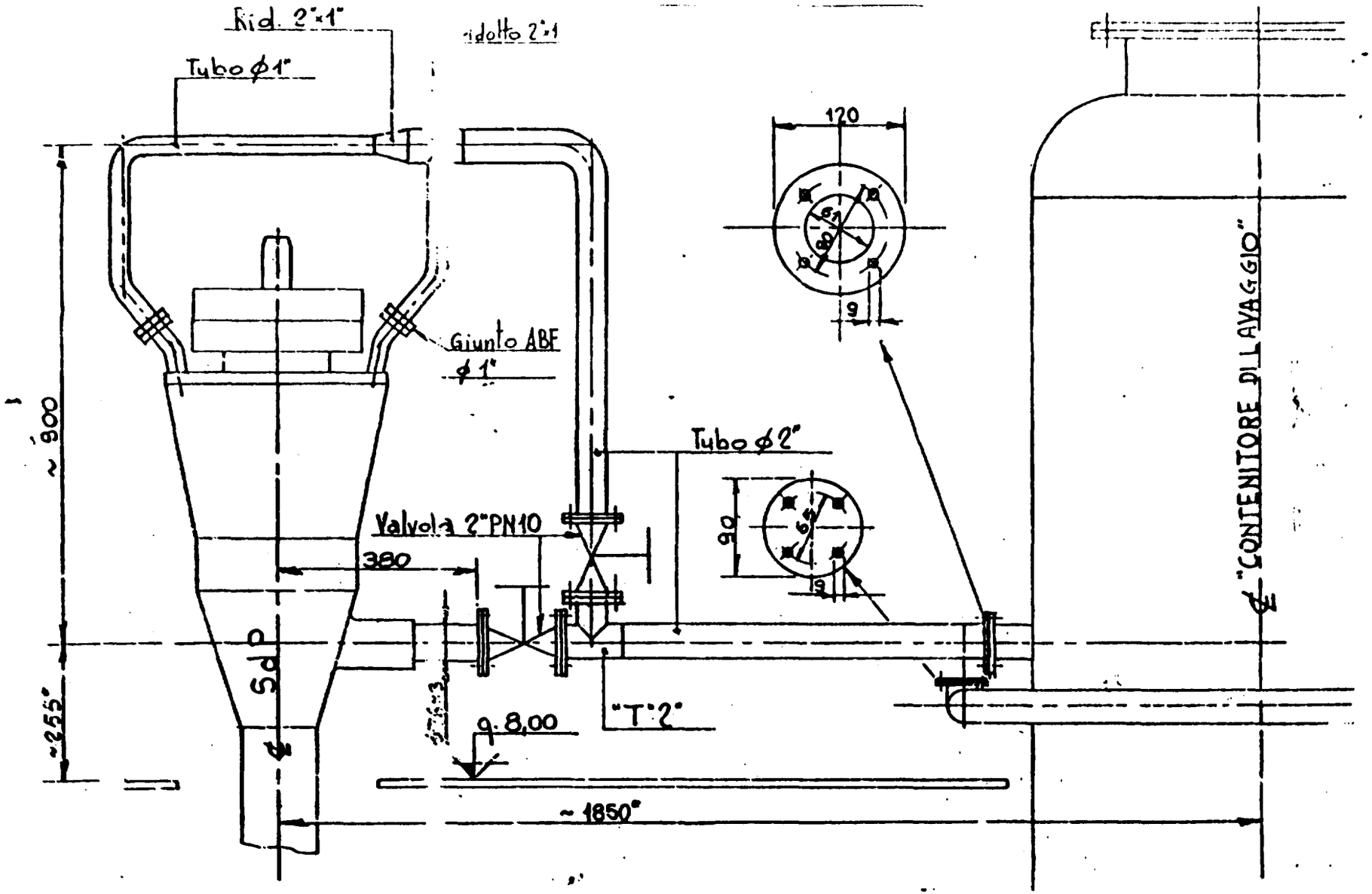


Fig. 5 - Detail of the connection of the upper part of the channel to the tank SE 1

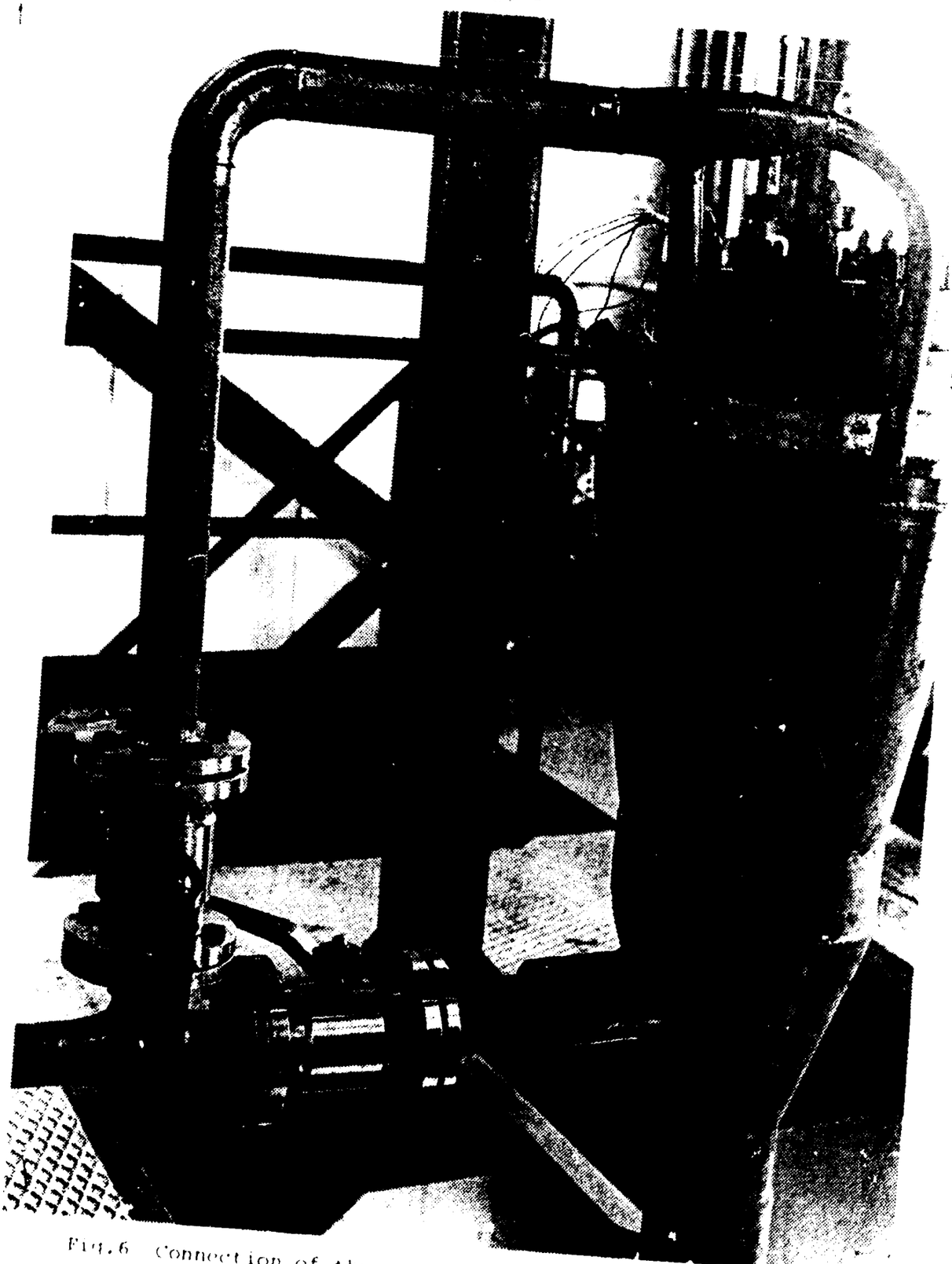


Fig.6 Connection of the upper part of the channel to tank SE 1 with flow regulation valves V1 and V2.

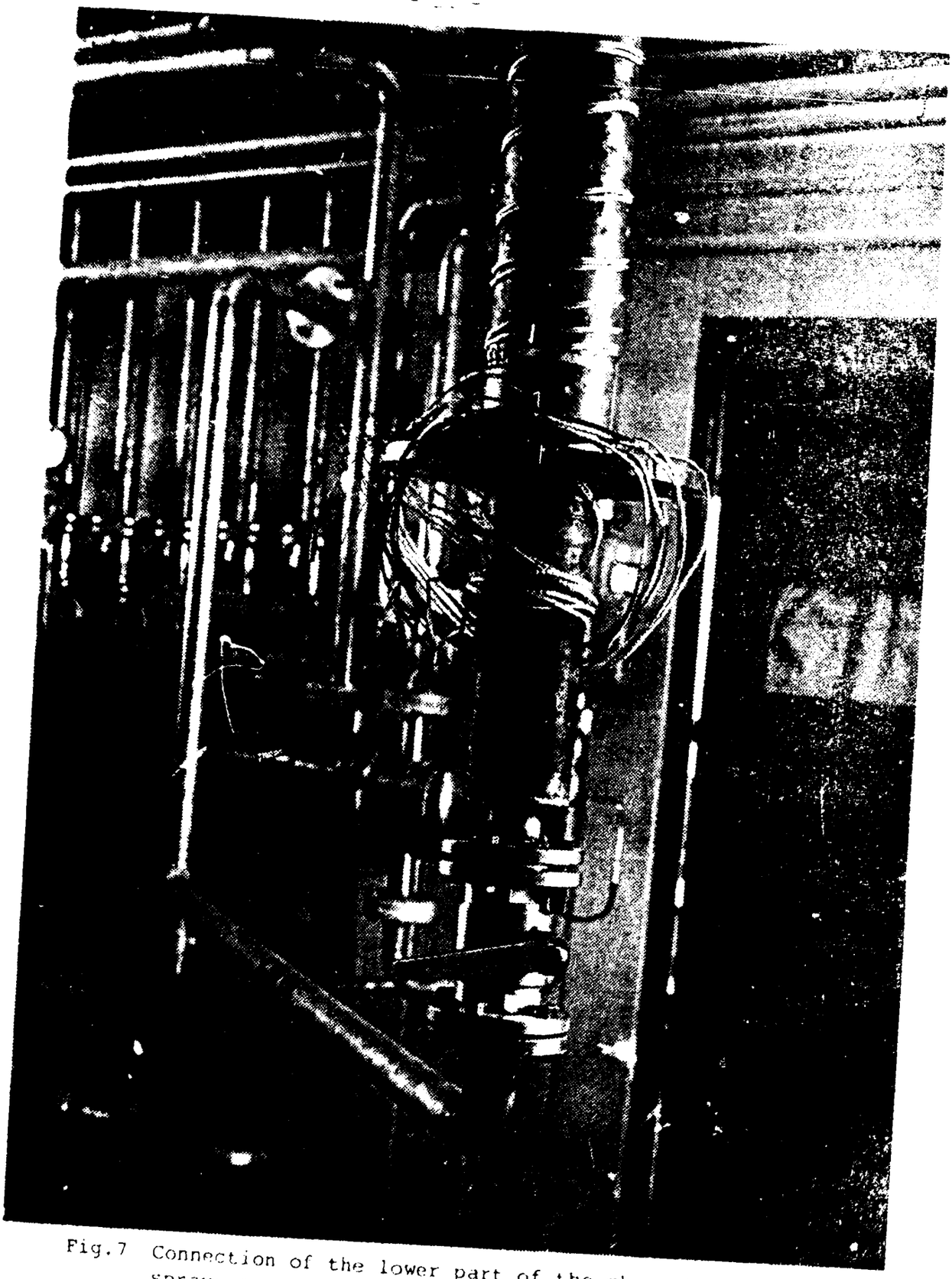


Fig.7 Connection of the lower part of the channel to the spray-nozzle manifold of the washing plant.

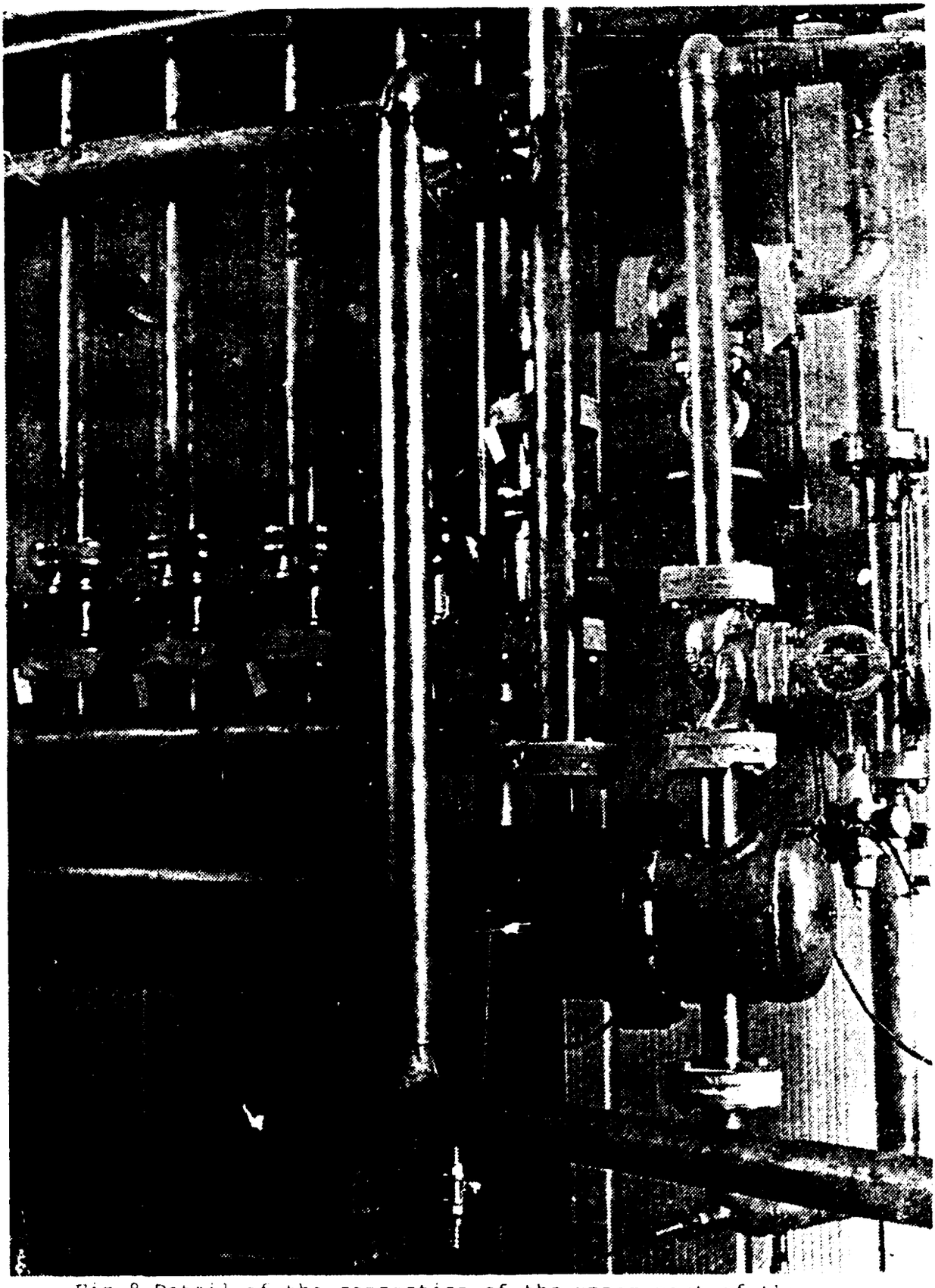


Fig.8 Detail of the connection of the upper part of the channel to the spray-nozzle manifold of the washing plant.