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Author: V. D. Ganzha, K.A. Konoplev, V.D. Trenin, V.T. Sharov

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An Ion-Exchanger for Obtaining Make-Up Water for a Reactor

V. D. Ganzha, K. A. Konoplev, V. D. Trenin, V. T. Sharov

The operation of water-cooled and water-moderated reactors requires a considerable quantity of demineralized, high quality, water. Four electrical distillers with an output of 60 liters/hour were designed to provide distilled water for the VVR-M * reactor. Experimental operation of the distillers, which were fed with artesian well water with a total salt content of some 400 mg/liter (basically calcium and magnesium bicarbonates) was unsatisfactory. The distilled water obtained had a comparatively low specific resistance (on the order of $4 \cdot 10^4$ ohms/cm); because of the low capacity the distillers had to be in constant operation and their operation supervised. Moreover, the distillers had to be shown down for scale removal after every 10 m³ of distillate had been obtained.

* V. V. Goncharov, and others. In the book "Proceedings of the Second International Conference on the Peaceful Use of Atomic Energy," Reports of Soviet Scientists, Vol. 2. Moscow, Atomizdat, 1959, p. 243.

Supplying the reactor with demineralized water from other sources proved to be time consuming and expensive. Accordingly, The Physical-Technical Institute imeni A. F. Ioffye of the Academy of Sciences of the USSR designed and built an ion-exchanger which makes it possible to desalt artesian well water directly, without first purifying it by other methods, such as distillation, for example. The installation has made it possible to obtain high quality water (total salt content 1 mg/liter, number of chlorine ions less than 0.02 mg/liter) for the needs of the reactor and for other of the Institute's laboratories. Installation productivity is 3 m³/hour of desalted water, and the total amount of make-up water suitable for the purpose obtained between two regeneration cycles is 50 m³. This high productivity for the comparatively low total volumetric capacity of the filters was selected in order to make rational use of the tank with a total capacity of 40 m³ available in the reactor, and designed for the emergency reserve of shut-down cooling water for the reactor's primary circuit, and for storing make-up water. The installation was small enough to be installed in a space with an area of 15 m². The ion-exchanger includes (cf., the sketch) four ionite filters (using KU-2 cation-exchange resin and EDE-10P anion-exchange resin; each filter is charged with 250 liters of swollen resin), each with a volume of 500 liters, two airlifts for desalting the water, 200 liters each, two airlifts with a volume of 500 liters for preparing the acid and base regeneration solutions, a mixer and a neutralizer for mixing and neutralizing the regeneration mixtures dumped, and the system of piping and valves which makes it possible to do all the work involved in operating the installation. The structural material is stainless steel, Mark 1Kh18N9t. Installation operation involves the following sequence: desalting, loosening, regeneration, wash out.

For desalting the artesian well water passes successively through four filters and is collected in the airlifts used to collect the desalted water. Compressed air is used to blow the water from the airlifts to the make-up water tank for the reactor, or to other requirements.

Quality control of the water obtained is obtained by constant measurement of specific resistance of the water (in the watercourse) with a laboratory conductance

meter, by conducting periodic chemical analyses for the presence in the waters of ions Ca^{++} , Mg^{++} , $\text{Fe}^{++} + \text{Fe}^{+++}$, chlorine, HCO_3^- , and SiO_3^{--} , by measuring pH, by analysis for oxidizability, and by determining the dry residue (see table). Prior to regeneration, the ion exchange resin (ionite) is loosened with technical water directed from the bottom upward. The cation-exchange resin filters are regenerated with 1.5, 3, and 6% solutions of sulphuric acid, one after the other, per 500 liters. The regeneration solution is made with technical water in the acid airlift and passed through the filter at a velocity of 5 meters/hour ($1 \text{ m}^3/\text{hour}$). 100 kg of concentrated sulphuric acid is used to regenerate the cation-exchange resin filters. A 6% solution of caustic soda is used to regenerate the anion-exchange resin filters. The regeneration solution is made in the base airlift with desalted water. 30 kg of caustic soda are used. The installation can be completely regenerated in 8 hours, after which the cation-exchange resin filters are washed out with technical water until the acidity is about 1 mg-equivalent/liter for methyl orange; the anion-exchange resin filters are washed out with cation water until the alkalinity is about 1 mg-equivalent/liter for phenolphthalein.

The ion-exchanger has been in operation since October 1961. The quality of the water obtained from it meets the requirements imposed for reactor water purity (see table). The installation is started up periodically, once every two to three months and can be serviced by one man when it is in operation. Use of the ion-exchanger has permitted us to improve the quality of the reactor make-up water and to reduce the cost to get it 1,000 times (resulting from operational expenditures).

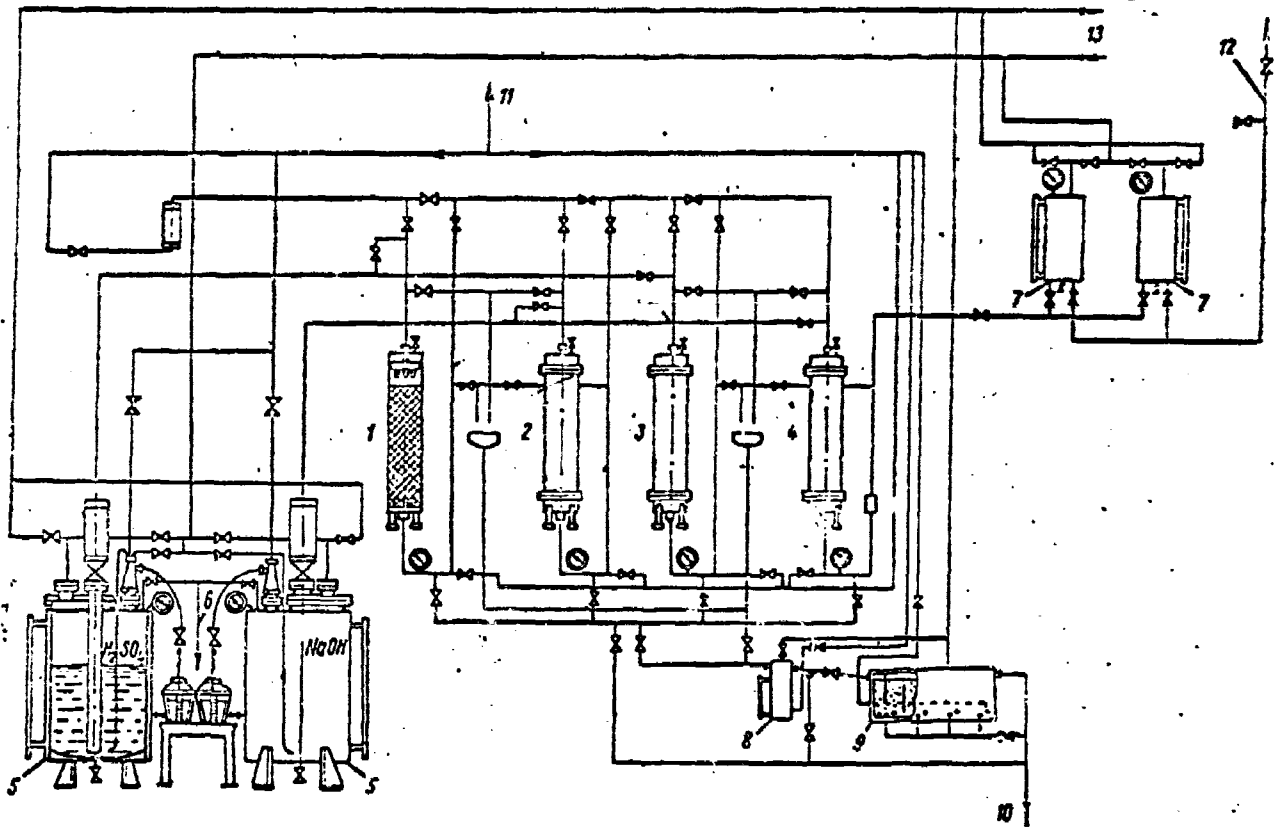
The authors wish to express their deep appreciation to B. P. Konstantinov for the suggestion to switch to the ion-exchange purification system, and to D. M. Kaminker for support in the work, as well as to P. P. Korystin and I. V. Vol'f, on the staff of the All-Union Scientific-Research Institute for Hydraulic Engineering and Sanitary Engineering Work for their help in conducting the laboratory tests of the installation and for submission of recommendations for its design.

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Results of Chemical Analysis of Original and Desalted Waters

Water characteristics	Dry residue,	Specific resistance,	pH	Oxidizability	
	mg/l	ohms/cm		by O_2	
Original water	341	1×10^3	7.3	1.8	
Desalted water	about 1.0	0.7 to 1.7 $\times 10^6$	6.8	1.02	

Composition, mg/liter								
Ca^{++}	Mg^{++}	Na^+	Fe^{++}	Cl^-	HCO_3^-	SO_4^{--}	SiO_2	
Original water	54.75	5.18	34.27	0.02	3.0	268.4	6.7	2.4
Desalted water	None	Not determined	Not determined	None	Less than 0.02	Less than 0.005 mg-eq/l	Not determined	0.4 to 0.6



Schematic diagram of desalting installation.

1, 3 - cation-exchange resin filters; 2, 4 - anion-exchange resin filters;
 5 - airlifts for preparing regeneration solutions; 6 - vacuum; 7 - airlifts
 for receiving desalted water; 8 - mixer; 9 - neutralizer; 10 - to sewer;
 11 - technical water; 12 - to tank with desalted water; 13 - compressed air.