APPENDIX

The discharge of the old Päijänne channel

Several investigators have performed observations and measurements on the outflow of ancient Lake Päijänne on the border of the parishes of Pihtipudas and Haapajärvi, near the Jyväskylä—Haapajärvi railway line. Lastly, Dr. Risto Aario has measured the height of the hard base he met under the bog layers in the narrow channels of this region, which one can assume determined the discharge from the lake basin. As various investigators have estimated on the basis of shore rims the water level of ancient Päijänne before its breakthrough into the Kymijoki River as being at the height in the old outflow whose height nowadays is NN + 123.00, Dr. Aario has requested me to examine with the aid of hydraulic computations how large the discharge flowing through the channel actually was during the said period. It would serve to explain the humidity of our country's climate at the time.

The outflow of ancient Päijänne has been interrupted by a number of islets. In his dissertation »Development of ancient Lake Päijänne», Helsinki 1965, Risto Aario has treated as the outflow the Tolvanen (A) and Ollove (B) thresholds. From Kotajärvi below these begins the Hinkuanjoki River, nowadays flowing into the Kalajoki River, the former apparently being on the base of the old discharge channel of Lake Päijänne. Here, immediately below Lake Kotajärvi is Karhunpiilo narrows (C) and below this, too, still some 600 metres of comparatively narrow channel where the decline is slight. Just after this the channel broadens and steepens to such an extent that it has been omitted from the investigation. »Tail race» below Karhunpiilo I have divided into two 300 metre long portions, of which the upper is somewhat narrower than the lower.

If the water heights of the tail race had not affected the discharge dimensions, the water heights above Karhunpiilo would have been located in the height zone of 122.30. . .122.50 (Table 1). On this account I have assumed the water heights for the middle of the second portion of the tail race 121.30. . .122.40, and from these determined for the discharges 600. . . 800 m^3/s the water height above Karhunpiilo. Progressing from these I have obtained corresponding water heights above thresholds A and B. The results appearing in the tables indicate that the different initial heights for the calculation affect the final results only by a few centimetres.

For the result of the computation it is seen that water has discharged from ancient Päijänne at a height of NN + 123.00 at about 630. . .650 m^3/s, which corresponds to a mean run-off of about 7 l/s. km^2 from the watercourse of that time. This value is 20 % smaller than the present value. In present climatic conditions ancient Päijänne would, however, have been only 35 cm higher than the water level stated, so the result is susceptibly dependent on the correct estimation of the shoreline height.

TABLE 1.

Discharge graph of Karhunpiilo (C) without the effect of the tail race

			600 m³/s			700 m³/s			800 m³/s		
W	A	t	v	$\frac{v^2}{2g}$	H	v	$\frac{v^2}{2g}$	H	v	$\frac{v^2}{2g}$	H
121.50	54.2	1.28	11.0	6.20	7.48	12.96	8.50	9.78	14.70	11.0	12.28
122.00	119	1.78	5.04	1.30	3.08	5.9	1.77	3.55	6.74	2.3	4.08
122.25	199	2.03	3.02	0.49	2.52	3.52	0.63	2.66	4.02	0.82	2.85
122.50	277	2.28	2.16	0.24	2.52	2.53	0.33	2.61	2.90	0.43	2.71
122.75	370	2.53	1.62	0.13	2.66	1.89	0.18	2.71	2.16	0.24	2.77
123.00	473	2.78	1.27	0.08	2.86	1.48	0.11	2.89	1.70	0.15	2.93
122.20	194	3.10	3.10	0.49	2.47						
Critical height:											
Min. $H = t + \frac{v^2}{2g}$					2.52			2.60			2.71
W_o					122.30			122.40			122.50

TABLE 2.

Frictional losses

A + B. L = 30 m. Coefficient of roughness M = 30. L/M² = 0.0333

W	A	A²	R	$R^{4/3}$	600	700	800	900	Q m³/s
123.00	403	162 409	0.97	0.96	0.08	0.10	0.14	0.17	$h_f \frac{m}{A+B}$

C. L = 60 m. Coefficient of roughness M = 30. L/M² = 0.0667

W	A	A²	R	$R^{4/3}$	600	700	800	900	Q m³/s
122.00	119	14 161	0.47	0.365	4.65	6.31	8.25		
.25	207	42 849	0.66	0.575	0.97	1.32	1.72	2.18	$h_f \frac{m}{C} =$
.50	277	76 729	0.77	0.705	0.44	0.61	0.79	1.00	
.75	370	136 900	1.06	1.08	0.16	0.22	0.29	0.36	$\frac{Q^2.L}{A^2.M^2.\ R^{4/3}}$
123.00	473	223 729	1.10	1.13	0.10	0.13	0.17	0.21	

Tail race, upper portion L = 300 m. M = 30. L/M² = 0.667

W	A	A²	R	$R^{4/3}$	600	700	800	900	Q m³/s
121.00	90	8 100	0.62	0.530	27.9	38.00	49.7	62.9	
.50	180	32 400	0.84	0.790	4.68	6.36	8.32	10.51	
.75	222	49 284	0.97	0.960	2.54	3.45			$h_{f3}m$
122.00	295	87 025	1.20	1.270	1.08	1.47	1.92	2.43	
.25	358	128 164	1.31	1.440	0.65	0.88	1.16	1.46	
.50	431	185 761	1.43	1.600	0.40	0.55	0.72	0.91	

Tail race, lower portion. L = 300 m. M = 30. L/M² = 0.667.

W	A	A²	R	$R^{4/3}$	600	700	800	900	Q m³/s
120.00	98	9 604	0.48	0.375	33.30	45.30	59.20	74.90	
.50	204	41 616	0.93	0.920	3.20	4.35	5.69	7.20	
121.00	317	100 489	1.38	1.535	0.80	1.09	1.42	1.80	$h_{f4}m$
.50	440	193 600	1.70	2.020	0.31	0.42	0.55	0.69	
122.00	585	342 225	1.83	2.220	0.16	0.22	0.28	0.36	

TABLE 3.

Flow-check calculation from half-way on the tail race lower portion against the current.

	600			700			800 m³/s		
W tail race lwr. portion centre	121.30	121.60	122.00	121.70	122.00	122.30	122.00	122.20	122.40
$1/2.h_{f4}$	0.21	0.13	0.08	0.16	0.11	0.07	0.14	0.10	0.07
W tail race ctr.	121.51	121.73	122.08	121.86	122.11	122.37	122.14	122.30	122.47
h_{f3}	1.02	0.81	0.54	0.84	0.64	0.45	0.72	0.58	0.44
W tail race beginning	122.53	122.54	122.62	122.70	122.75	122.82	122.86	122.88	122.91
h_{fC}	0.23	0.23	0.18	0.19	0.17	0.15	0.17	0.17	0.16
Velocity loss	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
W Kotajärvi	122.80	122.81	122.84	122.93	122.96	123.01	123.08	123.10	123.12
h_{fA+B}	0.08	0.08	0.08	0.10	0.10	0.10	0.14	0.14	0.14
Velocity loss	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
Ancient Päijänne	122.92	122.93	122.96	123.07	123.10	123.15	123.27	123.29	123.31