Züchtung durch Auslese der Familien, die in einem Merkmal besonders hervorragen, erscheint relativ einfach. Sowohl Selektionsdifferential als auch Heritabilität könnten hoch genug sein, um einen meßbaren Fortschritt zu gewährleisten. Gleichzeitige Auslese auf zwei Merkmale ist ebenfalls möglich, würde aber gewöhnlich erhebliche Opfer an Selektionsdifferential in dem einen oder anderen Merkmal mit sich bringen. Keine Familien wurden gefunden, die sich in zwei oder mehr Merkmalen signifikant vom Bestandsmittel abhoben.

Résumé

Titre de l'article: *Variation génétique dans 140 descendances maternelles de pin sylvestre venant de 9 peuplements.*

A l'automne 1958, des chercheurs européens ont envoyé des graines récoltées sur 9 peuplements en Norvege, Belgique et Allemagne et representant 140 descendances individuelles par fécondation libre. Elles ont été semées dans la pépinière forestiere MSU a East Lansing, Michigan, au printemps de 1959 et y ont ete cultivées pendant 3 ans. On a utilisé un dispositif en blocs complets modifié, avec 4 répetitions. Dans la terminologie génétique, cette expérience constituait un test de descendance maternelle, chaque lot de graines representant une famille «half-sib». Chaque série de mesures a fait l'objet d'une analyse de variance. Les écarts-types ont ete repartis entre : interaction parcelle unitaire X répétition (= σ^2_e), variance des familles à l'interieur d'un peuplement (= σ^2_F) et variance entre peuplements (= σ^2_S). Les héritabilités des descendances ont été calculees d'après la formule:

$$\text{Héritabilité de la descendance} = \frac{\sigma^2_F}{\sigma^2_e/4 + \sigma^2_F}$$

Les correlations entre les caractères ont été calculees séparément pour chaque peuplement en utilisant comme bases les moyennes des descendances.

Pour la plupart des 9 peuplements, on trouve une variation significative entre descendances pour la vitesse de croissance, la date de formation du bourgeon la première année et la presence de feuilles secondaires en Octobre 1959. La couieur des aiguilles à differentes dates et leur longueur sont des caracteres génétiquement variables pour lesquels la variation entre les descendances diffère de façon considerable suivant les peuplements. Les héritabilités des cinq caracteres les plus variables se situent entre 0,5 et 0,8 pour les populations d'Allemagne et de Belgique.

Dans la population d'Allemagne mais non dans celle de Belgique, les differences entre peuplements sont significatives pour plusieurs caracteres. L'existence de differences significatives entre les peuplements indique que la sélection des peuplements serait une mesure d'améloration efficace.

Au cours des 3 années, les differences constatées dans la hauteur relative pour les pays, les peuplements et les descendances se sont maintenues. Les estimations de cette constance ont egalement été faites pour les huit déterminations de couleur. Les tendances a la coloration ne changent pas de façon appreciable entre les pays. En ce qui concerne les différences de couleur entre les descendances du même peuplement, on constate plusieurs changernents du classement entre le premier et le second automne et entre l'été et l'automne, mais aucun changement du second au troisième automne.

L'amélioration par selection des deseendances sur un seul caractere semble relativement simple. L'écart de sélection et l'héritabilité paraissent tous les deux assez élevés pour assurer un progrès appreciable. La selection simultanée pour deux caraoteres est également possible, mais entraînera un sacrifice sérieux de l'écart de sélection pour l'un ou pour l'autre trait. On n'a trouve aucune descendance qui s'écarte significativement de la moyenne du peuplement pour trois caracteres ou plus.

Literature Cited

(1) Wright, Jonathan W., and Bull, W. Ira: Geographic Variation in Scotch pine — three-year results. Silvae Genetica 12, 1–25 (1963). — (2) Lerner, I. M.: The Genetic Basis of Selection. 298 pp. Wiley: New York (1958). — (3) Falconer, D. S.: Introduction to Quantitative Genetics. 365 pp. Ronald Press: New York (1960).

Growth stresses in trees

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Growth stresses in trees were observed by Martley about 1928 but received increasing attention after the observations of M. R. Jakobs (1938—1955). Since then they have been studied by a number of investigators, viz. Boyd, Mayer-Wegelin, Perkitny, Kübler and others. According to Mayer-Wegelin, the presence of gelatinous fibres increases these stresses. They can play an important part in timber utilization (as they have to be taken note of), e. g. defect-free seasoning of wood, conditioning of logs for peeling into veneers, etc. They can also be the cause of stresses, etc., in standing trees. A defect known as "water blister" in teak trees has been noticed in the Kerala State (*vide* Bakshi and Boyce, 1960). Several discs from a tree suffering from "water blister" were available for examination. They are shown in *fig. 1.* The discs showed evidence of stresses (cracks and splits). It was considered worth while to see whether these were subjected to growth stresses, especially as no data on growth stresses in Indian trees are available. For the authors' work they are of importance in the conditioning of logs for peeling, etc.

For evaluation of the stress intensity and distribution the discs were planed to uniform thickness and three radii at 120° to one another marked on them. The thickness (X) of the disc along these radii at definite intervals was measured with the help of a Hilger Watts microptic machine with an accuracy of $\pm 10^{-5}$ cm. Then radial strips were cut (about 1 cm. in width) along these radii and the measurements (Y) taken at the same places. They were then cut into pieces about 1 X 1 cm. at the places of measurement and the measurements taken again (Z). It was noticed that $X > Y > Z$ suggesting that tensile stresses along the grain were present in the disc. The length variation

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(parallel to the grain) along the radii in these discs as also for a disc which was normal are shown in *fig. 2 to 6*. In the axial direction the length changes were as follows: Disc 14: 0.08% to 0.24%; Disc 5: —0.14 to —1.93% (—0.5 to 0.98%, and 0.22 to 0.7%); Disk 2: —1.3 to —0.44%; —0.93 to —0.3%; —0.97 to 0.25%. In the tangential direction the variations (*figs. 7 to 9*) were as follows: Disc 2: —0.5 to +0.28%; —.52 to +0.14%; —0.44 to +0.04%; Disc 1: —0.46 to +0.04%; —0.45 to +0.18%; —0.47 to +0.05%. The modulus of elasticity in bending was also measured in a few places by taking adjacent samples. These values are given in *Table 5*. As can be seen, they are low as compared to values for a disc from a tree free from water blister. The length contractions indicate that a maximum tensile stress of even about 400 kg/cm^2 can be present in these trees in places and thus account for the "water blister", possibly in combination with root pressure. It is also interesting to record that the ratio of maximum stress to minimum stress in these discs was almost the same, about 6, but in the disc free from blister it was only about 3. The maximum value also decreases from bottom (496) to top (152) of the tree. Exudation of sap before the appearance of fresh foliage due to root pressure in spring has been observed in birch, beech, maple, while with oak, ash and lime and conifers root pressure is not sufficient (Trendelenburg). According to Huber (*vide* Trendelenburg) in ring porous wood the velocity of the transpiration stream is about 50 m. per hour as against 5 m. per hour in diffuse porous woods and 1 m. per hour in conifers. It would be interesting to conduct some root pressure and transpiration velocity studies. In the disc from the top portion of the tree (No. 11) stresses are comparatively very little. *Fig. 9* shows the length variation in the tangential direction on cutting.

Swelling pressure measurements were also taken on the samples from various locations. These are shown in *figs. 10 to 27* and *tables 1 to 4*. It was noticed that in some cases when the specimens (along the grain) were introduced in water, there was a sudden contraction before development of swelling pressure, which means further release of tensile stresses due to the plasticising action of water.

If we take the normal disc, then in general the swelling pressure is in this order: $S_T > S_R > S_L$. This is to be expected. Only near the pith $S_R < S_L$. If we take the other discs it will be noticed that S_L is equal to or even greater than S_R in places and in one case it was even greater than S_T. We also noticed reversal of the relative magnitude of swelling pressure, i. e. $S_T < S_R$ in places. The kinetics of the swelling pressure shows that in the axial and radial directions often the maximum is reached within a second or so. The zigzag course of the swelling pressure along radii in these discs also indicates the 'labile' conditions in these discs.

In this connection it is interesting to record that nearly 18 years ago in some experiments on the thermal expansion of wood, negative values were obtained, with some teak specimens consistently (Narayanamurti and Jain). Possibly these were due to stresses present in the sample.

From the above it would appear that growth stresses can offer a plausible explanation for the defect known as "water blister" and have to be taken into account.

M. R. Jacobs in his book entitled "*Growth Habits of the Eucalypts*" says "growth stresses of considerable magnitude develop in the trunks of eucalypts as they grow. These forces influence the behaviour of the wood significantly, especially in the case of small sizes and rapidly grown stems. A knowledge of them is necessary for an understanding of certain desirable practices in the treatment of eucalypts." It would therefore be of interest to

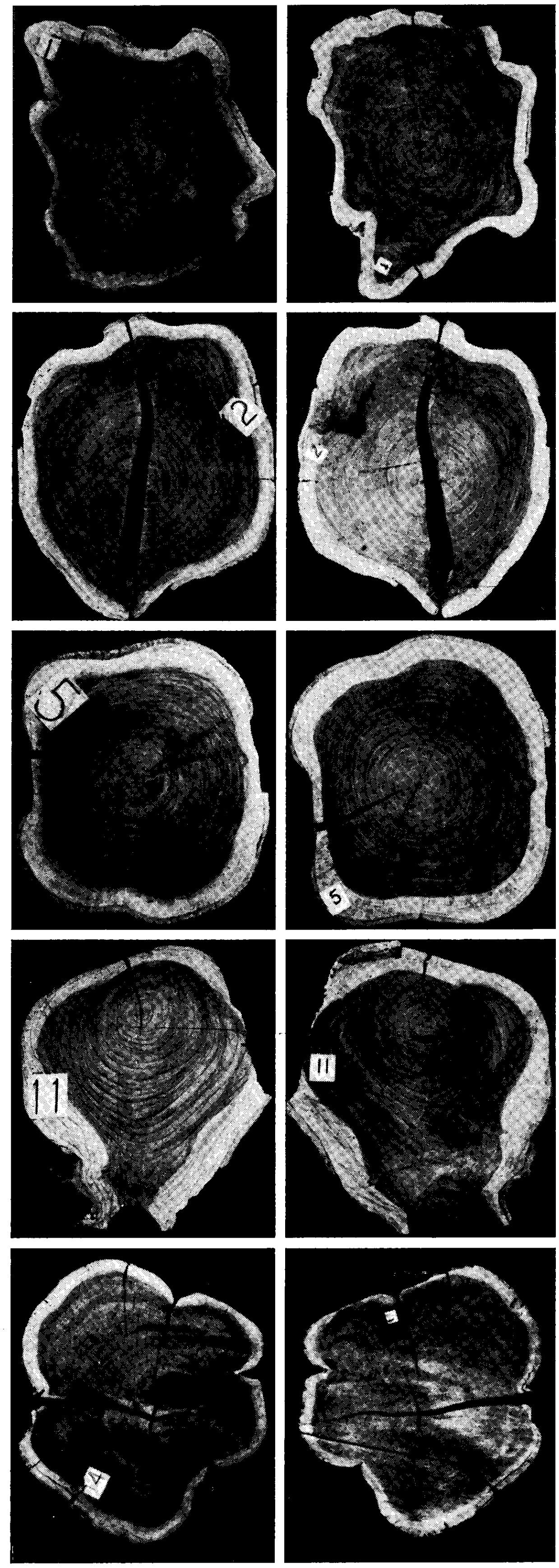


Fig. 1. — Photograph of Discs.

Table 1. — Disc. No. 1.

Specimen No.	Distance from pith	Tangential			Radial			Axial			S_R/S_T	S_R/S_L	% Swelling			S.Pr. % Swelling			Water % absorption		
		Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.			T	R	L	S.Pr./Sw. % T	R	L	T	R	L
A1	21.6	8.46	.722	11.72	5.37	.763	7.04	0.48	.758	0.63	0.63	11.19	0.96	0.4	0.3	8.81	13.42	1.60	17.0	16.0	5.0
A2	19.7	6.64	.759	8.75	4.19	.752	5.57	0.42	.769	0.55	0.63	9.98	0.95	0.81	0.3	6.99	5.17	1.40	25.5	14.4	7.50
A3																					
A4	12.9	14.4	.762	18.90	1.61	.766	2.10	1.21	.762	1.59	0.11	1.33	1.80	0.58	0.63	8.0	2.78	1.92	16.6	14.4	8.8
A5																					
A6	8.9	11.73	.740	15.85	4.68	.752	6.22	3.11	.748	4.16	0.40	1.50	2.0	1.0	0.4	5.87	4.68	7.78	18.5	9.7	8.0
A7																					
A8	2.8	10.85	.736	14.74	6.22	.732	8.50	7.32	.725	10.10	0.57	0.85	1.95	0.95	0.83	5.56	6.55	9.15	12.6	10.3	7.3

Table 1 a. — Disc. No. 2.

Specimen No.	Distance from pith	Tangential			Radial			Axial			S_R/S_T	S_R/S_L	% Swelling			S.Pr. % Swelling			Water % absorption		
		Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.			T	R	L	T	R	L	T	R	L
A1	16.4	9.5	0.686	13.84	5.45	0.688	7.92	4.56	0.684	6.67	0.574	1.195	1.8	0.54	0.37	5.28	10.09	12.32	24.7	11.1	5.5
A2	15.2	6.37	0.677	9.41	1.58	0.680	2.32	2.37	0.678	3.50	0.248	0.667	1.0	1.0	0.6	6.37	1.58	3.95	1.25	11.3	5.5
A3	13 8	8.62	0.673	12.81	3.89	0.680	5.72	1.54	0.678	2.27	0.451	0.253	1.87	1.0	0.2	4.61	3.89	7.70	16.5	10.0	5.0
A4	12.0	7.2	0.705	10.21	4.8	0.710	6.76	2.40	0.707	3.39	0.667	2.000	1.8	0.75	0.5	4.00	6.40	4.80	25.0	20.0	11.4
A5	10 3	1.93	0.707	2.73	4.83	0.712	6.78	2.33	0.707	3.30	2.503	2.073	1.0	1.9	0.56	1.93	2.54	4.16	15.0	13.0	7.0
A6	8 5	3.97	0.787	5.04	3.17	0.783	4.05	2.38	0.792	3.01	0.793	1.332	1.4	1.2	0.6	2.84	2.64	3.97	19.0	9.0	7.0
A7	7.9	4.93	0.779	6.33	4.93	0.765	6.44	1.64	0.777	2.11	1.000	3.006	2.4	1.4	0.57	2.05	3.52	2.88	20.0	12.0	6.0
A8	5 0	8.71	0.683	12.75	3.17	0.680	4.66	2.28	0.688	3.31	0.364	1.390	1.8	0.78	0.7	4.84	4.06	3.26	16.5	11.2	5.5
A9	2.8	7.14	0.687	10.39	1.20	0.683	1.76	1.18	0.689	1.71	0.167	1.017	2.8	0.9	0.57	2.55	1.63	2.07	16.6	10.0	5.5

Table 2. — Disc. No. 2.

Specimen No.	Distance from pith	Tangential			Radial			Axial			S_R/S_T	S_R/S_L	% Swelling			S.Pr. % Swelling			Water % absorption		
		Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.			T	R	L	T	R	L	T	R	L
B1	14.9	12.77	0.638	20.00	11.2	0.652	17.18	2.91	0.647	4.50	0.877	3.849	1.32	1.22	0.7	9.67	9.18	4.16	25.0	22.5	12.5
B2	13.4	15.98	0.710	22.5	4.1	0.715	5.73	2.12	0.720	2.94	0.257	1.934	1.0	0 9	0.6	15.98	4.56	3.53	16.6	16.6	11.1
B3	11.5	11.85	0.682	17.38	3.24	0.672	4.82	1.57	0.686	2.29	0.273	2.064	1.8	0 8	0.6	6.58	4.05	2.62	22.2	16 6	11.0
B4	9.2	7.2	0.766	9.4	5.71	0.775	7.37	1.98	0.762	2.60	0.793	2.884	1.98	0.75	0.55	3.64	7.61	3.60	16.0	9 0	4.0
B5	8.4	6.03	0.756	7.98	21.02	0.770	2.62	1.58	0.769	2.05	0.335	1.278	1.97	0.75	0.57	3.06	2.69	2.77	16.0	9 0	7.0
B6	7.4	6.16	0.758	8.13	3 96	0.752	5.27	2.01	0.746	2.69	0.643	1.190	1.57	1.00	0.6	3.92	3.96	3.35	19.5	17.0	11.3
B7	5 9	8.1	0.795	10.19	3.99	0.798	5.00	2.05	0.800	2.56	0.493	1.946	1.98	1.2	0.6	4.09	3.33	3 42	19.0	12.0	8.0
B8	3 6	8.00	0.778	10.28	6.37	0.770	8.27	2.36	0.758	3.11	0.796	2.699	1.98	0 9	0 3	4.04	7.08	7.87	17.0	12.0	6.0
B9	1.8	9.59	0.788	12.77	6.4	0.793	8.07	3.17	0.784	4.04	0.667	2.019	1.8	0.7	0.6	5.33	9.14	5.28	18.0	13.0	7.0

Table 2 a. — Disc. 2.

Specimen No.	Distance from pith	Tangential			Radial			Axial			S_R/S_T	S_R/S_L	% Swelling			S.Pr. % Swelling			Water % absorption		
		Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.			T	R	L	T	R	L	T	R	L
C1	17.7	10.66	0.726	14.68	5.12	0.730	7.01	5.24	0.727	7.21	0.480	0.977	1.4	0.6	0.8	7.61	8.53	6 55	12.0	13 0	9.0
C2	16 0	5.9	0.815	7.24	1.62	0.810	2.00	6.85	0.820	8.35	0.275	0.237	1.0	0 4	0.80	5.90	4.05	8.56	11.1	11.1	5.2
C3	14.3	7.44	0.775	9.60	3.24	0.772	4.20	4.75	0.769	6.18	0.438	0.684	1.90	1.00	0.58	3.92	3.24	8 19	19.0	13 0	6.0
C4	12 8	9 03	0.787	11.47	6.22	0.798	7.79	4.87	0 801	6.08	0.689	1.277	2.0	1.2	0.8	4.52	5.18	6 09	23 0	18.0	10.0
C5	11.2	7.39	0.773	9 56	5.67	0.773	7.34	3.99	0.770	5.18	0.767	1.421	1.97	1.2	0.6	3.75	4.73	6.65	12 0	12.0	9 0
C6	9 3	8.23	0.749	10 99	4 05	0.766	5.29	3.63	0.782	4.64	0.492	1.116	1.6	0 8	0.43	5.14	5.06	8 44	24 5	11.1	6.5
C7	7.4	8 0	0.735	10 88	5.6	0.754	7.43	2.0	0.732	2.73	0.700	2.800	2.4	1.0	0.8	3.33	5.60	2.50	22 0	18 9	11.1
C8	4 8	4.77	0.765	6.24	3.98	0.766	5.20	1.59	0.761	2.09	0.834	2.503	1.2	1.0	0.6	3.98	3.98	2 65	13.0	9 0	7.0
C9	2.5	7.14	0.759	9.41	5.56	0.769	7.23	1.98	0.764	2.59	0.779	2.808	2.0	0.9	0.9	3.57	6.18	2.20	13.0	10.0	8.0

Table 2 b. — Swelling Pressure, Disc. No. 2.

A						B						C					
No.	S_T	S_R	S_A	S_R/S_T	S_R/S_A	No.	S_T	S_R	S_A	S_R/S_T	S_R/S_L	No.	S_T	S_R	S_A	S_R/S_T	S_R/S_A
1	9 5	5.45	4.56	0 574	1.195	1	12.77	11.2	2.91	0.877	3.849	1	10.66	5.12	5.24	0.480	0.977
2	6 37	1.58	2.37	0.248	0 667	2	15.98	4.1	2.12	0.257	1.934	2	5.9	1 62	6.83	0.275	0 237
3	8 62	3.89	1 54	0 451	0.253	3	11.85	3.24	1.57	0 273	2.064	3	7.44	3.24	4.75	0.435	0.684
4	7 2	4.8	2.40	0.667	2.000	4	7.2	5.71	1 98	0.793	2.884	4	9.03	6.22	4.87	0.689	1.277
5	1 93	4.83	2 33	2 503	2 073	5	6 03	2.02	1.58	0 335	1.278	5	7.39	5.67	3.99	0.767	1.421
6	3 97	3.17	2.38	0.798	1.332	6	6 16	3.96	2 01	0.643	1 970	6	8 23	4.05	3.63	0.492	1 116
7	4 93	4 93	1 64	1 000	3.006	7	8 1	3.99	2.05	0 493	1.946	7	8 0	5 6	2 0	0.700	2.800
8	8 71	3.17	2.28	0 364	1.390	8	8.00	6.37	2.36	0 796	2 699	8	4.77	3 98	1.59	0.834	2 503
9	7.18	1.20	1.18	0.167	1.017	9	9.59	6.4	3.17	0.667	2.019	9	7.14	5.56	1.98	0.779	2.808

Table 3. — Disc. No. 5.

Spezimen No.	Distance from pith	Tangential			Radial			Axial			S_R/S_T	S_R/S_L	% Swelling			S. Pr. % Swelling			% Water absorption		
		Swelling pr.	Sp. Gr.	S. Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S. Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S. Pr./Sp. Gr.			T	R	L	T	R	L	T	R	L
B1	11.6	22.1	0.581	38.04	4.71	0.584	8.07	6.86	0.583	11.77	0.213	0.687	1.94	0.93	2.13	11.39	5.06	3.22	31.2	37.5	10.0
B2	10.2	7.8	0.621	12.56	4.48	0.636	7.04	5.43	0.622	8.73	0.574	0.825	1.40	0.7	1.21	5.57	6.40	4.49	25.0	12.4	11.6
B3	8.4	9.72	0.699	13.93	10.1	0.739	13.67	12.75	0.667	19.12	1.039	0.792	1.56	0.9	1.13	6.23	11.22	11.28	22.5	12.0	5.5
B4	7.4	15.28	0.698	22.21	2 24	0.684	3.27	2.33	0.682	3.42	0.147	0.966	1.3	1.0	0.7	11,75	2.24	3.33	12.0	10.5	5.0
B5	6.8	19.62	0,769	25.51	3 38	0.697	4.85	1.58	0.770	2.05	0.165	2.076	1.6	1.0	0	12.26	3 38	—	25.0	5.0	25.0
B6	5 2	7.4	0.759	9.75	16.1	0.761	21.16	4.5	0.763	5.90	2.176	3.578	1.14	1.29	0.79	6.49	12.48	5.70	20.0	18.1	10.4
B7	4 3	14.8	0.769	19.25	3.94	0.767	5.14	3.83	0.790	4.85	0.266	1.029	1.92	1.34	0.1	7.71	2.94	38.3	14.2	13.6	9.0
B8	3.5	11.95	0.783	15.26	9.58	0.768	12.47	9.93	0.750	13.24	0.802	0.965	1.50	1.14	0.33	7.97	8.40	41.70	15.0	10.0	10.0

Table 3 a. — Disc. No. 5.

Specimen No.	Distance from pith	Tangential			Radial			Axial					% Swelling			S.Pr. % Swelling			% Water absorption		
		Swelling pr.	Sp. Gr.	S. Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S. Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S. Pr./Sp. Gr.	S_R/S_T	S_R/S_L	T	R	L	T	R	L	T	R	L
F1	12.4	15.8	0.673	23.48	7.01	'0.670	10.46	6,4	0.663	9.65	0.444	1.095	1.6	0.7	0.3	9.88	10.01	21.33	28.0	16.6	5.2
F2	10.7	9.14	0.703	13 00	3.08	0.700	4.40	1.49	0.701	2.13	0.337	2.067	1.5	0.2	0.3	7.13	15.40	4.97	16.0	15.0	5.0
F3	9.1	9 20	0.662	13.90	5.35	0.655	8.17	3.73	0.659	5.66	0.582	1.434	1.51	0.5	0.5	6.03	10.70	7.46	10.5	29.0	8.4
F4	8.3	9 50	0.734	12 94	15.5	0.727	2.13	2.35	0.731	3.21	0 163	0.660	1.30	0 3	0.5	7.31	51.67	4.70	20.0	20 0	6.1
F5	7.6	19.1	0.713	26.79	5.32	0.700	7.60	6.61	0.71	9.31	0.279	0.805	1.54	0.25	0.3	12.40	21.28	22.03	30.5	20 0	5.0
F6	6.2	12.95	0.705	18.37	11.03	0.713	15.47	3.02	0.690	4.38	0.852	3.652	1.14	0.58	0.5	11.36	19.02	6.04	25.0	30.0	7.0
F7	4 9	7.05	0.677	10.41	3.72	0.673	5 53	6.64	0.661	7.02	0.527	0 802	1.51	0.77	0.58	4.67	4.83	8.00	27.7	16.6	5.5
F8	3.6	4.13	0.709	5.83	8.49	0.703	12.08	2.87	0.691	4.15	2.056	2.958	1.38	0.79	1.15	2.99	10.75	2.50	11.1	11.1	7.7

Table 3 b. — Disc. No. 5.

Specimen No.	Distance from pith	Tangential			Radial			Axial			S_R/S_T	S_R/S_L	% Swelling			S.Pr. % Swelling			% Water absorption		
		Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.			T	R	L	T	R	L	T	R	L
D1	12.0	20.62	0.584	35.31	7.13	0.583	12.23	10.32	0.588	17.55	0.346	0.691	2.32	1.1	1.89	8.89	6.48	5.46	26.6	20.0	10.8
D2	11.0	9.49	0.595	15.95	5.36	0.612	8.76	2.27	0.620	3.66	0.565	2.361	1.89	0.70	1.3	5.02	7.66	1.75	29.4	17.6	11.1
D3	10.1	25 31	0.661	38.29	7.67	0.656	11.69	1.47	0.663	2.22	0.303	5.218	1.76	0.8	0.3	14 38	9.59	4.90	27.7	16 6	36 8
D4	9.2	15.88	0.671	23.67	11.14	0.674	16 53	2.99	0.671	4.46	0.702	3.726	1.50	0.7	0.4	10 59	15 91	7.48	32 0	22.0	10.5
D5	8 1	8.64	0.602	14.35	7.93	0.604	13 13	5.55	0.588	9.44	0.918	1.429	1.37	0.5	0.3	6 31	15.86	18.50	31.2	31.2	12.5
D6	6 3	16 19	0.654	24.76	13.01	0.665	19 56	5.42	0.650	8 34	0.816	2.437	1.9	0.7	0.4	8 52	18.59	13.55	16.6	33 3	5 8
D7	5.0	13 95	0.667	20 91	12.51	0.670	18.67	8 67	0.665	13.07	0 897	1.440	0.9	1.5	0.6	15.50	8 34	14.48	16.5	5.2	5.2
D8	3.6	20.52	0.784	26.17	11.98	0.788	15.20	5.59	0.779	7.18	0.584	2.143	1.97	0.99	0.50	10.42	12.10	11.18	15.0	10.0	5.0

Table 3 c. — Swelling Pressure, Disc. No. 5.

B						D						F					
No.	S_T	S_R	S_A	S_R/S_T	S_R/S_A	No.	S_T	S_R	S_A	S_R/S_T	S_R/S_L	No.	S_T	S_R	S_A	S_R/S_T	S_R/S_A
1	22 1	4.71	6.86	0.214	0.687	1	20 62	7.13	10 32	0 346	0.691	1	15.8	7 01	6.4	0.444	1.095
2	7 8	4.48	5.43	0 574	0.825	2	9.49	5 36	2.27	0.565	2.361	2	9.14	3.08	1 49	0.337	2.067
3	9 72	10.1	12.75	1.039	0.792	3	25.31	7.67	1 47	0 303	5.218	3	9 20	5 35	3.73	0 582	1.434
4	15.28	2.25	2 33	0.147	0.966	4	15 88	11.14	2 99	0.702	3.726	4	9.50	1.55	2.35	0.163	0.660
5	19.62	3.28	1.58	0.165	2.076	5	8.64	7.93	5.55	0 918	1.429	5	19 1	5 32	6 61	0.279	0 805
6	7.4	16.1	4 5	2.176	3.578	6	17.19	13 21	5.42	0.816	2.437	6	12.95	11.03	3 02	0 852	3.652
7	14.8	3.94	3.83	0 266	1.029	7	13 95	12.51	8.69	0 897	1.440	7	7.05	3.72	4 64	0 527	0.802
8	11.95	9.58	9.93	0.802	0.965	8	20.52	11.98	5.59	0.584	2.143	8	4.13	8.49	2.87	2.056	2.958

Table 4. — Disc. No. 14.

Specimen No.	Distance from pith	Tangential			Radial			Axial			S_R/S_T	S_R/S_L	% Swelling			S.Pr. % Swelling			% Water absorption		
		Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr./Sp. Gr.	Swelling pr.	Sp. Gr.	S.Pr,/Sp. Gr.			T	R	L	T	R	L	T	R	L
A1	16 3	11.45	0 557	20 56	4.52	0.555	8.14	4.33	0.543	7.97	0 395	1.044	2.2	1.13	0 5	5.20	4 00	8.66	50 0	31.2	25 0
A2	14 6	14.58	0.719	20.28	4 95	0.715	6.92	1.13	0.715	1.58	0 340	4 381	1.71	1.51	0 5	8 53	3 28	2.26	20 0	15 0	5.0
A3	12 6	11 26	0.727	15.49	7.84	0.729	10 75	1.50	0.724	2.07	0 696	5 227	2.4	1 5	0 8	4.69	9 80	1 88	20 0	13 0	7.0
A4	10 4	16 2	0.643	25 19	5.67	0.624	9 09	1.57	0.622	2.52	0 350	3 611	2 4	1.0	0 2	6 75	5.67	7.85	20.0	30 0	5 6
A5	8 5	22.58	0 613	36 84	3 28	0.609	5 39	0.83	0.614	1.35	0.145	3 952	2.13	0.7	0 33	10 60	4 69	2.52	25 0	18 7	12 5
A6	6 0	12.77	0.606	21 07	3 14	0.603	5 21	0.78	0.610	1.28	0 246	4 026	2.1	0.5	0 2	6 08	6 28	3 90	25 0	15 0	8.7
A7	3.9	16.59	0.703	23 60	3 15	0 683	4 61	0.79	0.674	1.17	0 190	3 987	2.2	0 95	0 2	7 54	3.32	3.95	20 0	16 2	6 25
A8	2.0	19 17	0.710	27.00	3.92	0.715	5.48	1.17	0.712	1.64	0.204	3.350	2.1	0.9	0.4	9.13	4.36	2.93	15.7	16.6	5.6

Table 5. — *Stresses in Teak discs.*

Disc No.	% Distance from the pith	Sp. Gr. at test.	M of E in Kg/cm²	Strain	Stress Kg/cm²	Maximum or minimum
1	87.6	0.784	31420	0.015801	496	Max.
1	42.2	0.736	35500	0.002332	83	Min.
2	95 9	0.715	20660	0.019156	396	Max.
2	60.2	0.733	28560	0.002428	69	Min.
5	93 2	0.608	18890	0.019155	362	Max.
5	27.1	0.674	31610	0.001768	56	Min.
11	72 6	0.810	22200	0 006885	152	Max.
11	14.7	0.783	13230	0.002147	28	Min.
14	60.8	0.672	76400	0.002438	186	Max.
14	22.8	0.631	64000	0.000829	53	Min.

examine a number of trees of teak and other important species and see whether there is any variation due to genetical and/or environmental factors. Mayer-Wegelin (1955) draws attention to the fact that stresses widely differ even between neighbouring trees in the same area. In Kerala where water blister occurs in teak trees this was noticed to the extent of 10 to 15% in the same area. This suggests that perhaps inherent characteristics rather than environmental factors are more important. It would be worthwhile to study these factors so that trees less prone to this defect can be grown.

In view of the importance of the subject for various aspects of wood technology work on other important species is contemplated.

Our thanks are due to Dr. S. Kedarnath, Forest Geneticist for the teak discs used in this study.

Summary

After a brief introduction on the occurrence and importance of growth stresses in trees to forestry and wood utilisation, results of experiments on discs of teak from trees showing 'water blister' are described. Tensile stresses along the grain were noticed which decreased from about 500 kg/cm² at the bottom of the tree to about 150 kg/cm² at the top. In the tangential direction also stresses were noticed and measured in various positions in the discs. Swelling pressure measurements showed that while in a 'normal disc' $S_T > S_R > S_L$, in the other discs S_L could be even greater than S_R and S_T at places. Reversal of the relative magnitudes of S_T and S_R was also noticed. The kinetics of the Swelling pressures also gave interesting information. The importance of these observations with regard to the incidence of water blister and the possible use of such studies in tree breeding work is indicated.

Zusammenfassung

Titel der Arbeit: *Wachstumsspannungen bei Bäumen. — Einige Versuche an Teak.*

Nach einer kurzen Einführung in das Auftreten von Wachstumsspannungen bei Bäumen und ihre Bedeutung für die Forstwirtschaft und die Holzverwertung werden Versuchsergebnisse an Stammscheiben von Teakbäumen beschrieben, welche „water blister" aufwiesen. Zugspannungen entlang der Faser wurden festgestellt, welche von etwa 500 kg/cm² am Stammfuß auf etwa 150 kg/cm² am Zopf abnahmen. Auch in tangentialer Richtung wurden Spannungen festgestellt und an verschiedenen Stellen der Scheiben gemessen. Quellungsdruckmessungen (S) ergaben, daß gegenüber „normalen" Scheiben ($S_T > S_R > S_L$) in anderen Scheiben S_L stellenweise noch größer sein konnte als S_R und S_T. Umkehr der Größenverhältnisse von S_T und S_R wurde ebenfalls beobachtet. Auch die Kinetik des Quellungsdrucks ergab interessante Informationen. Auf die Bedeutung dieser Beobachtungen hinsichtlich des Auftretens von „water blister" und die mögliche Nutzung solcher Untersuchungen in der Forstpflanzenzüchtung wird hingewiesen.

Resumé

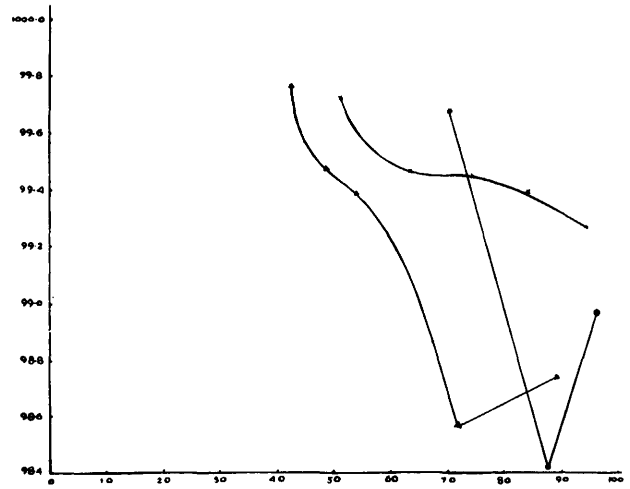
Titre de l'article: *Pressions de croissance chez les arbres — Expériences sur le teck.*

Après une courte introduction sur les pressions de croissance chez les arbres et leur importance pour la foresterie et la technologie du bois, on discute les résultats d'expériences faites sur des disques de teck prélevés sur des arbres présentant des «poches d'eau». Les tensions le long des fibres décroissent de 500 kg par cm² environ au bas de l'arbre jusqu'à 150 kg par cm² au sommet. Des pressions tangentielles ont été également mises en évidence et mesurées dans diverses positions sur les disques. La mesure des pressions de gonflement a montré que si dans un disque normal $S_T > S_R > S_L$, dans d'autres disques S_L pouvait être plus grand par endroits que S_R et S_T. On a également noté des inversions des valeurs relatives de S_T et S_R. La cinétique des pressions de gonflement donne également des renseignements intéressants. On conclut sur l'importance de ces observations en ce qui concerne la fréquence des poches d'eau et l'utilisation possible de telles études pour des travaux d'amélioration.

References

(1) Bakshi, B. K., and Boyce, J. S.: Paper submitted to Teak Subcommission. Indian Forester 85, 589 (1959). — (2) Jacobs, M. R.: Growth Habits of the Eucalypts. Canberra, 1955. — (3) Kübler, H.: Holz als Roh- u. Werkstoff 17, 1, 44, 77 (1959). — (4) Martley, J. F.: Forstry 2, 69 (1928). — (5) Mayer-Wegelin, H., und Mammen, E.: Allg. Forst- u. Jagdzeitg. 125, 287 (1954). — (6) Mayer-Wegelin, H.: Internationaler Holzmarkt, 1955, Nr. 4, p. 17. — (7) Trendelenburg, R., und Mayer-Wegelin, H.: Das Holz als Rohstoff. Carl Hanser Verlag, München 1955. — (8) Narayanamurti, D., and Jain, N. C., unpublished work.

Figs. 2—27 to the paper follow on pages 94—99.



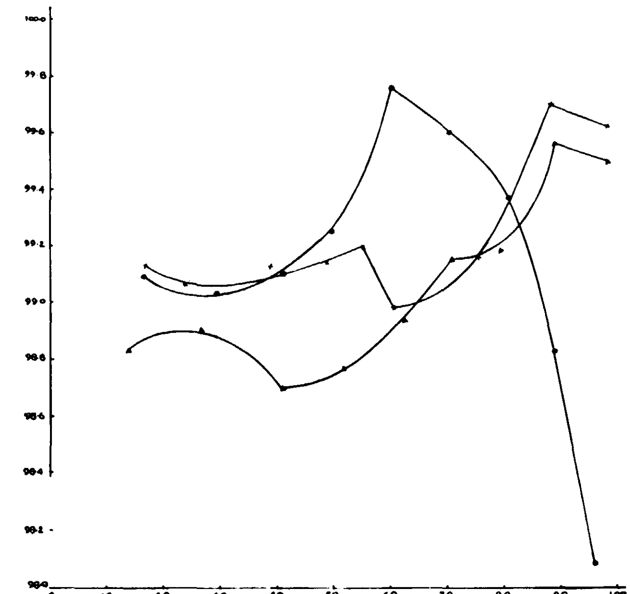


Fig. 2—3. — Axial strain in Teak. — *Fig. 2:* Disc No. 1 (above). *Fig. 3:* Disc No. 2 (below).

Abscissa: $\%\ \frac{\text{Distance from pith}}{\text{Distance from pith to periphery}}$

Ordinate: $\%\ \frac{\text{Axial length after cutting into specimens}}{\text{Axial length in situ}}$

Legend: ⊙ = Radius A
× = Radius B
△ = Radius C

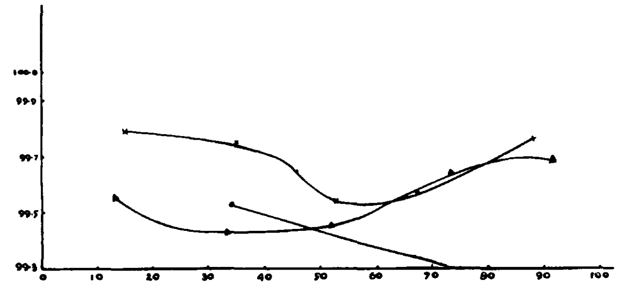
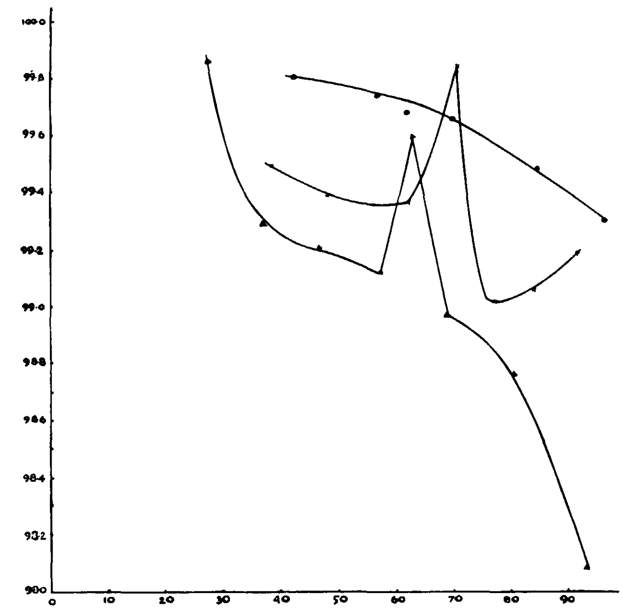


Fig. 4. — Axial strain in Teak. — Disc No. 11. — Abscissa and Ordinate: Same as in fig. 2. —

Legend: ⊙ = Radius X
× = Radius Y
△ = Radius Z



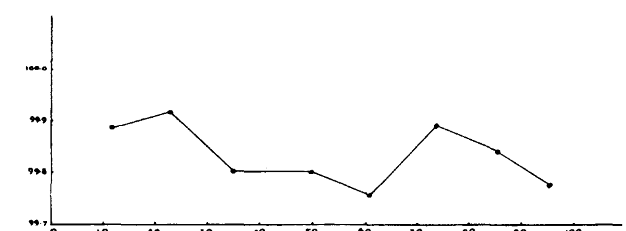
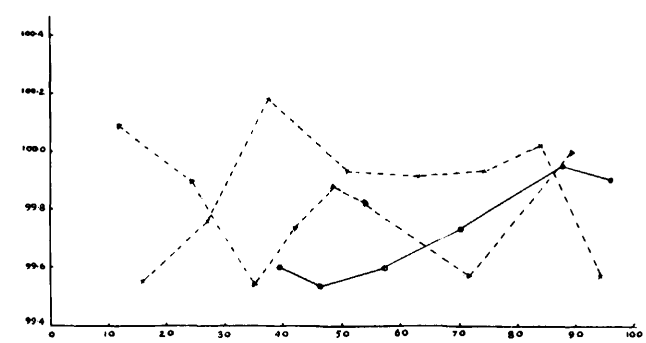


Fig. 5—6. — Axial strain in Teak. — *Fig. 5:* Disc No. 5 (above). *Fig. 6:* Disc No. 14 (below). — Abscissa and Ordinate: Same as in fig. 2. —

Legend: ⊙ = Radius B
× = Radius D
⎵ = Radius F



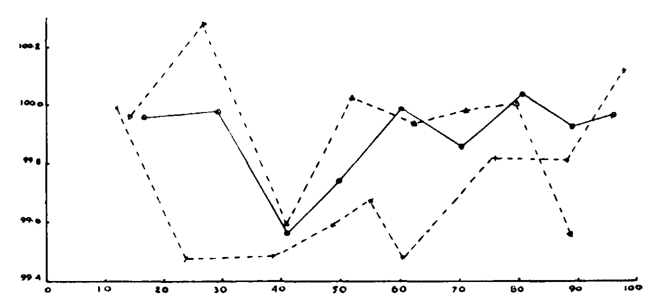


Fig. 7—8. — Tangential strain in Teak. — *Fig. 7:* Disc No. 1 (left). *Fig. 8:* Disc No. 2 (right). — Abscissa and Legend: Same as in fig. 2. —

Ordinate: $\%\ \frac{\text{Tangential length after cutting into specimens}}{\text{Tangential length in situ}}$

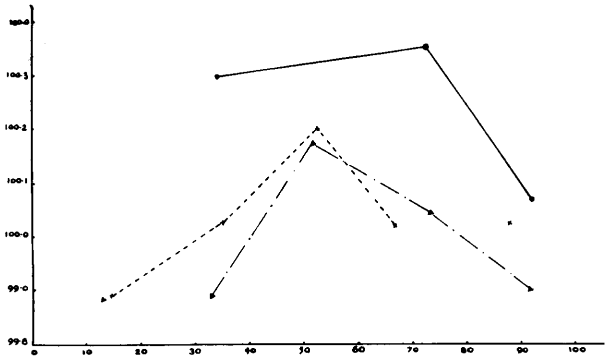


Fig. 9. — Tangential strain in Teak. — Disc No. 11. — Abscissa and Ordinate: Same as in fig. 7. —
Legend: ⊙ = Radius X
× = Radius Y
△ = Radius Z

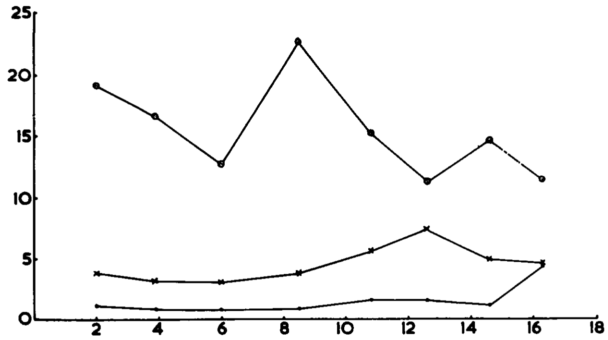


Fig. 10. — Variation of swelling pressure with the position of the specimens in the Disc No. 14 (from pith to periphery). — Abscissa: Distance from the pith (cms.). Ordinate: Swelling pressure Kg/cm².
Legend: ⊙ = Tangential
× = Radial
● = Axial

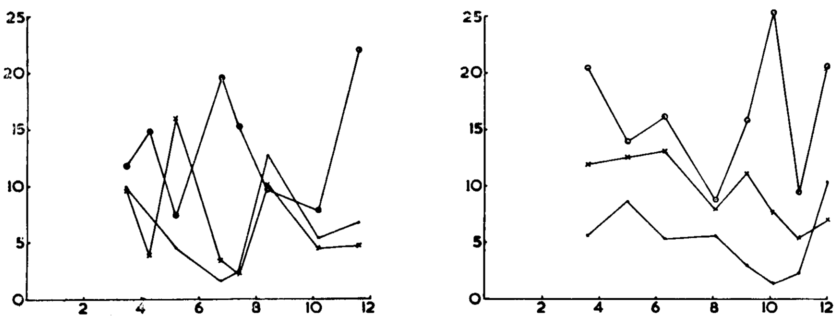


Fig. 11—12. — Variation of swelling pressure with position of the specimens. — *Fig. 11:* Disc No. 5, Radius F (left). — *Fig. 12:* Disc No. 1, Radius A (right). — Abscissa, Ordinate, and Legend: Same as in fig. 10.

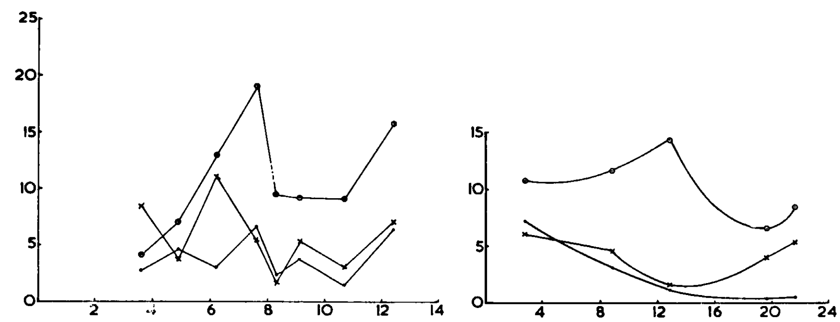


Fig. 13. — Variation of swelling pressure with the position of the specimens in the Disc No. 5, Radius B, and Disc No. 5, Radius D. — Abscissa, Ordinate, and Legend: Same as in fig. 10.

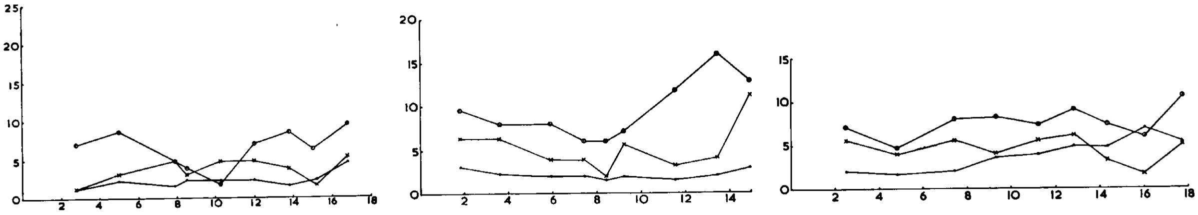


Fig. 14.—16. — Variation of the swelling pressure with the position of the specimens. — *Fig. 14:* Disc No. 2, Radius A (left). — *Fig. 15:* Disc No. 2, Radius B (middle). — *Fig. 16:* Disc No. 2, Radius C (right). — Abscissa, Ordinate, and Legend: Same as in fig. 10.

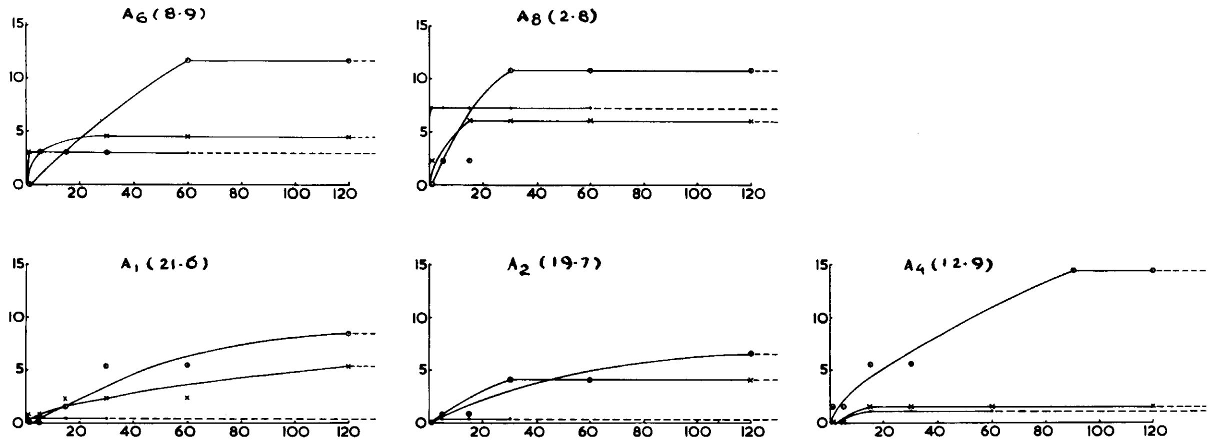


Fig. 17. — Development of swelling pressure with time. — Disc No. 1. — Figures in brackets show distance from pith in cms. — Abscissa: Time (minutes) of soaking in water. Ordinate: Swelling pressure Kg/cm².

Legend: ⊙ = Tangential
× = Radial
● = Axial

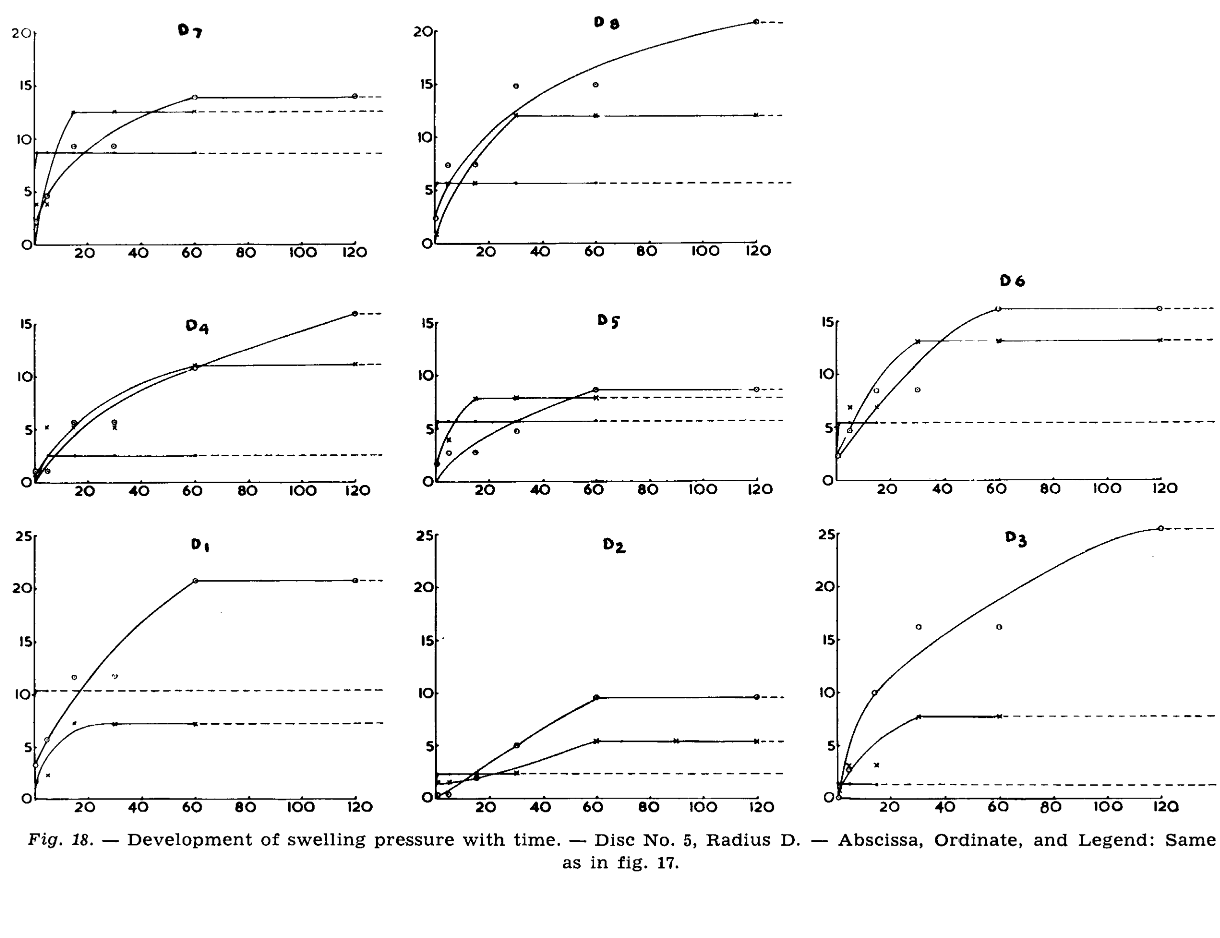


Fig. 18. — Development of swelling pressure with time. — Disc No. 5, Radius D. — Abscissa, Ordinate, and Legend: Same as in fig. 17.

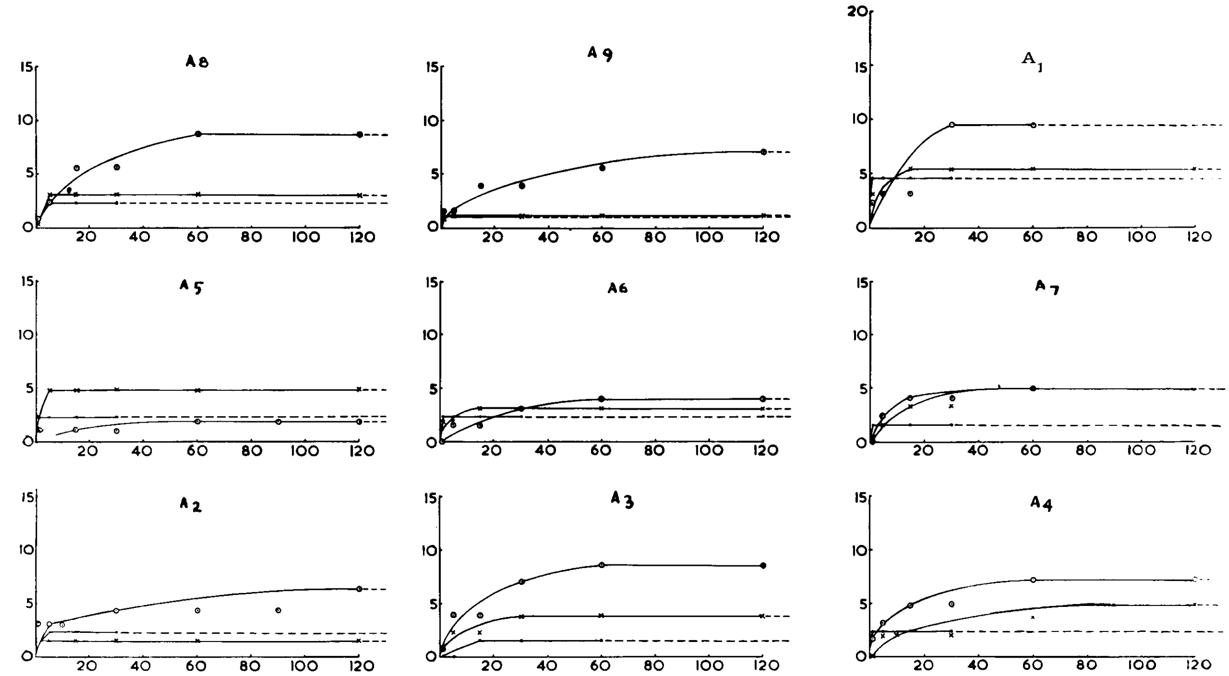


Fig. 19. — Development of swelling pressure with time. — Disc. No. 2, Radius A. — Abscissa, Ordinate, and Legend: Same as in fig. 17.

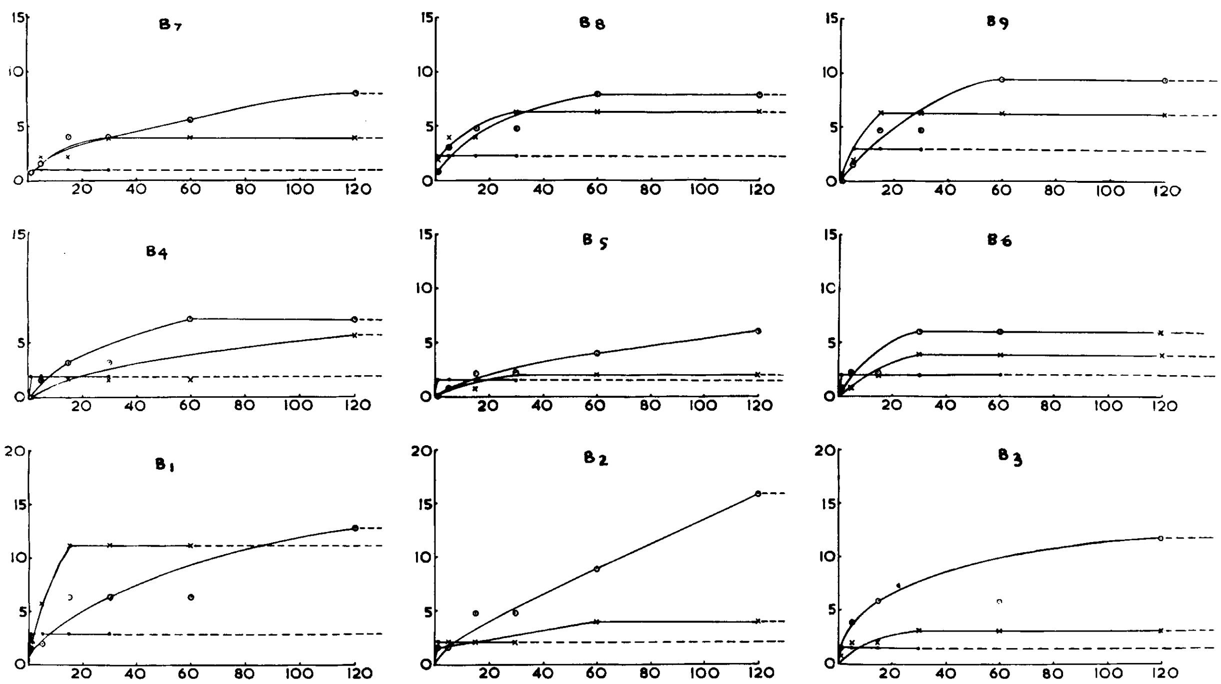


Fig. 20. — Development of swelling pressure with time. — Disc No. 2, Radius B. — Abscissa, Ordinate, and Legend: Same as in fig. 17.

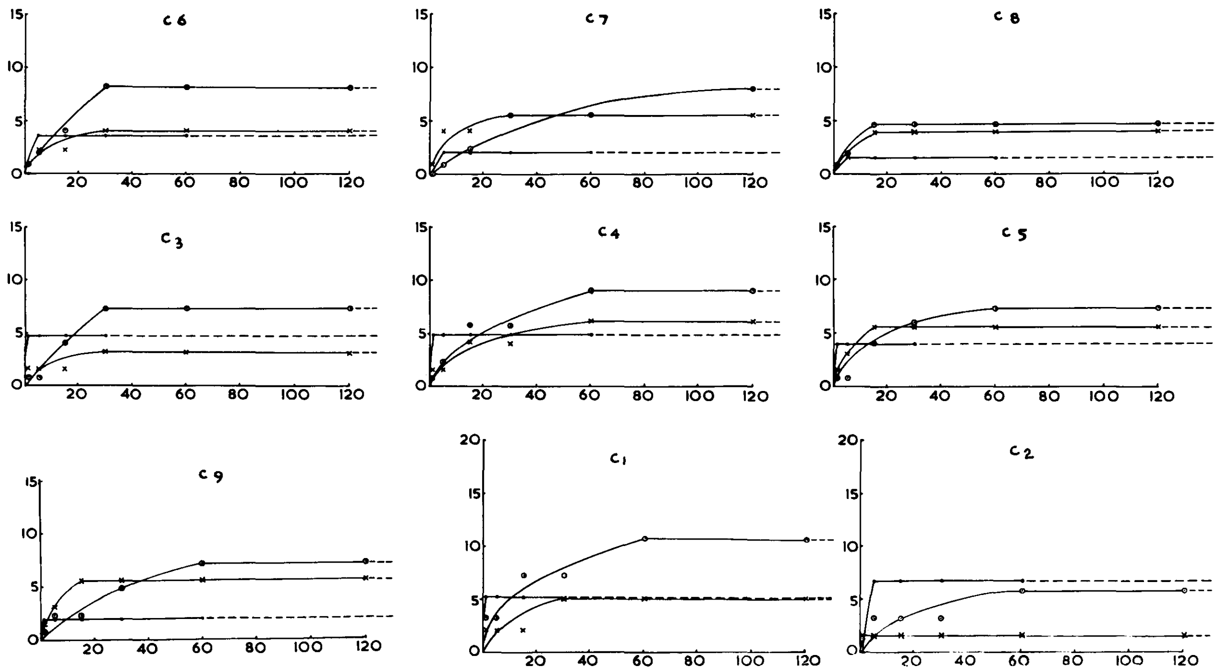


Fig. 21. — Development of swelling pressure with time. — Disc No. 2, Radius C. — Abscissa, Ordinate, and Legend: Same as in fig. 17.

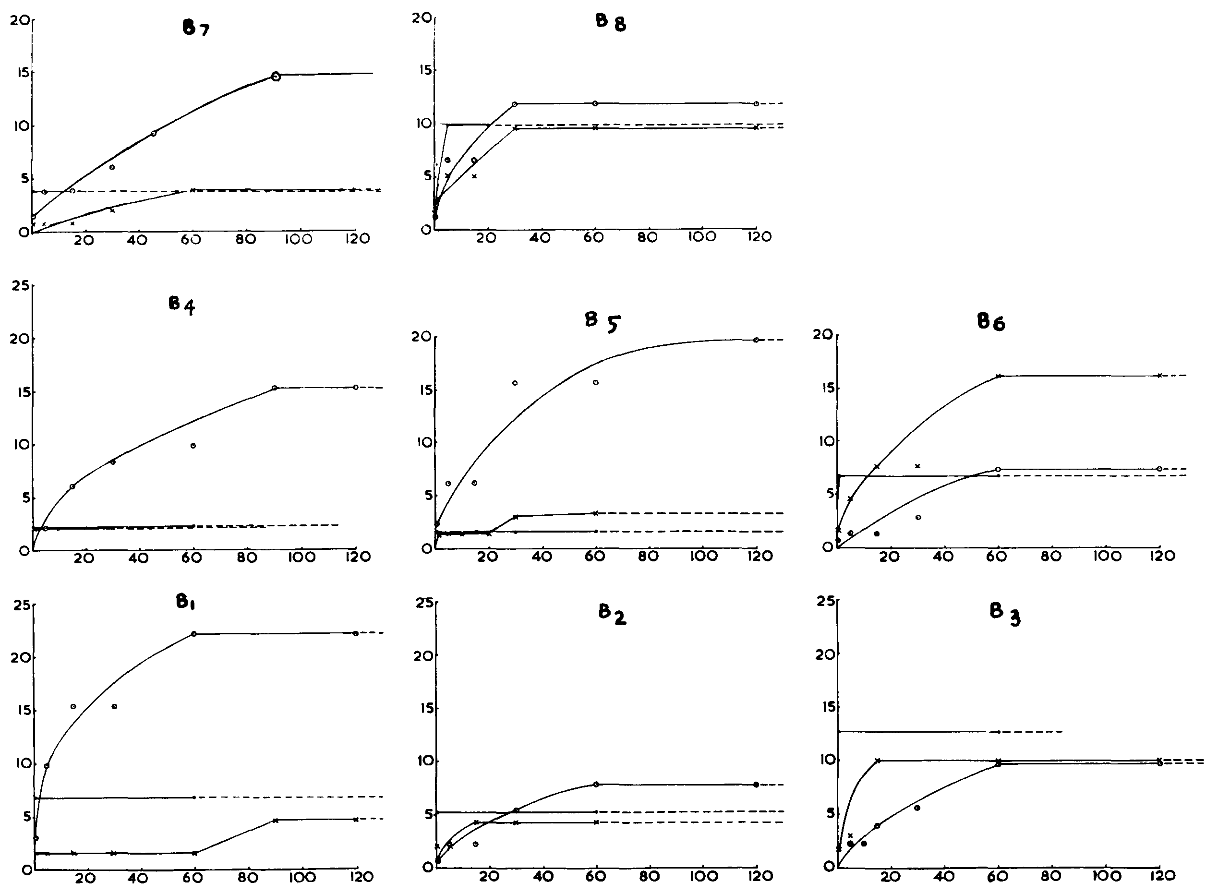


Fig. 22. — Development of swelling pressure with time. — Disc No. 5, Radius B. — Abscissa, Ordinate, and Legend: Same as in fig. 17.

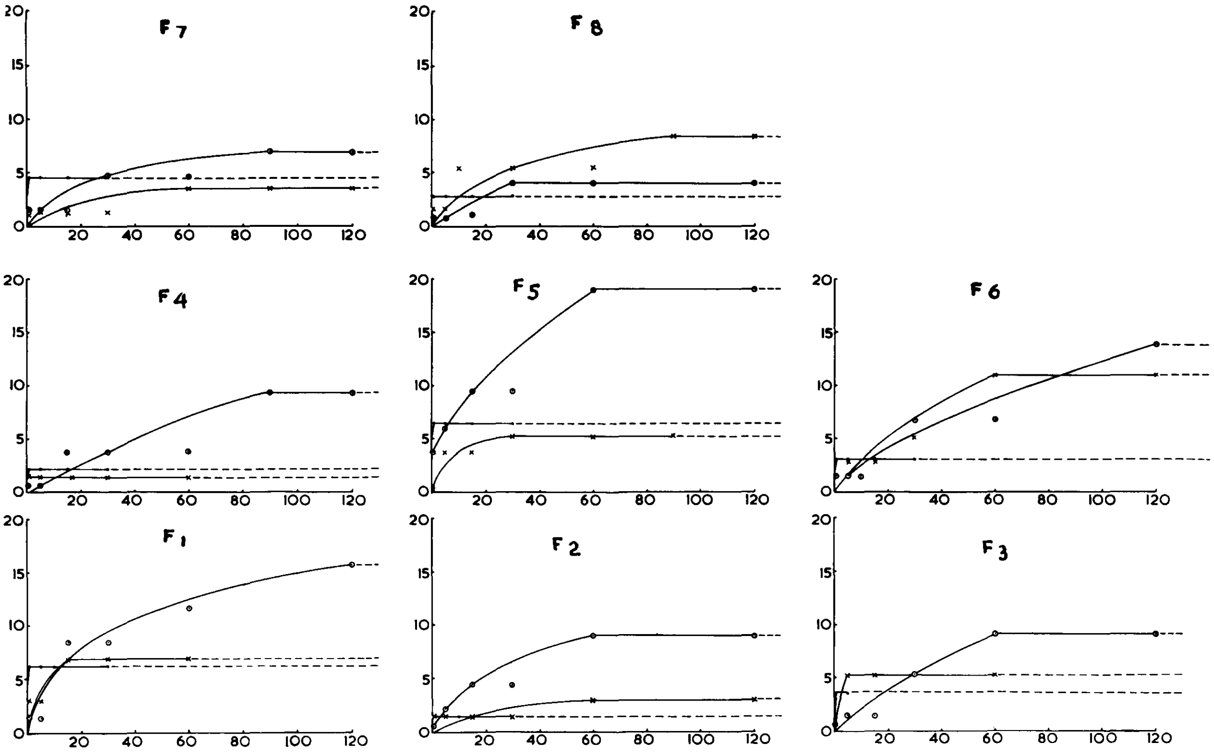


Fig. 23. — Development of swelling pressure with time. — Disc. No. 5, Radius F. — Abscissa, Ordinate, and Legend: Same as in fig. 17.

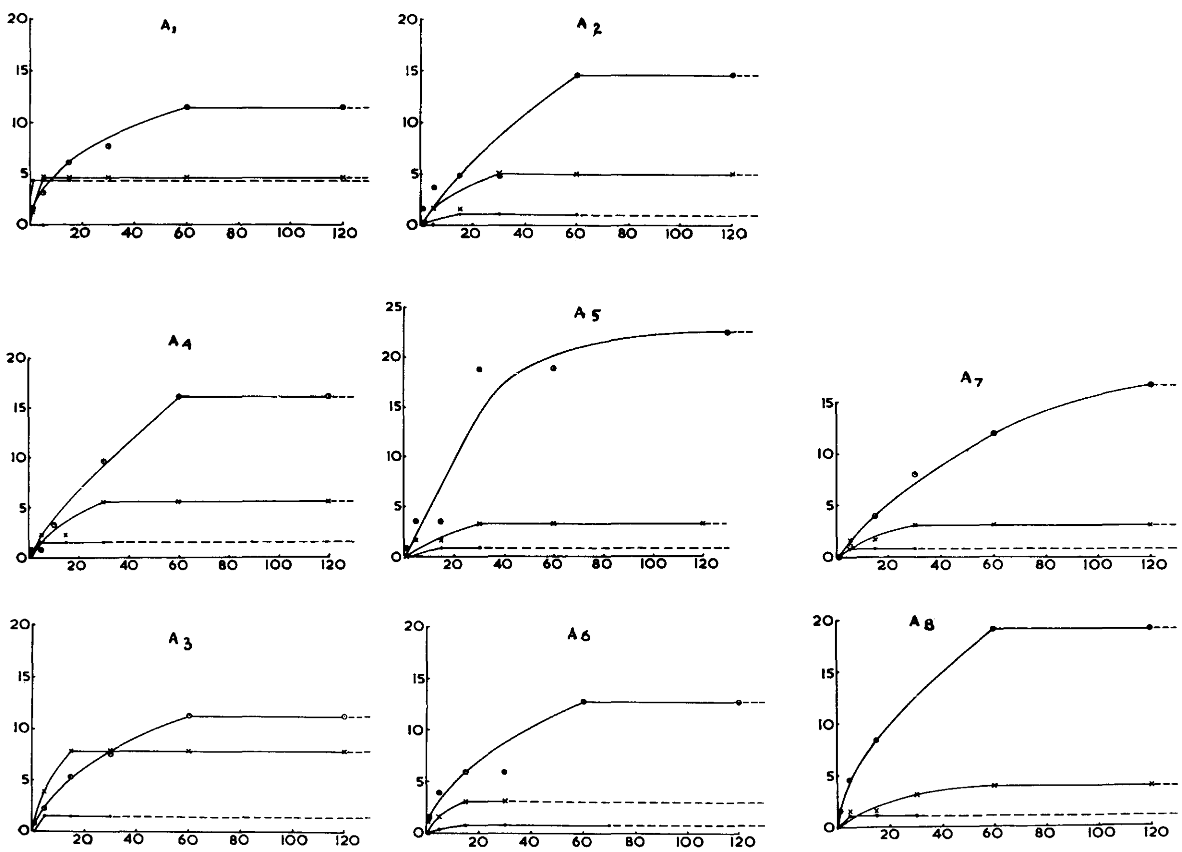


Fig. 24—27. — Development of swelling pressure with time. — Disc No. 14. — Abscissa, Ordinate, and Legend: Same as in fig. 17.