Changes in the Freeness, Fibre Length and Strength Properties of Papers due To Repeated use of Retree

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SUMMARY

Experiments were carried out at the Hand Made Paper Research Institute, Poona to study the changes taking place in the freeness of the stock average fibre lengths and the strength properties of papers when retree was converted to stock and then to paper and again back to stock and paper and likewise for a number of times using the same starting fibres. Cotton fibres from new hosiery cuttings were selected as the starting raw material. Beating was done in a hollander beater and sheets were made by hand made paper manufaturing process in the Poona pattern vat. Fibre length, freeness and the strength properties of papers were compared at different stages. The experiments show a marked decrease in the fibre length and strength of papers in the parent paper and the first retree and the retrees exhibit a gradual decrease in the strength properties in the first few stages and a slow decrease in the later stages from stages to stage. These experiments indicate that the use of retree in a number of stages diminish as the binding strength of the fibres from stage to stage and the fibres used for a large number of times as retree can serve only as a fibrous filler rather than contributing to the strength of the paper.

Admixture of retree to a fresh stock is an ever existing operation in the field of paper making. The Paper Maker very well knows that the initial strength attained in the paper with the use of virgin fibres of any origin is different from the one produced entirely of retree or mixture with retree in any percentage. In spite of the deteriorating effect of retree on the strength properties of paper, the Paper Maker cannot afford to ignore the utilisation of retrees on economic point of view.

The fibres derived from retree are different in their structural characteristics to the virgin fibres which have once been beaten to attain the necessary fibrilation. When retree is being used in a fresh stock care is taken that the retree is not unduly beaten which would cause too much shortening of the fibres and increase in the amount of fines which results in increase in the drainage period. The retree more or less serves as a fibrous filler than actually contributing to the strength of paper.

Addition of retree may amount to about 40% specially in the hand made paper making where scrupulous sorting is done so as to avoid any defects in the

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paper. Now the retree used in such substantial amount in the paper if reused as retree in the stock in the next manufacture and the process so on repeated it will be noticed that the retrees used in different manufactures are different from the one used for the first time.

The retrees go on added up. Even though the parent stock may contain say about 60% of virgin fibres the other 40% of the stock is a mixture of retrees in different stages of evolution in different preperation. Now what would happen to the paper if it is made of retree only and what happens to the retree when it is used and reused would be of much interest to the Paper Technologist. How the structural properties of the fibres would change, how the stock will behave in its freeness and how the strength properties of the paper would change at different stages is not only of academic interest, but of much practical value also, since the high grade paper manufacturer can have an estimate of the quality of his paper when retree is used.

The phenomena taking place in the structure of the fibre, when the virgin fibre is beaten is different than that would occur to fibres that break away their original bonding in the paper. Fibrils, mutually drawn together, entangled during formation of paper are broken up from the main fibre and remain more or less inactive in fibre bondage when retree is remade into paper. Besides, when internal sizing is done these get a further coating of resinous matter which acts in hardening the fibrils. These once detached fibrils will, therefore, have to pack up in the inter fibrillar space in the next stage of manufacture when fibre bonding will have to be reformed by opening up new fibrilae in the fibres. The fibres which have once already received beating treatment have their structure in an open state, and though some of the fibrilae are broken away from the main fibre, fibrilae still exist in the body of the fibres. The process of disintegration in the water medium will have to assist in distending the remaining fibrilae attached to the fibre which from adjacent fibre come together during paper formation. Now it will be observed that the end portion of the fibrilae, and subfibrilae are already detached and the fibrilae present now are in a broken state. As only disintegration is done there is less chance of getting new fibrilation which, however, can exist, to some extent due to friction between fibre and fibre, in the process of Pulp circulation. But this fibrilation will be less effective to improve the strength of paper. The fibre in the first stage of beating which was once in an open structure has been subjected to mechanical compression in the sheet of paper during pressing and callendering. Now the disintegration has first to undo this effect and then break up the fibrilae and separate the fibres so as to keep them in suspension in water. The next process would be to open up the residual fibrilae which will also have reduced in length by this time and to cause new fibrilation. But this will happen to a limited extent as only disintegration is done. The bonding property of the broken blunt fibrilae will be lesser and lesser in successive stages. All this should cause a loss in strength properties of the paper produced.

When the retree is reused in the next manufacture the fibres in the retree will receive a second treatment of disintegration in which course the fibres may be further shortened, the fibrillation decreased and loss in the elasticity of the fibres is possible.

The stock will, therefore, attain an altogether different property than in the previous stage. The paper produced from this stock would change in the strength properties. Now when the paper from this second stage is re-used as retree in the next stage a yet another different stock will be obtained with different properties. If this process is repeated as would naturally happen in the course of paper manufacture, a series of phenomena will take place at different stages and will cause an effect on the strength properties of the paper.

The phenomena that takes place as cited above were studied at the Hand Made Paper Research Institute of Poona to observe the effects produced by the use of retree in the manufacture of high grade papers by hand made paper manufacturing process. Experiments were conducted on the base paper which is partially sized with rosin and alum, the paper being further tubsized with gelatin. Even though in the natural manufacturing process the retree occuring in the paper is a mixture of retrees at various stages, experiments were conducted to study the phenomena as it occurs on one series of fibres.

Experimental :

Parent Paper :

Since cotton rags are the main raw material for high grade hand made paper manufacture in India, cotton fibres from new hosiery cuttings were selected as the starting raw material in the experiments. The rags were sorted out from foreign material and were cut into pieces of 6-8 sq. cm. They were then broken and disintegrated in the pilot plant Hollander beater of the Institute, being simultaneously washed also in the same machine. The material was then beaten at a pulp consistence of 4 percent for two hours to a freeness of 203° Canadian Standard Freeness. The pulp was sized with 1% rosin in the form of rosin soap emulsion aud 1½ percent sulphate of alumina during the next 30 minutes mixing period.

Paper of 100 gms were made in the Laboratory Poona vat, which is a semi-automatic sheet making device designed at the Institute. The machine consists of a storage tank for white water in which is suspended an assembly of deckle and mould which can be operated by a lever system. Papers of 1000 sq. cm having uniform formation could be prepared on the mould which were then transferred on to woolen felts. A number of sheets about 15, each in contact with the woolen felt was pressed in a screw press and thereafter separated from the felts and then air dried on wooden stands. The papers

were then callendered in a hand callendering machine. The papers were placed in contact with glazed zinc plates and passed through rolls under an accurately manipulated load. The number of papers during wet pressing and callendering and the load applied on the rolls during callendering were maintained the same throughout the experiments. The papers were conditioned to 65% R.H. for 24 hours before testing for their strength properties.

Retrees :

The above parent paper was considered as retree and was disintegrated in the Laboratory Beater for conversion into paper. Now the retree to be blended with fresh pulp is generally disintegrated separately in a Hollander and is mixed with the adequately beaten pulp before the size is added. It was assumed that no beating would be done during sizing and the duration of sizing and further disintegration is about one half hour. In order that the same process of disintegration is assured as that occurs during usual process of blending, this period ($\frac{1}{2}$ hour) was fixed for disintegration of retree for sizing and further disintegration. The period of disintegration before sizing was fixed 90 minutes; this period though a little more than necessary was fixed in order to have pronounced effect of disintegration so as to assure that an adequate change takes place in the fibres and any change in the properties of the pulp and paper be appreciable and the change assessed due to disintegration factor only.

Paper of 100 gms were prepared in the Poona vat as in the previous case for parent paper.

This paper was considered as retree of the first stage from the parent paper. Experiments were continued using this retree for disintegration and produce retree of the second stage. The second stage retree was disintegrated and made retree of the third stage and thus the experiment was conducted upto eighth stage. In all the stages the stock preparation schedule was maintained as follows :

1. The retree was torn to pieces and soaked in water for a period of one hour.
2. The soaked pieces were fed to the Laboratory Hollander containing water to maintain final consistency of 2.5 percent and were disintegrated for a period of 90 minutes.
3. At the end of 90 minutes 1 percent rosin was added and the disintegration continued for 15 minutes after which 1.5 percent of alum was added and the disintegration continued for further 15 minutes.
4. The clearance between the bed plate and the beater roll was maintained the same in all the eight stages of the experiment. Papers of 100 gms were prepared in all the stages of the experiment and the same method of sheet making, pressing, drying and callendering was adopted.

Study of the Fibre Structure, Fibre Length and Strength Properties of paper.

The property of the pulp after complete disintegration, in case of parent paper and the retree of all the stages was studied by finding out the freeness of pulp, determination of the fibre lengths and strength properties of standard sheets.

Freeness of the pulp was determind in the Canadian Standard Freeness tester. The freeness of the pulp at 20°C are recorded in table No. 1 and represented in graph in Fig. I

For determination of the fibre length the fibres were stained with methylene blue dye, diluted to 0.05 percent consistency and were distributed on a microscopic slide. The fibres on the slide were dried at 65-70°C. Fibre lengths were determined by taking pencil sketches of the images projected on a screen using Bausch and Lomb Microprojector. During the determination of the fibre lengths care was taken that only the integral fibres were measured. Since in such an observation of beaten pulp it is highly complicated to assess and classify the short and long fibrilae peeled out from the body of the fibre, it was thought that only determination of fibre length of solid fibres will suffice to judge the characteristics of the pulp though this would mean incomplete estimation.

Discussion of Results.

The average fibre length of the virgin cotton fibres used for the series of experiments was about 23 mm. This was reduced to an average length of 1.24 mm in the stock of the parent paper. In the next stage when the parent paper was disintegrated there was an immediate drop in the fibre length from 1.24 mm to 0.87 mm. The decrease in the fibre length in the next stage is also considerable i.e. 0.87 mm to 0.83 mm but in the further stages the decrease in the fibre length is very gradual but not considerable (vide table No. 1 and Fig. 1)

The effect of the marked decrease in the fibre length from parent paper to the 1st stage retree is immediately seen in the marked reduction in the internal tearing resistance which reduced from 155 g to 117 g from parent paper to 1st stage retree. In the further stages the decrease in the internal tearing resistance has been gradual upto the sixth stage and negligible in the further stages (vide table No. 3 and Fig. 4)

The Canadian Standard Freeness and the strength properties of the Papers are recorded in Table Nos. 2 and 3. The freeness of the stock of the parent paper was 203° at 20°C. This was reduced to 172° when the parent paper was disintegrated. Such a reduction in the freeness can be explained as due to reduction of longer fibres to shorter ones and formation of fines which hinder the drainage of water. When the same retree is reconverted to pulp the fibrillation of the main fibres comparatively decrease and the fines, torn pieces of the fibrilae increase. However, the short fragments of the fibrilae pass through the meshes of the wire

mould used in sheet making and these fines were not re-furnished in the further stages. Due to decrease in the fibrillation during the disintegration of retrees in the further stages, water drainage through the fibres has enhanced and increase in the freeness of the pulps is evidenced (vide fig. 2).

That the fibrillation and the binding properties of the fibres are reduced considerably from the parent stock to the stock of 1st stage retree is evidenced from the remarkable decrease in the breaking length and folding endurance of the respective papers which have reduced from 2890 meters to 2090 meters and 373 to 59 double folds respectively. The decrease in the breaking length and folding endurance in the further stages is not so pronounced. There is also considerable drop in the bursting strength from parent paper to 1st stage retree. That the degree of fibrillation reduces gradually from stage to stage and there is still some amount of fibrillation in the eighth stage is evidenced from the fact that strength properties of the papers are gradually decreasing and the eighth stage retrees till possesses some strength (vide table No. 3 and Figs. 3 to 6). That the retrees in the final stages have low strength and the decrease in the strength properties of retrees in the final stages is much less show that the formation of new fibrilae in the fibres by continued use of retree is limited.

Conclusions :

Disintegration of retree changes the structural characteristics of the fibres as a consequence of which the freeness of the stocks are affected. There is considerable decrease in the fibre length and degree of fibrillation from parent paper to the first stage retree which tells of the remarkable decrease in the strength properties of the 1st stage retree compared to that of the parent paper. The changes in the fibre length and degree of fibrillation in the further stages of retrees are gradual and in the later stages much insignificant. This is evidenced by gradual decrease in the strength properties of retrees from stage to stage and in the first few stages and in the later stages the decrease in strength is less. Retrees after the fifth stage are found to be very weak.

The experiments were conducted on the cotton fibres having high intrinsic strength and the papers were made by hand made process. The phenomena exhibited may be enhanced if chemical pulps already degraded during the digestion are tried on the actual paper machines as the fibres are subjected to more frictional forces and heat treatment during drying and callendering processes. The fibres may ultimately have to find their use as bulk giving fibrous fillers rather than contributing to the strength of the papers when they are used again and again as retrees.

TABLE NO. I

AVERAGE FIBRE LENGTHS (mm.)

Virgin cotton fibre	Parent stock	RETREES							
		1	2	3	4	5	6	7	8
23.0	1.24	0.87	0.83	0.83	0.82	0.82	0.81	0.80	0.78

TABLE NO. II

FREENESS OF PULPS (CSF)

Parent stock	RETREES							
	1	2	3	4	5	6	7	8
203	172	218	230	239	246	260	265	268

TABLE NO. III

STRENGTH PROPERTIES OF PAPERS

		Breaking length (meters)	Internal tearing resistance (G)	Burst Factor	Folding endurance (No. of double folds)
Parent Paper		2890	154	21.0	373
R E T R E E S	1	2090	177	15.4	59
	2	2000	106	13.3	43
	3	1750	95	10.7	37
	4	1670	88	9.8	33
	5	1660	84	8.4	24
	6	1470	80	7.4	15
	7	1470	80	7.2	11
	8	1330	79	7.0	10

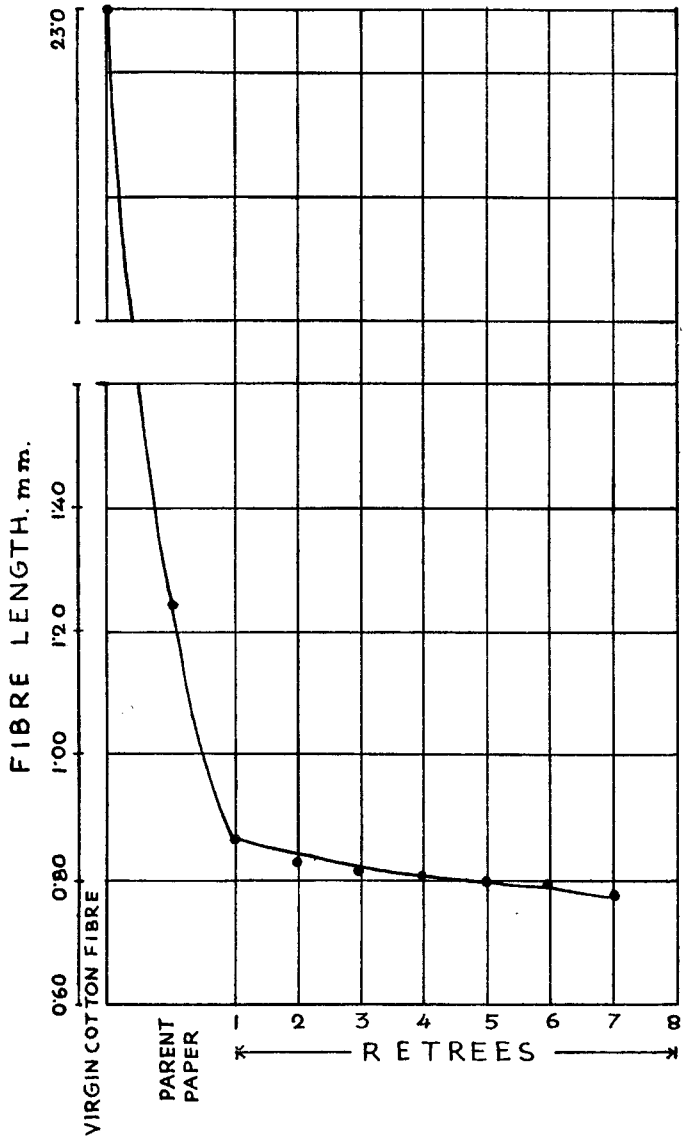

FIBRE LENGTH. mm.
2·30
1·40
1·20
1·00
0·80
0·60
VIRGIN COTTON FIBRE
PARENT PAPER
1
2
3
4
5
6
7
8
RETREES

Fig. No. 1

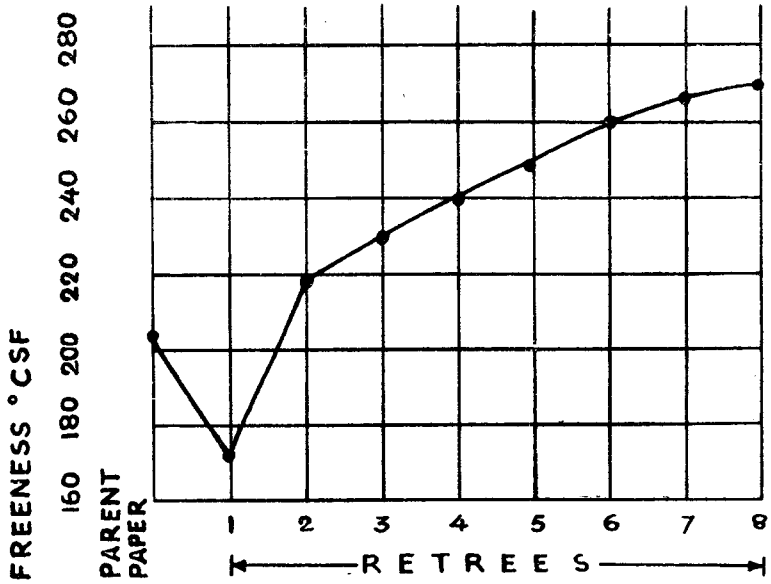
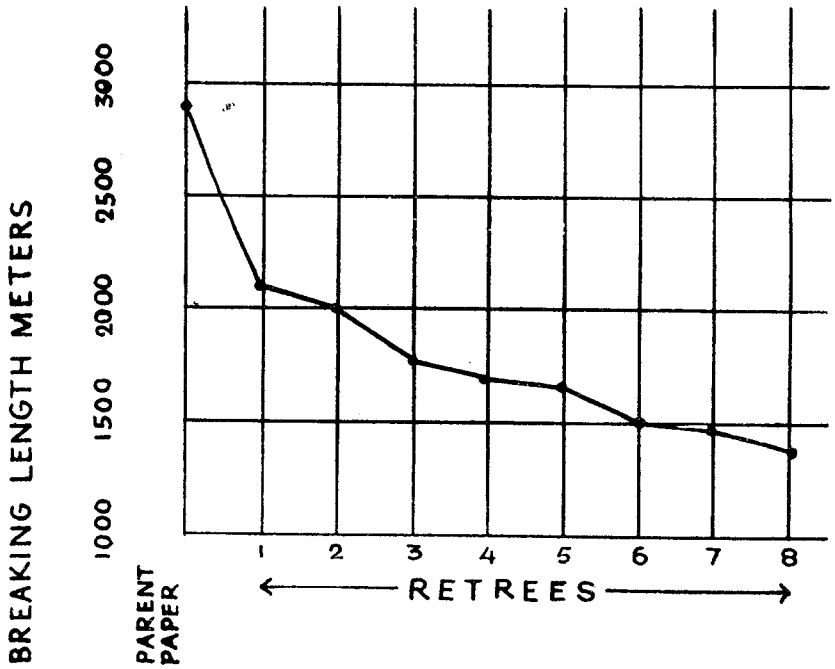


Fig. No. 2



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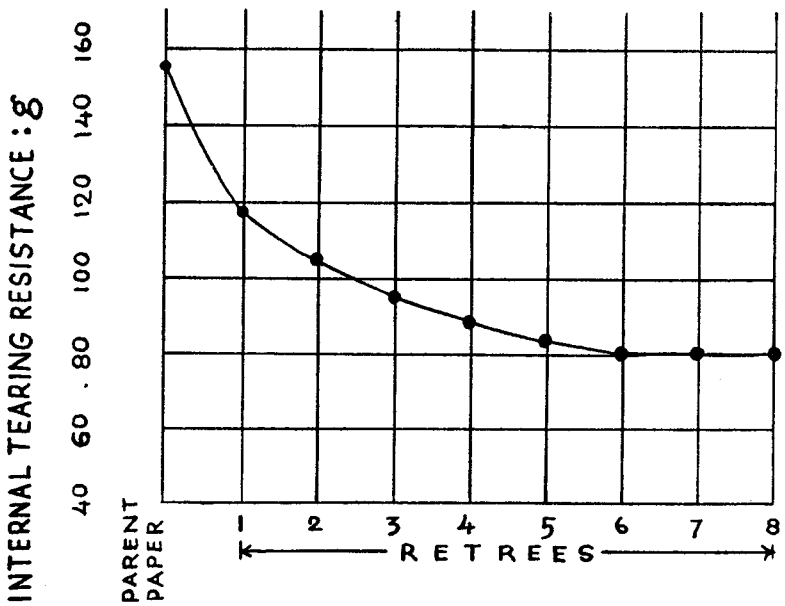

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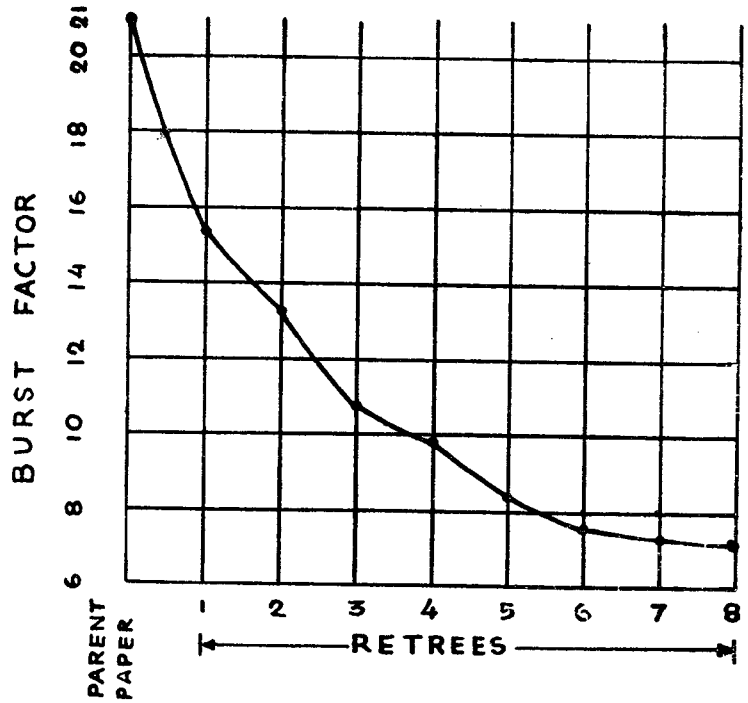

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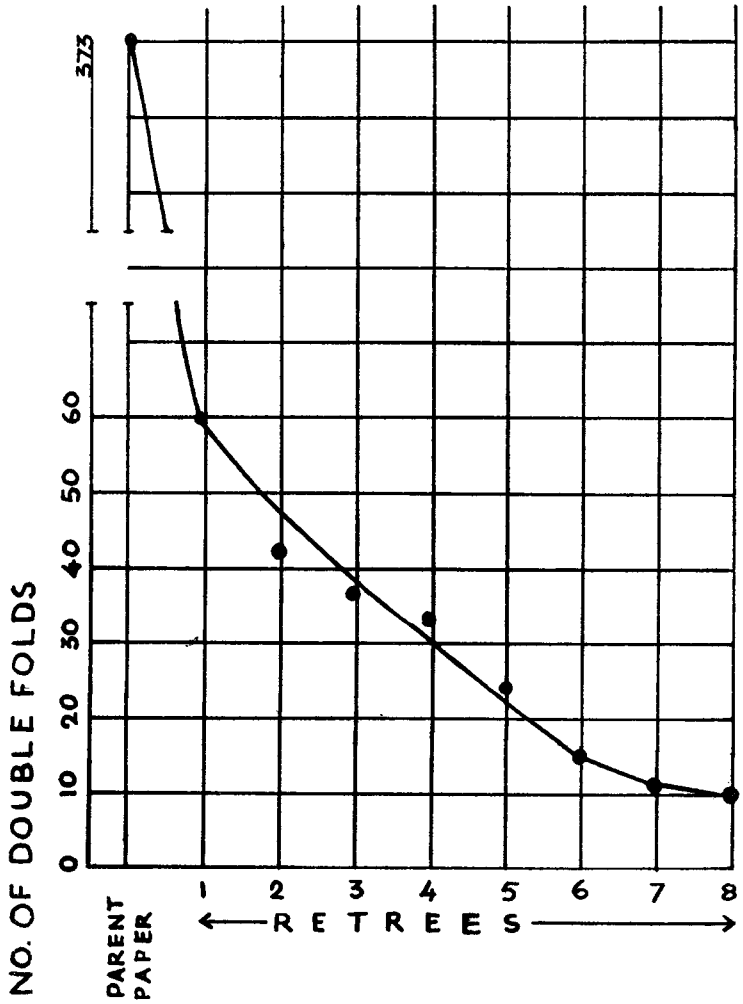
373
NO. OF DOUBLE FOLDS
0
10
20
30
40
50
60
PARENT PAPER
1
2
3
4
5
6
7
8
RETREES

Fig. No. 6