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Flotation Deinking of Offset Printed Newsprint Versus Letterpress Printed Newsprint

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FLCTATION DEINKING OF OFFSET PRINTED NEWSPRINT

VERSUS

LETTERPRESS PRINTED NEWSPRINT

by

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INTRODUCTION

With the ever increasing threat of insufficient virgin pulp to supply the world market of the future, a renewed interest in deinked pulp as a supplement has begun. Although this solution seems to be very practical and inexpensive, it is not without it's many problems, one of which being it's environmental impact. This problem along with others can usually be solved in time as can be represented by the development of flotation deinking. This process and others like it are increasingly replacing the old washing method which has a history of being a high energy and water user. The method of flotation deinking is relatively new and so this field of study is wide open to research and new ideas.

The purpose of this paper is twofold. The main intent is to discover the differences, if any, in flotation deinking of newsprint which has been printed by two different processes, letterpress versus offset. The concurrent study is the evaluation of some current market flotation chemicals of which two of them with the best results will be used for the bleaching study of this experiment.

HISTORICAL DISCUSSION OF DEINKING

The re-use of printed waste paper has a very early origin with the first recorded attempt at the mill of George Balthasar Illy in Denmark in 1695.[1] From this point the development of deinking grew slowly until the middle of the 1800's, when the era of machine manufactured paper made waste paper available in large quantities. The deink stock at this point in time consisted mainly of chemical pulp papers with little attempt at the deinking of groundwood papers. Deinking of groundwood soon became practical after the 1930's in which considerable progress in groundwood bleaching occurred.[1] A good example of the increase in groundwood deinking is the production of newsprint by the Garden State Paper Company. In October of 1961 this company started production of newsprint from 100% deinked waste newsprint and because of its success, it has expanded it's production to almost 1100 tpd.[11,12,13]

Until recently the process for deinking has changed very little. The main objective was to pulp up the waste paper using alkali to saponify the ink vehicle and the soaps thus generated would emulsify and disperse the ink. This stock was then washed several times to remove the ink particles and consequently a large amount of the fines and fillers present. The high shrinkages thus involved plus the large volume of water needed for washing has led the paper industry to search for a more efficient deinking process. One such process which has become popular today is deinking by flotation.

Separation of contaminants by flotation has been practiced by the mining industry for many decades. In recent years, European countries have applied the principle of flotation to deinking due to the higher cost of energy and lower water usage and effluent problems.[11] With their continued progress and success with the flotation process plus the more stringent pollution controls and higher energy costs, this process has become increasingly popular in the United States.

INKS

Ever since the art of printing began, so have the science of ink manufacture. The number of inks and ink compositons up to this date ranges into the thousands. All inks though can be broken down into five general components. These are: pigments, binders or nonvolatile vehicle, solvent, drier, and certain additives (waxes, surface-active agents, etcetra) which can be grouped under the heading of "compounds".[1] Each ink thus contains a combination of these five components according to the particular use, type of paper to which it will be applied, the type of printing process used, etcetra.

The two types of inks which are currently used for the printing of newsprint are very similar. The ink used for letterpress consists of a mineral oil base (80%), carbon black pigment (9-15%), and a hydrocarbon pitch (2-5%).[2] Ink used for offset printing of newsprint also consists of a mineral oil base (40-80%), a carbon black pigment (10-18%), hydrocarbon pitch (2-5%), and a hydrocarbon resin (10-30%).[2] The main difference is the hydrocarbon resin present in offset ink along with a large portion of the mineral oil base being replaced with a less viscose mineral seal oil.

These inks do not really dry but are absorbed into the paper thus leaving a film of carbon black bonded to the fiber surface by the pitch and/or resin. Since both the pitch and resin vehicle cannot be saponified by alkali, the carbon pigment must be removed from the fibers by mechanical attrition and emulsification. This problem could be particularly enhanced for the offset ink because of it's resin content.

PULPING

The waste paper to be deinked must first be broken up into individual paper fibers and ink particles so that the two may be separated. The common practice employed for this is the pulping of the paper at elevated temperatures and a PH of 9-10.5. The alkaline conditions used serves the purpose of swelling the fibers and also saponifying certain ink vehicles and any rosin sizing which may be present. The pulping temperatures usually range from 160-212°F for nongroundwood pulps and 100-160°F for groundwood pulps.[1] Lower temperatures are used for pulping groundwood so as to alleviate the darkening caused by high temperatures in the presence of alkali.

The alkali most commonly used in the pulper is sodium hydroxide, with or without sodium silicate. Sodium peroxide plus sodium silicate or hydrogen peroxide plus sodium hydroxide and sodium silicate are two other popular alkali combinations used when pulping groundwood. In this case the peroxide acts as a bleaching agent to counteract the darkening of the lignin in groundwood when pulped under alkaline conditions. It also converts glue, casein, starch and certain oils into water soluble types, thereby aiding in the dispersion of inks, coatings, and sizing materials.[1] The sodium silicate used acts as a detergent (dispersant), penetrant, PH buffer, and a stabilizer in peroxide solutions.[3]

The pulper is also where most other deinking chemicals are added. These chemicals might include detergents to help disperse the ink and counteract any reabsorbtion onto the fibers, solvents to help dissolve ink vehicles, and foaming plus collecting agents for use in flotation deinking.

After the pulping operation, which usually lasts from thirty minutes to an hour, the pulp is dumped into a tank or soak pit. Here it will remain, usually at pulping temperatures, for thirty minutes to two and one half hours.[15] This process is thought to be necessary in order that there is ample time for the fibers to swell and the chemicals to react in order that the ink can be separated easily.[5]

FLOTATION DEINKING

The cooked pulp is then passed through sand traps and coarse screening to remove large debris. A deflaker can be followed after screening or the pulp can be diluted and pumped directly to the flotation cells.

The flotation process for separation of ink from the pulp is based on the relative wettability of each of the components surfaces.[4] The surfaces may possess some natural non-wettability, but they usually must be treated with various flotation reagents in order to produce the desired degree of wettability or non-wettability.[4]

The flotation mechanism involves the dispersion of fine air bubbles into the pulp. These bubbles must be very small and stabilized by addition of a foaming or frothing agent. This chemical is an organic compound which contains both a hydrophilic (water hating) and hydrophobic (water loving) group. The compounds usually used are fatty acid soaps such as sodium oleate or higher alcohols such as amyl and terpineol alcohols.[4] These chemicals reduce the surface tension of water thus allowing the air bubbles to rise to the surface and resist rupture until the froth can be scraped off.[5]

As the stabilized air bubbles are dispersed into the adgitated pulp, they make contact with the particles of ink. These ink particles must be make non-wettable in order that they will stick to the bubbles and float to the surface. This is accomplished by the use of a collecting agent. This chemical can be cationic or anionic in nature depending on whether the adsorbing ion is positively or negatively charged. Examples of cationic collectors are quanternary ammonium, pyridinium, quinolinium, and sulfonium salts.[4] The common anionic collectors used are sulfhydrics and carboxylics of which the last consists of fatty acids or their soaps.[4]

Since paper fibers have a slight negative charge and are easily wetted and carbon particles have a slight positive charge, an anionic collector is used. The anionic collectors generally used are the fatty acids which will form insoluble calcium and magnesium soaps with hard water.[4,14] The soap's hydrophobic end then sticks to the carbon particles thus leaving the hydrophilic end exposed outward. This causes the particles to be very non-wettable and so the hydrophilic ends collect at the bubbles air-water interface and are floated to the surface. The froth containing the ink particles is then scraped off leaving the pulp relatively clean.

There are many variables associated with flotation deinking other than paper stock, ink type and chemicals used. Some of these include: temperature of deinking, deinking time, water hardness, filler quantity, and PH. All of these have been investigated by F.E. Raimondo who used a Voith type flotation cell and based his conclusions on brightness measurements.[6] From his experiments, he showed how the brightness increased as deinking temperature and time was increased. With water hardness he found that after about 75 ppm of $CaCO_3$ the brightness increase leveled off. It seems that a minimum amount of ions are needed to cause the action of the collectors but an excess does not seem to cause any problems.[6] The brightness versus PH showed a definite favorable range of 8 to 10 with a rapid brightness drop above or below this PH range. As far as the effect of filler on the deinked brightness, he found that the brightness increase was due to the higher brightness of the filler itself and not due to better deinking.*

BLEACHING OF GROUNDWOOD

In most cases, the resulting brightness of deinked groundwood is not sufficient for the intended purpose. It is there-

* A copy of Mr. Raimondo's graphs is included in the appendix.

fore necessary to bleach the pulp to the required brightness. Since groundwood contains practically all of the original wood substituents, the bleaching process must be different from that of a chemical pulp. This difference results from the high lignin content of groundwood which cannot be bleached out as with a chemical pulp due to the resulting high chemical cost and low yield. In this case, the bleaching agent must destroy the colored lignin compounds without attacking and removing them. This is accomplished by either oxidizing or reducing the colored phenolic hydroxyl and carbonyl groups on the phenylpropane units of lignin.[7]

The oxidizing agents currently used are sodium and hydrogen peroxide. In deinking it is usually added to the pulper to help counteract the browning tendency of groundwood subject to hot alkaline conditions. Along with peroxide, a pH buffer and stabilizer is usually added which consists of sodium silicate and magnesium sulfate. The decomposition of peroxide by certain metal ions such as copper, iron, manganese, and nickel must be counteracted by use of a sequestering or chelating agent.[3,8] The common chemicals used are polyphosphates or organic chelating agents such as sodium EDTA.[3]

The reducing agents for bleaching which are commonly used include sodium and zinc hydrosulfites.[8] These chemicals are usually used for a single stage bleach or as the second part of a two stage peroxide-hydrosulfite bleaching sequence. This two stage sequence cannot be reversed to a hydrosulfite-peroxide sequence do to reversion of the hydrosulfite brightness by peroxide.[9]

The use of hydrosulfite must also involve the use of a sequestering agent because of the decomposition of hydrosulfite by metal ions such as iron.[10] Another problem of hydrosulfite is it's decomposition in the presence of oxygen. In effect, the hydrosulfite combines with oxygen in the presence of water to form sodium bisulfite and bisulfite. These products have very little bleaching power and since the rate of this reaction is far greater than the rate of the bleaching reaction, the exclusion of air during bleaching is imperative.[3]

EXPERIMENTAL PROCEDURE

Since the object of this thesis was the comparison of the deinkability of offset versus letterpress newsprint, two comparably printed samples were obtained. The samples chosen were, The Kalamazoo Gazette (letterpress), and the Western Herald (Offset). Both of these papers have approximately the same basis weight (Gazette-49.7 g/m^2, Herald-49.5 g/m^2), ink coverage, and unprinted brightness(Gazette-55.7, Herald-55.1).

The deinking chemicals were supplied by Texo Chemical Corporation and Nalco Chemical Company. Of the two Texo chemicals that were used, the first, LP 758, is a solvent based with a small amount of surfactant added. The second, LP 728 A, is a complete substitute for both a foaming and collecting agent. The two Nalco chemicals used, 7684 and 7685, were both a blend of low foaming surfactants and dispersants.

The collecting agent used with all of the above chemicals except LP 728 A, was technical grade oleic acid. The two concentrations of this chemical which were used are .5% and .8% based on oven dried fiber.

A total of fourteen runs were made with offset and letterpress samples with the chemicals, concentrations, and conditions listed below. The flotation aid concentrations were suggested by the manufacturer with all other chemical concentrations developed from previously published literature.

PULPING*

Pulper Stock 125g.

PULPING-con't.*

Flotation Aid

7684 - .25%

7685 - .4%

LP 758 - .38%

LP 728 A - .85%

Collector (Oleic Acid) .5%, .8%

Caustic (NaOH) .2%

Sodium Silicate (42.2 Be) 5%

Hydrogen Peroxide (30%) 1%

Pulping pH 10

Pulping Water Hardness 300 PPM ($CaCO_3$)

Pulping Time 15 Minutes

Pulping Consistency 3.1%

Soaking Time 45 Minutes

Soaking Temperature 120° F

Soaking Consistency 3.1%

FLOTATION

Flotation Time 12 Minutes

Flotation Temperature 100° F

Flotation Consistency .65%

Flotation pH 9

BLEACHING

Tetrasodium EDTA .5%

*All concentrations are standard unless noted and are based on oven dried fiber

BLEACHING-con't.

Sodium Hydrosulfite 1%

Bleaching Time 60 Minutes

Bleaching Temperature 120° F

Bleaching Consistency 4%

Bleaching pH 8

The moisture content of the offset and letterpress were first determined so that 125g. samples, based on oven dried fiber, could be weighed out. These samples were then deinked using the same chemicals, concentrations, and conditions so that a direct comparison of deinkability could be made.

Before deinking, the samples were put into a 10 liter stainless steel container which contained 4 liters of tap water adjusted to a hardness of 300 PPM $CaCO_3$, and the pulping chemicals mentioned above. They were then pulped for 15 minutes with a special mixer powered by a Waring blender motor. The motor, which was set at a low speed, was controlled by a rheostat. The rheostat setting for all runs was 30. Temperature control during pulping and soaking was maintained by use of a rheostat controlled heating mantle which surrounded the stainless steel container. This type of a set up was used because it more closely resembles commercial pulping conditions.

After pulping, the stock was allowed to soak for 45 minutes to allow the chemicals to more fully break up and disperse the ink. At the end of this soaking period, a 10g sample of stock was taken for use in making handsheets.

The remaining stock was then added to a 15 liter Voith Morden flotation cell without washing. It was then diluted to .65% consistency with 100° F tap water which was adjusted to a water hardness of 300 PPM $CaCO_3$. The cells air valve was left in the wide open position and the recirculation valve was adjusted to give maximum recirculation without sucking in additional air. A flotation time of 12 minutes was used which is approximately equivalent to the retention time in a 10 cell commercial unit.

After flotation, a 10g sample of stock was taken for producing handsheets and the remainder, which was approximately 100g, was dewatered to 4% consistency by draining it through an 80 mesh sieve. The stock was then mixed with .5% tetrasodium EDTA to complex any heavy metal ions. It was then placed in a plastic bag along with 1% sodium hydrosulfite, after which the bag was sealed to prevent contact with air. The contents was agitated to evenly mix the hydrosulfite and placed in a hot water bath at 120° F for one hour. After bleaching, a sample was taken without washing, for producing handsheets.

Handsheets were made at approximately $60g/m^2$ basis weight, on the Noble and Wood handsheet mold. A minimum amount of tap water was used to dilute the stock (Approximately 1% consistency) so that the washing of dispersed ink from the sheet would be at a minimum. Three handsheets were made from each sample which were tested for brightness and CIE tristimulus. Each handsheet was first folded into quarters with the wire side facing out and tested in four different areas. The twelve brightness values from each sample were then averaged and the procedure was repeated with the felt side out.

DISCUSSION OF RESULTS

Comparison of the offset versus letterpress shows a general trend of higher brightness for offset after flotation and approximately the same brightness for each after bleaching. One exception to this was the low bleached brightness of letterpress using 7685 as compared to the offset.

TABLE I

FLOTATION AID	LETTERPRESS		OFFSET	
	AFTER FLOTATION	AFTER BLEACHING	AFTER FLOTATION	AFTER BLEACHING
7684 .5% Oleic Acid	51.3	54.0	52.9	55.8
.8% Oleic Acid	51.7	54.4	52.6	54.4
7685 .5% Oleic Acid	50.8	52.6	52.6	55.7
.8% Oleic Acid	51.0	53.8	52.6	55.9
LP 758 .5% Oleic Acid	50.2	53.5	51.2	54.1
.8% Oleic Acid	52.8	55.9	52.6	54.7
LP 728 A .No Oleic Acid	52.3	55.2	52.5	55.0

It should be noted that all the runs with letterpress resulted in a much lower brightness of the wire side versus the felt side except after bleaching. The cause of this could be the low foaming tendency and consequently poor ink removal in the flotation cell for each letterpress run. The remaining ink which wasn't floated out would then collect on the wire side during handsheet formation. The lack of two-sidedness for the bleached handsheets could be caused from washing out the residual dispersed ink when the dilute cell stock was dewatered to 4% consistency for bleaching.

To prove this, several runs with letterpress were conducted with the use of Triton X 100 which produced a stable foam in a sufficient quantity for deinking. The results showed a large reduction of the two-sidedness.

The runs using offset samples did not show as great a tendency for two-sidedness as did the letterpress. This could be attributed to the larger quantity of stable foam which was generated in the flotation cell during all of the offset runs. The cause of the better foaming tendencies of the offset is thought to be from sizing in the sheet, though the Hercules sizing test gave a negative result.

Along with the brightness reasings, CIE Tristimulus readings were taken to determine the color region of the sheets. It was found that the dominant color wavelength for all sheets ranged between 575 and 580.

Because of the yellowing effect of the caustic, a sample of letterpress and offset were deinked using LP 758, .8% oleic acid and all the other standard pulping chemicals except sodium hydroxide. The results showed a slightly lower brightness of the handsheets as compared to the same runs with caustic but a large decrease in the yellowing effect.

In composing the effectiveness of the different deinking chemicals, it can be seen that each chemical except NALCO 7685 results in approximately the same deinked and bleached brightness (plus or minus a brightness point)(See TABLE I). The 7685 gave comparable results for the offset but poor results for the letterpress (Brightness; 55.7, 55.9 Herald, 52.6, 53.8 - Gazette).

Increasing the concentration of oleic acid resulted in very little brightness increase with all the chemicals except LP 758 (See TABLE I).

Upon examination of the offset and letterpress handsheets of the same brightness, it can be seen that the offset sheets contain many dark fibers where as the letterpress does not. This is probably caused by the offset ink which contains more resin and so binds the ink more tightly to the fibers.

Finally it should be noted that the brightness of the offset is much higher than the letterpress after pulping each up without any chemicals. This shows that although the offset and letterpress papers have approximately the same ink coverage, the thickness of ink must be larger for the letterpress.

BRIGHTNESS AFTER PULPING

	No Chemicals
Offset	45.8
Letterpress	40.9

CONCLUSIONS

The deinkability of offset versus letterpress printed newsprint did not show any appreciable difference. Both papers can be deinked to the same brightness without difficulty and without different chemicals for each.

However, to the naked eye, the deinked letterpress looks cleaner than the offset sheets which are of the same brightness. This is due to ink covered fibers which are still left in the offset sheet.

The solvent based chemical versus the surfactant chemicals that were used did not make a difference in deinkability. Also the increased concentration of oleic acid did not result in any appreciable difference in deinked brightness. The exception to this was the LP 728 which resulted in higher brightness at the higher oleic acid concentration.

RECOMMENDATIONS FOR FURTHER WORK

1. Deinking with other collecting agents and concentrations.
2. Altering pulping conditions or chemicals to reduce amount of ink covered fibers in the deinked offset.
3. Optimizing bleaching conditions to improve the final brightness of the deinked newsprint.

BRIGHTNESS VALUES

		LETTERPRESS	OFFSET	AVERAGE OF FELT AND WIRE LETTERPRESS	AVERAGE OF FELT AND WIRE OFFSET
Nalco 7684 .5 % Oleic Acid					
After Pulping	WIRE	50.2	51.9	51.0	52.3
	FELT	51.7	52.7		
After Flotation	WIRE	50.7	52.9	51.3	52.9
	FELT	51.9	52.8		
After Bleaching	WIRE	53.7	55.7	54.0	55.8
	FELT	54.3	55.9		
Nalco 7684 .8 % Oleic Acid					
After Pulping	WIRE	50.2	51.7	51.3	51.8
	FELT	52.4	51.9		
After Flotation	WIRE	50.9	52.8	51.7	52.6
	FELT	52.4	52.3		
After Bleaching	WIRE	54.2	54.6	54.4	54.4
	FELT	54.6	54.1		
Nalco 7685 .5 % Oleic Acid					
After Pulping	WIRE	49.3	51.7	50.3	52.2
	FELT	51.2	52.7		
After Flotation	WIRE	50.1	52.5	50.8	52.6
	FELT	51.5	52.6		
After Bleaching	WIRE	51.7	55.7	52.6	55.7
	FELT	53.4	55.7		
Nalco 7685 .8 % Oleic Acid					
After Pulping	WIRE	48.9	50.2	49.9	50.7
	FELT	50.8	51.1		
After Flotation	WIRE	49.9	52.4	51.0	52.6
	FELT	52.0	52.8		
After Bleaching	WIRE	53.5	55.9	53.8	55.9
	FELT	54.0	55.8		
TEXO LP 728 A No Oleic Acid					
After Pulping	WIRE	51.4	51.2	52.2	51.4
	FELT	52.9	51.6		
After Flotation	WIRE	51.8	52.7	52.3	52.5
	FELT	52.8	52.3		
After Bleaching	WIRE	55.0	55.2	55.2	55.0
	FELT	55.3	54.8		

BRIGHTNESS VALUES-con't.

TEXO LP 758 .5% Oleic Acid		LETTERPRESS	OFFSET	AVERAGE OF FELT AND WIRE LETTERPRESS	AVERAGE OF FELT AND WIRE OFFSET
After Pulping	WIRE	50.3	49.4	51.1	49.8
	FELT	51.9	50.2		
After Flotation	WIRE	49.3	51.0	50.2	51.2
	FELT	51.1	51.4		
After Bleaching	WIRE	53.1	54.0	53.5	54.1
	FELT	53.8	54.1		

TEXO LP 758 .8% Oleic Acid		LETTERPRESS	OFFSET	AVERAGE OF FELT AND WIRE LETTERPRESS	AVERAGE OF FELT AND WIRE OFFSET
After Pulping	WIRE	50.5	50.2	51.4	50.7
	FELT	52.3	51.1		
After Flotation	WIRE	52.3	52.3	52.8	52.6
	FELT	53.3	52.8		
After Bleaching	WIRE	55.8	54.7	55.9	54.7
	FELT	55.9	54.6		

Nalco 7684 .8% Oleic Acid		(TRITON X 100) LETTERPRESS	LETTERPRESS	AVERAGE OF FELT AND WIRE (TRITON X 100) LETTERPRESS	AVERAGE OF FELT AND WIRE LETTERPRESS
After Pulping	WIRE	49.4	50.2	50.1	51.3
	FELT	50.7	52.4		
After Flotation	WIRE	52.1	50.9	52.3	51.7
	FELT	52.4	52.4		

TEXO LP 758 .8% Oleic Acid		(TRITON X 100) LETTERPRESS	LETTERPRESS	AVERAGE OF FELT AND WIRE (TRITON X 100) LETTERPRESS	AVERAGE OF FELT AND WIRE LETTERPRESS
After Pulping	WIRE	49.0	50.5	49.7	51.4
	FELT	50.4	52.3		
After Flotation	WIRE	52.1	52.3	52.5	52.8
	FELT	52.8	53.2		

TEXO LP 758 .8% Oleic Acid No NaOH		(TRITON X 100) LETTERPRESS	LETTERPRESS	AVERAGE OF FELT AND WIRE (TRITON X 100) LETTERPRESS	AVERAGE OF FELT AND WIRE LETTERPRESS
After Pulping	WIRE	49.5	50.5	49.5	51.4
	FELT	49.5	52.3		
After Flotation	WIRE	51.5	52.3	51.6	52.8
	FELT	51.6	53.3		
After Bleaching	WIRE	55.9	55.8	55.6	55.9
	FELT	55.3	55.9		

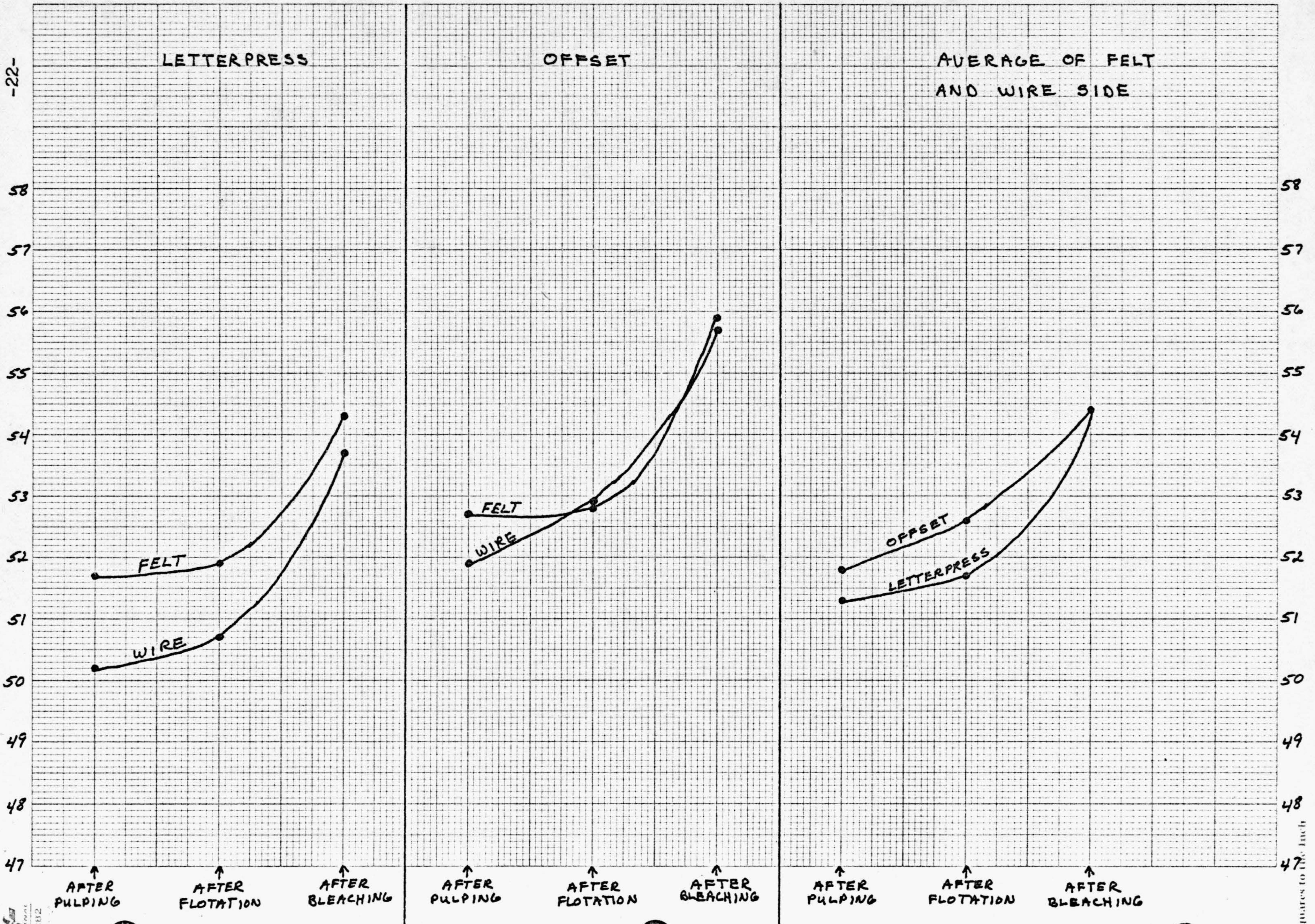
BRIGHTNESS VALUES-con't.

TEXO LP 758 .8% Oleic Acid		(No NaOH) OFFSET	OFFSET	AVERAGE OF FELT AND WIRE (No NaOH) OFFSET	AVERAGE OF FELT AND WIRE OFFSET
After Pulping	WIRE	48.4	50.2	48.5	50.7
	FELT	48.6	51.1		
After Flotation	WIRE	50.5	52.3	50.4	52.6
	FELT	50.2	52.8		
After Bleaching	WIRE	53.5	54.7	53.6	54.7
	FELT	53.6	54.6		

UNPRINTED No Chemicals		LETTERPRESS	OFFSET
After Pulping	WIRE	55.7	55.1

PRINTED No Chemicals		LETTERPRESS	OFFSET	AVERAGE OF FELT AND WIRE LETTERPRESS	AVERAGE OF FELT AND WIRE OFFSET
After Pulping	WIRE	40.5	45.7	40.9	45.8
	FELT	41.3	45.9		

UNPRINTED BLANKS					
After Pulping	WIRE	55.0	54.7	54.9	54.5
	FELT	54.7	54.3		
After Bleaching	WIRE	58.7	58.3	58.4	58.1
	FELT	58.0	57.9		


LETTERPRESS
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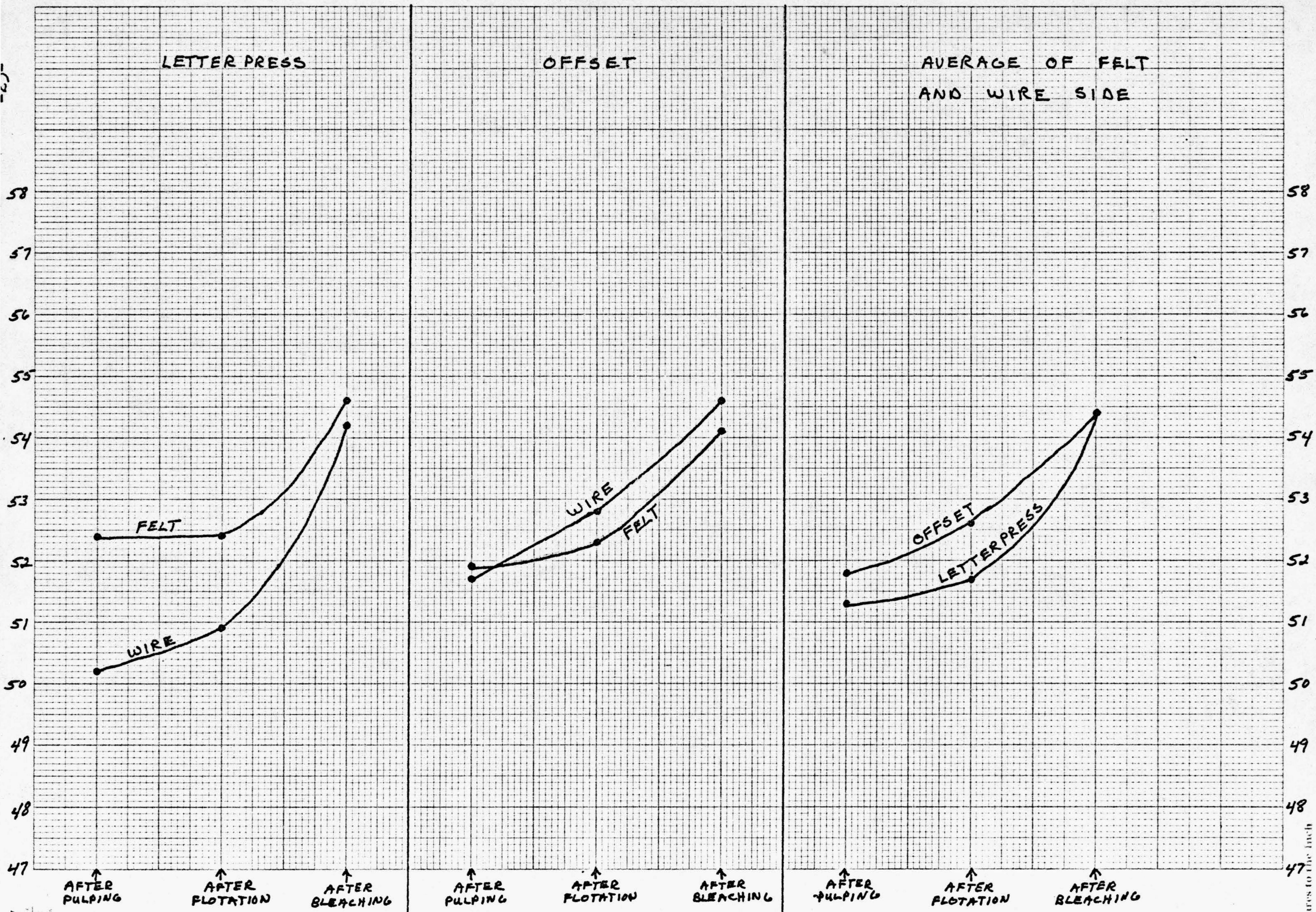
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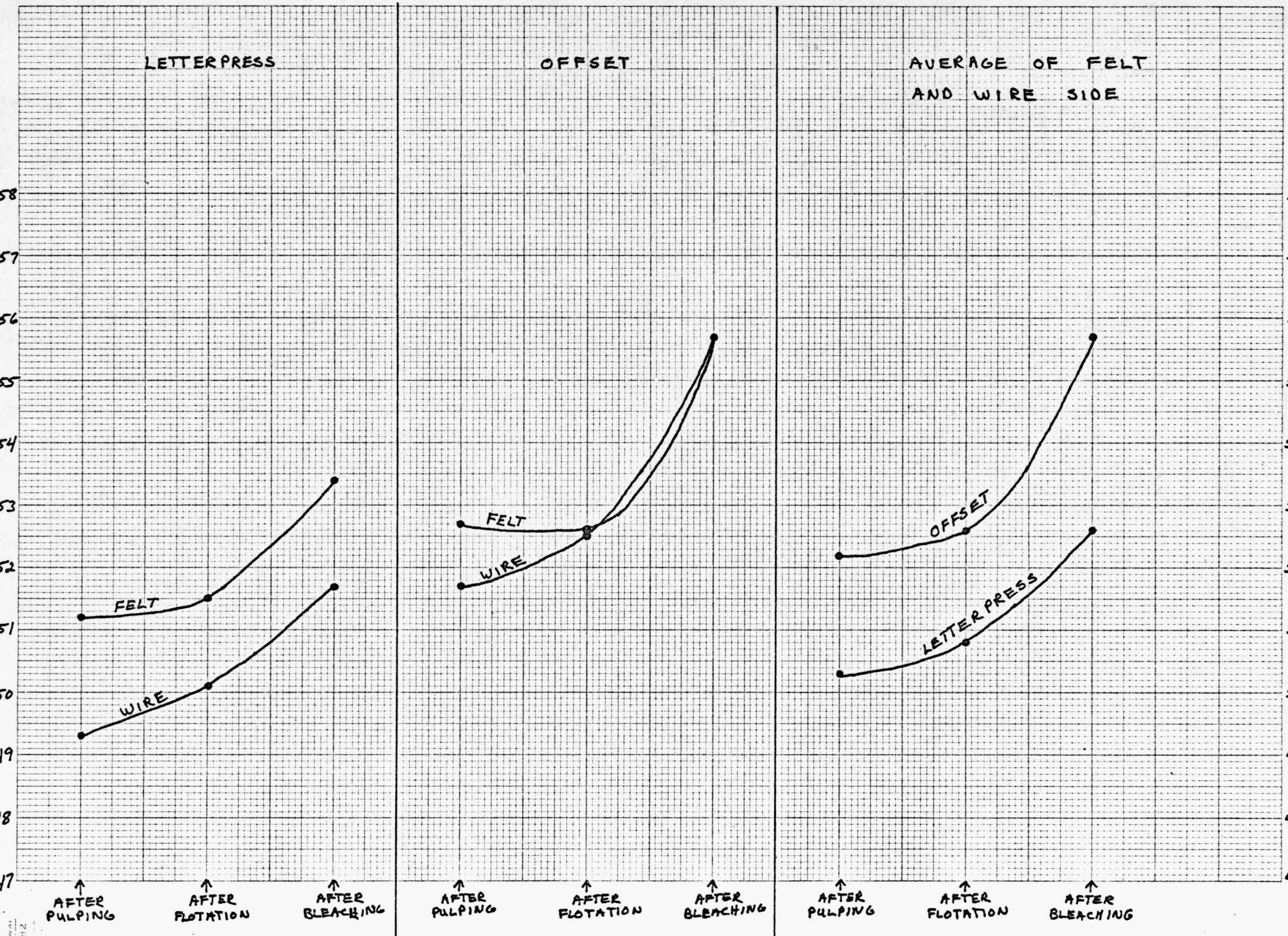
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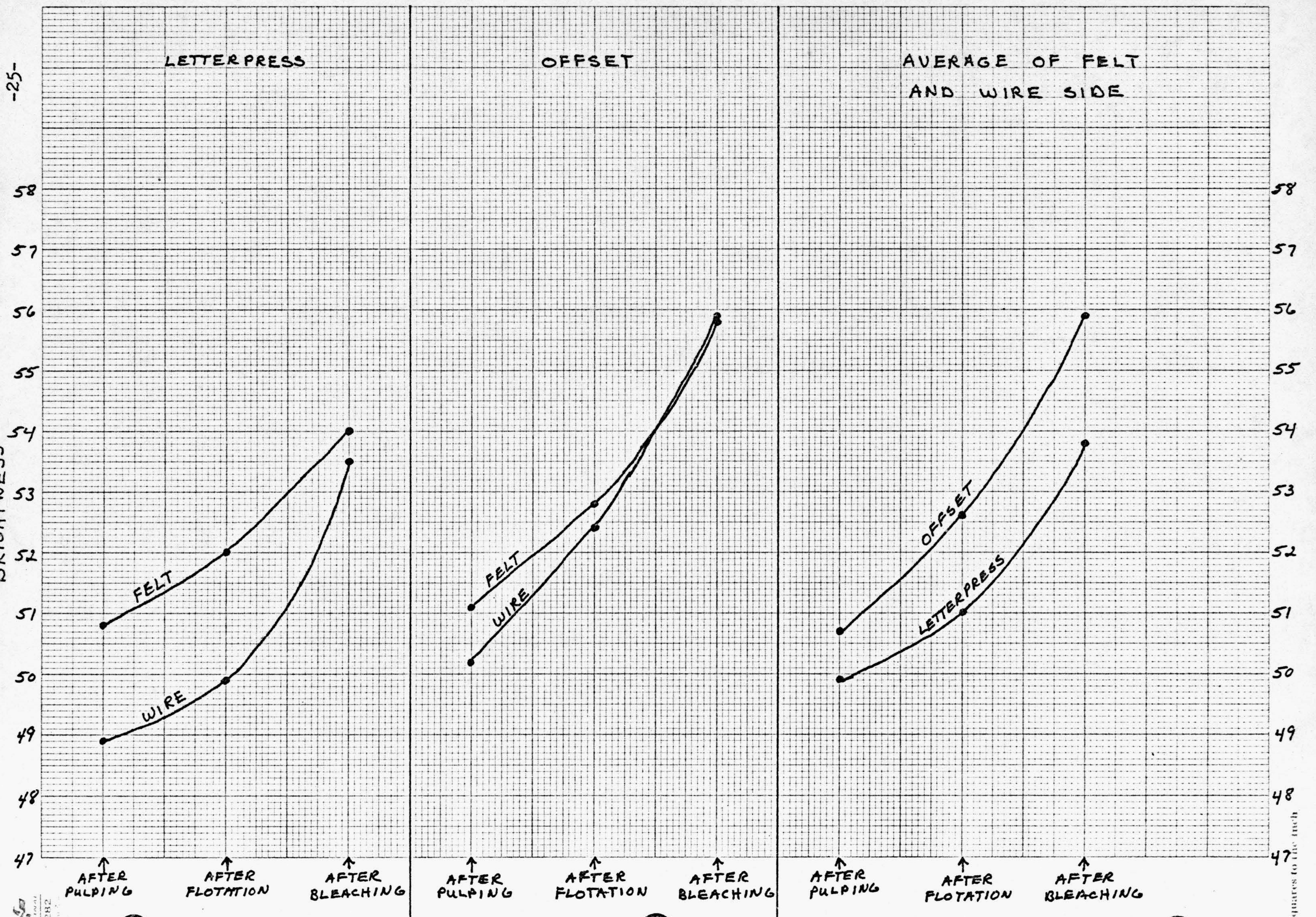
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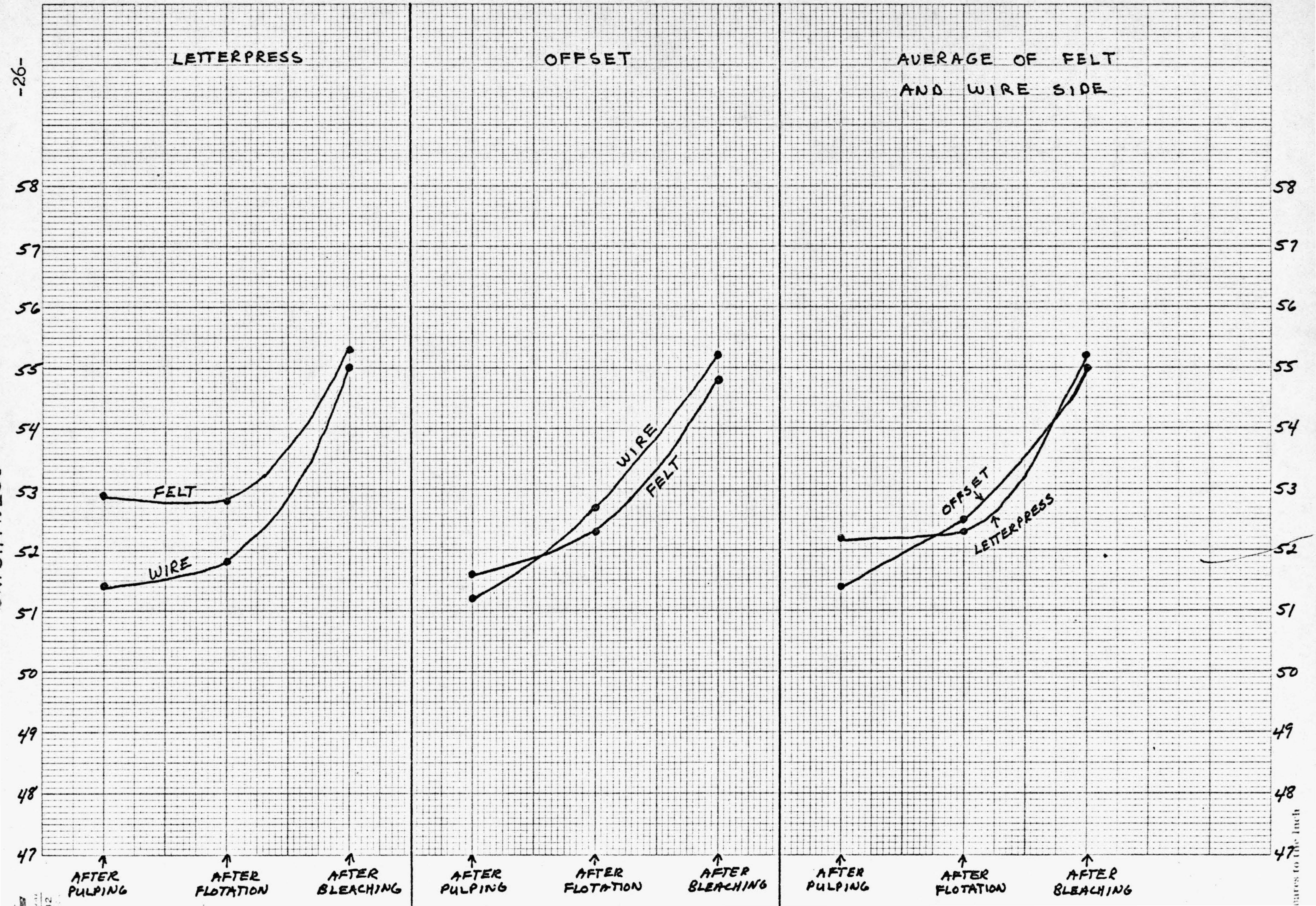

LETTERPRESS
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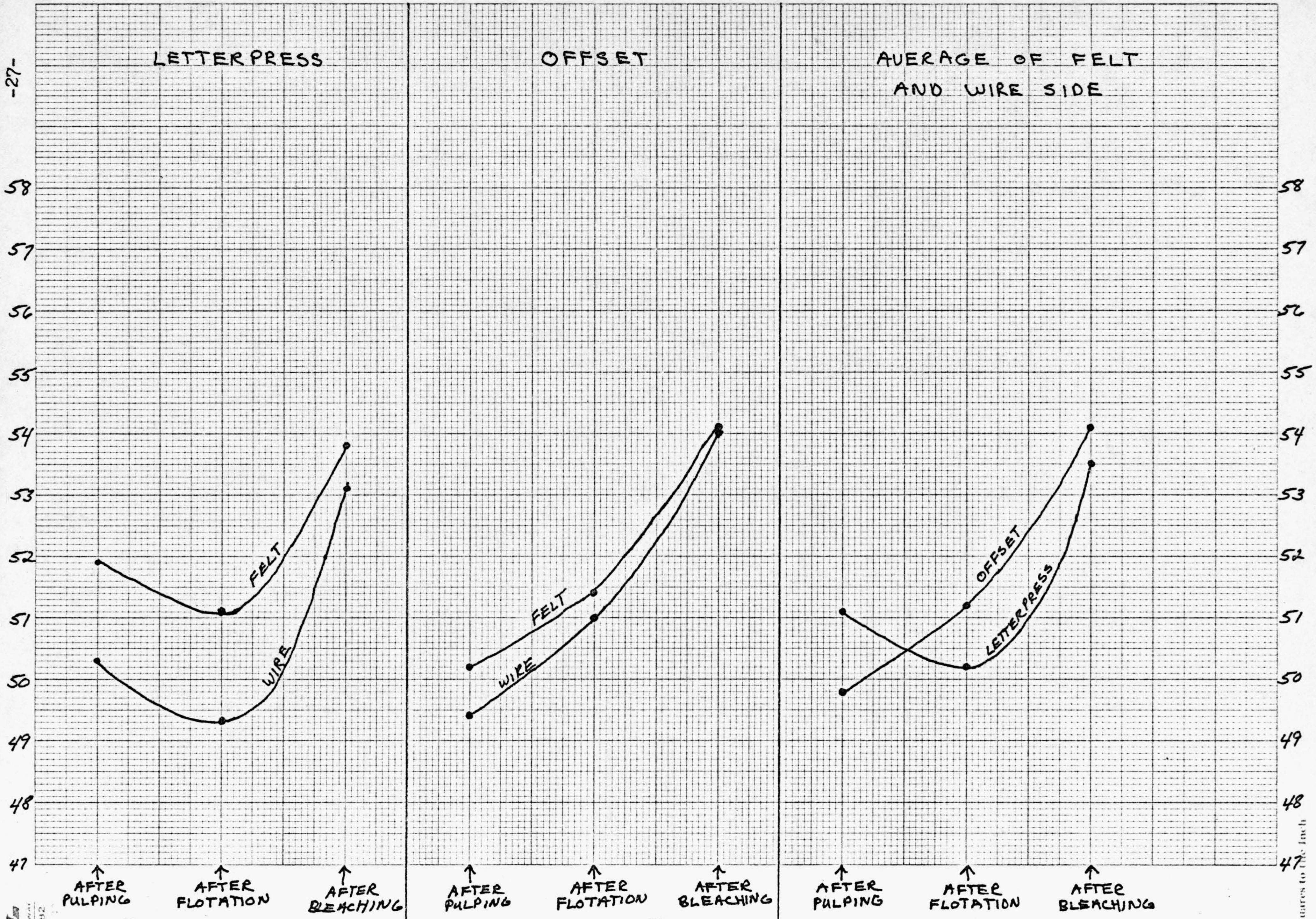
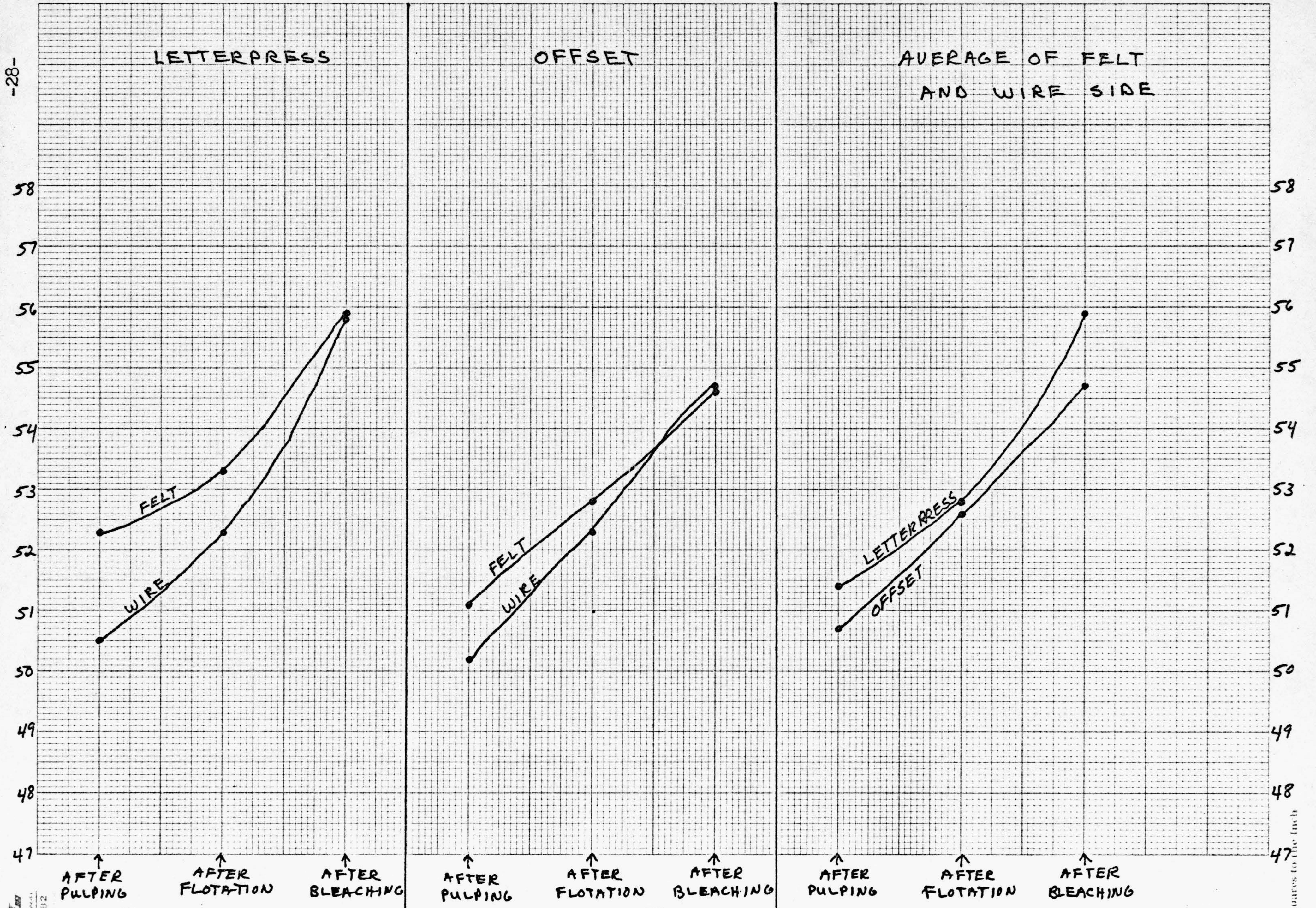
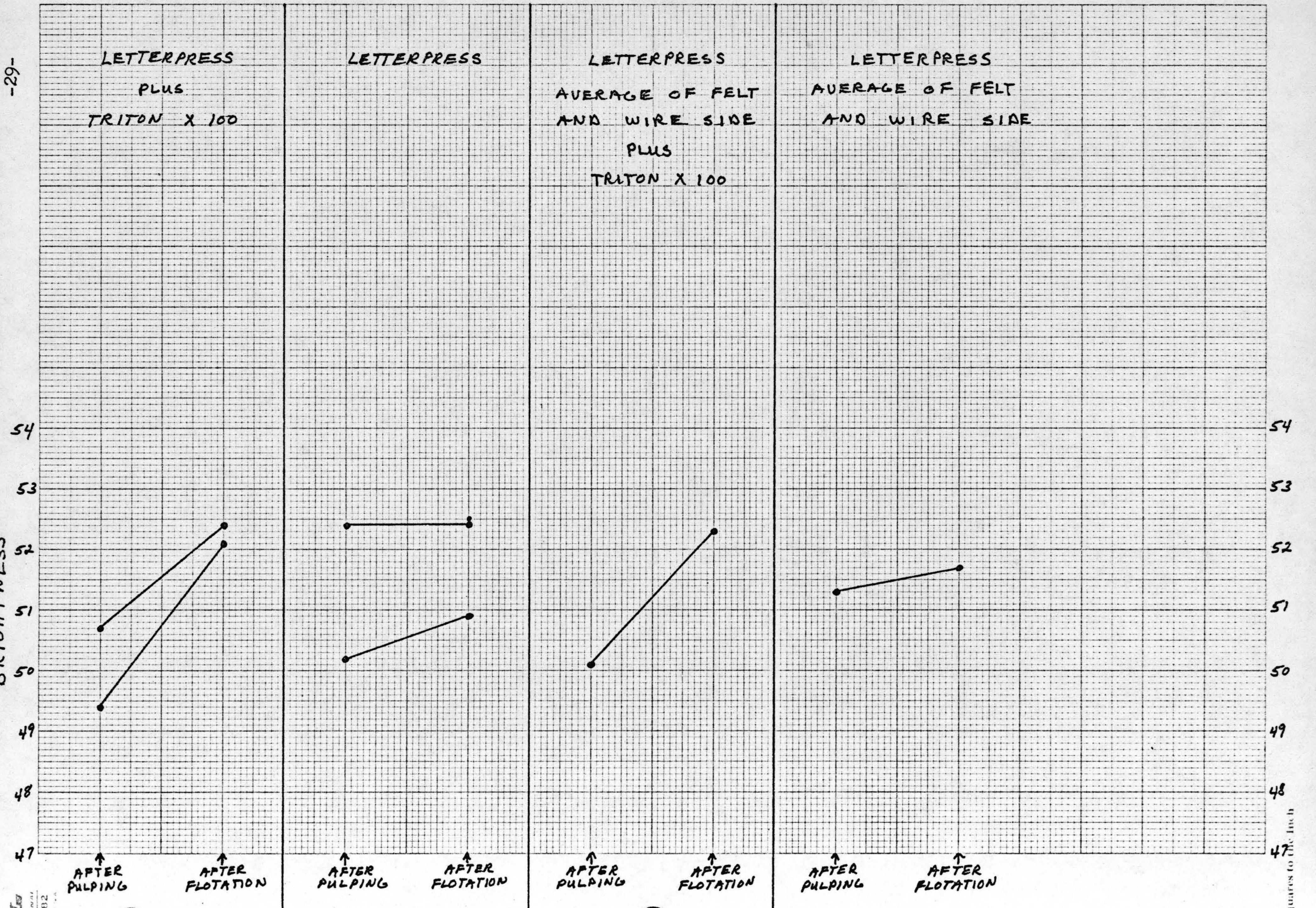
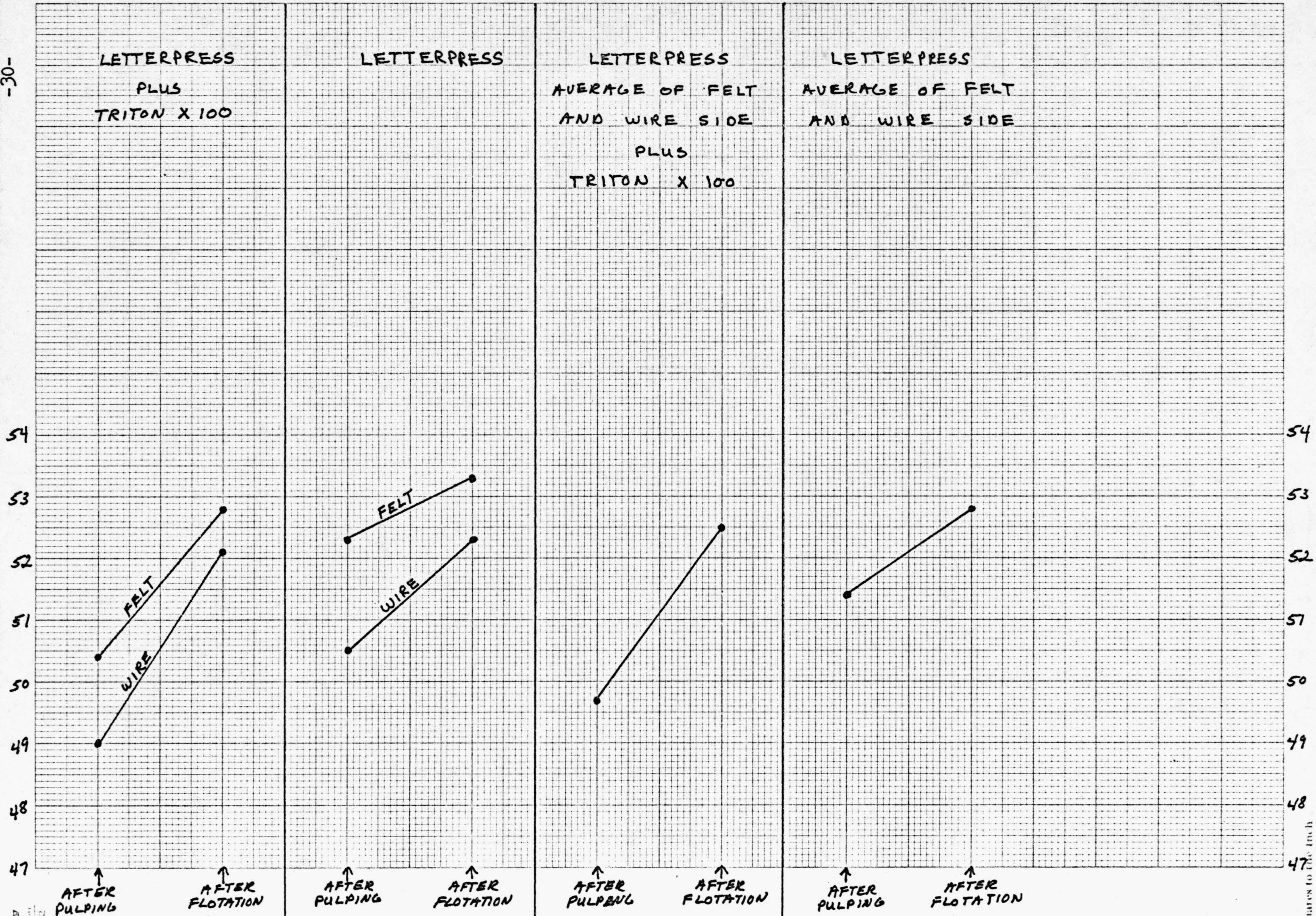
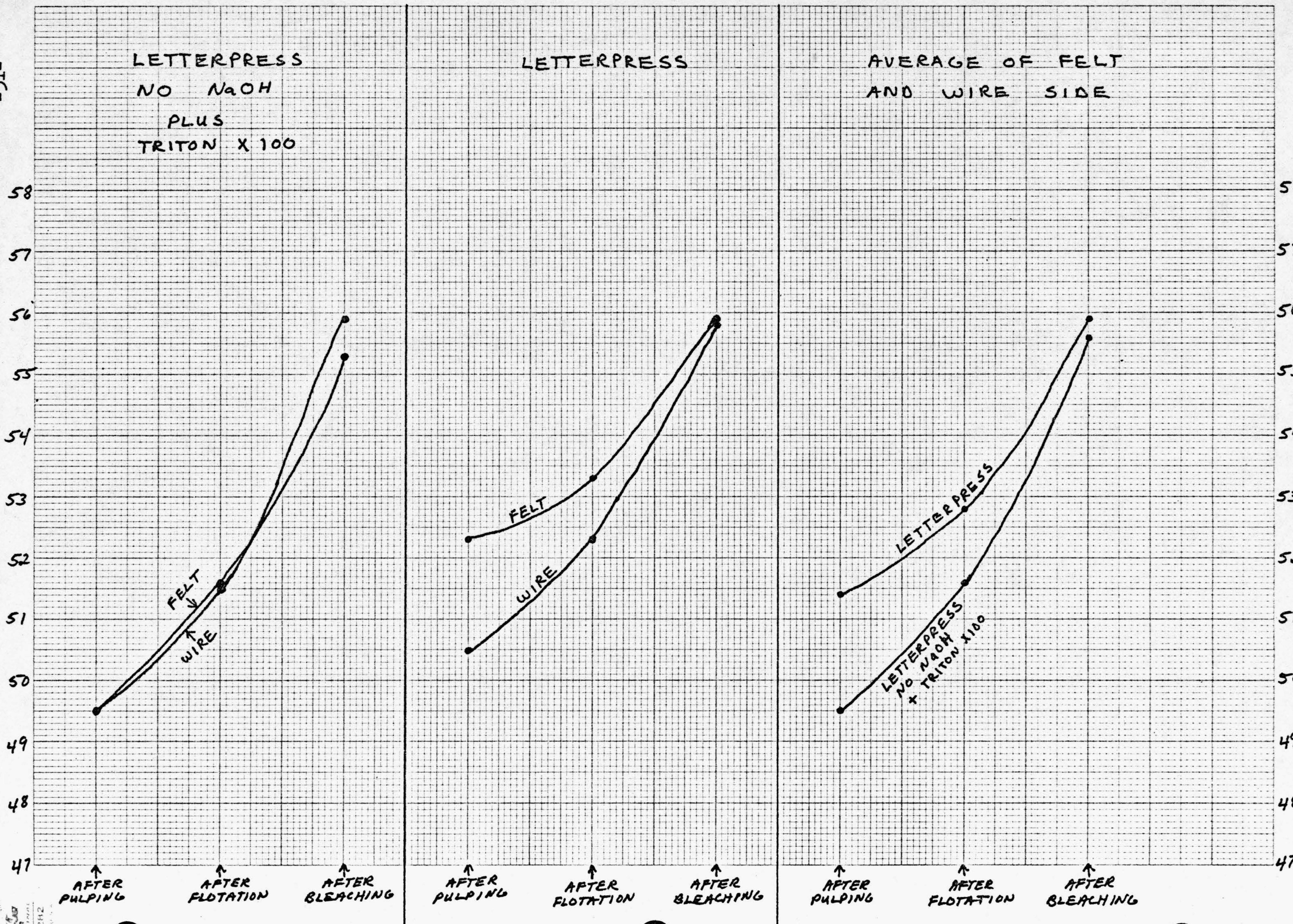
AVERAGE OF FELT
AND WIRE SIDE
FELT
WIRE
WIRE
FELT
OFFSET
LETTERPRESS
58
57
56
55
54
53
52
51
50
49
48
47
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING


LETTERPRESS
OFFSET
AVERAGE OF FELT AND WIRE SIDE
58
57
56
55
54
53
52
51
50
49
48
47
FELT
WIRE
OFFSET
LETTERPRESS
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING

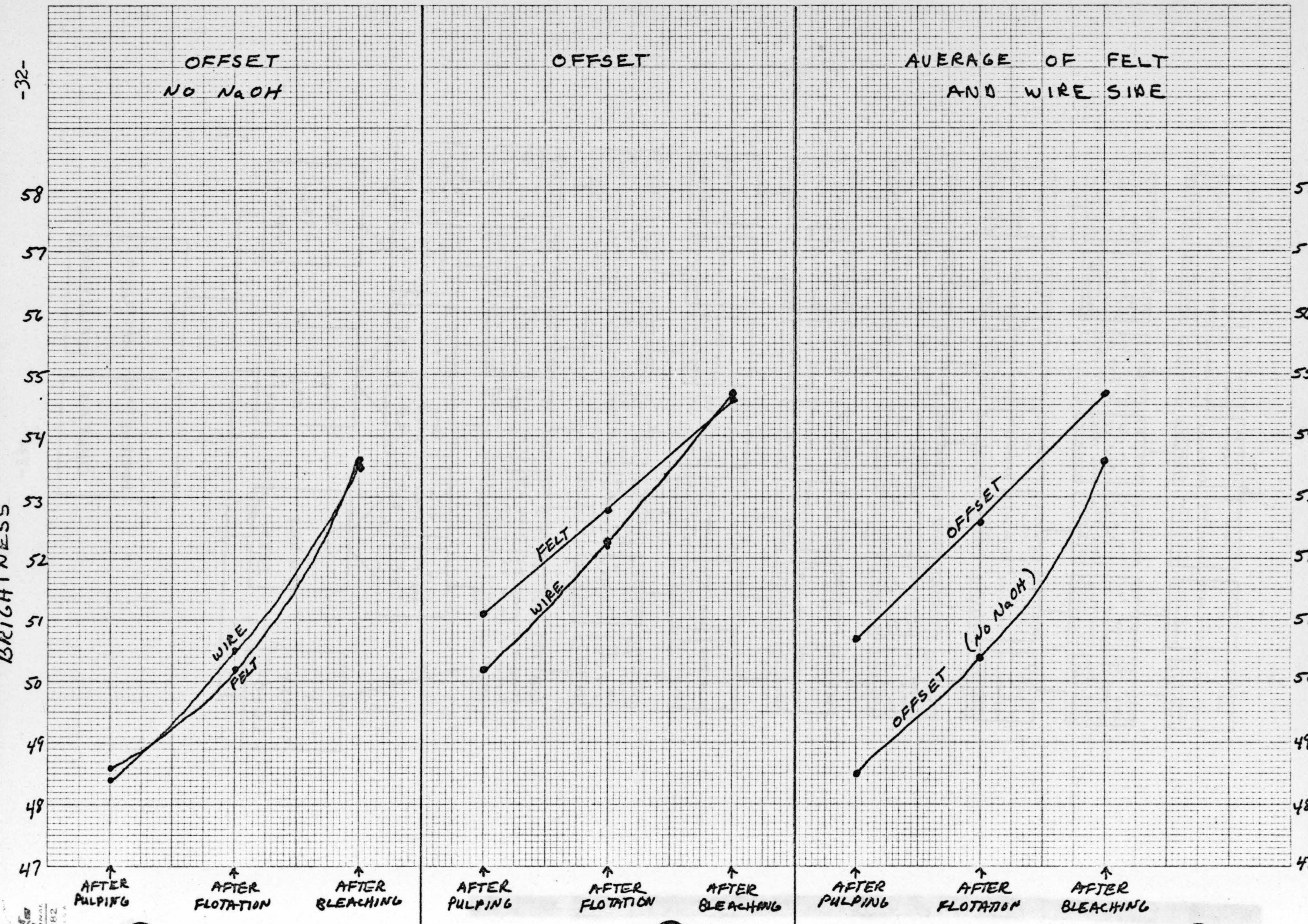

LETTERPRESS
OFFSET
AVERAGE OF FELT
AND WIRE SIDE
58
57
56
55
54
53
52
51
50
49
48
47
FELT
WIRE
FELT
WIRE
LETTERPRESS
OFFSET
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING

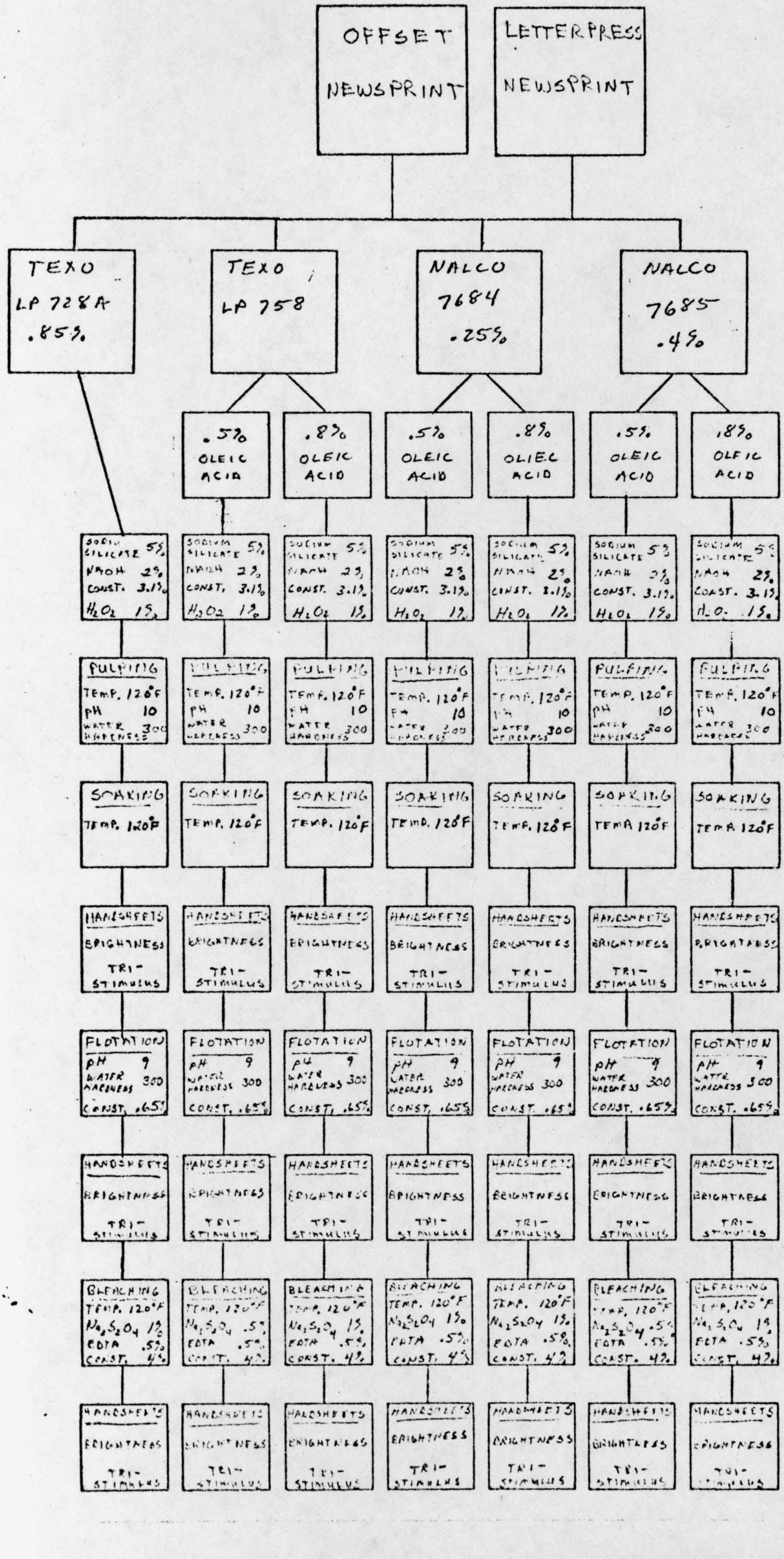

LETTERPRESS
PLUS
TRITON X 100
LETTERPRESS
LETTERPRESS
AVERAGE OF FELT
AND WIRE SIDE
PLUS
TRITON X 100
LETTERPRESS
AVERAGE OF FELT
AND WIRE SIDE
47
48
49
50
51
52
53
54
AFTER PULPING
AFTER FLOTATION


LETTERPRESS
PLUS
TRITON X 100
LETTERPRESS
LETTERPRESS
AVERAGE OF FELT
AND WIRE SIDE
PLUS
TRITON X 100
LETTERPRESS
AVERAGE OF FELT
AND WIRE SIDE
FELT
WIRE
FELT
WIRE
54
53
52
51
50
49
48
47
AFTER PULPING
AFTER FLOTATION
AFTER PULPING
AFTER FLOTATION
AFTER PULPING
AFTER FLOTATION
AFTER PULPING
AFTER FLOTATION



LETTERPRESS
NO NaOH
PLUS
TRITON X 100
FELT
WIRE
LETTERPRESS
FELT
WIRE
AVERAGE OF FELT
AND WIRE SIDE
LETTERPRESS
LETTERPRESS
NO NaOH
+ TRITON X100
58
57
56
55
54
53
52
51
50
49
48
47
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING


OFFSET
NO NaOH
OFFSET
AVERAGE OF FELT
AND WIRE SIDE
BRIGHTNESS
58
57
56
55
54
53
52
51
50
49
48
47
WIRE
FELT
FELT
WIRE
OFFSET
OFFSET (NO NaOH)
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING
AFTER PULPING
AFTER FLOTATION
AFTER BLEACHING


OFFSET NEWSPRINT
LETTERPRESS NEWSPRINT
TEXO LP 728A .85%
TEXO LP 758
NALCO 7684 .25%
NALCO 7685 .4%
.5% OLEIC ACID
.8% OLEIC ACID
.5% OLEIC ACID
.8% OLIEC ACID
.5% OLEIC ACID
.8% OLEIC ACID
SODIUM SILICATE 5% NAOH 2% CONST. 3.1% H2O2 1%
PULPING TEMP. 120°F pH 10 WATER HARDNESS 300
SOAKING TEMP. 120°F
HANDSHEETS BRIGHTNESS TRI-STIMULUS
FLOTATION pH 9 WATER HARDNESS 300 CONST. .65%
HANDSHEETS BRIGHTNESS TRI-STIMULUS
BLEACHING TEMP. 120°F Na2S2O4 1% EDTA .5% CONST. 4%
BLEACHING TEMP. 120°F Na2S2O4 .5% EDTA .5% CONST. 4%
HANDSHEETS BRIGHTNESS TRI-STIMULUS

Mr. Raimondo's Graphs

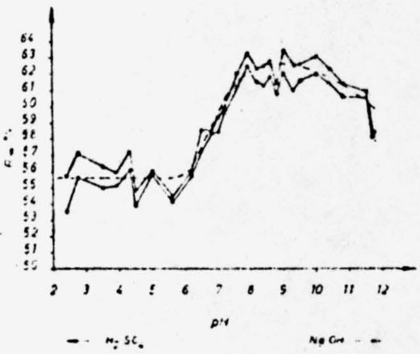


Fig. 9. Effect of pH on brightness.

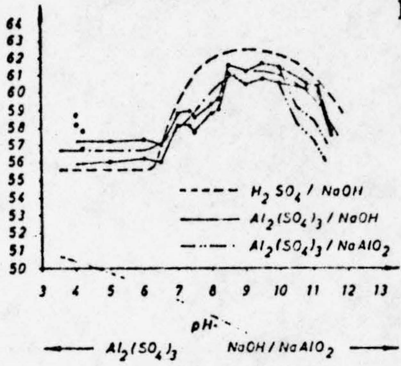


Fig. 10. Effect of pH on brightness.

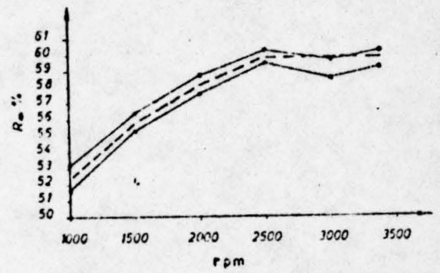


Fig. 11. Effect of impeller speed of rotation on brightness.

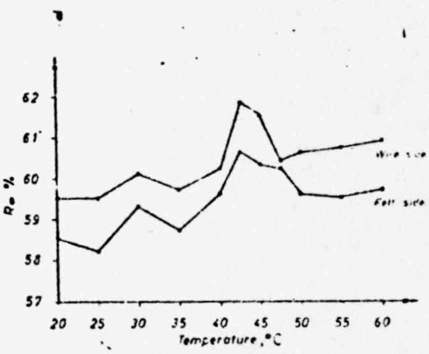


Fig. 7. Effect of flotation shock temperature on brightness.

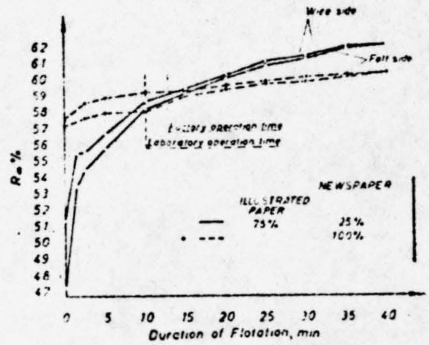


Fig. 6. Effect of duration of flotation on brightness.

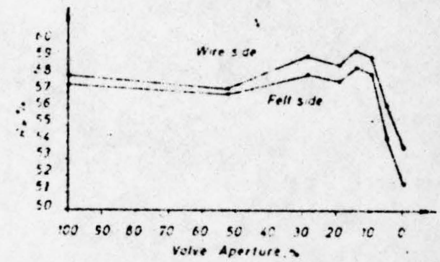


Fig. 12. Effect of air quantity present in stock on brightness.

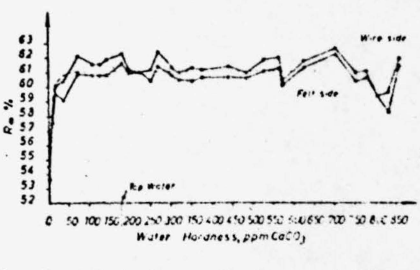


Fig. 8. Effect of water hardness on brightness.

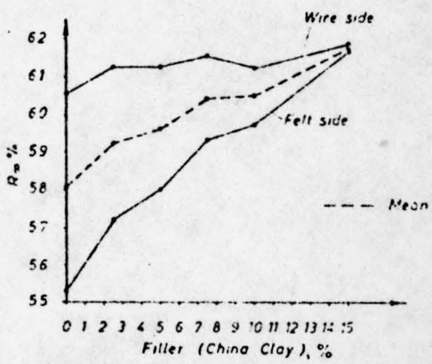


Fig. 13. Effect of filler quantities on brightness.

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