8-109 SR LOSS REFERENCE SEARCH ROOM
FIP8309 XR 2,920,011

Jan. 5, 1960 E. F. EILERS, JR 2,920,011
ELEVATED TEMPERATURE AND PRESSURE TWO STAGE HYPOCHLORITE PEROXIDE PULP BLEACHING PROCESS
Filed March 18, 1955 3 Sheets-Sheet 1

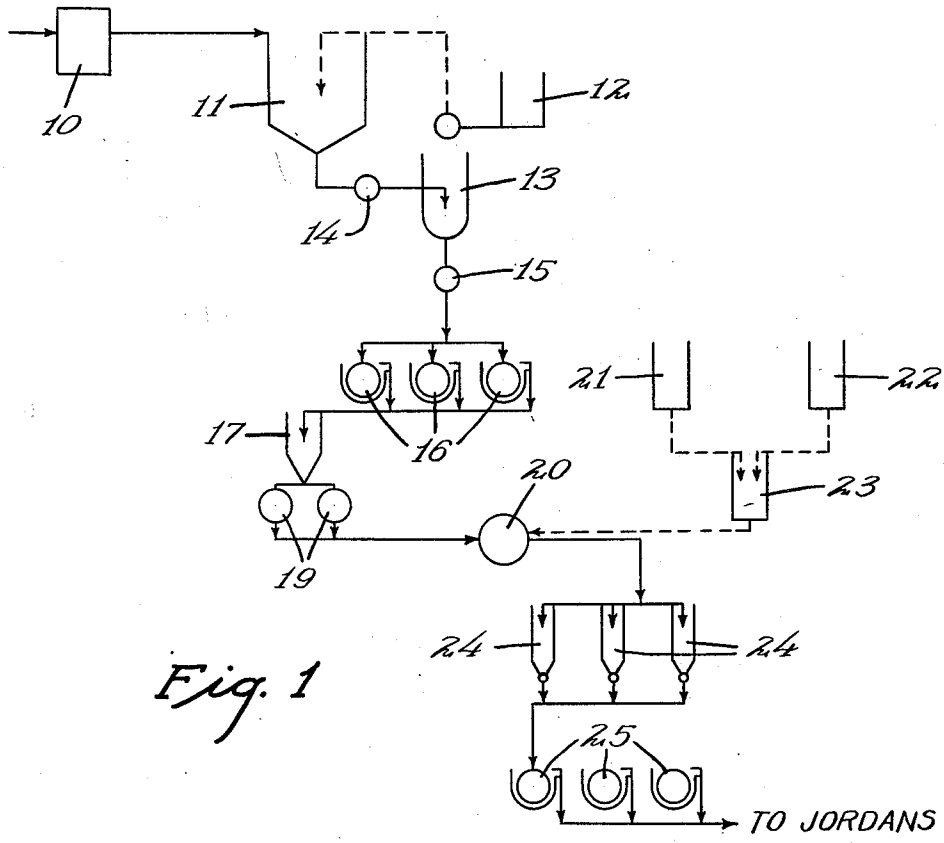


Fig. 1

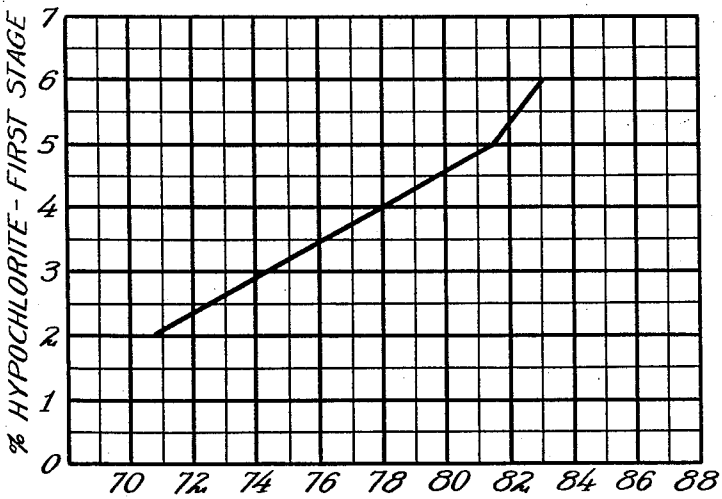


Fig. 2

INVENTOR
Ernest F. Eilers Jr.
BY Robertson, Dunning
ATTORNEY

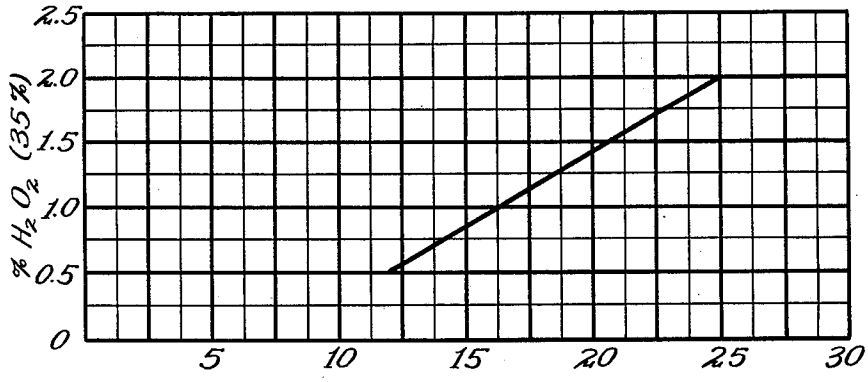


Fig. 3

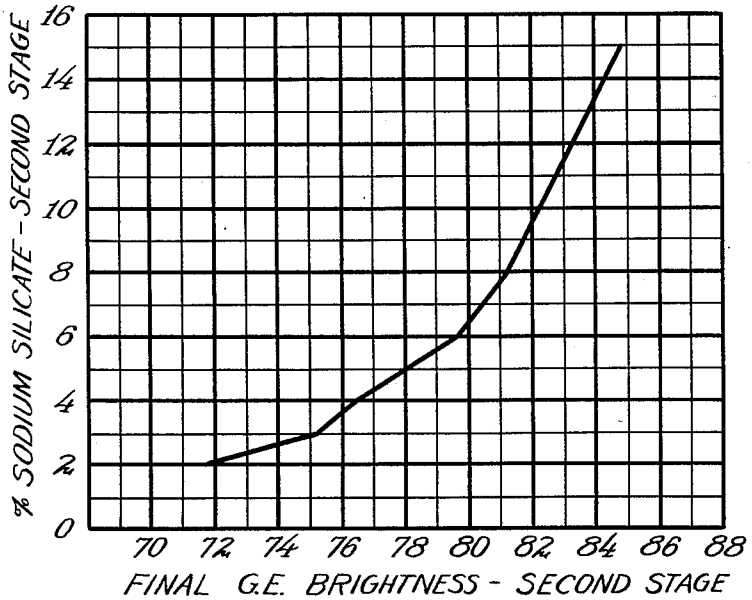


Fig. 4

INVENTOR
Ernest F. Eilers Jr.
BY Robertson, Dunning.
ATTORNEY

Jan. 5, 1960 E. F. EILERS, JR 2,920,011

ELEVATED TEMPERATURE AND PRESSURE TWO STAGE HYPOCHLORITE PEROXIDE PULP BLEACHING PROCESS

Filed March 18, 1955 3 Sheets-Sheet 3

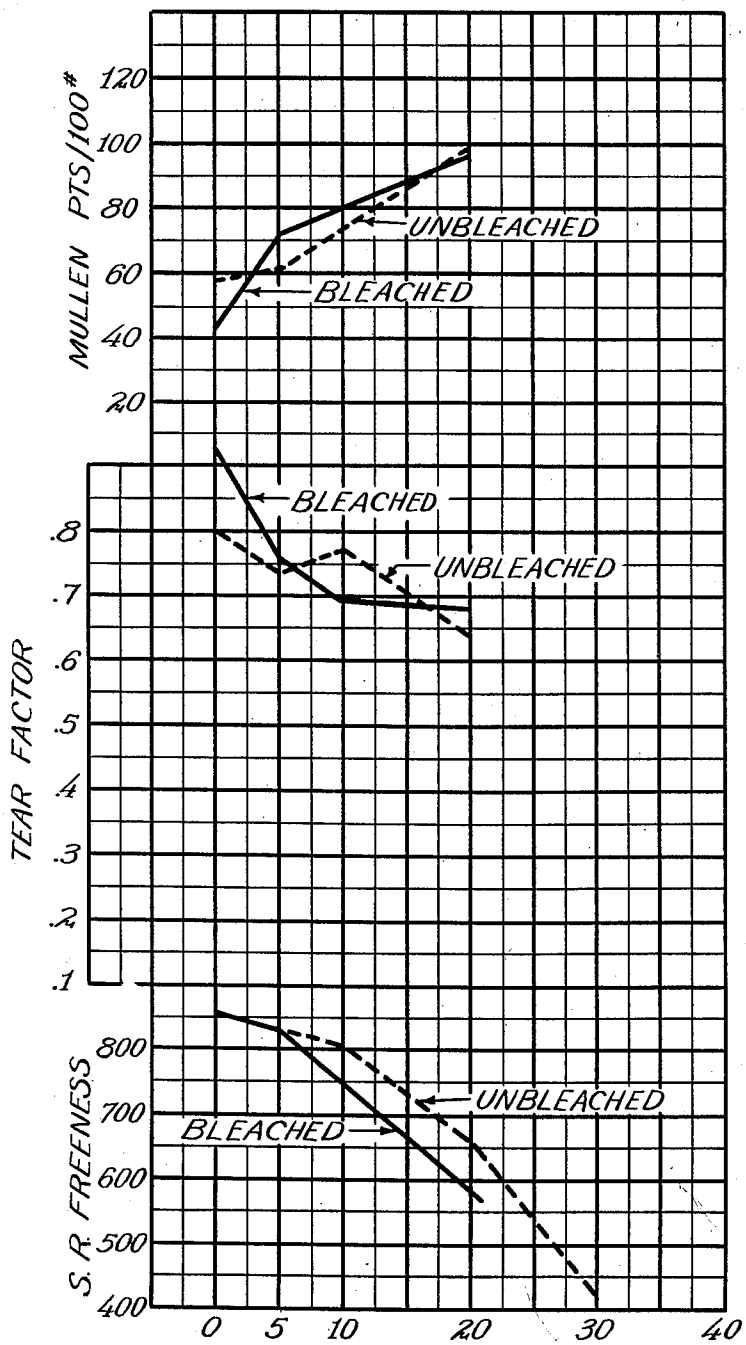


Fig. 5

INVENTOR

Ernest F. Eilers Jr.

BY Robert M. Dunning

ATTORNEY

United States Patent Office 2,920,011 Patented Jan. 5, 1960

2,920,011

ELEVATED TEMPERATURE AND PRESSURE TWO STAGE HYPOCHLORITE PEROXIDE PULP BLEACHING PROCESS

Ernest F. Eilers, Jr., St. Paul, Minn., assignor to Waldorf Paper Products Company, Wabash, Conn., a corporation of Minnesota

Application March 18, 1955, Serial No. 495,104

6 Claims. (Cl. 162—78)

This invention relates to an improvement in elevated temperature and pressure two stage hypochloride, peroxide pulp bleaching process and deals particularly with an effective method of bleaching pulp.

In the production of paperboard from wood chips and other furnish, it is common practice to bleach the pulp after it has been partially prepared so as to improve the quality of the finished sheet. Various methods have been employed for bleaching the pulp and a great number of commonly used methods require several individual bleaching steps to economically produce the proper board brightness without reducing the physical properties of the finished sheet. For example, chemicals such as calcium hypochlorite, hydrogen peroxide, chlorine and chlorine dioxide or combinations thereof have been employed to accomplish the desired result. Usually, however, the time required for producing an effective bleach is relatively long and, as a result, considerable storage space for handling the pulp in the various bleaching stages for the necessary length of time is required.

Efforts have been made to decrease the bleaching time by carrying on the operations at elevated temperatures. However, it has long been thought that the use of high temperatures will result in a pulp which is greatly inferior to the same pulp before bleaching. Thus, in most of the literature describing bleaching systems, the use of high temperatures has been considered unwise and impractical.

It has been found that under certain circumstances and under predetermined conditions, the use of elevated temperatures is entirely practical in conjunction with the stages of a two stage bleaching process. Contrary to previous information it has been found that when the peroxide second stage of a two stage bleaching process is carried on under high temperatures and pressures, the resulting pulp will not only be more effectively bleached but will not lose its strength or other desirable physical properties. The object of the present invention resides in the provision of such a process.

A feature of the present invention resides in first bleaching the pulp in more or less the usual manner to increase the brightness of the stock to some extent. This first stage bleach, when carried on for the usual time, leaves the pulp substantially brighter than before the bleaching operation but does not remove the shives or fiber bundles usually present in pulp of the type in question. The pulp is then subjected to a peroxide second stage bleach under elevated temperatures and pressures. The peroxide second stage bleach removes the shives or fiber bundles and increases the brightness of the finished sheet to a marked degree.

A feature of the present invention resides in the provision of a two stage bleach which requires substantially less time than a one stage bleach while, at the same time, producing substantially better results. For example, a one stage bleach of a conventional type carried on for a period of two hours produces considerably inferior results to the present two stage process carried on for a

total period of less than one hour. Accordingly, the product is improved while the time required is greatly reduced.

A further feature of the present invention resides in the economy of the two stage bleach described. As compared with a conventional one stage bleach, the two stage bleach costs but slightly more per ton for the chemicals employed if the most effective bleach is desired. However, at the same time, the time required is more than cut in half and the results obtained are greatly enhanced, resulting in a better product for the same amount or slightly more than the one stage bleach.

A feature of the present invention resides in the provision of a bleaching system which is a continuous operation and which may be carried on in an unusually short period of time without impairing the strength of the sheet formed from the pulp. Tests indicate that the strength of the sheet is approximately equal to or perhaps greater than the strength of a sheet made from the unbleached pulp.

A further feature of the present invention resides in the provision of a two stage bleaching process capable of increasing the brightness of the stock from a brightness indication of perhaps less than 44.0 as measured upon a G.E. brightness meter to a brightness of well over 80 as indicated on the same meter. This is much superior to the bleach obtained by the usual one stage bleaching process or two stage hypochlorite peroxide bleaching process and is equal to or better than the results obtained in many four and five stage bleaching processes.

These and other objects and novel features of my invention will be more clearly and fully set forth in the following specification and claims.

In the drawings forming a part of the specification:

Figure 1 is a flow diagram showing in general the two stage bleaching system.

Figure 2 is a graph indicating the increase in brightness of a neutral sulfite semi-chemical paperboard sheet in the second bleaching stage upon variations in the amount of chemical used in the first bleaching stage.

Figure 3 is a graph showing the brightness increase of the sheet employing different percentages of hydrogen peroxide in the second stage.

Figure 4 is a graph showing the variations in brightness in a sheet with relation to the amount of sodium silicate used in the second stage.

Figure 5 is a graph showing a comparison of bleached and unbleached pulp.

In carrying out the bleaching process, sulfite pulp is prepared and refined in any suitable manner. At this point the pulp is normally of approximately four to five percent consistency after refining and washing. In other words, about four to five percent of the mixture is the oven dry weight of the solids.

The pulp thus prepared is directed to a conventional chest or hydropulper. At this point the pulp is subjected to the action of calcium or sodium hypochlorite equivalent to 6% available chlorine based upon the weight of the oven dry pulp. At the same time the pH of the pulp is adjusted to above 11. This is accomplished by adding the proper quantity of sodium hydroxide or a similar basic chemical.

The pulp is allowed to bleach at a temperature of substantially 100° F. to 150° F. until the calcium hypochlorite is exhausted. The time required for this bleaching action is approximately thirty to thirty-five minutes, depending upon the temperature of the pulp. In other words, the elevation of the temperature to some extent decreases the necessary bleaching time.

At the completion of this first bleaching stage, the pulp may form a sheet having a brightness which would provide a reading of perhaps 48 to 55 on the G.E.

brightness meter. At the completion of this first bleaching stage, the pulp is not fully bleached and the shives or fiber bundles are quite visible. At the completion of the first stage of bleaching, the pulp is directed to thickeners which act to increase the dry solids content of the mixture and simultaneously remove certain reaction products resulting from the first stage of bleaching. Preferably the pulp is washed and is then directed through presses such as a Davenport or a similar apparatus for squeezing the water from the pulp. At the completion of the thickening operation, the pulp is usually from 10% to 35% solids.

The pulp is next directed to a suitable apparatus such as a Rotopulper, which is a commercial mixing device used in this process for mixing the pulp and bleach chemicals, or other device capable of mixing the second stage bleach chemicals and the pulp. Preferably the peroxide bleach liquor contains hydrogen peroxide, sodium peroxide, or mixtures thereof sufficient to give any desired percent of active oxygen from 0.04% to perhaps 0.66%, based upon the oven dry weight of the pulp present. Even more peroxide may be employed but usually above 2% active oxygen the process is considered uneconomical.

If hydrogen peroxide alone is used as a source of active oxygen, the bleach liquor must also contain caustic soda (sodium hydroxide) to neutralize the acidity of the hydrogen peroxide. If sodium peroxide alone is used as the source of active oxygen, the alkali supplied by the sodium peroxide must be partially neutralized. This is most economically done with sulphuric acid.

Preferably the peroxide bleach liquor also contains magnesium sulphate to inhibit the catalytic decomposition of the alkaline peroxide by heavy metals such as copper, iron and manganese, which are normally present in traces in mill process waters.

Sodium silicate is also added to buffer the bleach liquor. While sodium silicate has been commonly used in conjunction with other chemicals such as hydrogen peroxide, the percentage of sodium silicate employed in the present process is preferably increased. In other words, 4% to 6% sodium silicate is preferable in the present pressure bleaching stage.

The pulp after being thoroughly mixed with the bleaching chemicals is introduced into a heating chamber where it can be subjected to elevated temperatures and pressures. In describing elevated temperatures and pressures, these may range from perhaps fifteen pounds to fifty pounds in the preferred embodiment of the process. Less pressure may be employed if preferred, but the time required for the bleaching operation increases and certain of the advantages of the process are lost. Pressures of perhaps ten pounds per square inch to substantially over fifty pounds per square inch are operable, but pressures of approximately fifty pounds have the disadvantage of increased chemical cost. In other words, in order to buffer the reaction a substantial amount of sodium silicate alone or in conjunction with sodium hydroxide must be employed and the cost normally overbalances the improvement in results.

The temperature employed is the temperature equivalent of saturated steam at the pressures mentioned. The time of the bleaching operation varies inversely with variations in pressure and temperature, the reaction time decreasing as the pressure and temperature increase. It is desirable that the bleaching action under temperature and pressure be discontinued before all of the active oxygen is consumed in the bleaching reaction, thus leaving a slight peroxide residual in the bleached pulp.

It seems apparent that the sodium silicate serves as a buffering agent to protect the strength of the pulp fiber during the second stage of bleaching as well as to aid in maintaining the desired alkalinity in the bleaching solution. It is for this reason that the increased proportion of sodium silicate be employed. After the second stage bleach the pulp may be stored at high density or may be diluted for more immediate use. In the event the pulp is stored, the residual peroxide continues its bleaching operation until it is exhausted. If the pulp is to be more immediately used, sulphur dioxide, or a similar reducing agent is employed to destroy the residual peroxide before the pulp is refined and directed to the paper machine. As a specific example of a pulp process, unbleached neutral sulfite semichemical pulp at 4% moisture free consistency after cooking and washing is added 2% sodium hydroxide, based on the weight of dry pulp present. The pulp is bleached in the first stage with calcium hypochlorite bleaching liquor equivalent to 6% available chlorine based on the weight of dry pulp present. Bleaching is performed at a temperature of 130° F. and at atmospheric pressure for a period of thirty-five to forty minutes. After exhaustion of the calcium hypochlorite, the pulp is washed to remove impurities and then passed into thickeners. After thickening to a consistency of 15%, 8% sodium silicate, based on the weight of dry pulp present, is added. After mixing with the pulp, 2% hydrogen peroxide of 35% concentration, equivalent to 0.33% active oxygen based on the weight of dry pulp present, is added to the pulp and mixed thoroughly therewith. The pulp is then placed in the pressure chamber and cooked from fifteen to eighteen minutes, using fifteen pounds per square inch pressure and a corresponding saturating steam temperature which is about 249° F. The pulp is then diluted with water and used.

The cost of the process may be compared with a single stage bleaching process in which 10% hypochlorite bleach equivalent to 10% available chlorine is employed. Using 6% hypochlorite equivalent to 6% available chlorine in the first bleaching stage and 2% hydrogen peroxide of 35% concentration with 8% sodium silicate in the second stage, the cost of the two stage bleach has been found to approximate 140% of the one stage bleach if the time of treatment is disregarded. Using a smaller percentage of hydrogen peroxide decreases the brightness of the sheet but also decreases the cost of the operation so that, if slightly less than 1% of hydrogen peroxide of 35% concentration is used in the second stage, the cost of the two stage bleach is the same as the cost of the one stage bleach disregarding the treatment time. The results obtained by the two stage bleach are greatly superior. For example, the one stage bleaching process described produces a pulp having a brightness of 63 to 65 G.E. in which unbleached shives are distinctly visible. The brightness obtained by the two stage bleach can be shown in the following Table I:

TABLE I

Method of Bleaching	Percent of 35% concentration peroxide used	Cost ton of bleached pulp	Brightness	Shives Content
1 Stage	----------	$14.12	63-65	Unbleached shives quite visible.
2 Stage	2	19.67	80-83	All shives bleached.
	1.5	17.67	77-80	Do.
	1	15.67	74-77	Almost all shives bleached.
	.5	13.67	69-73	Few shives visible—better looking pulp than 10% hypochlorite bleach.

In order to determine the amount of chemicals used in the first stage of the process, the amounts of available chlorine used in hypochlorite bleaching were varied from 2% to 10% based on the weight of dry pulp

bleached, while the chemicals employed in the second stage remained constant. The following Table II discloses the effect of varying the chlorine consumed in the hypochlorite first stage:

TABLE II

1ST STAGE

Percent Chlorine, 1st Stage	25 Grs. of pulp cc. $Ca(OCl)_2$ of 60 g.p.l. available chlorine, cc.	1st Stage, G.E. Brightness
2	8.4	44.4
3	12.5	48.5
4	16.6	52.4
5	20.9	56.5
6	25	57.6
10	41.8	63.4

2ND STAGE

Percent H_2O_2 of 35% Concentration, 2nd Stage	Percent Sodium Silicate	G.E. Brightness, 2nd Stage	Increase in Brightness Pts.
2	10	71.2	26.8
2	10	74.5	26.0
2	10	78.2	26.0
2	10	81.7	25.2
2	10	83.3	25.7

NOTE.—All percentages based on weight of dry pulp present.

It will be noted that hypochlorite equivalent to 4% to 6% chlorine produces a first stage brightness of over 50 as measured on the G.E. brightness meter. A smaller percentage of chlorine could be used with somewhat inferior results and a greater amount may be used with more desirable results, but at an increased cost. Thus, 4% to 6% chlorine appears to be the most economical range.

Table II also shows that the second stage apparently increases the brightness of the sheet approximately 25 to 27 points regardless of the brightness of the pulp after the first stage. Furthermore, the second stage removed all of the shives or fiber bundles regardless of their visibility at the completion of the first stage. Figure 2 of the drawings presents graphically the information found in Table II.

Tests were also conducted to determine the effect of various amounts of peroxide on the brightness of the finished sheet. Table III indicates the results obtained:

TABLE III

.5% H_2O_2 (35%) yields 11–13 points increase in brightness

1% H_2O_2 (35%) yields 15–18 points increase in brightness

1.5% H_2O_2 (35%) yields 20–22 points increase in brightness

2.0% H_2O_2 (35%) yields 24–26 points increase in brightness

It will be noted that the same information is illustrated graphically in Figure 3 of the drawings.

The increase in brightness as indicated on the G.E. brightness meter varies from approximately twelve points increase with 0.5% hydrogen peroxide (35% concentration) to approximately twenty-five points increase at 2% hydrogen peroxide (35% concentration) and the curve shows a steady increase as the amount of peroxide is increased.

Table IV shows the effect of various amounts of sodium silicate in the second stage of the bleaching process. As will be noted from the results of this table, a minimum of approximately 6% to 8% sodium silicate, based on the weight of dry pulp present appears necessary to bleach out the shives. At 6% sodium silicate certain of the shives are still visible, while at 8% and higher no shives may be seen. Thus, it appears that more sodium silicate is preferable than is normally used in conventional bleaching processes. In the test shown in Table IV the following conditions were maintained:

Conditions

I. 1st Stage	II. 2nd Stage
a. 4% Cons't	*a.* 2% H_2O_2 (35%).
b. Hypochlorite equal to 6% available chlorine.	*b.* 2% through 15% sodium silicate.
c. 2% NaOH	*c.* Temp. 250° F.
d. Temp. 150° F	*d.* Pressure 15 pounds.
e. Time 35 minutes	*e.* Time 20 minutes.

NOTE.—All quantities of chemicals based on weight of dry pulp present.

The results of Table IV are also indicated in Figure 4 of the drawings. Table IV is as follows:

TABLE IV

Sample No.	Percent H_2O_2 (35%)	Sodium Silicate, Percent	Initial pH	G.E. Brightness, Final	Shive Bleaching
1	2	2	9.2	71.9	Shives did not bleach out.
2	2	3	9.5	75.4	Not as bad as No. 1.
3	2	4	9.8	76.4	Few shives.
4	2	6	10.0	79.6	Very few shives.
5	2	8	10.2	81.2	No shives visible.
6	2	10	10.2	82.2	Do.
7	2	15	10.5	84.8	Do.

NOTE.—All quantities of chemicals based on weight of dry pulp present.

Tests were made to determine the amount of caustic and silicate necessary to give best bleaching results in the second stage peroxide pressure bleach. The tests were made to determine whether similar results may be obtained by employing some other caustic substance in place of the sodium silicate. The conditions under which the experiments were carried on may be listed as follows:

Experimental Conditions

	1st Stage	2nd Stage
1	4% Cons't	2% H^2O^2 (35%).
2	$Ca(OCl)_2$ equivalent to 6% available chlorine.	1 and 4% Sodium Silicate.
3	2% NaOH	.5% through 4% NaOH.
4	150° F. for 35 min.	250° F. and 15 pounds pressure for 20 min.
5		10% Cons't.

As a result of these tests, it was found that apparently the sodium silicate serves a dual purpose. In the first place, his chemical acts as a pH adjuster and, in the second place, the sodium silicate apparently acts as a buffer for the reaction while under pressure. The tests made indicate that sodium hydroxide acts only as a pH adjustment and does not buffer the reaction, causing a subsequent darkening of the pulp while under pressure. A combination of 4% sodium silicate and 4% caustic will give the same results approximately as 8% sodium silicate. Due to the comparative costs of these chemicals, 8% sodium silicate has been recommended.

Table V is as follows:

TABLE V

Sample No.	Percent H_2O_2 (35%)	Percent Sodium Silicate	Initial pH	Percent NaOH	G.E. Brightness	Points Increase in Brightness from 1st stage	Shive Bleaching
A	2	1	9.0	.5	65.5	5.5	No bleaching of shives except on F in which all shives bleached out.
B	2	1	10.3	1	68.5	8.5	
C	2	1	11.2	1.5	71.0	11	
D	2	1	11.3	3	74.0	14	
E	2	1	11.5	4	76.0	16	
F	2	4	11.6	4	80.2	20.2	

Note Table V: All quantities of chemicals based on weight of dry pulp present.

Tests were also conducted to determine the comparative physical strengths of the bleached and unbleached pulp. Figure 5 of the drawings indicates the results obtained. It will be noted that the bursting (Mullen) strength of the unbleached pulp stock is in general greater than that of the unbleached stock. The relative tear strength of the pulp remains essentially unchanged by bleaching. The freeness of the bleached pulp is lower than that of the unbleached stock as would be expected.

As a second example, unbleached acid sulfite pulp containing perhaps 4% solids is subjected to the action of calcium hypochlorite having approximately 6% available chlorine and 2% sodium hydroxide for a period of substantially forty minutes at a temperature of 140° F.

The pulp is pressed to a solids content of about 25%, and treated with 2% peroxide (35% concentration) and 8% sodium silicate, using twenty pounds steam pressure and a corresponding saturated steam temperature, for a period of seventeen minutes. The unbleached pulp was found to have a brightness of 49 G.E. After the first stage of bleach the brightness was 64 G.E., and after the second stage of bleach, the brightness was increased to 82 G.E.

While only two specific examples have been given, other various examples could be listed. However, the various preferred ranges of the chemicals employed, as well as the temperatures and pressures employed, have been listed. Increasing the temperature and pressure results in a decreasing of the time required for the second stage of bleaching. Increasing the quantity of certain of the chemicals has an advantageous effect as has been indicated from the various experiments listed.

The apparatus indicated in Figure 1 of the drawings is merely for the purpose of illustration, as other apparatus can also be employed. The unbleached stock is supplied from a suitable source **10** to a hydropulper **11** and bleach is supplied from a storage tank **12** to mix with the pulp in the hydropulper. The pulp is usually directed to a bleaching chest **12** where it remains for approximately a predetermined time. Pumps **13** and **14** are provided to accomplish this result. After the pulp has been bleached it is pumped by the pump **15** to the thickeners indicated at **16** where the pulp may, if desired, also be washed. The partially thickened pulp passes through the bin **17** to the presses **19** where more water is expressed therefrom. The pulp then enters a suitable type of bleach mixer **20**. The bleaching chemicals for the second stage are stored in the hydropulper storage tank **21** and sodium silicate storage tank **22** and may, if desired, be mixed by the device **23**. After being mixed with the pulp, the product is passed into pressure chambers **24** which normally contain a feed screw so that the pulp may gradually move from one end to the other of the chamber while under elevated temperature and pressure. Any suitable means such as a plug forming screw or rotary valve at the entrance end of the chambers **24** may be employed. The pulp is forced through a suitable chamber outlet capable of maintaining pressure within the chambers.

The bleached pulp may then be diluted by the apparatus **25**, if desired, and directed to subsequent pulp refining equipment or the paper machine or may be stored at high density until used.

In accordance with the patent statutes, I have described the principles of construction and operation of my method of bleaching paper pulp, and while I have endeavored to set forth the best embodiment thereof, I desire to have it understood that obvious changes may be made within the scope of the following claims without departing from the spirit of my invention.

I claim:

1. A two stage bleaching method for bleaching semi-chemical and chemical paper pulp, the steps comprising a first stage of bleaching including subjecting the pulp to the action of hypochlorite having 2% to 10% available chlorine based on the weight of oven dry pulp with the pulp mixture having a pH in the range of 9 to 14, bleaching the pulp about 30 to 40 minutes at a temperature of about 100° F. to 150° F. until a prepared sheet of this pulp provides a G.E. brightness of about 44 to 65, washing the pulp, mixing the pulp with second stage oxygen producing chemicals which produce active oxygen in amounts of from .04% to .66% based upon the dry weight of the pulp present, adjusting the pH to within the range of 9 to 14, subjecting the mixture to pressures of about 10 pounds per square inch to 50 pounds per square inch and temperatures equivalent to that of saturated steam at this pressure for a period which varies inversely with the variations in pressure and temperature, discontinuing the bleaching action while leaving a slight residual oxygen producing chemical in the pulp and after a time interval of not over about twenty minutes, for a total bleaching time of not over about one hour for the first and second stages of bleaching until sheet material prepared therefrom has a G.E. brightness reading of from about 72 to about 85.

2. The method of claim 1 and in which the oxygen producing chemical is an inorganic peroxide.

3. The process of bleaching washed semi-chemical and chemical pulp which has been partially bleached to a G.E. brightness reading of about 43 to about 65 and has a consistency of 10% to 35% solids, the process including the steps of mixing the pulp with oxygen producing bleaching chemicals which produce active oxygen, adjusting the pH to within the range of 9 to 14, subjecting the mixture to pressures of about 10 to 50 pounds per square inch and to temperatures equivalent to that of saturated steam at the pressure used for a period of time which is inversely proportional with the variations in pressure and temperature, discontinuing the bleaching action while still retaining residual oxygen producing bleaching chemicals in the pulp and after a time interval of not over about twenty minutes until sheet material prepared therefrom has a G.E. brightness reading of from about 72 to about 85.

4. The process of claim 3 and in which the pH of the pulp is adjusted by the addition of a caustic selected from the class consisting of sodium silicate, sodium hydroxide, and mixtures thereof.

5. The process of bleaching washed semi-chemical and

chemical pulp which has been partially bleached to a G.E. brightness reading of about 43 to about 65, the process including the steps of mixing the pulp with inorganic peroxide bleaching agent, adjusting the pH of the pulp to within the range of 9 to 14 by the addition of a sodium silicate caustic, the sodium silicate acting as a buffer for the peroxide bleach, subjecting the mixture to pressures of about 10 to 50 pounds per square inch and to temperatures equivalent to that of saturated steam at the pressure used for a period of time which is inversely proportional with the variations in pressure and temperature, discontinuing the bleaching action while still retaining residual oxygen producing bleaching chemicals in the pulp and after a time interval of not over about twenty minutes until sheet material prepared therefrom has a G.E. brightness reading of from about 72 to about 85.

6. A two stage bleaching method for bleaching semi-chemical and chemical paper pulp and obtaining a G.E. brightness finish of about 72 to about 85 in a total treatment time of about one hour in a relatively continuous operation after refining and washing the pulp material, the steps comprising a first stage of bleaching including subjecting the pulp to the action of a hypochlorite equivalent to about six percent available chlorine based upon the weight of the oven dry pulp with the pulp mixture having a pH adjusted to about 11, bleaching the pulp for a period of about thirty minutes to about forty minutes at a temperature of about 100° F. to 150° F. until a prepared sheet of this bleaching stage provides a G.E. brightness reading of about 48 to about 65, washing the pulp, thickening the solids content of the pulp to about 10% to about 35% solids, mixing the thickened pulp with sufficient second stage oxygen producing bleaching chemicals which produce active oxygen in amounts of from .04% to .66% based upon the dry weight of the pulp present, adjusting the pH to about 11, subjecting the mixture to pressures of about 10 pounds per square inch to about 50 pounds per square inch and to temperatures equivalent to saturated steam at the relative pressure utilized for a period which varies inversely with the variations in pressure and temperature, discontinuing the bleaching action while still retaining residual oxygen producing chemicals in the pulp, and after a time interval of not over about twenty minutes, for a total bleaching time of not over about one hour for the first and second stages of bleaching until sheet material prepared therefrom has a G.E. brightness reading of from about 72 to about 85.

References Cited in the file of this patent

UNITED STATES PATENTS

68,261	Tiffany	Aug. 27, 1867
1,860,432	Richter	May 31, 1932
2,026,068	Scheller	Dec. 31, 1935
2,029,985	Clark et al.	Feb. 4, 1936
2,257,716	Kauffmann	Sept. 30, 1941
2,527,563	McEwen	Oct. 31, 1950
2,668,095	Fennell	Feb. 2, 1954
2,839,353	Coleman	June 17, 1958

FOREIGN PATENTS

436,268	Great Britain	Oct. 8, 1955

OTHER REFERENCES

Paper Trade Jour., vol. 122, No. 17, Tappi Sect., pp. 179–183, Apr. 25, 1946.

Canadian Chem. Processing, February 1953.