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The Comparison of Linear Nip Pressing vs. Extended Nip Pressing on the Bulk and Strength of Unbleached Kraft Linerboard

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THE COMPARISON OF LINEAR NIP PRESSING VS. EXTENDED NIP PRESSING ON THE BULK AND STRENGTH OF UNBLEACHED KRAFT LINERBOARD

by

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Abstract

It is of increasing importance to find improved methods of dewatering in the wet press section. New technology has allowed us to improve dewatering and final sheet properties with the press section. Presently, we are faced with a choice between two pressing configurations; the conventional roll press and the extended nip press. Both press configurations are discussed. The fundamental characteristics of paper which affect it's properties are density, fiber dimensions, fiber strength, fiber orientation, and fiber bonding. This thesis investigates the effect of the pressure pulse on the final sheet properties of bulk and strength of a kraft linerboard. Strength and bulk should both be optimized in the manufacture of linerboard. With the proper press configuration this may be accomplished. The KMW dynamic press simulator, it's operation, and it's use in this thesis is discussed. The procedure of the experiment is also outlined. The results of the experiment produced three significant conclusions: 1) Extended nip pressing gives higher dewatering rates than conventional nip pressing at comparable energy levels. 2) The longer nip dwell time and lower maximum pressure imparted by the extended nip press is more beneficial for higher bulk. 3) Conventional roll nip pressing imparts higher internal bond strength when crushing is not a factor. Also, this type of pressing gives higher bulk at specific strength levels in comparison to the extended nip pressings.

Keywords: bulk density, mechanical properties, pressing, simulation, water removal

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The Comparison of Linear Nip Pressing vs. Extended Nip Pressing on the Bulk and Strength of Unbleached Kraft Linerboard (Simulaton by the KMW Dynamic Press Simulator)

As a nation, we are confronted with an increasing energy demand coupled with decreasing domestic production of natural gas and petroleum. More efficient use of energy in industry can play a part in alleviating this impending shortage. Energy consumption in current papermaking processes is by far greatest in paper drying.

The increasing use of new wet press technology together with the need for more efficient use of energy, has increased the importance for understanding the mechanisms restricting water removal from the wet web. This resistance becomes rate controlling for water removal when new press and felt designs are used. One area of investigation of increasing importance is the effect of the pressure impulse on the resistance to water flow and final sheet properties such as bulk and strength.

The major purpose of the press section is to remove as much water as possible mechanically before the sheet enters the dryer section. Other press section objectives are: the conveyance of the wet sheet from the Fourdrinier to the dryers, assistance in proper machine runnability, and imparting sheet stability to the web.[1]

With the onset of new pressing technology, we can look at the role of the press section in imparting web strength and the occurrance of crushing. This technology has provided us with a new type of press loading, namely the extended nip press. This press is a result of the theory that when residence time in a nip is extended by a factor of four or more, significant increased dryness can be obtained. The extended nip press can reduce the force under which the web is pressed due to the increased pressing duration. This feature theoretically may reduce crushing and damage to the wet web structure caused by high linear nip loads and short dwell times.

As a result of the extended nip press, two opposing opinions have been formed regarding sheet stability. On one hand, the traditional thought; maximum sheet strength with minimum sheet structure damage can be obtained with conventional wet pressing (high linear nip load and short dwell). On the other hand, the recent trend; maximum sheet strength with little sheet damage can be obtained by extending the nip dwell time while decreasing the nip load.

It is my intention to investigate the validity of the two arguements above. With the use of a laboratory dynamic press simulator, the two variables (maximum pressure and dwell time) will be controlled to give the two types of nip pressure profiles. The effects of these factors on the resulting sheet strength (z-directional), and sheet bulk will be studied.

The Roll Press

A significant area of wet pressing development has been the application of high nip load presses opertating at 800-1200 pli on kraft linerboard. On this linerboard, high nip pressures have resulted in increased sheet dryness, greater uniformity levels into the dryers, and ultimately production increases of 15-20%. An equally important result has been increased burst strength, the most important linerboard test specification. This increase in burst strength has reduced reliance on wet end additives and allowed for less refining, resulting in better drainage on the wire and a further improvement in the sheet dryness entering the dryers. Burst improvement also provides the potential for increased utilization of secondary fiber or higher yield pulps in the linerboard furnish.[2]

The total nip pressure developed by the externally applied forces can be shown as the algebraic sum of two components: the internal hydraulic force in the web and the compressive force acting on the fiber structure.

As the sheet and felt(s) enter the converging nips of 2 opposing rolls they are subjected to progressively increasing nip pressure. Initially, the pressure begins compaction of the fiber structure until the voids have been virtually eliminated and continuous capillaries or channels filled with water have been established. Complete saturation is effected before significant hydraulic pressure starts. Once saturated, the mass of water in the webs begins to carry some of the pressure load applied and a hydraulic pressure develops which will support the flow or movement of water.[3] The following explanation breaks the pressing of the wet web down into four distinct phases. (see figure 1).

Phase one starts at the entrance of the nip where the pressure curve begins and continues until the paper has become saturated. (No hydraulic pressure).

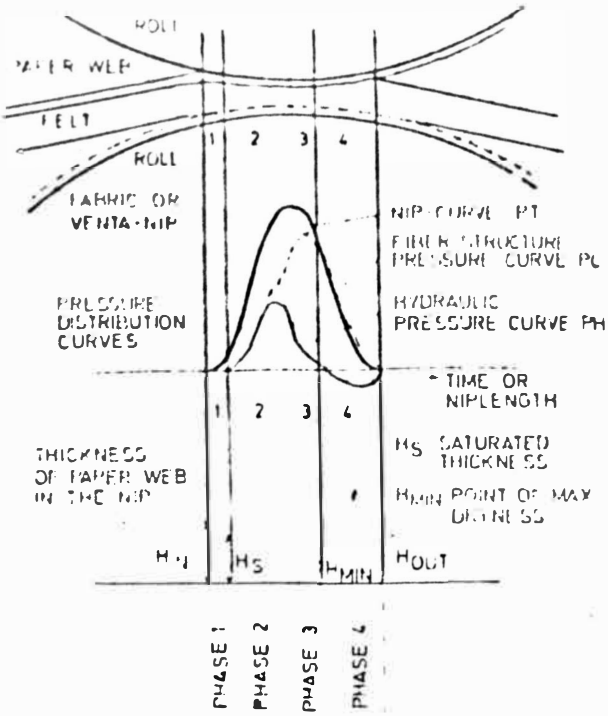
Phase 2 extends from the point of saturation to mid nip, or more accurately to the maximum point of the total nip pressure curve. In this phase the felt also reaches saturation.

Phase 3 extends from the maximum point of the nip curve to the point of maximum paper dryness. This maximum dryness point corresponds to the maximum in the paper structure pressure curve, and zero hydraulic pressure in the paper. In this expanding part of the nip, the felt passes zero hydraulic pressure and becomes unsaturated.

Phase 4 covers the point where the paper starts to expand and becomes unsaturated creating a two-phase system of water and air. The felt is unsaturated through this whole phase and expands continuously.[4]

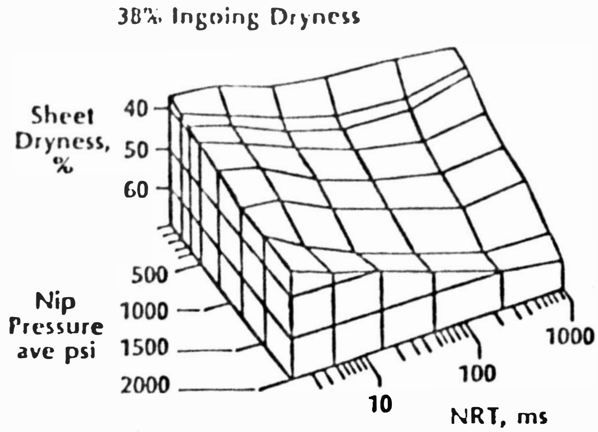
Wet press nip loads on linerboard have increased significantly over the past 20 years, from a 450 pli suction press with two soft rubber covers to 1200 pli with one soft rubber cover. And, most recently, 1600 pli loadings have been successfully applied.

Applicatons of more open and compressible felts along with vented nip technology has further reduced the flow resistance external to the sheet itself. As nip loads are increased, it becomes more important that the felts stay open and resist compaction.[5]



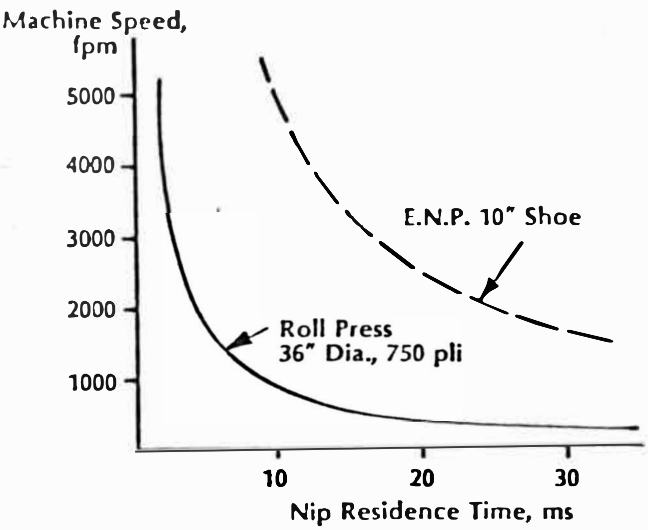
Transversal flow nip

FIG 1



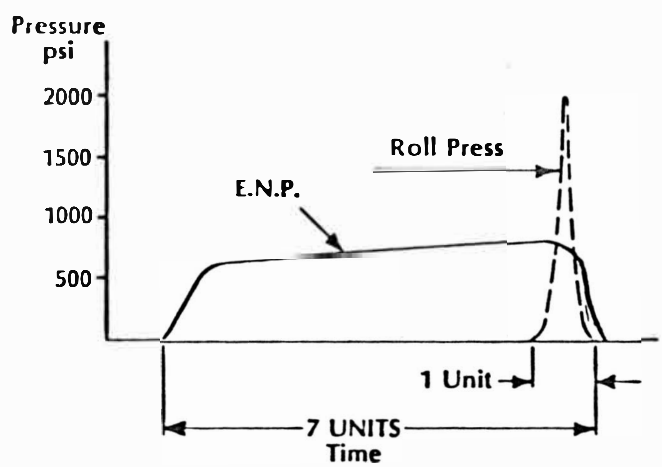
Dryness vs. Time and Pressure

FIG 2



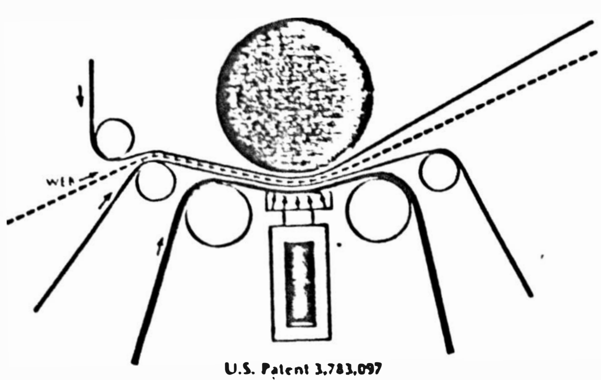
Machine Speed vs. Nip Residence Time

FIG 3



Nip Pressure Profiles

FIG 4



Design Schematic

FIG 5

The best known limitation of high nip load pressing is the mechanical properties of press roll rubber covers and press felts. While the development of high nip load presses has been successful, it has been accompanied by press roll rubber cover and press felt problems as nip loads were increased. Heat generation due to increased hysteresis at higher nip loads and damage due to wads are the primary rubber cover problems. Compaction and damage are the primary press felt problems.[2]

The Extended Nip Press

In 1971, Busker[6] explored the possibilities of increasing time under pressure for increased dryness of a sheet following a press. The net results of this work was that significantly increased dryness could be obtained if the residence time in a nip could be extended by a factor of four or more. Data generated from this work indicated that dryness increases with freeness; dryness increases with sheet temperature in the nip; dryness increases with time in the nip; and dryness increases with average nip pressure.[6]

Figure 2 gives a three-dimensional plot of two-roll press data showing the effect of nip residence time and nip pressure on sheet dryness after pressing.

Figure 3 is a plot of time in the nip for two 36 in. rolls and for a 10 in. wide extended nip in order to illustrate the nip residence times for different machine speeds. For example, a roll press at 2600 fpm gives 3 ms dwell, and an extended nip at

2600 fpm gives 20 ms dwell.

Figure 4 is a plot of unit pressure vs. position in the nip, showing both the shape and duration of the pressure in a roll nip as compared to the attained pressure in a 10 in. long extended nip. Notice that the time for the roll nip is quite short, and, although the peak pressure is quite high, it exists for a very short time. There is very little that can be done with a roll nip to change the rate of pressure rise or fall. On the other hand, the profile of the pressure curve for an extended nip is controllable by the designer in the shaping of the load shoe at the entrance and the exit from the load zone. The nip pressure level and the length of the nip are both adjustable and controllable by the designer.[7]

Extended Nip Design

The basic design configuration used to accomplish the extension of the nip and runnability is shown in figure 5. In this configuration, a single grooved press roll is opposed by a stationary loaded shoe. The press is double felted, with a top felt against the roll and a bottom felt passing through the nip surrounding the shoe and it's supporting beam. The paper web passes through the nip between the two felts. Between the shoe and the felts is an impervious elastomer belt which is lubricated by oil to create a slipper bearing between the shoe and the inside of the belt and to permit force to be applied to the felts and paper sandwich and the opposing roll. The shoe acts as a slipper bearing, and is loaded against the sandwich and the roll with a hydraulic piston underneath extending continuously cross machine. The design control of the tilt and contour of the shoe is such as to give the desired shape of the pressure load curve through the nip.

Under present day practice, the loading averages 600 psi along the 10 in. length of the shoe. This is equivalent to 6000 pli by the normal method of stipulating press loadings. The designers of this press claim that the low pressure together with the controlled rate of compression greatly reduces the crushing potential. The important variable is that the 600 psi is sustained for a long period of time in the nip, which is five to eight times that obtainable with roll presses.

Data presented by Cronin and Justus indicate that the effects of he extened nip press are: increased dryness to the level of 45% into the dryers on virgin linerboard; increased physical properties, such as burst strength, ring crush, and tensile strength, with some reduced caliper and porosity; and improved uniformity of dryness as a result of longer time in the nip.

From the papermaking point of view, the indicated benefits of extended nip pressing are:

1. Less energy per ton of paper dried.
2. Reduction of additives used for strength purposes.
3. Increased yield for a given strength.
4. Lower-strength pulps for a given sheet strength.
5. Reduced refining for a given sheet strength with a given

pulp.

6. Increased production off the machine.
7. Reduction of dryer section length for a given tonnage.[8]

Final Sheet Properties

The fundamental characteristics of paper that affect it's properties are density, fiber dimensions, fiber strength, fiber orientation, and fiber bonding. These variables are manipulated by the paper manufacturer to prepare papers and paperboards to different specifications.

One of the most important characteristics of paper is the apparent density and bulk. Density is the reciprocal of bulk. Tappi calculations of bulk are made by the formula:

$$\text{Bulk} = 25.4\ T/r$$

T = single sheet thickness in thousands of an inch, r = the basis weight in oven dry grams per square meter of paper.

In sheet formation, the fibers are brought closer together as water is removed. This results in continued increase in the dry fibers per unit of wet thickness. The forces that bring this about are surface tension, interfiber tension, extraneously applied forces of vacuum and pressure, interfiber bonding, area shrinkage of fibers, and the coiling and twisting of the fibers in the final stages of drying.

Contraction begins on the wire forming surface where there is sufficient water to fill completely the interfiber spaces. Surface tension forces are small at this point, but they become stronger when the drainage advances to the point when there is some air in the sheet. This occurs at solids contents of 11 to 12 percent.

The bulk in any sheet might be determined by the resistance of the fibers to various forces that pull the fibers together. A plastic fiber will offer less resistance to the compacting forces than will an elastic fiber.

Dr. Diehm noted that when the bulk of paper is decreased there will be an increase in burst and tensile strength and a decrease in tear, opacity, porosity and water absorption in unsized papers. Increases in burst and tensile will decrease the bulk; high opacity and high tearing resistance go hand in hand with high bulk.[9]

EQUIPMENT

The Dynamic Press Simulator

In order to simulate a physical event, such as press operation, a complete knowledge of the various parameters is required. When the sheet passes through the press nip it experiences a pressure pulse. This press impulse is defined as follows:

$$\text{impulse} = P(t)dt$$

where: t = nip dwell time

$P(t)$ = nip pressure at time t

For a paper machine press nip, the press impulse is equal to the linear load divided by the machine speed. In the press simulator, the press impulse equals:

$$\text{simulator impulse} = mv_1 - mv_2 /A$$

where: m = mass of the hammer

v_1 = velocity before impact

v_2 = velocity after impact

A = area of the sample

theoretically: $v_1 = (2gh_1)$

$v_2 = (2gh_2)$

where h_1 and h_2 equal the drop height and rebound height and g equals the acceleration due to gravity.[10]

The pressure distribution in the machine direction is determined by the nip width. For example, a short nip width will give a narrow pressure distribution (a high specific pressure and a short press time).

A dynamic press simulator operates as follows: A pressure pulse generator (weight-loaded hammer) is dropped from a variable height, it rebounds off the sample and anvil and is caught at the top of its rebound. A force transducer detects the pressure pulse and the pulse is recorded. The shape of the pressure pulse is in good agreement with measurements performed in actual (conventional-roll) press nips.

The simulator can readily be modified to model different types of presses. For instance, two felts may be used to simulate a double-felted press. The structures supporting the felts may be changed to model plane presses, fabric presses, grooved presses, etc. Drilled hole patterns can be copied to study shadow markings or to simulate a specific press. Also, by changing the specific pressure and the press time, one can study effects of roll diameter, cover hardness, felt caliper, and load. The caliper and softness of the attached rubber sheet (attached to hammer or anvil) is selected for a given impulse to give a suitable nip dwell time. If only the drop height of the hammer is changed, the maximum pressure will be changed at constant nip dwell time for the rubber materials used.[11]

The dynamic press simulator used was originally developed by Zotterman and Warren. The press nip consists of a hammer and an anvil. The anvil consists of a 3.5" diameter piece of steel made to cover a force transducer. On top of the steel is a 3.5" piece of hard or medium hard rubber. The hardness depends upon the type of pressing simulated. The hammer consists of a steel plate which has a 3.5" piece of hard rubber attached to the lower side.

The hammer travels on two hard-cased steel posts. Brass bushings are mounted on the hammer to ride on the posts. These bushings were kept well lubricated.

This configuration uses a simple drop mechanism. The hammer is attached to a cable with a quick release mechanism. The hammer is raised to a desired drop height and released by the quick release. When the hammer hits the anvil, it rebounds and is caught by a spring-loaded catch system. (see figure 6)

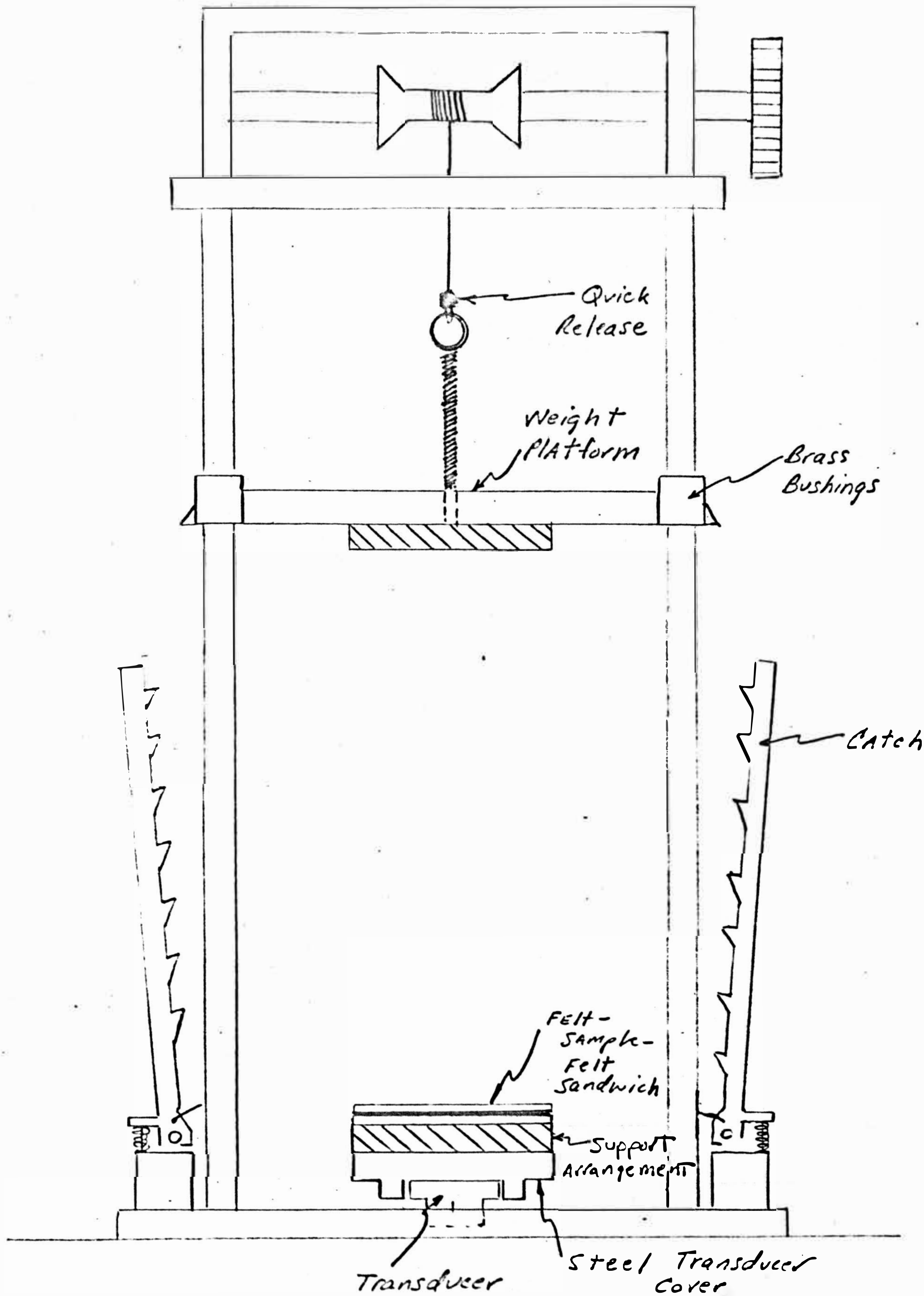
Oscilloscope

The oscilloscope used in this experiment was a Hitachi Storage Oscilloscope, model number is V-134. The scope was borrowed from the Electrical Engineering department at Western Michigan University. The scope settings were kept constant throughout the experiment at: 1 volt/division (vertical), 1 ms/division (horizontal), and normal storage mode. A Piezotronics "PCB" power unit and transducer, model 484B, was used in conjunction with the oscilloscope.

Drying Rings

After each sheet was pressed, it was air dried at constant temperature and humidity. Each handsheet was restrained from shrinking during drying; this was accomplished by placing each on a polished aluminum plate (the plates used from the British handsheet mold). On top of the handsheet was placed a rubber canning jar ring with a 3" inner diameter, and on top of this was placed an aluminum ring 1" high and 3" inner diameter. The aluminum rings each had 6 1/2" holes drilled around the circumference to allow air circulation. The plates and rings

Figure 6

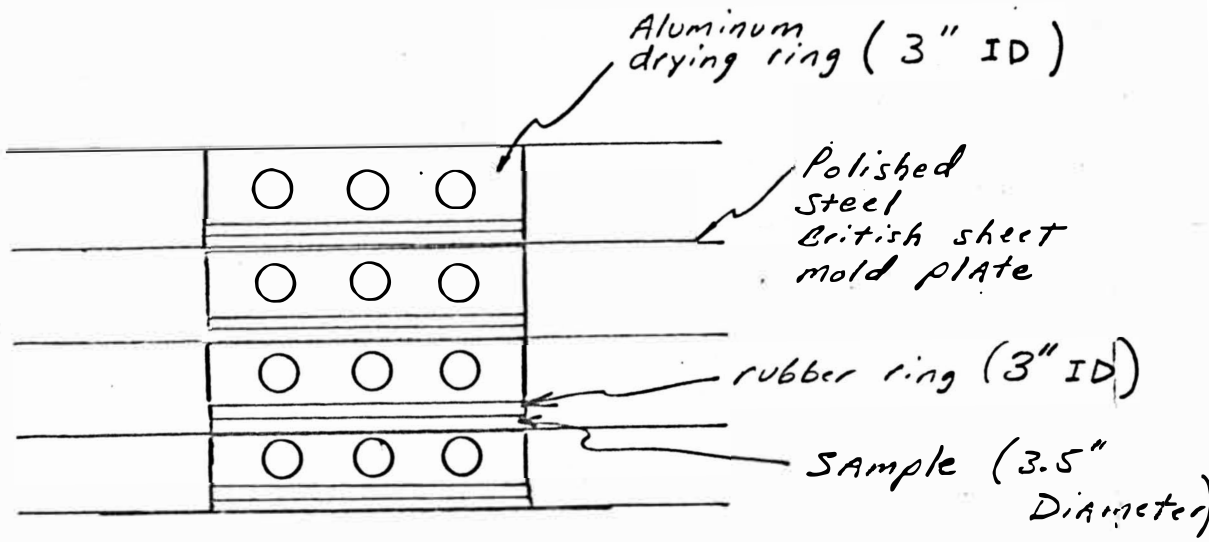

Quick Release
Weight Platform
Brass Bushings
Catch
Felt-Sample-Felt Sandwich
Support Arrangement
Transducer
Steel Transducer Cover

were stacked 10 high on top of each other, and a 10 pound weight was placed on top of the stack. (see figure 7)

Testing Equipment

A motor-operated micrometer was used to determine caliper, from which bulk was calculated. A Scott Bond internal bond tester was used to evaluate internal bond strength.

Figure 7


Aluminum drying ring (3" ID)
Polished Steel British sheet mold plate
rubber ring (3" ID)
Sample (3.5" Diameter)

Procedure

In order to compare data generated from simulations of conventional roll nip pressing and extended nip pressing, a series of "blank drops" were performed. The blank drops are pressings performed without the felt-sample-felt sandwich being loaded onto the press simulator. By means of trial and error, press configurations were developed for both types of simulation. See figure 8 for figures showing the exact press configurations. By completing the series of blank drops described below, appropriate drop heights and drop weights were determined.

A storage oscilloscope was used to generate curves from each set of drop conditions. These conditions consisted of the type of pressing simulated, the weight loading on the hammer, and the drop height. The generated curve gives the relationship between pressure and time for the press impulse. The output of the transducer is directly proportional to the pressure of the drop; therefore, the oscilloscope becomes the most practical tool of measurement for force.

Another reason for carrying out this procedure was to assure the ability of the press simulator to produce identical impulse curves for each set of conditions. This was easily accomplished with the storage capacity of the oscilloscope. Each drop condition was repeated five times without resetting the oscilloscope. At almost all conditions, the drops repeated themselves very accurately. The curve on the oscilloscope retraced itself. The only occurances when the drops did not repeat themselves were when the operator failed to load the press

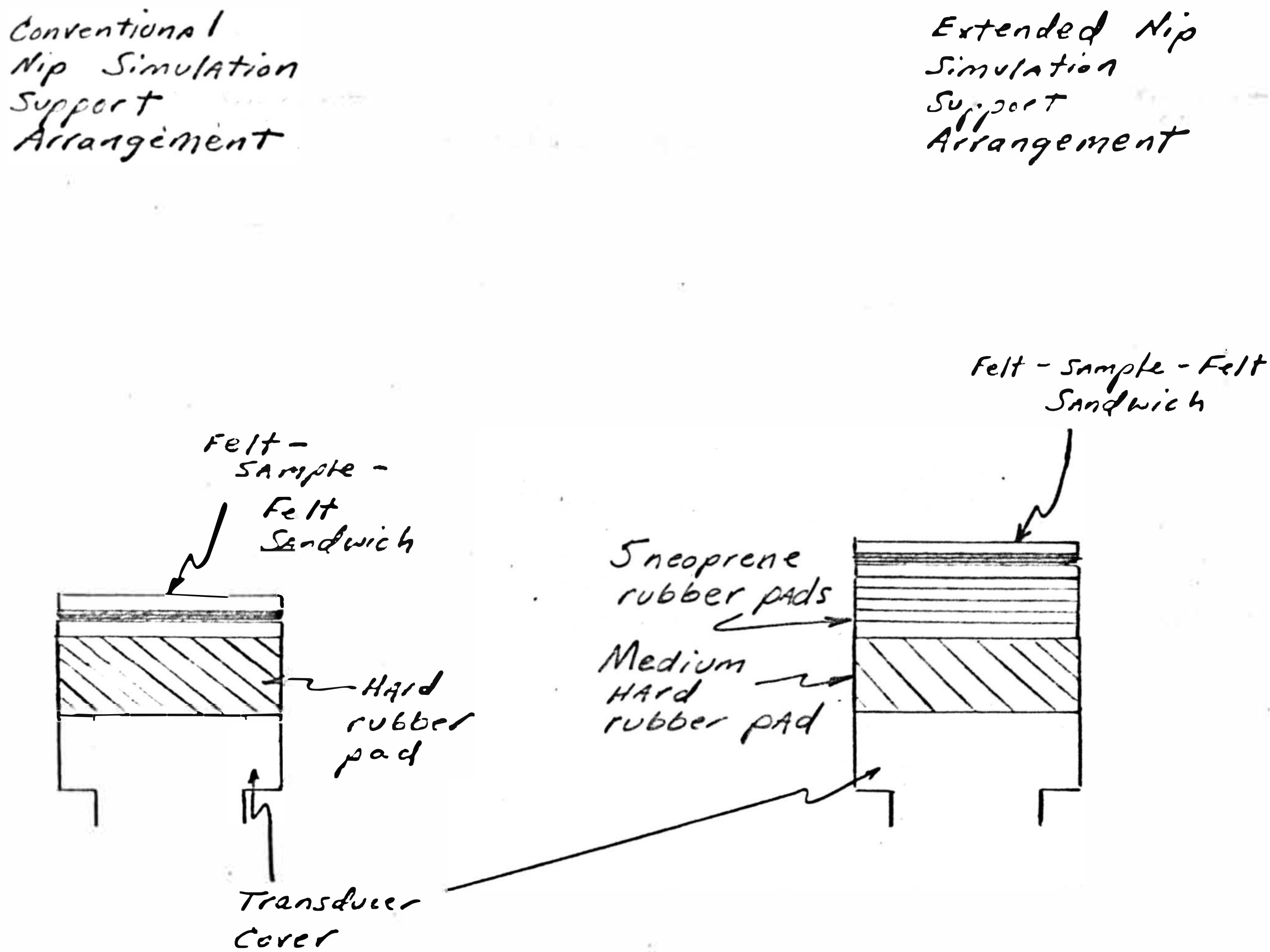

Conventional
Nip Simulation
Support
Arrangement
Extended Nip
Simulation
Support
Arrangement
Felt - Sample - Felt
Sandwich
Felt -
Sample -
Felt
Sandwich
5 neoprene
rubber pads
Medium
Hard
rubber pad
Hard
rubber
pad
Transducer
Cover

Figure 8

properly.

The sequence of drop conditions performed was as follows: Five drops were made at each condition. All combinations of the following drop heights and drop weights were performed:

Weight (pounds)	Height (inches)
0*	9
10	11 1/4
20	14
30	16 1/4
40	18 1/2
	21
	23

* 0 drop weight refers to zero weight loading on the hammer; the weight of the hammer is accomplishing the pressing.

The total number of drops = 2 types of simulation (extended and conventional) x 5 (drops at each condition) x 5 (drop weights) x 7 (drop heights) = 340 drops total.

After making each blank drop five times, a trace of the curve was made manually onto a sheet of translucent parchment paper. This tracing was then transferred to engineering forms. The forms were ten millimeter squares to the centimeter. The impulse energy imparted by each drop condition was quantified by approximating th number of squares under each curve.

Once a quantitative analysis was completed on all the drop conditions, the four sets of conditions having the most equal impulse areas were selected. Each set contained two drop conditions: one from the extended nip simulation group of blank drops, and one from the roll nip simulation group. These drop conditions were as follows:

Group 1: Conventional nip: 0 lb weight loading, 23 inch drop
Extended nip: 0 lb weight loading, 21 inch drop

Group 2: Conventional nip: 20 lb weight loading, 21 inch drop
Extended nip: 10 lb weight loading, 23 inch drop

Group 3: Conventional nip: 40 lb weight loading, 18 1/2 inch drop
Extended nip: 40 lb weight loading, 11 1/4 inch drop

Group 4: Conventional nip: 40 lb weight loading, 23 inch drop
Extended nip: 40 lb weight loading, 21 inch drop

Appendix I contains the curves generated by all of the blank drops performed. The number in parentheses, on each graph, is the number of squares covered by the curve.

Furnish

The furnish used in this experiment was one-hundred percent softwood unbleached kraft fiber. The majority of work completed previously found in the literature was performed using unbleached kraft. Also, the issues addressed in this thesis pertain to the paperboard industry.

The furnish was prepared at Western Michigan University using laboratory equipment, including a Morden slushmaker and a laboratory Hollander beater. The stock was refined according to Tappi standard T 200 os-70 to 650 csf. This freeness was chosen not only because handsheet formation was very good, but also because a relatively free stock is desirable in the board industry.

Handsheets

Handsheets were produced with the British sheet mold. Tappi standard T 205 om-81 for paperboard stock was followed for all procedures excluding pressing. The target basis weight of 150 grams per square meter was chosen. A plastic 3.5 inch diameter ring was used in the sheet mold to produce 3.5 inch diameter handsheets which would fit the press simulator. Once a sheet was produced according to this method, it was blotted to over 20% consistency and stored in a ziplock baggie.

Pressing preparation

In preparing a sample to be pressed in the simulator, the following steps were performed:

1. Two felts (3.5 inch diameter) were wetted to 30% moisture. OD felt weights and 30% moisture weights were previously calculated.

2. The handsheet was removed from the baggie and wetted to 20% consistency. Assuming a basis weight of 30 lb/1000 ft , the 20% consistency weight is 4.35 grams. This method worked very well because the handsheet weights were uniform throughout the experiment.

3. After the handsheet was placed between the two wetted felts, it was ready for pressing.

Pressing

The felt-sample-felt sandwich was loaded onto the press simulator, which was previously set for the appropriate simulation. The construction of the sample sandwich and subsequent loading onto the press was carried out rapidly. This was to reduce the time available for water in the handsheet to migrate into the felts before pressing. The release on the simulator was sprung, activating the press, and the pressed sandwich was removed. The handsheet was then weighed and placed in the drying rings.

Ten handsheets were pressed at each press setting outlined previously. Eighty handsheets were pressed in total.

Pressed Sheet Drying

After a sheet was pressed, it was placed in the drying rings and dried at constant temperature and humidity. The sheets were allowed to dry for no less than 36 hours.

In order to calculate the consistency of the sheet before and after pressing, the OD weight of each sheet was required. After the sheets were dried at constant temperature and humidity, they were oven dried and weighed for this purpose. Following this procedure, the handsheets were again allowed to equilibrate at constant temperature of 70 degrees F and relative humidity of 50%. The handsheets were then ready for testing.

Testing

Caliper and Scott Bond internal strength tests were performed on each sample.

In order to calculate bulk according to Tappi standards, the caliper of the sample must be known in thousands of an inch. A motor-operated micrometer was used to measure caliper according to Tappi standard T 411 om-83.

Tappi calculations for bulk are as follows: Bulk = 25.4T/r, where T equals caliper and r equals basis weight in dry grams per square meter. Two caliper determinations were taken on each handsheet. An average caliper was then calculated for each group of 10 handsheets (for 1 set of drop conditions). An average basis weight was also calculated for each group. Bulk was then calculated.

The evaluation of internal strength was determined with the Scott bond internal bond tester. The data generated was to be an indication of bonding degree and level of crushing imparted by the various pressing conditions. Tappi control method RC-308 was followed for the use of the Scott bond tester. Three internal bond determinations were performed on each handsheet.

RESULTS

Table 1 contains the averaged results for all of the handsheet pressings. This table contains handsheet consistency before and after pressing, and percent moisture reduction. Caliper, bulk, and Scott bond are also included.

The "group" designations refer to the drop condition groups outlined in the procedure section.

Graphs 1 through 7 plot the relationships of the studied properties with press impulse energy and percent moisture reduction.

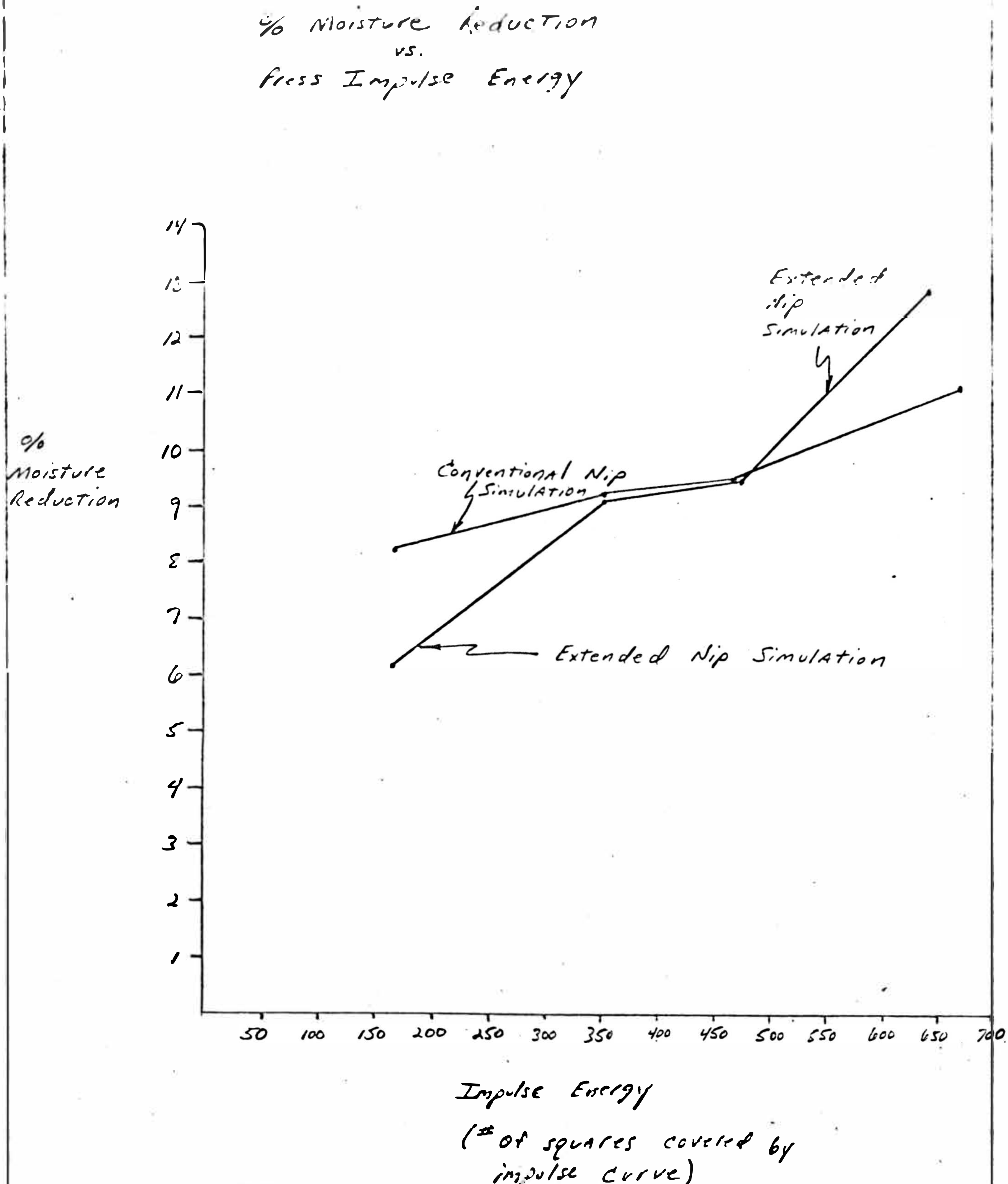
DISCUSSION OF RESULTS

Good correlation between moisture reduction and impulse energy was observed. Graph 1 shows that small differences existed between the two types of pressing arrangements. At low energy levels, the conventional simulation removed more water than the extended nip simulation. At higher energy levels, however, the opposite situation occurred. The higher energy levels studied are closer to the energy levels reached in actual production; therefore, the trends at these higher levels are more significant in this comparison. The larger weights used in the extended nip simulation caused a much longer nip dwell time than the smaller weights. This longer dwell time produced much more dewatering. This data indicates that extended nip pressing gives higher dewatering rates than conventional roll nip pressing on linerboard stock.

The trends noticed from the comparisons of caliper and bulk to impulse energy are as expected. Caliper and bulk decrease

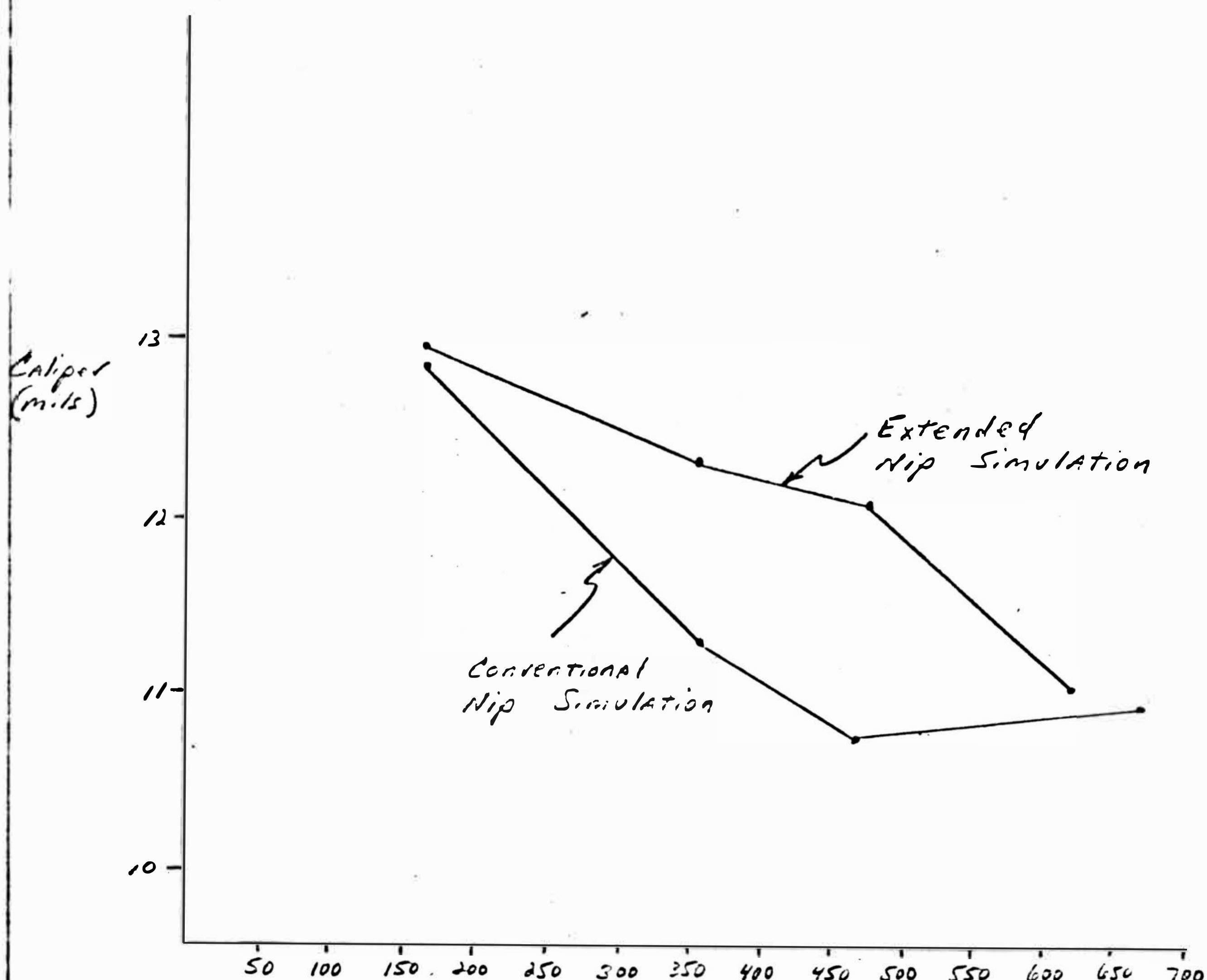
	Avg. Consistency Before pressing %	Avg. Consistency After pressing %	Avg. Moisture Reduction %	Avg. Basis Weight dry g/m²	Avg. Caliper mils	Avg. Bulk	Avg. Scott Bond Ft. lb
Group 1 Conventional Nip Simulation	22	30.35	8.35	155.2	12.85	2.103	93.97
Group 1 Extended Nip Simulation	22	28.2	6.2	153.4	12.99	2.151	89.17
Group 2 Conventional Nip Simulation	22	31.3	9.3	152.5	11.31	1.884	109.3
Group 2 Extended Nip Simulation	22	31.2	9.2	156.3	12.34	2.005	85.5
Group 3 Conventional Nip Simulation	22	31.5	9.5	156.0	10.78	1.755	122.3
Group 3 Extended Nip Simulation	22	31.5	9.5	155.2	12.10	1.980	90.0
Group 4 Conventional Nip Simulation	21	32.2	11.2	149.7	10.96	1.860	123.5
Group 4 Extended Nip Simulation	21	33.7	12.7	149.2	11.05	1.881	94.5

TABLE 1


% Moisture Reduction
vs.
Press Impulse Energy
14
13
12
11
10
9
8
7
6
5
4
3
2
1
%
Moisture
Reduction
Extended Nip Simulation
Conventional Nip Simulation
Extended Nip Simulation
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Impulse Energy
(# of squares covered by impulse curve)

GRAPH 1

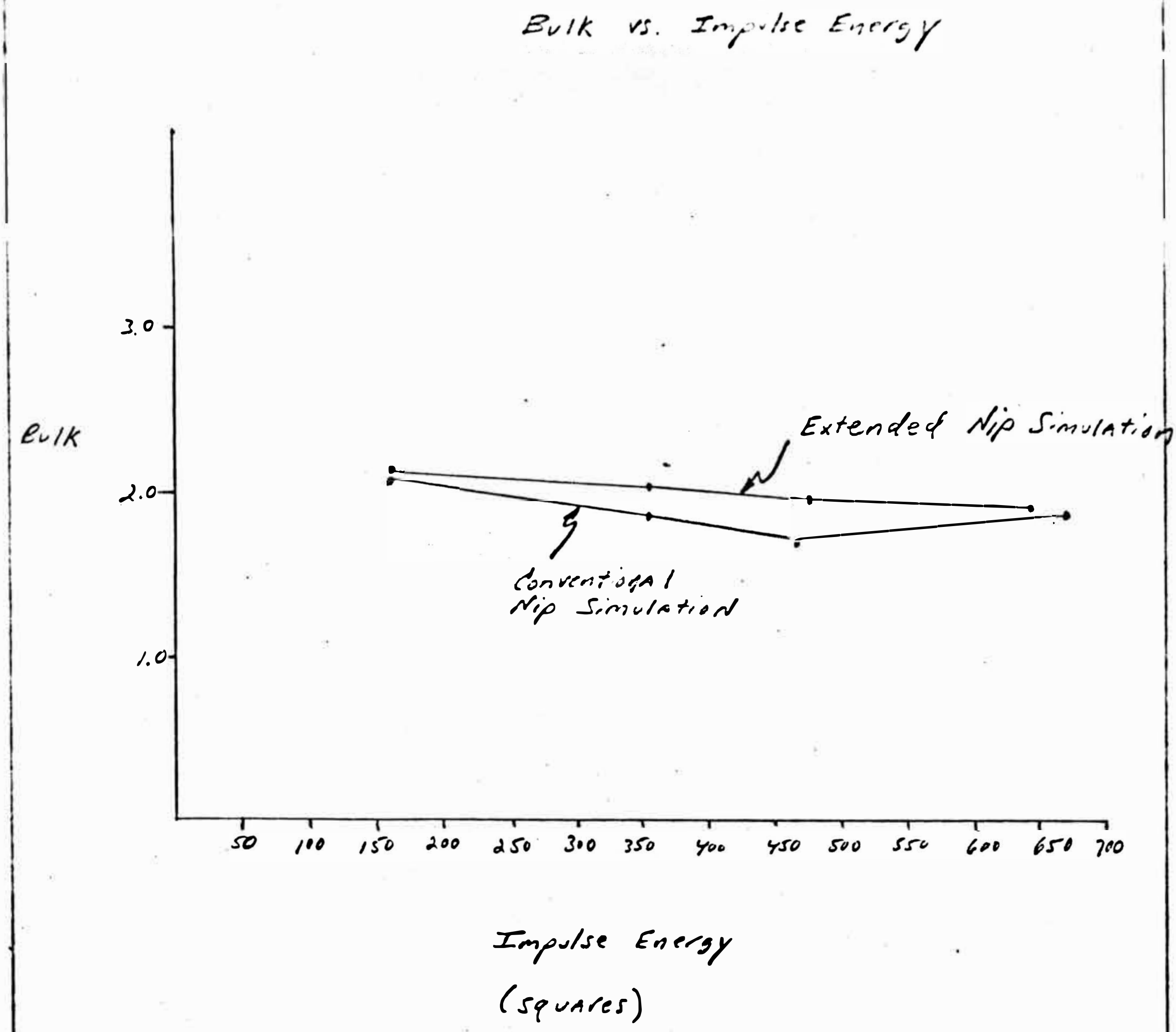
Caliper vs. Press Impulse Energy



Impulse Energy

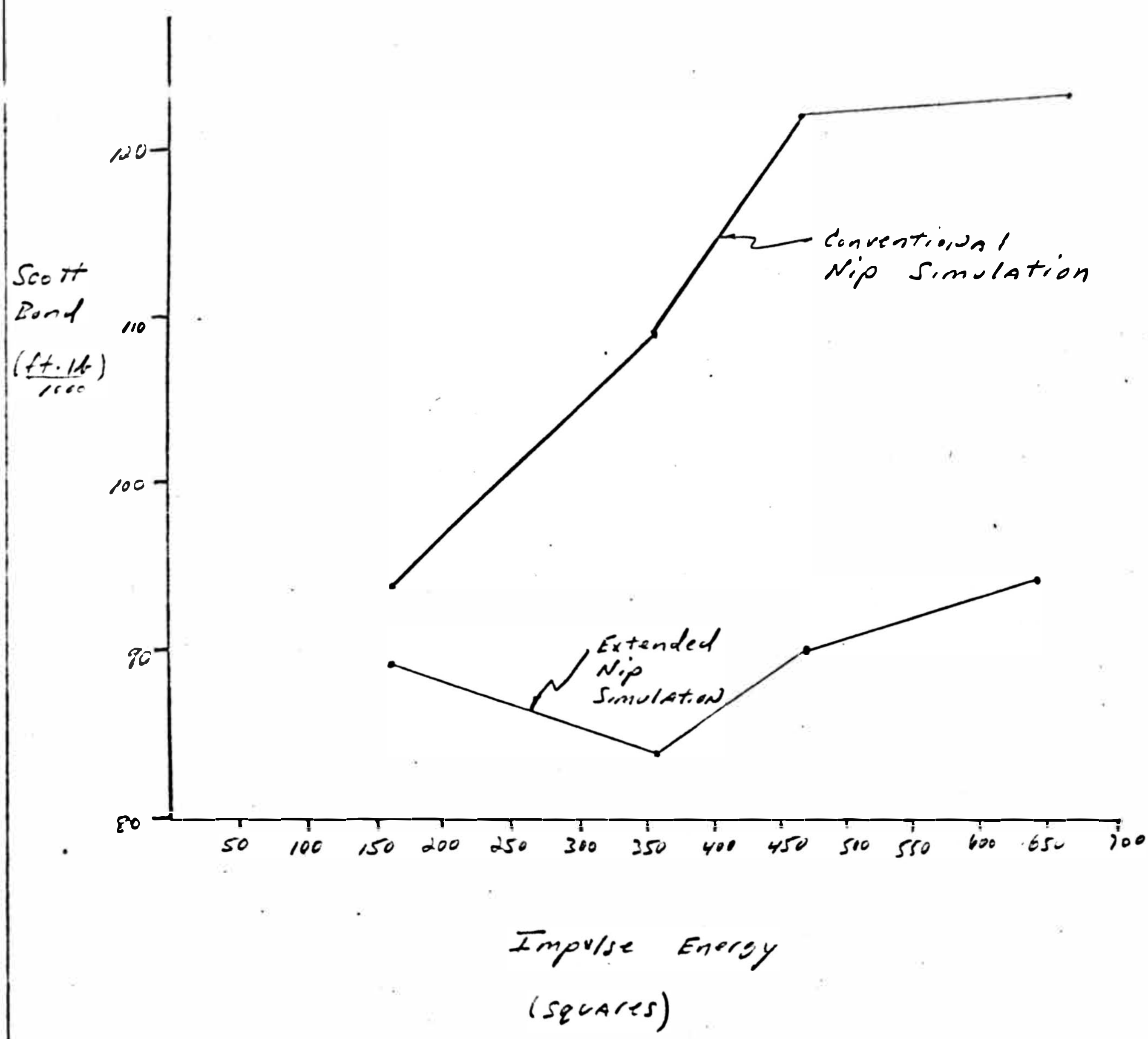
(squares covered by impulse curve)

GRAPH 2

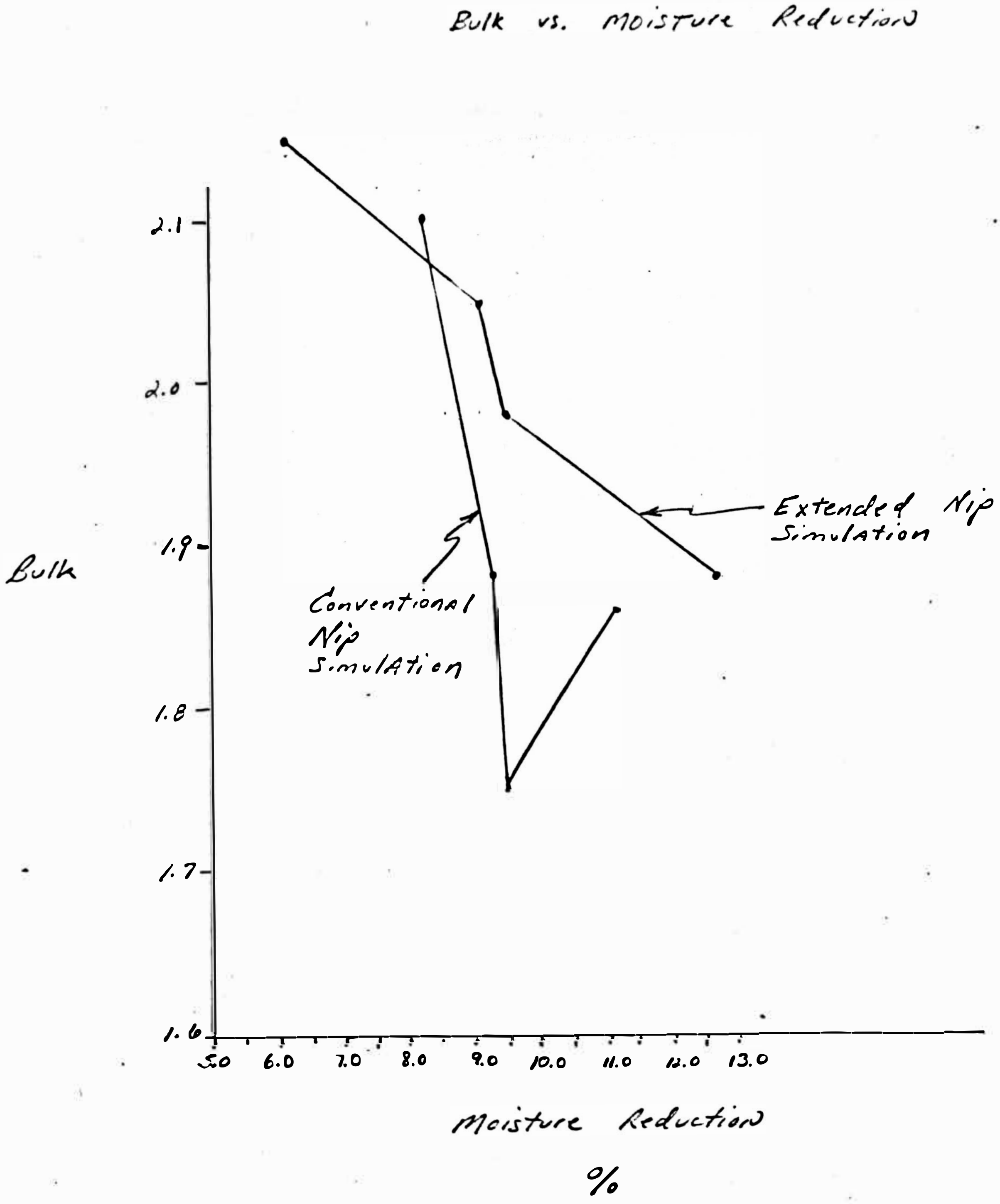

Bulk vs. Impulse Energy
Bulk
3.0
2.0
1.0
Extended Nip Simulation
Conventional Nip Simulation
50 100 150 200 250 300 350 400 450 500 550 600 650 700
Impulse Energy
(squares)

GRAPH 3

Scott Bond vs. Impulse Energy

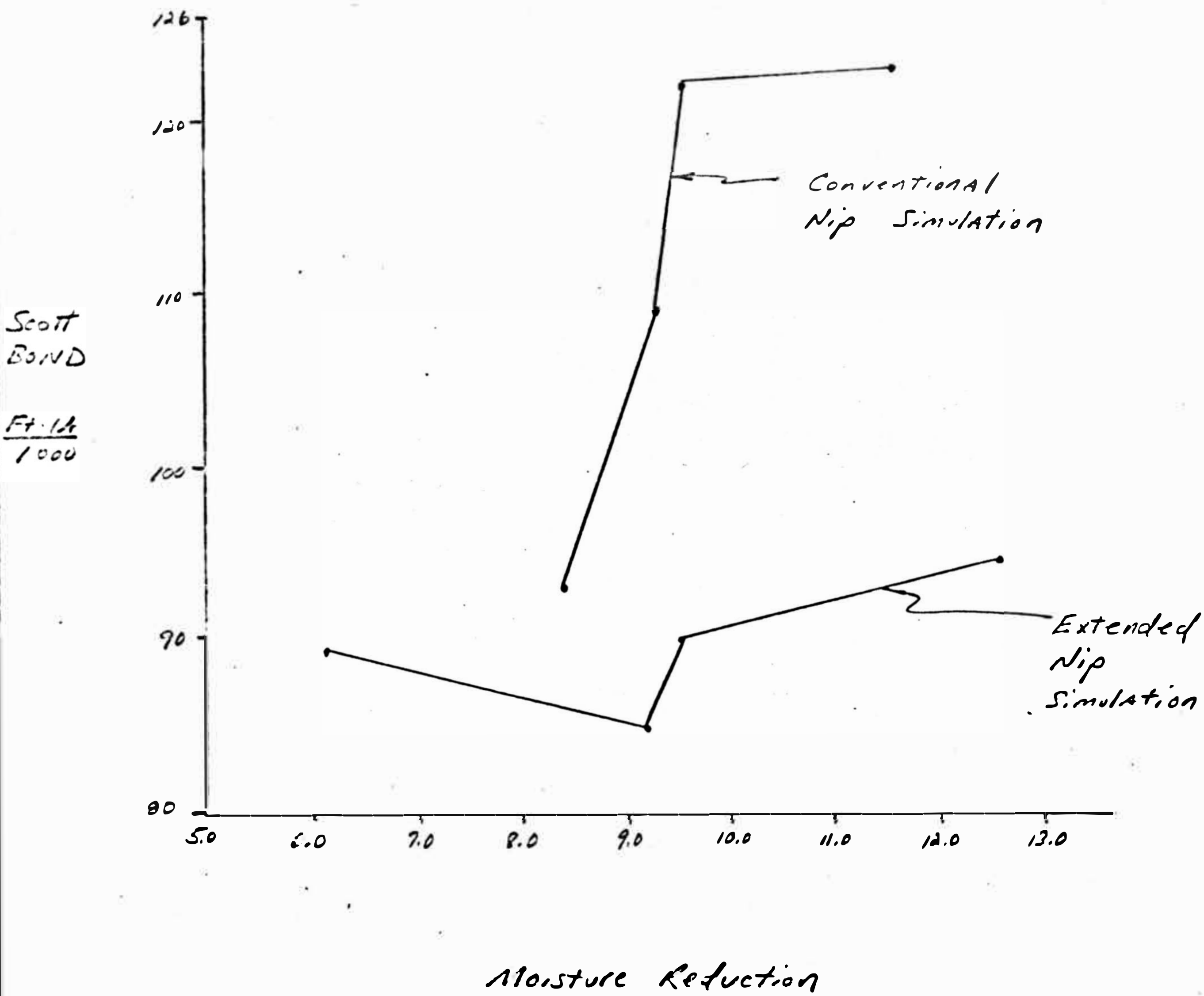


GRAPH 4

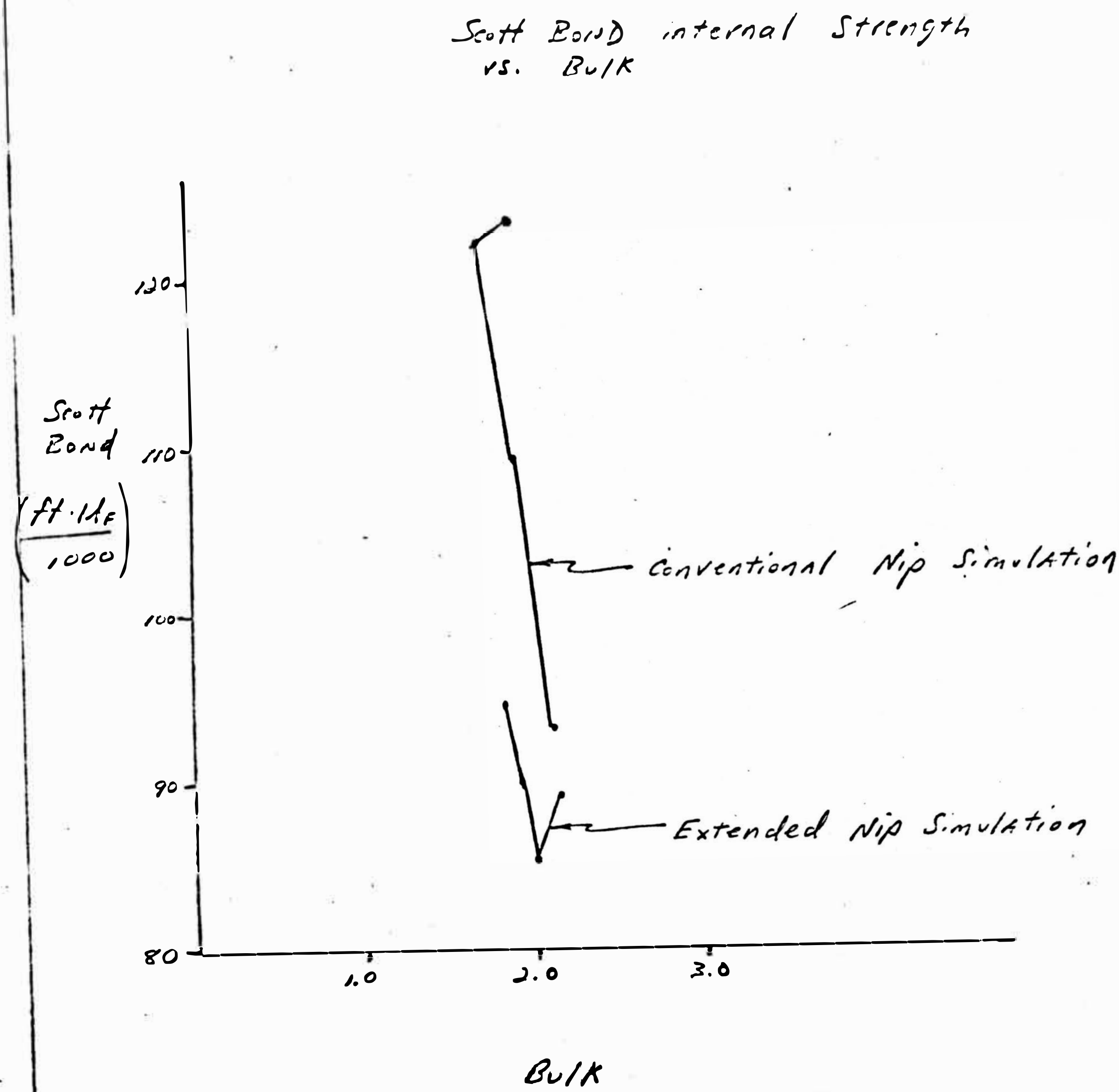

Bulk vs. Moisture Reduction
Bulk
2.1
2.0
1.9
1.8
1.7
1.6
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
Extended Nip Simulation
Conventional Nip Simulation
Moisture Reduction
%

GRAPH 5

Scott Bond vs Moisture Reduction



GRAPH 6


Scott Bond internal Strength
vs. Bulk
Scott Bond
(ft·lbF / 1000)
120
110
100
90
80
1.0
2.0
3.0
Conventional Nip Simulation
Extended Nip Simulation
Bulk

GRAPH 7

with increased energy input. The curve produced by the conventional nip simulation for bulk vs. energy shows a large dip and small increase with increasing energy. The reason for this discontinuity in the general trend is unknown. It is observed that the extended nip pressing simulation imparted more bulk than the conventional nip simulation. Evidently, a longer nip dwell time in combination with lower maximum pressure is more beneficial for high bulk.

A very interesting relationship was noticed between Scott bond and impulse energy. For the conventional simulation, a steady increase in internal bond strength with increasing energy input occurred. In the extended nip simulation, Scott bond decreased initially, then increased slightly with increasing input energy. This discontinuity was very small and played no role in the interpretation of the overall data.

The internal bond strength from conventional pressings were greater than those generated by the extended nip pressings. This relationship occurred at all energy levels.

At the levels studied in this experiment, crushing did not appear to be a major factor in sheet strength. The conventional nip simulation pressings compacted the sheet to a greater degree producing a higher level of bonding.

Moisture reduction in the sheets from both types of pressings were not extremely different. At the medium pressing levels they were almost equal; therefore, moisture in the sheet did not play a large role in the internal bond strength differences. It is also interesting to note that bulk remained higher for the extended nip simulation than that of the conventional nip at all applied impulses. The increased nip dwell applied by the extended nip provides more dewatering with lower compaction. With this combination, the extended nip simulation imparts higher bulk and lower strength.

A comparison is made between bulk and internal bonding in graph 7. This plot shows that the conventional pressing configuration gives much higher strength, at equal levels of bulk. It is believed that this occurred because crushing was not a factor in the strength of the samples. At the impulse energy levels used, crushing was not observed. This may be due to the condition of the wet web before pressing, or to the lower levels of pressing used. Perhaps, at high press loadings, the conventional roll nip pressing would cause crushing thus reducing strength. However, all evidence produced by this experiment point to conventional roll nip pressing as the best method to obtain higher strength with maximum bulk.

CONCLUSION

The following statements regarding the comparison of conventional roll nip pressing and extended nip pressing are evident:

1. Extended nip pressing gives higher dewatering rates than conventional nip pressing at comparable energy levels.
2. The longer nip dwell time and lower maximum pressure imparted by the extended nip press is more beneficial for higher bulk.
3. Conventional roll nip pressing imparts higher internal bond strength when crushing is not a factor. Also, this type of

pressing gives higher bulk at specific strength levels in comparison to the extended nip pressings.

RECOMMENDATIONS

The design of the simulator was modified prior to its use in this experiment. Previously, cast steel bearings were mounted on the weight platform to guide the hammer on the upright posts. The cast bearings tended to shatter under high loadings. Brass bushings now serve the same purpose. Also, the catch system was lengthened to allow the simulator to catch the higher rebounds after pressing. With these modifications, the simulator worked very well. The only recommendation which can be made for its use is that all moving parts should be kept well lubricated.

Another recommendation for anyone studying wet pressing with the simulator would be to use higher press loadings. It would be interesting to see the effect of higher loadings on the strength and bulk properties. Also, the higher loadings may have produced crushing.

Examining different types of furnishes would also be a good idea for anyone comparing conventional nip to extended nip pressing. The softwood used in this experiment may have been very flexible and resistant to crushing. A study comparing various types of pulp may clarify some of the differences in fiber flexibility and brittleness.

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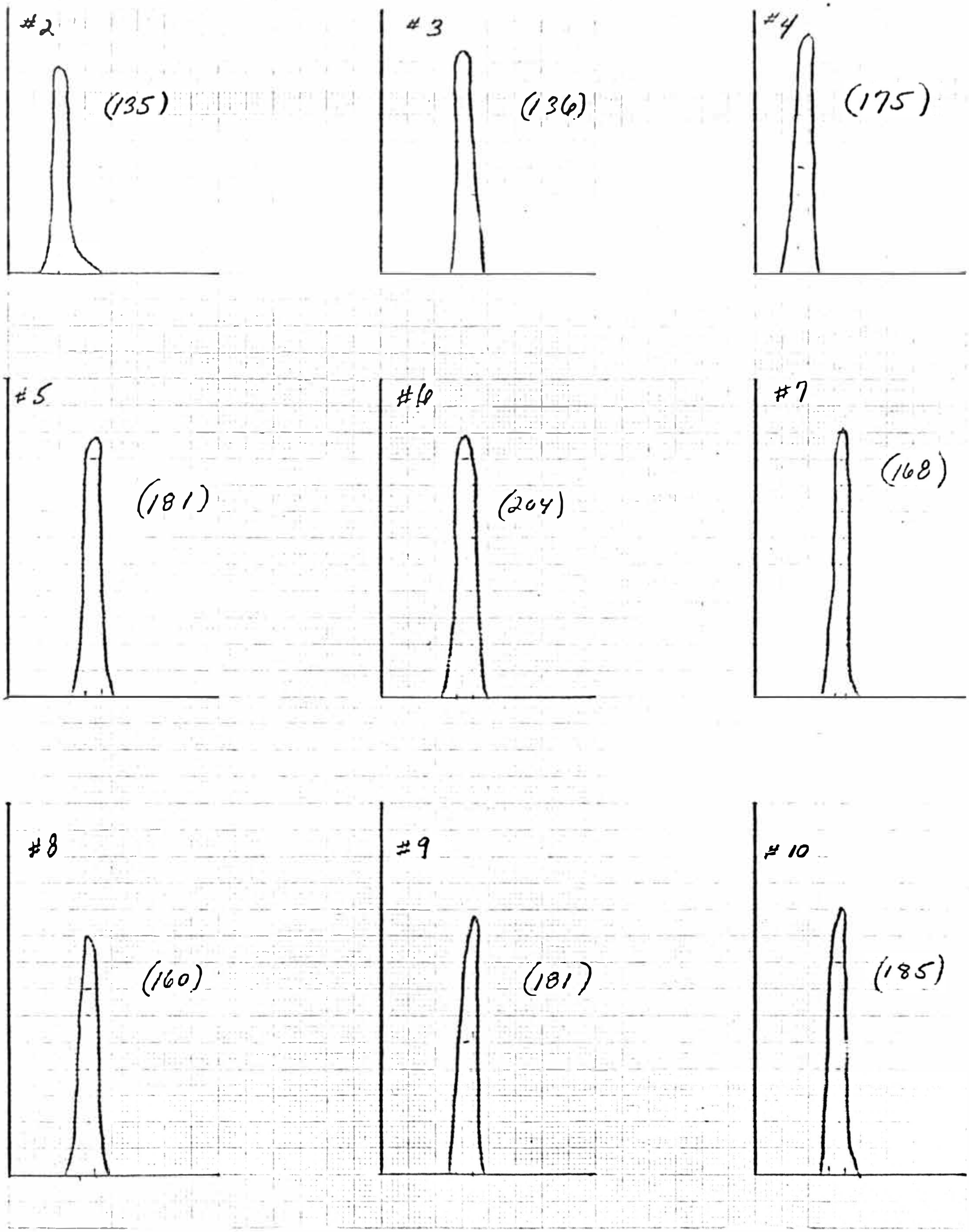
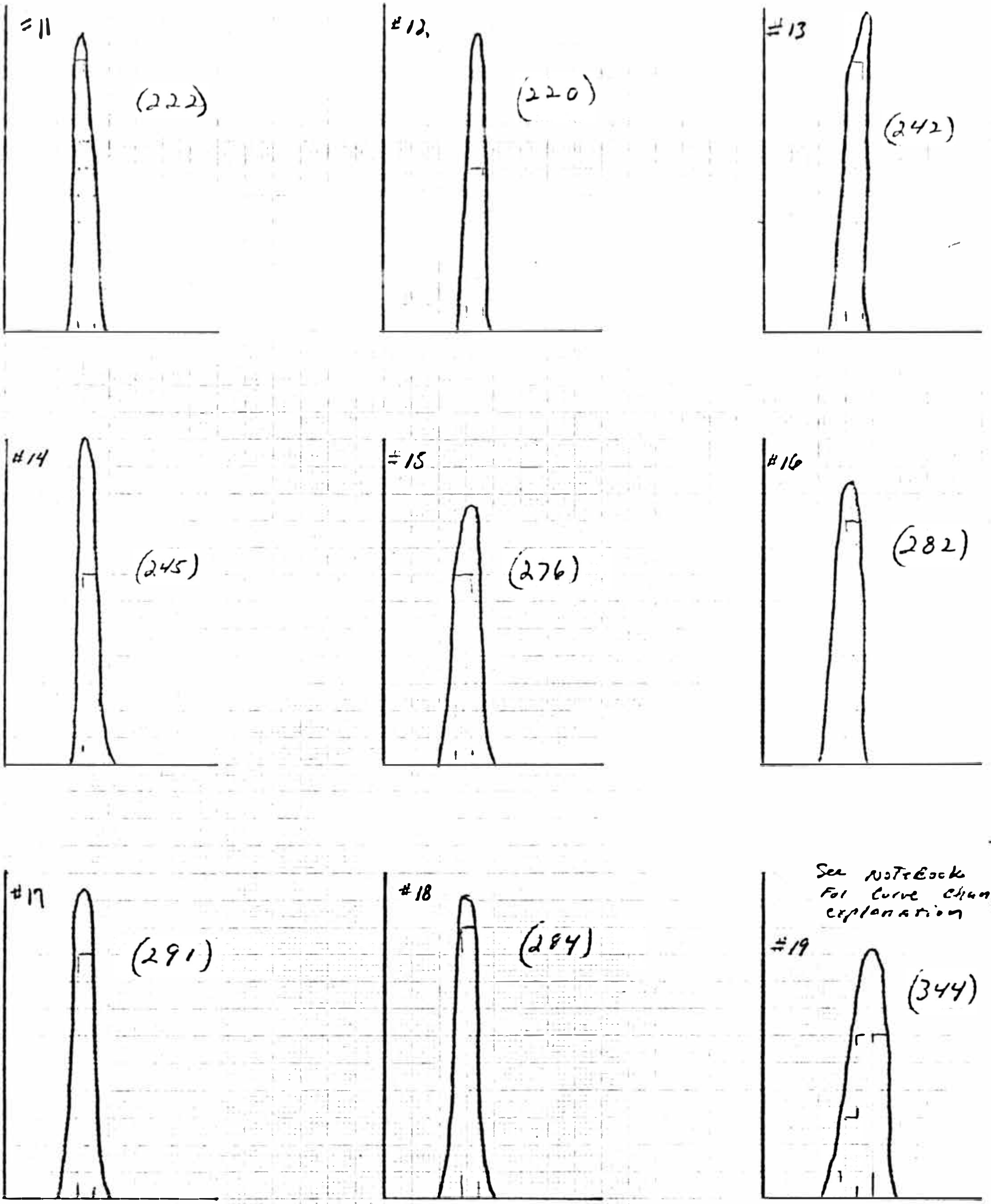
Appendix I

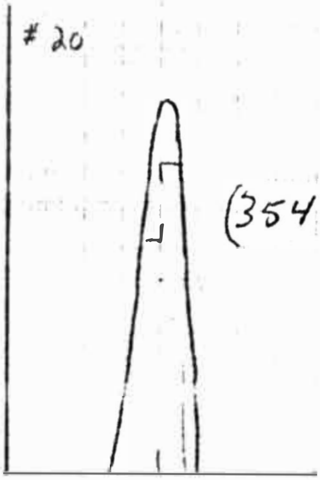
Impulse curves for conventional nip simulation. Horizontal axis-time, vertical axis-pressure.

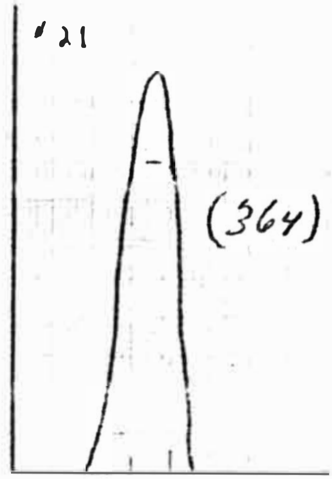


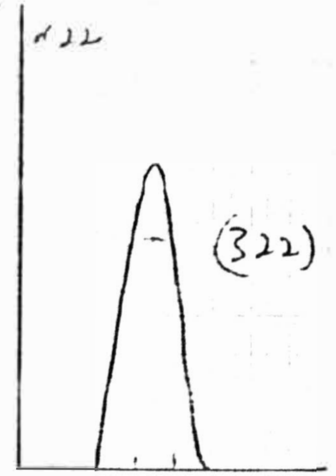
Conventional Roll Nip Simulation (cont)

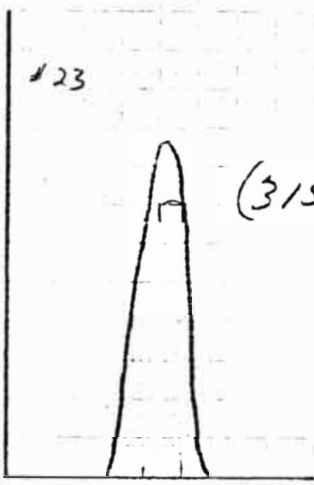


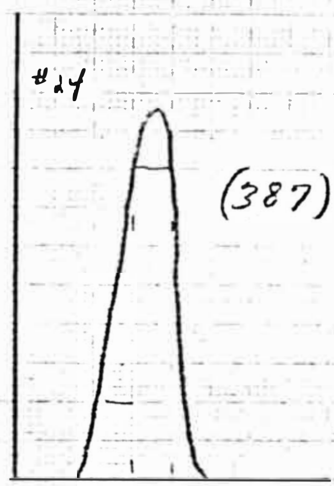
Roll Nip Simulation (Cont)

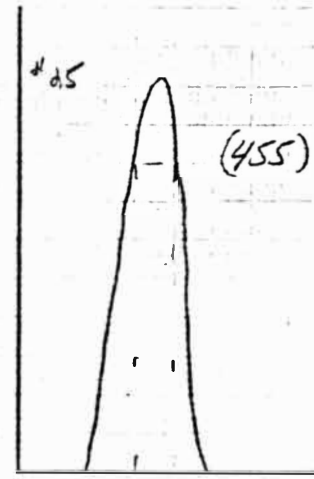


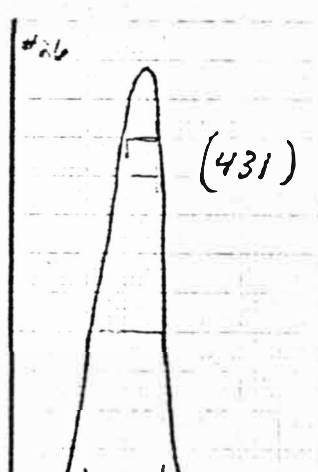


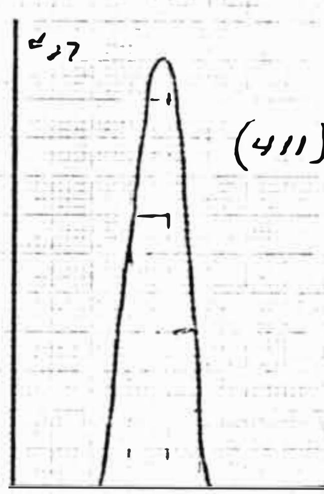


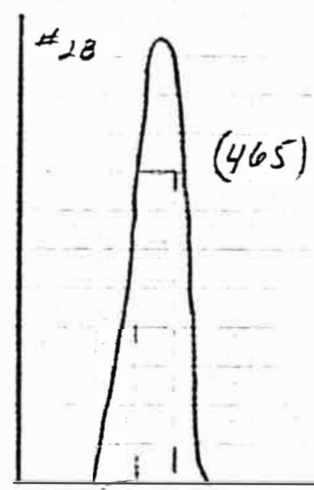




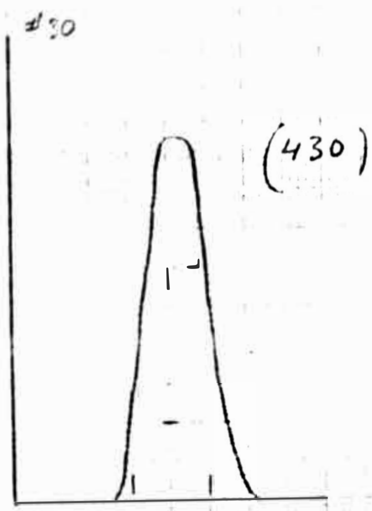


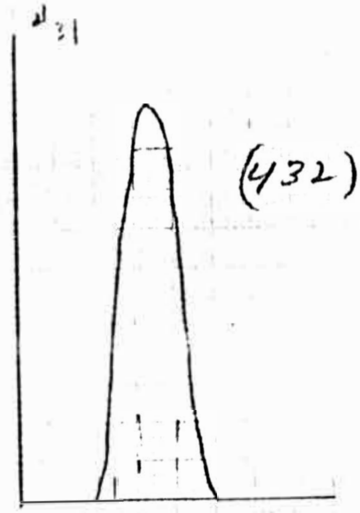


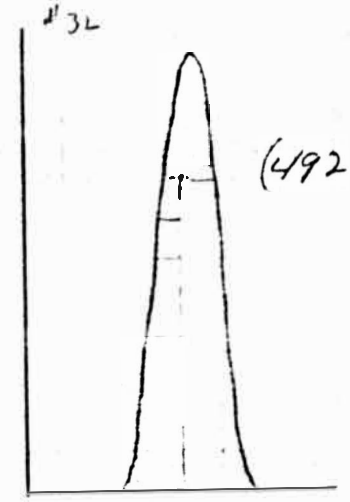


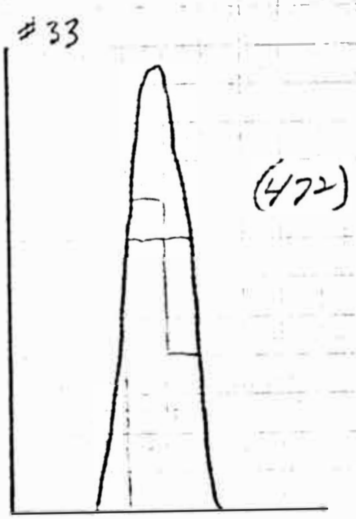


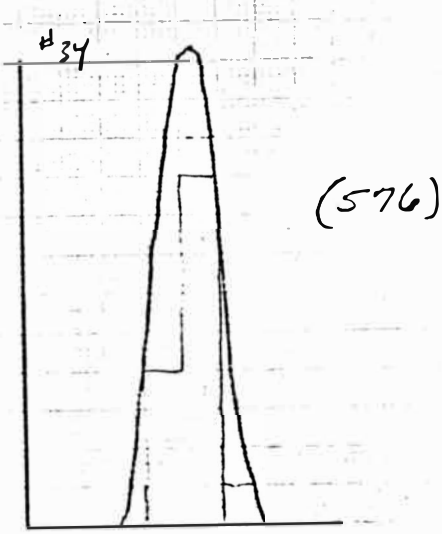
Roll nip Simulation (cont)

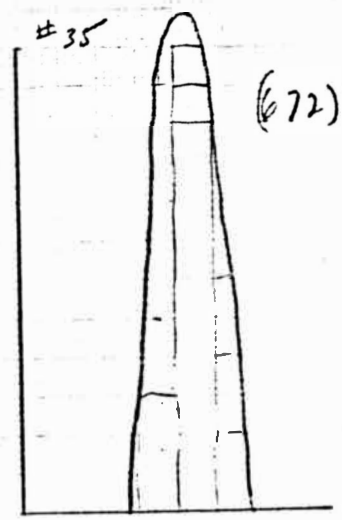




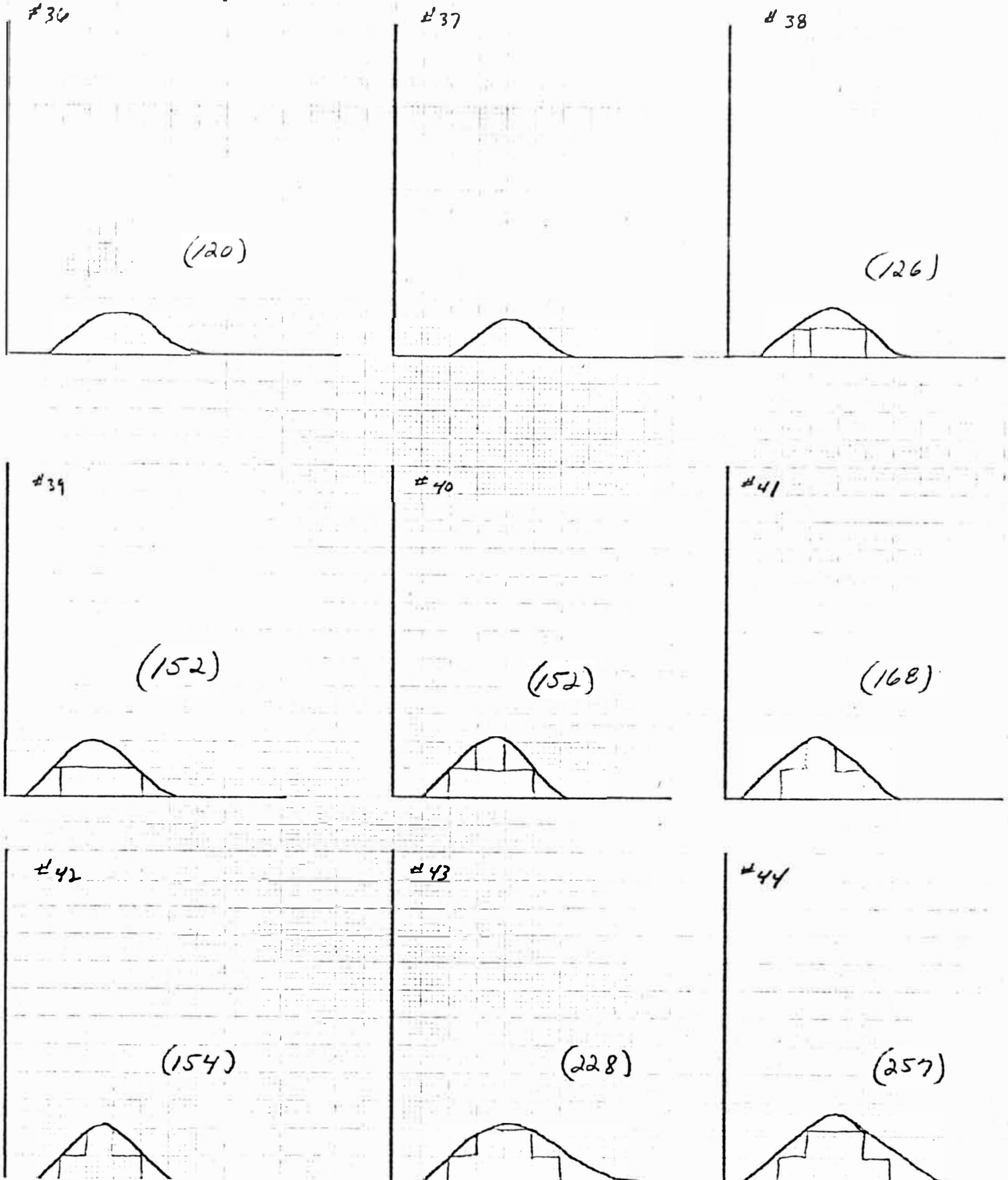




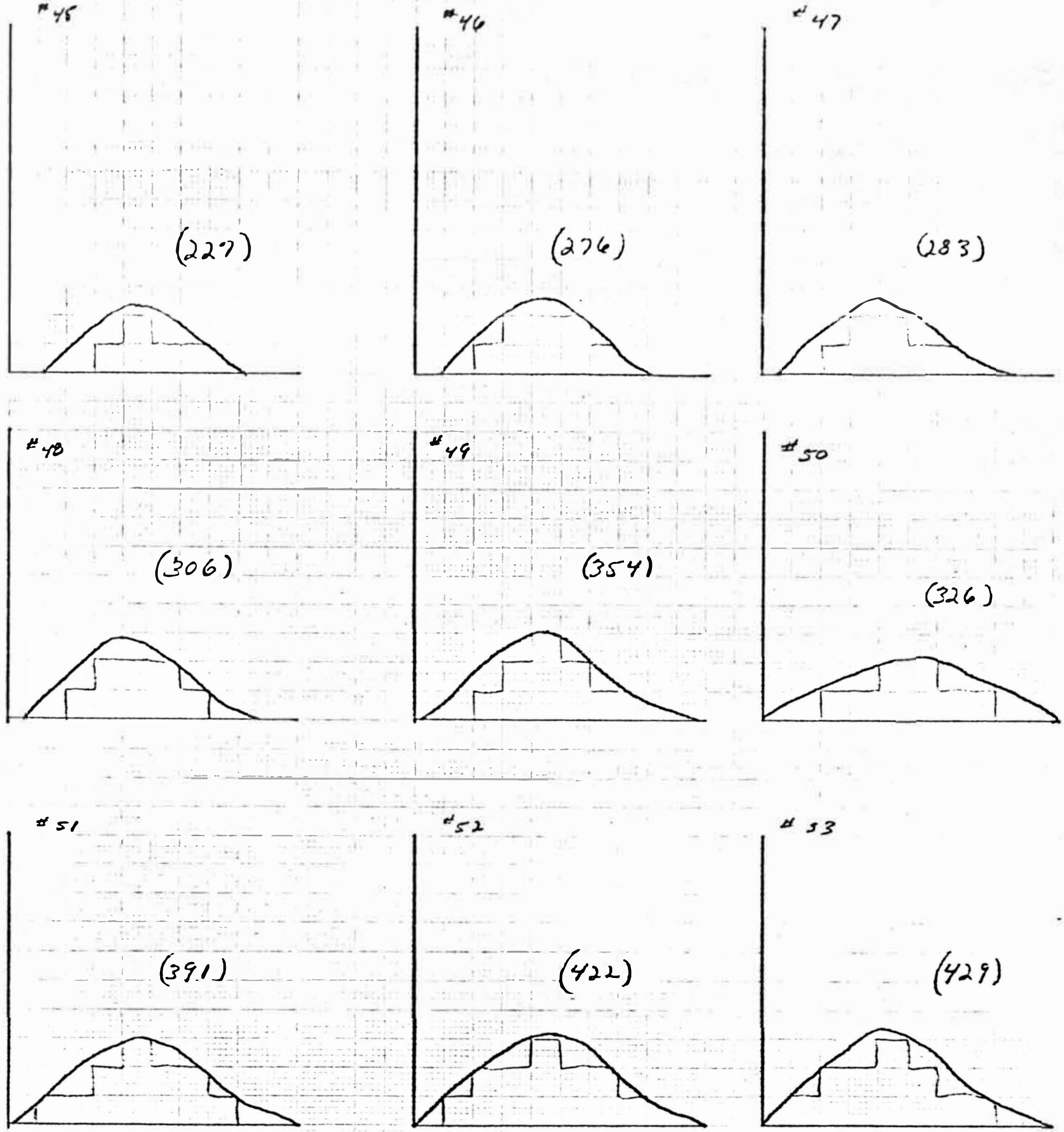




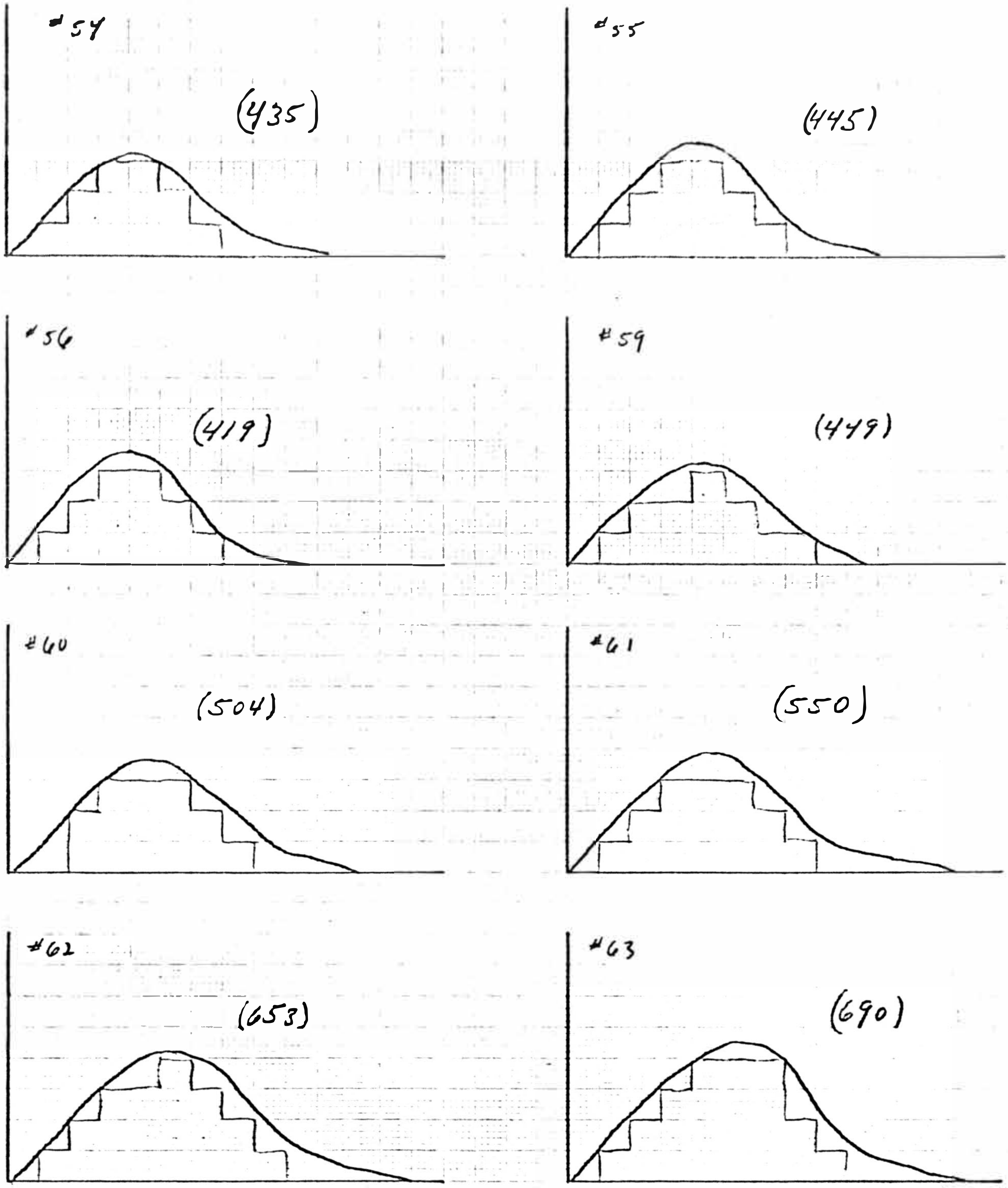
Impulse curves for extended nip simulation. Horizontal axis-time, vertical axis-pressure.



Extended Nip Simulation (cont) Impulse Curves



Extended N/f Simulation (cont) Impulse Curves



Extended Nip Simulation (cont) : Impulse Curves

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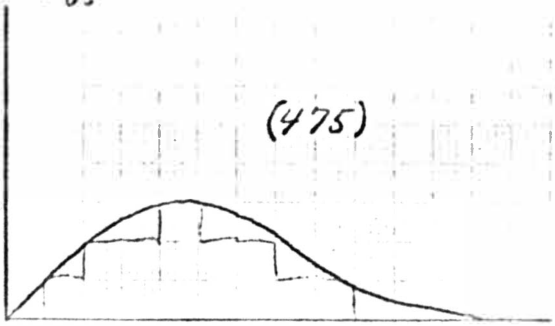

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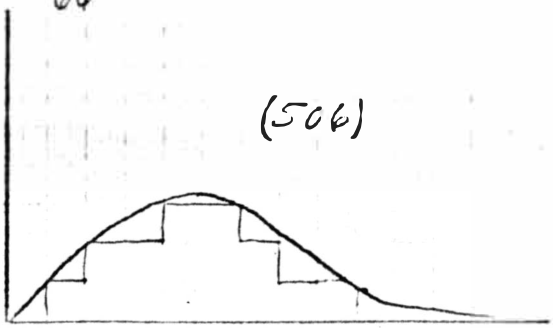

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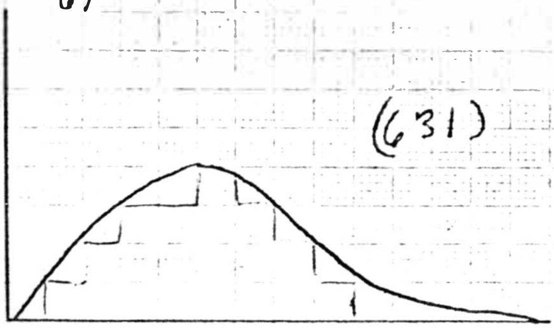

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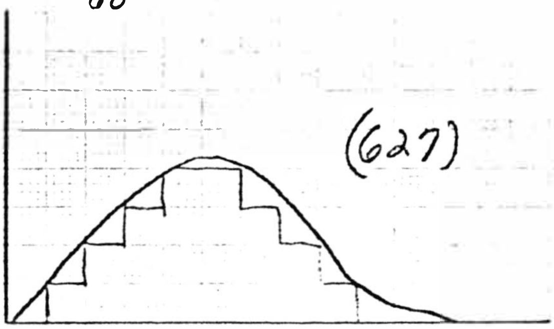

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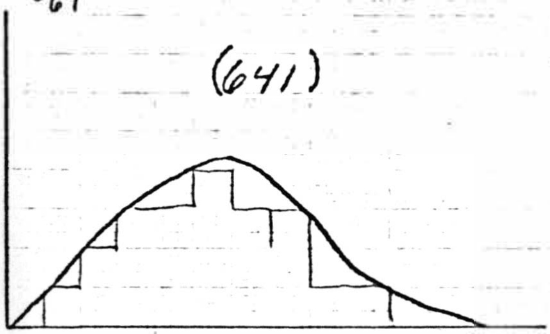

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