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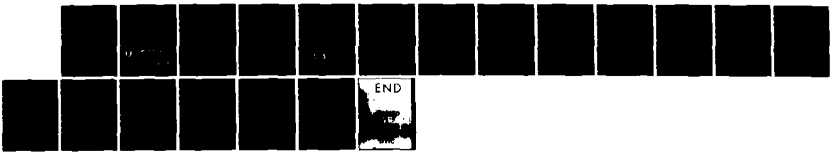

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DESIGN AND MANUFACTURE OF 155-MM MODULAR PROPELLING CHARGES

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AUGUST 1984

U.S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER
LARGE CALIBER WEAPON SYSTEMS LABORATORY
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Molded 155-mm propellant containers of two different lengths which could fit together to form propelling charges of varying sizes and an end cap containing the ignition charge were designed and manufactured. The end cap was capable of withstanding loading stress and could be easily assembled to the propelling charge without tools.

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CONTENTS

INTRODUCTION

A number of 155-mm rigid molded fiber modular charge containers intended for use in advanced artillery applications were manufactured. The containers are designed for ease and adaptability in assembly for zone charge selection, will provide for in-vehicle assembly, and will facilitate automatic handling and loading.

The modular charges were designed and fabricated to allow build up assembly to the higher firing zones rather than torn down to the low firing zone. Commonality in design was required to allow the modular charges to be assembled in any order providing for immediate zone selection capability. Each modular charge (body assembly) consists of a body and base. In addition, the longer body was eventually modified with button holes to allow for insertion of the end cap. The body assemblies were manufactured as follows:

a. 150 to a length of 8.06 inches (-2).

b. 300 to a length of 10.62 inches (-1).

c. 50 to a length of 10.58 inches (-1 revised) as determined by the Project Engineer for study on development of a uni-length modular charge.

Also accomplished was the design, acquisition of tooling for, and manufacture of 25 end caps, which would snap in mechanically and be retained by the rear module of the assembled zone charge, providing for ramming capability while still allowing ignition access.

All parts were manufactured to the composition set forth in Table 1.

The normal beater additive molded fiber process of manufacture (appendix) was used to produce all bodies and bases. The end caps were produced by a modified process wherein the wet preform (felt) after having been felted in a female (cavity) felter, is pre-dried in an oven, allowed to stabilize to atmospheric humidity, then press molded in a split female die using a rubber plug under pressure as a male die, (fig. 1). This process change was instituted due to the need to mold undercuts (attachment buttons) on the sidewalls of the end cap, (fig. 2). This process represents a tradeoff between the bag molding process currently being used by Armtec to produce the M203E2 igniter cup containers, and the dry preform process which has been used for a number of years in the manufacture of other combustible fibre components. It is the first time a hydraulic rubber plug has been used to successfully mold combustible fibre material.

CONTRACT PERFORMANCE

Modular Charges

The initial complement of 450 bodies and bases were felted and molded, using existing tooling that had been refurbished, with little trouble. However, during the trimming operations, on the molded bodies, it was noted that age and rework on the molding tools resulted in a molded part that was fragile in some areas and untenable on an extended production basis. Male die drainage grooves had been widened to approximately 0.300 inches by cleaning and rework, resulting in large drainage groove ribs and a significantly weaker sidewall. Machining of the nominally 0.080-inch-thick sidewall at the open end of the body to provide for assembly to the base, resulted in an extremely thin, weak base entry area which was emphasized by any out of roundness of the part in that area, even if within drawing tolerance. The parts were trimmed, inspected and shipped. See Tables 2 and 3 for results of the inspection.

End Cap

This portion of the contract required the design, tooling for, and manufacture of 25 end caps for the open (ignition) end of the body assembly. The end cap design was coordinated between Armtec and the ARRADCOM project engineer. The end cap is inserted into the open end of the body. It is held in place by means of four equally spaced sidewall protrusions (buttons) which are received by four corresponding holes in the body sidewall.

Tooling to produce this part required special consideration due to the molding die undercuts caused by the sidewall protrusions. The existing process to manufacture a similar product (the M203E2 igniter cup container) required a two stage molding operation consisting of a first stage normal die-dry molding, and a second stage bag molding operation. The process makes a very acceptable product, but is quite expensive in equipment and double tooling costs.

In order to reduce tooling costs, it was decided to attempt to make the product by a new process utilizing a pre-dried felt (dry preform) made in a female cavity felter and molded in a basic steam-heated die jacket with the mold die being a shaped rubber plug similar to those used in the hydroforming of sheet metal. Initially the rubber forming plug was permanently attached to the steel pressure cylinder, so the plug would move with the cylinder on opening of the press. However, initial efforts with this design showed that the cylinder and the plug, moving as a mass upon press opening, would create wrinkles in the sidewall. This was due to the extruded rubber (under pressure) not being able to relieve its internally built-up pressure as quickly as necessary to prevent sticking to the product inner walls. To obviate the problem, the plug was detached from the cylinder and inserted as a loose piece (fig. 1).

A Molding die, for the manufacture of the rubber plug itself, was fabricated by Pacific Moulding Company and two rubber plugs were made. Molded plug diameters were not entirely correct so a method was devised to machine the rubber plug diameters making mold rework unnecessary. With the new process, machine trimming of the molded end cap is minimal. The only trimming required is deflashing the four button holes and trimming to length. The 25 end caps were inspected and shipped along with the final 50 body assemblies. See Tables 2 and 3 for inspection results.

Modular Charge

The length selected for the final 50 modular charges was 10.58 inches. These parts were felted, molded, inspected and tested. The bodies were hand stretched after molding to a slightly larger outside diameter at the open end to provide for more even trimming of the base-end cap receiving area. This resulted in a stronger sidewall in this location and allowed the end cap to be forced into place with only slight tearing of the button holes in the body on assembly trials. Assembled units were loaded with 10 pounds and 30 pounds of lead shot and drop tested from three feet. All passed with no breakage. Twenty-five were punched to receive the end cap and were shipped with the end caps. Inspection and testing results are reflected in Tables 2 and 3.

Based upon the above results and anticipating the difficulties of inserting the newly designed end cap into the existing body, the body design was modified to allow easy insertion of the end cap. New molding and felting tools were designed and purchased to reflect this configuration.

CONCLUSIONS

1. An end cap of snap-in construction was designed and manufactured successfully by Armtec and ARRADCOM.

2. A new manufacturing method, Rubber Plug Molding, was developed which promises to lower tooling costs on selected products in the future. The rubber plug molding method is successful but it will require further refinement for large scale production.

3. The modular charge cartridge case design is valid and should be proven out by additional production.

Table 1. Nominal composition

Material	% by wt.	Source
Nitrocellulose, 12.6% N	72.0 ± 2.0	Radford AAP
Kraft paper, MIL-C-50269	17.0 ± 2.0	Federal Paperboard Co.
"Marbon 1600" Resin	10.0 ± 2.0	Revertex Ltd.

Table 2. Chemical and physical test results

Batch	NC %	DPA %	KRAD %	Density g/cm^3	Tensile psi	Stability
79	69.94	1.30	28.76	1.028	2284	ok
80	71.46	0.96	27.58	0.960	2216	ok
81	69.78	1.30	28.92	1.024	2276	ok
82	70.98	1.28	27.74	0.954	2329	ok
92	71.12	1.27	27.61	0.830	2083	ok
93	71.73	1.29	26.98	0.820	1787	ok
94	71.38	1.30	27.32	0.800	1875	ok
95	71.79	1.16	27.05	0.833	1828	ok
96	71.79	1.16	27.05	N.R.*	N.R.*	ok
98	71.82	1.17	27.01	0.875	1780	ok
99	71.51	1.27	27.22	0.861	1728	ok

* = Density and tensile not recorded. End cap component did not provide a large enough area to punch a sample.

NOTE!! Dead load tests on the body assembly with end cap using loads of 10 and 30 pounds of lead shot inside the body resulted in no assembly failure, even though three of the body button holes had been fractured inserting the end cap.

Table 3 - DIMENSIONAL INSPECTION RESULTS
(Dimensions in inches except where noted)

P/N 9344132-1, Body Rev B

DIMENSION	AVERAGE	HIGH	LOW
Inside dia. 5.750 ± 0.005	5.725	5.742	5.712
	5.746	5.754	5.739 *
Material thickness 0.080 ± 0.016	0.082	0.091	0.072
Length 10.620 ± 0.020	10.602	10.618	10.591
Straightness 0.125	ok	ok	ok
Depth to shoulder 1.21 + 0.01	1.221	1.277	1.183
Length from bottom to shoulder 9.270 ± 0.02	9.279	9.330	9.210
Ribs within 2 inches from rear visual	ok	ok	ok
Evidence of poor workmanship	ok	ok	ok
O.D. 2nd shoulder from bottom 5.750 ± 0.005	5.726	5.735	5.720
O.D. 1st shoulder from bottom 5.565 ± 0.005	5.535	5.560	5.473
Weight - gm - (information)	256.7	267.0	239.2
Length 2nd shoulder 1.125 ± 0.01	1.096	1.116	1.082
Length 1st shoulder 0.30 ± 0.01	0.266	0.304	0.236

* Refelects 25 units which were shipped with Task II End Caps.

Parts were stretched after molding.

P/N 9344132-2, Body Rev B

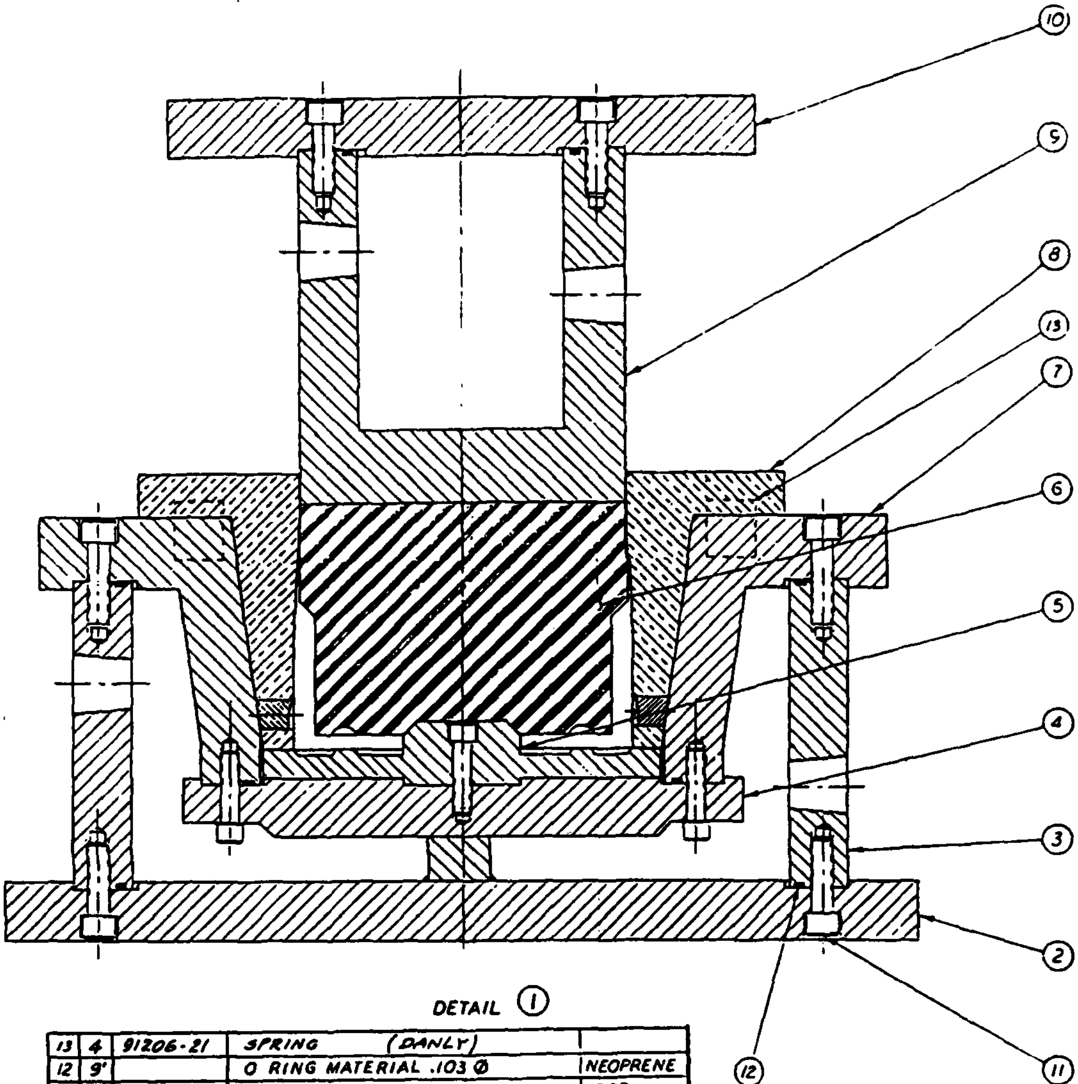
DIMENSION	AVERAGE	HIGH	LOW
Inside dia. 5.750 ± 0.005	5.744	5.778	5.714
Inside dia. 5.680 ± 0.010	5.679	5.684	5.674
Material thickness 0.080 ± 0.010	0.085	0.096	0.073
Length 8.060 ± 0.020	8.088	8.101	8.073
Straightness 0.125	ok	ok	ok
Depth to shoulder 1.21 + 0.01	1.203	1.236	1.143
Length from bottom to shoulder 6.750 ± 0.02	6.780	6.830	6.730
Ribs within 2 inches from rear visual	ok	ok	ok
Evidence of poor workmanship	ok	ok	ok
O.D. 2nd shoulder from bottom 5.750 ± 0.005	5.732	5.741	5.722
O.D. 1st shoulder from bottom 5.565 ± 0.005	5.538	5.543	5.530
Weight - gm - (information)	199.0	206.2	190.6
Length 2nd shoulder 1.125 ± 0.01	1.098	1.114	1.070
Length 1st shoulder 0.30 ± 0.01	0.280	0.292	0.263

P/N 9344130, Base Rev B

DIMENSION	AVERAGE	HIGH	LOW
Weight - gm - (information)	52.8	57.0	42.2
O.D. 5.750 ± 0.005	5.775	5.790	5.761
I.D. 5.150 ± 0.010	5.184	5.197	5.171
Depth to shoulder 0.290 ± 0.010	0.299	0.313	0.286
Material thickness 0.080 ± 0.010	0.094	0.097	0.091
Inside depth base 1.02 ± 0.02	1.024	1.047	1.001
Inside angle 15° ± 1°	15°30'	15°30'	15°30'
Radius 0.062 - 0.010R	0.070	0.070	0.070
Radius 0.125 - 0.010R	ok	ok	ok

P/N 9357961, End cap Rev XA

DIMENSION	AVERAGE	HIGH	LOW
Major O.D. (buttons) 5.95 - 0.02	5.930	5.945	5.922
Outside dia. 5.75 - 0.010	5.754	5.775	5.736
Material thickness 0.100 ± 0.010	0.078	0.085	0.069
Ht. ring bottom to flat 0.125 ± 0.010	0.159	0.170	0.148
Bottom to boss 0.050 - 0.01	0.488	0.505	0.469
Dia. boss 0.475 + 0.010	0.520	0.534	0.497
Spacing of boss	ok	ok	ok
4 inch dia. ± 0.01	ok	ok	ok
Height (trim) 1.00 - 0.02	1.007	1.028	0.993
Sidewall thickness	0.120	0.142	0.096
Weight - gm - (information)	70.1	71.2	69.2
Hole dia. 2.00 + 0.02	2.003	2.006	1.999



13	4	91206-21	SPRING (DANLY)	
12	9'		O RING MATERIAL .103 Ø	NEOPRENE
11	25		3/8-16 SOC. HD CAP SCREWS	SST
10	1	167-001-07	COVER MALE HEAT PLUG	H.R.S.
9	1	167-001-05	MALE HEAT PLUG	H.R.S.
8	1	SHEET 4	SPLIT FEMALE FORMING INSERT	BRASS
7	1	SHEET 2	FEMALE INNER STEAM JACKET	H.R.S.
6	1	167-001-08	FORMING RUBBER	NEOPRENE
5	1	SHEET 3	PLUG	H.R.S.
4	1	SHEET 3	COVER INNER STEAM JACKET	H.R.S.
3	1	167-001-02	FEMALE OUTER STEAM JACKET	H.R.S.
2	1	167-001-01	COVER OUTER STEAM JACKET	H.R.S.
1	1		RUBBER FORMING TOOL ASSEMBLY	VARIOUS

155MM MODULAR CHARGE RUBBER FORMING TOOL

Figure 1. 155mm Modular charge rubber forming tool

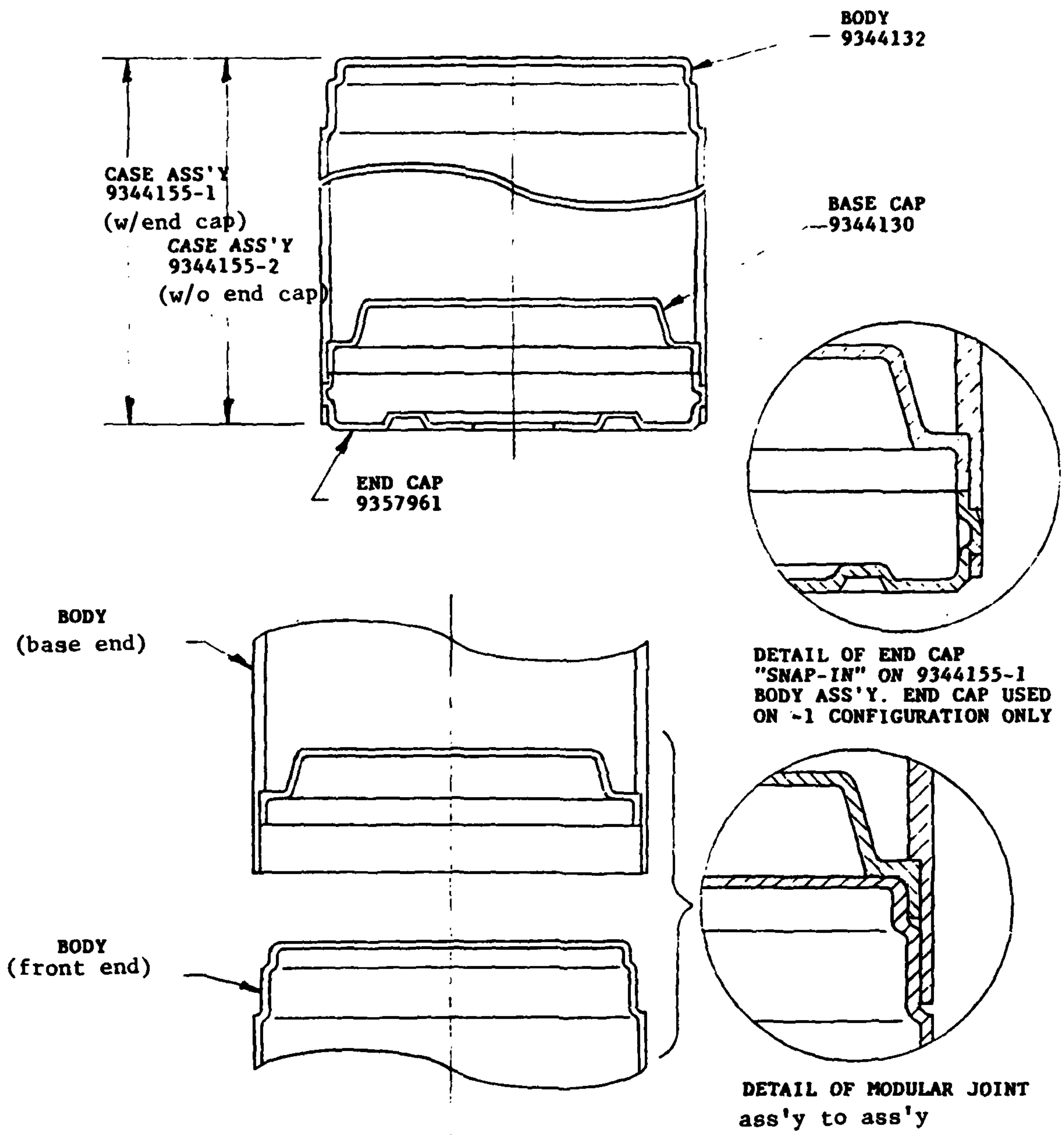


Figure 2. Modular charge details

APPENDIX

BEATER ADDITIVE PROCESS OF MANUFACTURE

The beater additive molded-fiber process is a manufacturing process for making molded products using modified pulp and papermaking procedures to produce an end product from mixed fibers and plastic resins.

The basic raw materials are nitrated cotton linters (Nitrocellulose) and natural cellulose fibers (Sulfite Kraft). Emulsified resins are added as binders for strength, moisture repellency, and other desirable characteristics. The natural fibers are hydrated and reduced to their unrefined state (i.e., individual fibers) in a beater with water to the freeness required by subsequent processing.

Nitrocellulose is added to the Kraft paper slurry in the beater and mixed until homogeneous. Resin is added to the slurry at this time along with the necessary chemicals and ionically precipitated to the individual fibers. Resin particles may be precipitated to the individual fibers, either anionically or cationically dependent on resin system used. Best results are obtained with smaller resin particles forming a sheath around each individual fiber, thus preventing mechanical dislodging of the resin from the fibers during subsequent processing. Nitrocellulose stabilizers are also added during the precipitation process. The slurry batch is transferred by pump from the precipitation tank to a large slurry supply tank where it is diluted with water to the proper consistency for the felting operation which follows. A consistency of 0.2% to 0.4% is generally used although thinner or heavier consistencies are feltable. Ideal consistency is largely dependent on product configuration.

The slurry batch is then pumped to the preforming tank. The slurry enters the tank at the bottom, fills it and overflows into a trough around the top circumference of the tank, creating a weir action. The slurry then flows to a pump where the material is returned to the supply tank on a continuous basis. This in-flow/out-flow of slurry provides the agitation required to keep the fibers in uniform suspension in the water. Auxiliary agitation may be necessary.

The preforming die (felter) consists of a hollow, perforated form, contoured to the part configuration, and covered with fine mesh screen. A vacuum line is connected to the hollow cavity of the die. The felting die is immersed into the slurry bath. Water is drawn through the die by vacuum, depositing the resinated fibers on the screen surface. After a predetermined time, the felter is raised out of the slurry with the vacuum still applied for a period of time to remove most of the free water from the resulting preform, leaving a wet felt approximately 60% water, 40% dry fibers and resin. The vacuum is then shut off and a quick, low pressure pulse of air is injected into the die cavity, stretching the preform slightly and loosening the fiber from the screen for easy removal of the preform. The wet preform is removed from the felter and placed over the male section of steamheated, matched metal molding dies, designed to produce a molded part to finished product dimensions, in a press. The male die contains vertical drainage grooves around its periphery which terminate at the base of the die in a vacuum manifold.

The female die is slowly closed over the felt on the male die, forcing water from the felt through the drainage grooves to the manifold by pressure and vacuum, thus molding the part to finished dimensions. The remaining moisture in the felt is vaporized by die heat and evacuated through the vacuum manifold. The resin in the product is cured at this time by the die heat. After a predetermined time, the dies are opened, a pressure pulse of air injected into the die, and the molded part removed. After molding, parts are trimmed and finished, as required, to finished part configuration. They are inspected physically, compositionally tested, as applicable, and packed out.

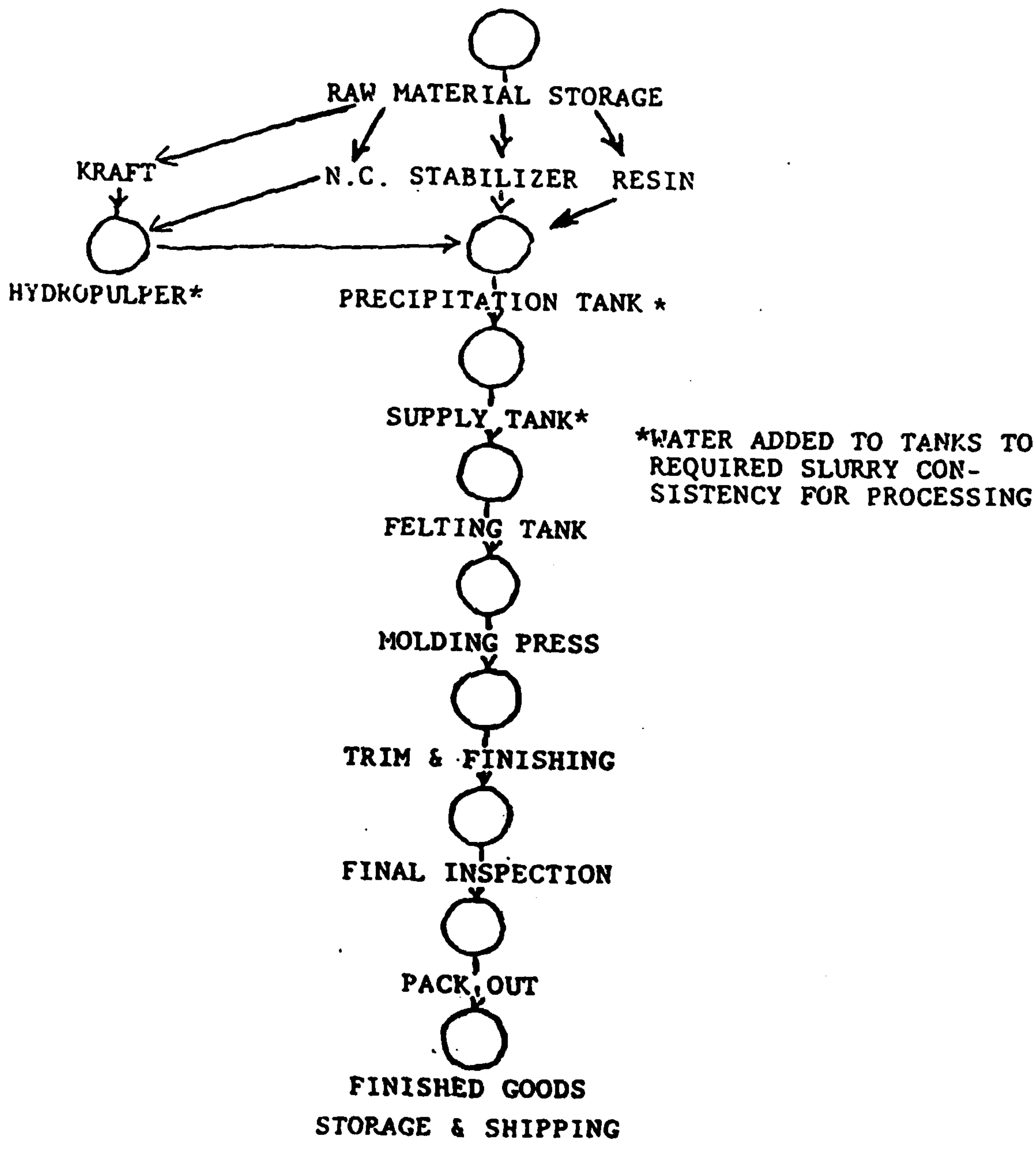


Figure A-1. Beater additive flow chart

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