PLANT REQUIREMENTS FOR MANUFACTURE OF RUBBER SOLING

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
COMMUNICATIONS RESOURCES DIVISION
Washington 25, D. C.

FOREWORD

This brochure is one of a series of reports resulting from overseas technical inquiries on factory or commercial establishments, operation, management, and engineering. The report is designed to provide only a general picture of the factors that must be considered in establishing and operating a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or an endorsement by the Agency for International Development, but merely a citation that is typical in its field.

This report was prepared in September 1956 by the Gidley Research Institute, Fairhaven, Massachusetts, for the industry program by the Office of Technical Services, U. S. Department of Commerce.

* * * * * * *

For further information and assistance, contact should be made with the local Productivity Center, Industrial Institute, Servicio, or United States AID Mission.

Code Number
PR-111

RUBBER SOLING

I. BASIC INFORMATION

Rubber soles for footwear are fabricated and combined with shoe uppers by three general methods.

The first method is the forming of a patterned, uncured sole and cementing it on a fabric upper section and then curing the entire assembly on a last (as in a vulcanizer or autoclave). This is the conventional method long used in making tennis shoes.

The second method is to join a slab (without pattern) of rubber compound directly to a fabric or leather upper section in an automatic heated mold under pressure. This method employs a special machine--typical of which (though varying in design and merits) are the Goliath, Pinto, Bata, Marvel and Desmer machines.

The third method is to separately fabricate and cure (with or without a pattern) the soling itself. The cured or vulcanized soling is then attached to a fabric or leather upper by cementing, sewing or nailing--or combinations of these methods.

It is this third method of making rubber soling which

is the subject of this report.

Essentially, this process consists of masticating rubber, adding pigments and other ingredients, sheeting out the soling compound and then curing it in molds or slabs.

The principal types of rubber soling manufactured are as follows:

1. Individually-molded plain soles.
2. Individually molded soles with surface designs or patterns.
3. Slab-molded soling (plain or patterned surface).
4. Nuclear soling (for example, Neolite).
5. Sponge soles (self-pressure molded).
6. Cork-rubber composite soling.
7. Fabric re-enforced soling.
8. Miscellaneous soling--Neoprene Soling, Latex Cast Soling, Buna N Soling, Jungle Boot Soling, Porous Soling, etc.

II. CAPITAL INVESTMENT REQUIREMENT

Note: The following proposed list of equipment is especially selected and balanced for a modest and efficient overseas installation. By contrast, a large U.S.A. operation would employ somewhat different equipment (such as a large Spiral-Flow, Banbury or Shaw Internal Mixer) and would be more mechanized and conveyorized with a large degree of automation, especially of control apparatus.

However, such equipment is usually only justified where labor is in excess of U.S. $1.80 per hour and where produc-

tion reaches several tons of the product per day. In any case, such capital investment would be prohibitive and unjustified for most overseas operations.

EQUIPMENT LIST

1.	Two Roll Mixing Mill with motor (36" to 60" rolls)	$5,000 to $11,000
2.	Pre-Form Cutter (for uncured stock)	800 to 1,500
3.	Compounding Equipment	500 to 800
4.	Hydraulic Press with 3 to 5 heated platens (90 to 250 tons' capacity)	1,800 to 4,000
5.	Laboratory Control Equipment (Optional)	2,500
6.	Molds (either slab type or individual sole types):	
	a. Slab Type (Patterned)	500 per mold
	b. Individual Sole Type Molds	100 to 180 per cavity
7.	Sole Cutting Dies (needed only if slab molds are used). One die needed for each size.	25 to 65 per die

Note: The total investment needed will not be a simple addition of the items listed, as investment will depend on (a) size mill selected and (b) whether individual soles or slab soles are to be made.

With the smaller mill (producing about 1,500 pounds of

compound per 8-hour shift) and making individual soles (average distribution of sizes), the total capital investment will be about $10,000 (without Laboratory Control Equipment).

With the larger mill (producing up to 3,500 pounds of compound per 8-hour shift) and making individual soles, the total investment will be about $16,000 (without Laboratory Control Equipment).

With the smaller mill and making slab soles, the total investment will be about $9,000 (without Laboratory Control Equipment).

With the larger mill making slab soles, the total investment will be about $14,000 (without Laboratory Control Equipment).

A. Description of Equipment

1. Two-Roll Mixing Mill

This will be used for both mastication (second shift) of raw rubber and compounding mixing (first shift). At least a 50 H.P. motor is recommended on a 36" mill and at least a 75 H.P. motor on the 60" mill. Preferred rolls are hardened steel (stress-relieved); second best are well-made, chilled iron rolls.

2. Compounding Equipment

This consists of a large scale, 200 lbs. capacity, and a small scale, about 10 lbs. capacity, with appropriate pans and containers (preferably metal) which may be locally made. Large two-handled

wash tubs are very satisfactory.

3. Hydraulic Press

For small operations, or where labor is under U.S. 50¢ per hour, this may be a manually-operated hydraulic jack press of about 100 tons' capacity. For larger operations, a hydraulic press (150 to 250 tons' capacity), capable of holding molds 32" square to 44" square, is preferred. Such a press will require an hydraulic pump producing 1,500 to 2,500 pounds per square inch, line pressure in sufficient volume to close the press in 2 to 10 seconds (this usually means 5 to 10 gallons-per-minute pumping capacity).

4. Individual Sole Molds

These molds are preferably tooled and engraved of steel for long life. Emblems, manufacturer's marks, crepe effects, vacuum cups, diamonds, basket-weaves and other patterns may be obtained in such molds. A mold is usually needed for each size and for lefts and rights. If the last 1/2" of peripheral pattern is plain or uniformly covered with a small design (such as dots), then one molded size may be subsequently die-cut to make at least 3 shoe sizes from one mold.

5. Slab Molds

These molds are from 24" x 24" to 48" x 48" and are either plain or patterned. A pattern is recom-

mended (even if only a light stipple or ripple design) as it obscures minor color variations which are often too obvious in a plain mold. The mold may consist of a designed top plate with various thickness female sections to go with it. This allows the manufacture of various sole thicknesses desired.

6. Pre-Form Cutters

These may be locally-made hand mallet dies; or a clicker-type press with rule dies may be used.

7. Cured Slab Cutters

These are also the same as the pre-form dies, but usually more accurately sized for the finished product.

III. LABOR REQUIREMENTS

The labor required will depend on the equipment selected and the type of soling made (individual or slab soling) and on the skill of the labor.

On the average, however, the following list will serve as a good guide:

DIRECT LABOR - DAILY NEEDS

	Individual Soles	Slab Soling
1. Compounding and Stores	1 Man 1 Helper	1 Man 1 Helper
2. Mixing and Breakdown	2 Men	2 Men
3. Preparation	1 Man	1 Man
4. Press Curing	1 to 2 Men	1 to 2 Men
5. Cutting	None	1 Man
6. Inspection and Packing	1 to 2 Females	1 to 2 Females

The potential productivity per day will average as follows (in pairs of soles):

1. Individual Soles (Small Mill) - 1,000 pairs
2. Individual Soles (Large Mill) - 1,500 pairs
3. Slab Method (Small Mill) - 1,200 pairs
4. Slab Method (Large Mill) - 1,800 pairs

To obtain the daily cost per 100 pairs of soles, insert the local cost per man in the above schedule. The men listed are assumed to be semi-skilled labor and the helpers are unskilled labor.

IV. WORK FLOW LAYOUT

The principal steps given in sequence are:

1. Raw Materials Storage
2. Weighing and Compounding
3. Mastication
4. Mixing
5. Pre-Form Preparation
6. Press Curing
7. Cutting (Slabs Only)
8. Inspection and Packing

In the beginning, if tested formulas are used, a laboratory control department is unnecessary for ordinary soling. For larger production or special soles, a single technician may be well employed with the following minimum equipment:

1. Laboratory Mill - 3" x 8" size
2. Small Scales (2)
3. Plastometer (Du Pont Type)
4. Small 8-Ton Hand Press

Additionally, a tensile and abrasion machine would eventually be desirable.

Total factory space layout for the above-described plants would be 35 feet x 50 feet, plus necessary storage space (about 30 feet x 30 feet).

V. ORGANIZATIONAL SET-UP OF TYPICAL PLANT

No particular formal or specific organization is desirable, or even necessary. We suggest:

1. General Manager - 1

   Handling payroll, personnel, costs and sales supervision.

2. Secretary (female) - 1

   For bookkeeping records and correspondence.

3. Operational Labor

   Labor as previously specified.

4. Product Tests

   Occasional plasticity and product tests can be made in spare time by Manager, assisted by the Compounder.

5. General Foreman

   Not needed unless two-shift operation is started.

VI. REPRESENTATIVE CONTROL FORMS

We recommend a minimum of control forms. The following records can easily be kept by the secretary, under the Manager's supervision:

1. Weekly materials used from stores.
2. Weekly payroll totals.

3. Weekly soles produced.

4. Materials costs per sole.

5. Labor costs per sole.

6. Weekly overhead expense (pro-rated per 100 pairs of soles).

7. Utility costs per month (steam, electricity and water).

The Compounder must follow prescribed formulas exactly and make no changes without permission.

VII. RAW MATERIALS AND BASIC FORMULAS

Soling stock formulas vary widely, depending on quality and special characteristics desired, but, in general, a basic pattern of formulation is as follows:

Ingredients	Pounds
Rubber (Natural or Synthetic)	50 to 100
Reclaimed Rubber	100 to 0
Zinc Oxide	3 to 5
Fatty Acid	0.5 to 2.5
Antioxidant	0 to 1
Sulfur	2 to 4
Pigments*	80 to 200
Resins or Oils	5 to 30
Accelerators	0.5 to 1.5

* Carbon Black, Clay, Whiting, Talc, Magnesium Carbonate, Ground Fibers, Cork, etc.

Typical specific formulas follow:

BLACK SOLE STOCK (Formula #1)

(Hardness 90-92)

Ingredients	Quality Grade
Smoked Sheets	75
Whole Tire Reclaim	40
Zinc Oxide	5
Beeswax	1
Carbon Black	80
Mineral Rubber	10 to 20
Stearic Acid	2
Antioxidant	2
Mercaptobenzothiazole	0.75
Diorthotolylguanidine	0.25
Sulfur	4

Recommended factory cure - 12 to 15 minutes at 315°F.

BLACK SOLE STOCK (Formula #2)

Ingredients	Competitive Grade
Smoked Sheets	50
Whole Tire Reclaim	100
Zinc Oxide	5
Carbon Black	100
Mineral Rubber	20
Paraffin Wax	2
Stearic Acid	2
Antioxidant	1.5
Butyraldehyde-amine	1.25
Sulfur	4

Recommended factory cure - 12 to 15 minutes at 315°F.

BROWN NON-MARKING SOLES (Formula #3)

Ingredients	
Smoked Sheets	100
Zinc Oxide	8
Hard Clay	150
Magnesium Carbonate	30
Stearic Acid	2
Glue	10
Montan Wax	10
Antioxidant	1.5
Mercaptobenzothiazole	1.75
Diorthotolylguanidine	0.25
Sulfur	4
Recommended cure - 15 minutes at 315°F.	
Shore Hardness	84-86

WHITE SOLING (Formula #4)

Ingredients	
Pale Crepe	100
Zinc Oxide	10
Lithopone	75
Clay	150
Ultramarine Blue	0.03
Stearic Acid	2
Montan Wax	5
Glue	5
Antioxidant (Non-Discoloring)	0.5
Mercaptobenzothiazole	1.75

Diorthotolylguanidine	0.25
Sulfur	4

Recommended cure - 15 minutes at 315°F.

Hardness	83-85

NUCLEAR SOLING (Formula #5)

(Hardness 88)

Ingredients

Copolymer Resin	50.00
Smoked Sheet	100.00
Hard Clay	100.00
Zinc Oxide	10.00
Cumar Resin	7.00
Paraffin	1.50
Light Petroleum Oil	5.00
Benzothiazyldisulfide	2.00
Tuads	0.15
Sulfur	3.00

Cure - 15 minutes at 315°F.

SYNTHETIC NUCLEAR SOLING (Formula #6)

(Hardness 90-92)

Ingredients

GRS Rubber	100.00
Copolymer Resin	50.00
Silene EF	25.00
Hard Clay	65.00
Cumar Resin	5.00
Light Process Oil	5.00
Paraffin Wax	1.50

Stearic Acid	1.00
Zinc Oxide	5.00
Benzothiazyldisulfide	2.00
Tuads	.20
Sulfur	3.00

Cured 10 minutes at 320°F.

CORK COMPOSITE SOLING (Formula #7)

(Cheap Filler Sole)

Ingredients

Smoked Sheet	10
Reclaim Rubber	100
Mineral Rubber or Hard Asphalt	50
Stearic Acid	1
Zinc Oxide	2
Litharge	1
Benzothiazyldisulfide	1.5
Tetramethylthiuramdisulfide	0.3
Sulfur	4
Cork	100

Cure - 6 minutes at 330°F.

Instructions: Break down the smoked sheet and reclaim rubber on a rubber mill and one-half the mineral rubber. Mix cork and rest of mineral rubber in an internal mixer. Add accelerator and sulfur. Cure in slab form.

CELLULAR SPONGE SOLING (Formula #8)

Ingredients

Smoked Sheets or Crepe	100
Styrene Copolymer*	30

Cotton Flock	8
Benzothiazyldisulfide	0.5
Diorthotolylguanidine	0.6
Tetramenthylthiuram monosulfide	0.1
Sulfur	2.
Stearic Acid	2
Zinc Oxide	5
Antioxidant	1
Cumar Resin	20
Blowing Agent	0.5
Petroleum Oil	10

* Pliolite S6, Goodrite 50, Dewey Almy Resin 43 G, Marbon 8000 or similar.

Instructions: Mix styrene resin on hot rolls, add rubber slowly, cool rolls to 150°F. add rest of materials except sulfur and blowing agent. Slab off hold overnight. Add sulfur and blowing agent on cool rolls. Cure in slab molds (allowing for 25% "blow"). Cure about 10 minutes at 320°F.

SPONGE RUBBER SOLING (Formula #9)

Ingredients

Smoked Sheets (well masticated)	100.00
Zinc Oxide	5.00
Stearic Acid	10.00
Soft Clay	75.00
Whiting	50.00
Petroleum Oil	8.00
Paraffin Wax	2.00
Soda Bicarbonate	8.00

Antioxidant	1.50
Sulfur	3.00
Benzothiazyldisulfide	0.50
Tetramethylthiuramdisulfide	0.06

MISCELLANEOUS SOLINGS

1. Special soling (cheap) can be made by wrapping thin sheets (uncured) of Formula #3 around a cured piece of Formula #7 and then molding individual soles.
2. Fabric scraps can be ground up and mixed on the mill with the previous formulas to give lowered cost and light weight.
3. Special Latex Compound formulas can be cast into inexpensive molds to make individual soles directly (requiring no mill or hydraulic press). This method has certain limitations for most overseas users, as follows:
   a. High cost per pound.
   b. Patent license complications.
   c. Good laboratory controls and technicians usually advisable.
4. Oil Resistant Soling

   May be made of Neoprene, Buna N rubber, or specially prepared natural rubber.
5. Special Use Solings

   Special use solings have been formulated for the following special applications:

   a. Soles resistant to jungle rot and fungi.

b. Non-slip snow and ice solings.

c. Basketball shoe solings.

d. Solings that "breathe".

e. Solings which discourage and prevent the growth of bacteria, odors and deterioration caused by perspiration.

f. Orthopedic solings.

g. Fire-resistant solings.

VIII. APPENDIX

A. Management and Consulting Engineering Firms capable of designing and building Rubber Sole Factories:

1. James F. Mumper Co.
   39 East Market Street
   Akron 8, Ohio

2. Binney Smith International
   New York, New York

3. Continental Machinery Co.
   260 Broadway
   New York, New York

4. Foram Corporation
   76 Beaver Street
   New York 5, New York

5. Gidley Laboratories, Inc.
   Fairhaven, Massachusetts

6. Giffels & Vallet, Inc.
   1000 Marquette Building
   Detroit, 26, Michigan

Also, consulting chemists or chemical suppliers should be separately consulted to provide specific formulas with maximum utilization of available local raw materials:

1. Rubber Chemicals Division
   E. I. du Pont de Nemours & Co., Inc.
   Wilmington, Delaware

2. Gidley Laboratories, Inc.
   Fairhaven, Massachusetts

3. V. L. Smithers Laboratories
   70 Cherry Street
   Akron 8, Ohio

4. R. R. Olin Laboratories, Inc.
   Akron 9, Ohio

5. R. T. Vanderbilt Co.
   230 Park Avenue
   New York, New York

G L O S S A R Y

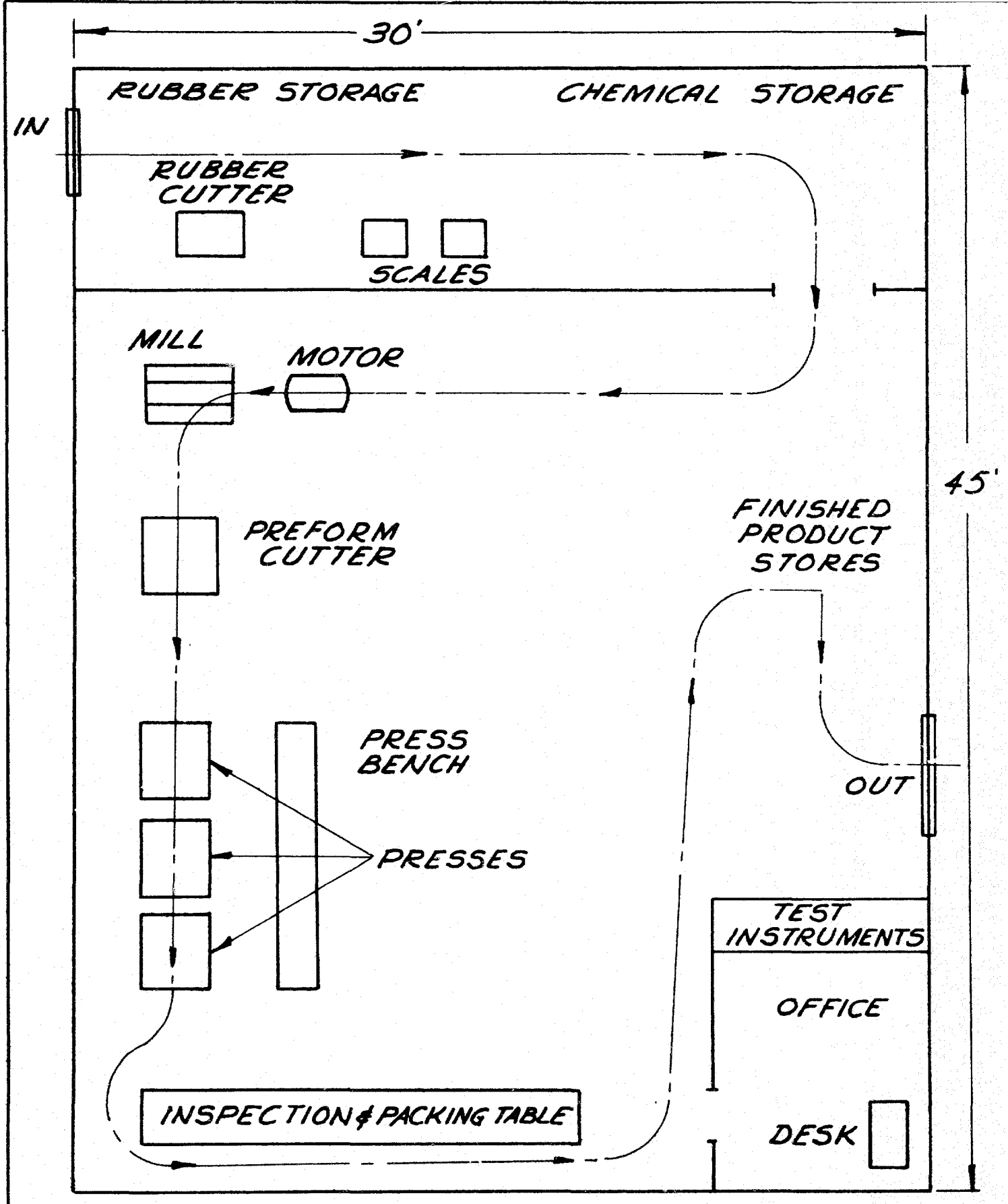
1. Plastometer = An instrument for measuring the softness of an uncured rubber compound.

2. Nuclear Soling = A soling stiffened or hardened by a low gravity resin or hard co-polymer rubber.

3. Pre-Form = An uncured piece of rubber compound cut or shaped to approximately the size of an individual mold cavity.

4. Mastication = The breakdown or softening of crude rubber on a mill or in an internal mixer.

5. Mold Release Agent = A water solution of a "soapy" material to avoid sticking of the cured rubber soling in the mold cavity.



RUBBER SOLING LAYOUT