DEVELOPMENT OF THE DESIGN OF A HIGH FREQUENCY GLUING MACHINE

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TABLE OF CONTENTS

TABLE OF CONTENTS (cont)

SUMMARY

A redesign of the Gillespie High Frequency Wood Gluing Machine was developed in conjunction with the Pico Machinery Corporation of Los Angeles. The new machine was designed to surpass the competition, and to eliminate some of the manufacturer's problems.

A market and consumer research was made to evaluate the competition and to determine the size of the market and its requirements. The survey indicated a demand for approximately 5,000 gluing machines. The gluing requirements of the woodworking industry varied widely.

A general research of wood gluing and the comparative methods being used was considered. Studies were also made of the dielectric heating application to wood gluing. A patent search was performed to reveal possible infringements and to stimulate ideas for design.

The accumulated information from the surveys was used in the design with modifications as to cost and manufacturing facilities. The main features of the new design are: simpler construction, elimination of installation difficulties, provision for stock variations, selector for conveyor travel, and a new medium of pressure application. The resulting design incorporated the considerations necessary to influence the market and benefit the manufacturer.

INTRODUCTION

It is a fact that two-thirds of the forest is lost during its subsequent manufacture and use. Of the logs brought to the saw mill, only 47 per cent reappears as unplaned lumber. It is further estimated that the building trade wastes 15 per cent and the furniture trade 75 per cent of this lumber. The price of lumber and the decreasing virgin forests has caused manufacturers to consider gluing.

The lamination of wood is an excellent opportunity to use small pieces of wood from the sawmill waste as well as successful milling of low grades of lumber which are not suitable for saw timber. Lamination has been encouraged with the new glues and the application of radio frequency to glue curing. In the manufacture of softwood yard lumber large quantities of material in lengths under 8 feet go to waste or are sold for but a fraction of their real value. Short length stock constitutes approximately five per cent of the total volume. Hardwood lumber up to four foot lengths is wasted. All this lumber can be utilized and its price raised by gluing it into panels or cores.

With the new lease on life that the forest products industry received during the war, now is the time to introduce adequate manufacturing techniques, utilize wastes and develop new products. High frequency dielectric heating is one of these techniques.

Machinery is a realm in which the Industrial Designer

has not been too active. A small beginning has been made to this end by Mr. Harold Van Doren. Industry, today, is analyzing the functional requirements of its own plants and equipment with greater sagacity than ever before. The factories are not only getting airier, cleaner and more conveniently arranged, but the machinery prefered is the simplest in organization for use, as it grows more astonishingly competent and complex in its operation.

The invitation to the possibilities in this field led to the selection of subject for this thesis. The Gillespie High Frequency Gluing Machine offered itself as an ideal problem. The machine was just being put on the market, the competition and means of merchandising had not been investigated, nor had the design of the machine been given industrial design consideration. The problem was to perform a market and consumer research, and to study the competition in order to ascertain the factors that would influence and determine the design of a new machine. There were also solutions to be reached on the manufacturer's problems of production, maintenance, and installation.

MARKET AND CONSUMER RESEARCH

Selected Areas

Representative manufacturers were surveyed in the four large woodworking areas of the country. By the representative manufacturers, it is meant those who are leaders and typify their localities. Some well-known consultants on the subject were also included in the survey. A complete catalogue of the persons interviewed is given in the appendix on pages 66-70, (according to their respective areas).

Stages of Making the Survey

1. Preparation of specific statement of the purpose of the survey.
2. Preparation of a job analysis, to insure an understanding of the objective and limitations of the survey project.
3. Investigation of how much of the desired information has already been assembled by other agencies.
4. Bringing together published data available from other sources.
5. Making a field survey.
6. Checking carefully to insure that the assembled information is correct and complete as necessary.
7. Preparing the final report.

Purpose of Survey

The purpose of the survey was to obtain such facts concerning gluing machines as would be of significance to

designer and client. This meant investigating the opportunities for sales by making an intensive study of the status of the woodworking industry, current and anticipated trends in gluing, and the kind of marketing necessary to sell the machine being designed.

Scope Realizations

The information on radio frequency dielectric heating was limited. The high frequency gluing machine being such a new invention was expected to be of great interest to all manufacturers concerned, but very limited criticism was expected for the same reason. It was difficult to find the man with the authority and familiarity of the industry to answer questions on subjects of production, trends of gluing, as well as on the buying practices of the establishment. The various information from surveys made by companies, financial institutions, newspapers, colleges, and government were not available since the interruption of this work by the war.

Assembled Information

The local trade organizations (Furniture Manufacturers Association, etc.), the Chamber of Commerce, and the merchant's associations have not made a survey since 1941. The local businessmen's organizations and the United States Department of Commerce had predictions of enormous expansions in the woodworking industry, but no figures were available. Technical and sales-promotion literature, advertising

material and reports on competitive activities, however, were available. The client's confidential correspondence files with remarks from either potential buyers, or answers to their personal queries of the product, were examined. The sales record was also investigated, but only two machines were sold at the time this work was undertaken.

Field Survey

As a preliminary step to analyzing the situation, information was requested of the client as to his sales policies, costs of various operations, and other such related factors. The client felt that the machine would introduce itself into the industry, by having the prospective customers hear of its production, and go to see it in operation. A selective initial distribution was the sales strategy employed. This machine, or equivalent, would be a necessary piece of equipment to other manufacturers in the area to meet the competition. Selling the machine directly, rather than through dealers, was to insure proper selling and to guarantee the customer satisfaction with the purchase.

The market and consumer analysis was conducted to show the designer and client where to concentrate their efforts:

(a) In the selling of the product

(b) In the engineering improvements of the product

(c) In the appearance

(d) In the design of an entirely new product

Other reasons for the survey were to determine if the present decisions of management were wise and how the machine compared with the others on the market.

It was decided that personal interviews were by far the best method to sample the buyer's opinions. In order to draw forth dependable answers, it was necessary to foresee and parry the suspicions, prejudices and idiosyncrasies of the people who were to give the answers.

At its best, a market survey is a continuous process. It must be realized by the manufacturer that the consumer's desires, needs and uses for products change constantly. Today, the knowledge of radio frequency gluing is very limited. The industry purchases most of its machines by having a salesman sell them one. Pride and a high competitive feeling prevents many manufacturers from seeing his competitor's machinery and their advantages. The woodworking industry does not expect to be able to purchase machines that will operate as they want them to, without making individual changes. Machinery of modern design is prefered to the older designs, if the production is at least the same. The buying habits of the industry are very cautious and slow in accepting new ideas. The elimination of workers and an increase in production figures are looked for in new machines. A need for an improved gluing method is the current problem of 90 per cent of the industry.

Some actual figures derived from the personal interviews with 88 selected persons listed in the appendix are:

Question	Yes	No	Indefinite
1. Do you do much gluing?	98%	2%	
2. Do you expect to do more gluing in the future?	98%	2%	
3. Do you do much special gluing?	30%	70%	
4. Have you noticed any improvements that can be made on your machine?	60%	40%	
5. Do you have gluings larger than 36" wide X 4" deep X (any length)?	5%	95%	
6. Have you investigated any of the gluing machines on the market?	20%	80%	
7. Do you know of better ways to glue than those you are using?	30%	20%	50%
8. Have you investigated R.F. gluing?	40%	30%	30%
9. In your opinion, do you feel high frequency gluing will replace the present methods? (reservations--	90%	5%	5%
10. Would you buy an R.F. machine today if you could get one at your price?	50%	40%	10%
11. Can an average industry (two Taylor clamps or more) afford a machine at a price of $19,000?	90%	10%	
12. Would you rather buy from a manufacturer than a dealer?	75%	25%	
13. Is production of a machine more important than the labor question?	60%	40%	
14. Have you made changes on your machine since its purchase?	85%	10%	5%
15. Do you favor buying well known trade name machines?	80%	15%	5%
16. Do you think the wood industry needs more automatic machinery?	70%	10%	20%

Marketing

The northwest and southern woodworking areas show the greatest promise for the use of high production gluing methods. Today, the market is in the same situation as it was years ago, the value of the machine has to be sold and not the special advantages of a particular model. Scientific purchasing is here to stay. In the next few years, with all sorts of new and promising products being put on the market, the buyers of durable goods will probably buy more and more on the strength of exact technical information. This means that there is a definite need for salesmen. They must have full and exact knowledge of the product and its performance characteristics, as well as, an imaginative insight into its uses and application. The present method of direct selling is recommended, but trained salesmen are needed. A reputable machinery distributor would handle the sales of this machine to the manufacturer's advantage. They are known and have the required sales force. No other method of distribution is recommended because the product needs installation service and training of operators.

The sales promotion and advertising must not only be cleverly conceived and executed, but they must be well co-ordinated with the other marketing weapons. This campaign must be aimed at the right targets, such as production groups of the correlated industries. It also must be big enough and sustained enough to do the job at the right

time, which is now during reconversion. The competitors' techniques of advertising in trade magazines and stressing production figures must be fought with equal measures. This product has a number of features that can be stressed in advertising. The message that could be used as a basis of the advertising appeal is a guaranteed operation of the machine with a saving of $100 a day on the glue clamping methods used today. There must be a well designed brochure as an advertising and promotional support. The media recommended for advertising is the industrial catalogs, trade magazines and direct mail.

Competition

On account of the experimentation with gluing that is going on today, the competition is expected to increase in a few years. The only two machines today that are acting as competitors in the gluing field are the Plycor and the Linderman machines. The Diehl-Dosker machine is not being produced today for sale, nor is the new Taylor machine. The Linderman machine is sold, mainly to be used in the manufacture of boxes and coffins.

The following machines and generators listed are the competition today. The descriptions of these machines are according to available information.

GLUING MACHINES & GENERATORS

MACHINE	CLAMP CARRIERS	PLYCOR	LINDERMAN	DIEHL DOSKER	NEW TAYLOR	RAYTHEON	BOWLING
TYPE	EVAPORATION	STEAM	WEDGE JOINT	R.F.	STEAM	R.F.	STEAM
PRICE	VARIETY	$ 19,000	$ 20,000	$ 19,000	$ 10,300	$ 11,000	-----
PRODUCTION	1000 B.FT./MAN/DAY	3½, 5, 6½, 9½ FT/MIN.	25-45 FT./MIN.	4-30 FT./MIN	3-10 FT./MIN.	8 FT./MIN.	17 FT./MIN.
OPERATION	MANUAL	AUTOMATIC	AUTOMATIC	AUTOMATIC	AUTOMATIC	MANUAL	MANUAL
GEN. POWER	NONE	NONE	NONE	10 KW	NONE	5 KW	NONE
LENGTH LIMIT	SIZE MACHINE	1'-7'	10" - 16'	15" - ANY	10" - 66"	0-5'	0-15'
WIDTH LIMIT	" "	NONE	NONE	37"	NONE	0-3½'	2"-52"
STOCK THICKN'S	SIZE CLAMPS	½" - 1½"	½" - 4"	¾" - 2"	½" - 1½"	⅜" - 1½"	1"-
SIDE PRESSURE	HAND CLAMPS	CHAINS AGAINST A DRAG	JOINT	SPRING DOGS	FAST ROLLS AGAINST DRAG	2 PISTONS	POWER SCREW
TOP PRESSURE	NONE USUALLY	NONE	NONE	INITIALLY ONLY	NOT KNOWN	CLAMP PLATE	" "
FLOOR SIZE	SOME 30'X15'	8'X15'	SOME 7'X65'	4½'X15'	6'X20'	6'X6'	5'-32'
WEIGHT	VARIETY	33,000 #	UP TO 28,500 #	UNKNOWN	UNKNOWN	8,000 #	UNKNOWN
GLUE CURE	50%	30%	NONE	40%	40%	40%	60%
ADJUSTMENT	SIZE OF PANEL	THICKNESS SAW CUT	CUTTERS, LENGTH, THICKNESS	THICKNESS 3- WIDTH	THICKNESS	WIDTH	WIDTH
GLUE-APPLICATOR	NONE	GLUE ROLL	BRUSH	NONE	GLUE ROLL	GLUE ROLL	FORCED ON WITH AIR
			GENERATORS				
NAME	R.C.A.	WESTINGHOUSE	"THERMEX"	"THERMONIC"	"POLIMERATOR"	MANN-RUSSELL	
POWER	4.5 KW.	5 KW	8 KW	3½ KW	6 KW	6.5 KW	
PRICE	$ 3,350	$ 4,000	$ 7,000	NOT KNOWN	$ 4,000	$ 4,000	
FREQUENCY	27.3 MC	ANY	4 SELECTION	15 - 28 MC.	VARIABLE	27.3 MC.	

Patent Search

A patent search was conducted at the Los Angeles Public Library and also during the market and consumer research. The search was necessary regarding the possibility of patent infringement and to stimulate the product development ideas. The only patents issued regarding gluing machines that needed consideration were: #2,317,281 regarding "spot gluing" held by Mr. George Lindquist, #2,320,715 pertaining to steam platens held by Mr. Robert T. Bowling, patent #2,366,588 on steam platens held by Mr. Oscar Boling, and patent #2,408,064 issued to Mr. Hall which is used by the Taylor Manufacturing Company in their new steam press. A great number of patents are pending in regards to presses for gluing, as well as for electrodes and R.F. circuits. The client has patents pending on the cold electrode conveyor used in the machine and claims regarding "Z" pattern gluing.

Summary

The latest figures available from the United States Chamber of Commerce lists 8,500 furniture manufacturers in the United States. This can be used as a conservative figure in estimating a possible number of users of high frequency gluing machines. The number of box manufacturers, coffin manufacturers and specialty manufacturers will more than replace the number of firms listed as furniture producers that cannot afford, or need this kind of gluing machine. Of the 8,500, about 500 can be considered as having

satisfactory machines, 2,000 can be assumed as having strict loyalty to other brands, and about 1,000 must retain their present machines for any number of reasons. The remaining 5,000 are probable buyers of a new gluing machine. These figures are extended from the results of the completed survey.

The survey was conducted in the selected four largest woodworking areas. This survey was most important because of the lack of any assembled information. All the information procured by personal interviews was screened and condensed to reveal only the pertinent facts. It showed that the greatest potential market for this machine is in the northwest and southern sections of the country. Regional distribution has been the method of introducing the machine to the market. The survey revealed that this strategy did not reach the desired proportion of the market. The industry showed the greatest interest in eliminating labor and increasing production. The confidence in well-known machinery manufacturers is instrumental in closing the eyes of some customers to a new manufacturer's product. The basis for acceptance of a new machine is its comparison to known and accepted practices.

One of the most important kinds of sales resistance, that the post war period has revealed, is an unexpected resistance to any product, the buying of which can be postponed. A general insecurity has given further impetus

to the postponement of purchasing. The consumer is very cautious and slow in accepting new methods, but experiences during the war tend to change this practice. The industry is depending upon research foundations or others in the industry to prove the worth of radio frequency gluing.

GENERAL RESEARCH

The following information was gathered during the survey of the industry, or from various literary sources, as technical reports, researches and trade magazines.

Gluing Considerations

The efficiency of a glued joint depends upon, (1) the kind of wood and its preparation for use, (2) the kind and quality of glue and its preparation, (3) the details of gluing, (4) the types of joints, and (5) the conditioning of the joints.

In general, it is more difficult to glue heavy woods than light woods, hardwoods than softwoods, and heartwood than sapwood. Table I, below, shows the classification of the various woods according to their gluing properties. The main considerations are the density and the structure of the wood.

TABLE I

Species	Group	Species	Group	Species	Group
Alder	2	Cypress	2	Maple	3
Ash	3	Elm	3	Oak	3
Beech	4	Fir	1	Pine	2
Birch	4	Gum	4	Poplar	2
Cedar	2	Hemlock	1	Redwood	1
Cherry	3	Hickory	3	Spruce	1
Cottonwood	2	Mahogany	2	Walnut	3

Group 1-woods that glue easily
Group 2-woods glue easily with moderate care
Group 3-woods glue satisfactorily with controlled conditions
Group 4-woods need special treatment

Data is from Forests Products Laboratory, Research department, U.S. Department of Agriculture.

The moisture content of the wood for gluing should be such that when it is increased by the moisture from the glue, it will be as near as practicable to the average moisture content needed in the finished article according to its use. Lumber with moisture content of 5 or 6 per cent is satisfactory for indoor furniture, while outdoor furniture may have up to 10 per cent. The moisture content of pieces for one assembly should not vary, one from the other, by more than 2 per cent. Case hardened lumber must not be glued without stress relieving it by steaming.

The wood surfaces to be glued should be relatively smooth, and above all, they should be true. Machine marks, chipped and loosened grain and other such irregularities are objectionable. Tests of glued joints that had intentionally roughened gluing edges showed no benefits. There is no substitute for good machining preparatory to good edge gluing. If 'glazed' surfaces from dull tools are glued, the joint is very weak because of the layer of crushed fibers. It is advisable to machine the surface to be glued, just prior to gluing, so that the surface will not have subsequent moisture changes.

Straight, plain joints between side grain surfaces can be glued and made substantially strong as the wood itself. The tongue and groove, dovetail, and other shaped joints present the theoretical advantage of larger gluing surfaces, but tests at the Forest Products Laboratory proved these

are weaker because of the difficulty of making perfect fits and the lumber's physical reactions. If a one-eighth inch tongue and groove is used by a plant that uses 10,000 board feet of lumber a day, there would be a waste of $12.00 worth of wood per day at the current prices of, for example, ponderosa pine selling for $125/1,000 board feet. The amount would be $72.00 per week, or a waste of $3,744.00 per year. A tongue and groove or a plain scarf joint is needed for end grain joints in order to get some of the side grain surfaces.

Any one of the thermosetting synthetic resin glues can be used, but the urea and phenol resins have so far been found most satisfactory. These glues have good dry strength and are high in water resistance and durability under damp conditions. Low conductivity glues are recommended to prevent arcing.

Manufacturer's directions should be followed for the preparation of the glues and stated precautions heeded. No guesses should be used in place of specified correct proportions needed. Clean, cool water should be used when mixing glues, unless warm water is specified. The mixed glue should be free from air bubbles, foam and lumps. Mixers, spreaders, and other equipment used with all glues should be thoroughly cleaned every working day. Where water is required in the preparation of the glue mixture, it is generally desirable to reduce the amount to the

minimum needed for a spreadable consistency and to substitute alcohol for about 1/3 of the required amount of water. This results in a quicker drying glue film and a shorter curing cycle.

The amount of glue required will vary with the density of the wood, the moisture content of the wood, the smoothness of the surfacing and the desired permissible assembly period. In general, smooth surfaced woods of low density will require from 50 to 70 pounds of mixed glue per 1,000 square feet of glue joint area. Tests at the Forests Products Laboratory, to compare the strength of joints that had one face of the joint glued as to both, showed no significant difference in the strength. The stock or workroom temperature at the time of gluing should not be less than 70°F, nor higher than 100°F.

The average usuable life of the glues that are used in high frequency operations is from 6 to 8 hours at 70°F, or 2 to 3 hours at 90°F. After the application of the glue, there is no required minimum assembly period, but a delay of 15 to 30 minutes allows a partial evaporation of the solvent and thus reduces the curing cycle.

It is known that good glue joints can be made with pressures which range from a few pounds, such as are exerted on rubbed joints, to 1,000 pounds per square inch. The successful use of light pressures presupposes that the wood surfaces are true and accurate. The viscosity of the

glue, at the time of pressing, the need to bring the wood surfaces into intimate contact, and the crushing strength of the wood affects the amount of pressure that should be applied while curing. The recommended pressures for gluing of different woods are given in Table II, below. The Table is based on the crushing strengths of the various woods at the 7 per cent moisture content. The crushing strength of wood decreases rapidly with the increase of moisture content.

TABLE II

Recommended pressures for gluing of different woods

Pressures (lbs/sq.in.)	200-250	150-200	100-150
Woods	Ash Hickory Maple Oak Birch Beech	Sycamore Walnut Elm Douglas Fir Mahogany Soft Maple	Basswood Cottonwood Fir Hemlock Pine Redwood Cedar Spruce Poplar

These pressures are recommended for wood with moisture content up to 7 per cent. The pressures are considerably lower with increased moisture content and higher temperatures than 100°F.

Investigation of the variations of pressure applications was performed. Progressive application showed improved results over the uniform method. Application of pressure from one end of the panel progressively to the other end showed greater improvement than the method of starting the application in the center of the panel and working outward

in both directions. Further trials using the method of progressive application of pressure were made in regards to having a delay of the full pressure until just before polimerization starts. The theory that the glue is wettest just before polimerization starts suggests itself that this is the time to get all the glue possible pressed into the wood, or forced out of the joint. The film of glue in the glue joint would thus be at a minimum. The variation of gluing conditions prevented conclusive figures and time did not allow further investigation, but an improvement was shown due to the delayed pressure. Downward pressure is needed for any warped stock being used. The method of having top pressure applied before the side pressure is applied provides alignment of the panel being glued. Once pressure is applied, it should be retained without the slightest disturbance while the glue is curing under the high frequency.

In gluing lumber edge to edge, the wood immediately adjacent to the joint absorbs water from the glue and therefore swells. If the glued pieces are surfaced before this excess moisture is dried out or distributed, more wood is removed along the joints than at intermediate portions. Subsequently, when the moisture content becomes uniform, shrinkage occurs at the joints and permanent depressions are formed. These depressions, called "sunken joints", are very conspicuous in a finished panel. Using

high frequency indicates less tendency to cause this, since most of the moisture is evaporated. Added precautions of using lumber with uniform low moisture content, and having a longer assembly period will prevent "sunken joints". Nevertheless, subsequent operations after gluing are not recommended until a lapse of an hour at least, to assure no sunken joints and save the wear on planer blades.

Dielectric Heating

Radio frequency power has been used to overcome what seemed to be insurmountable problems in production of certain products. Dielectric heating applications to wood are for drying and treating lumber, plywood manufacturing, scarf jointing and laminating lumber, and edge gluing, boards and veneers.

The principle of high frequency gluing is a simple application of dielectric heating. Power is taken from the regular power source, and is transformed and rectified by a high voltage rectifier, into high voltage direct current. This power is applied to the vacuum tube that acts as a means of transferring a high voltage direct current to an oscillating circuit at radio frequency voltage. The oscillating circuit, or tank circuit, is composed of inductance and capitance, thus determining the frequency of the power it supplies to the dielectric load circuit. A tuning system is used in the load circuit to get efficient transfer of radio frequency power to the load.

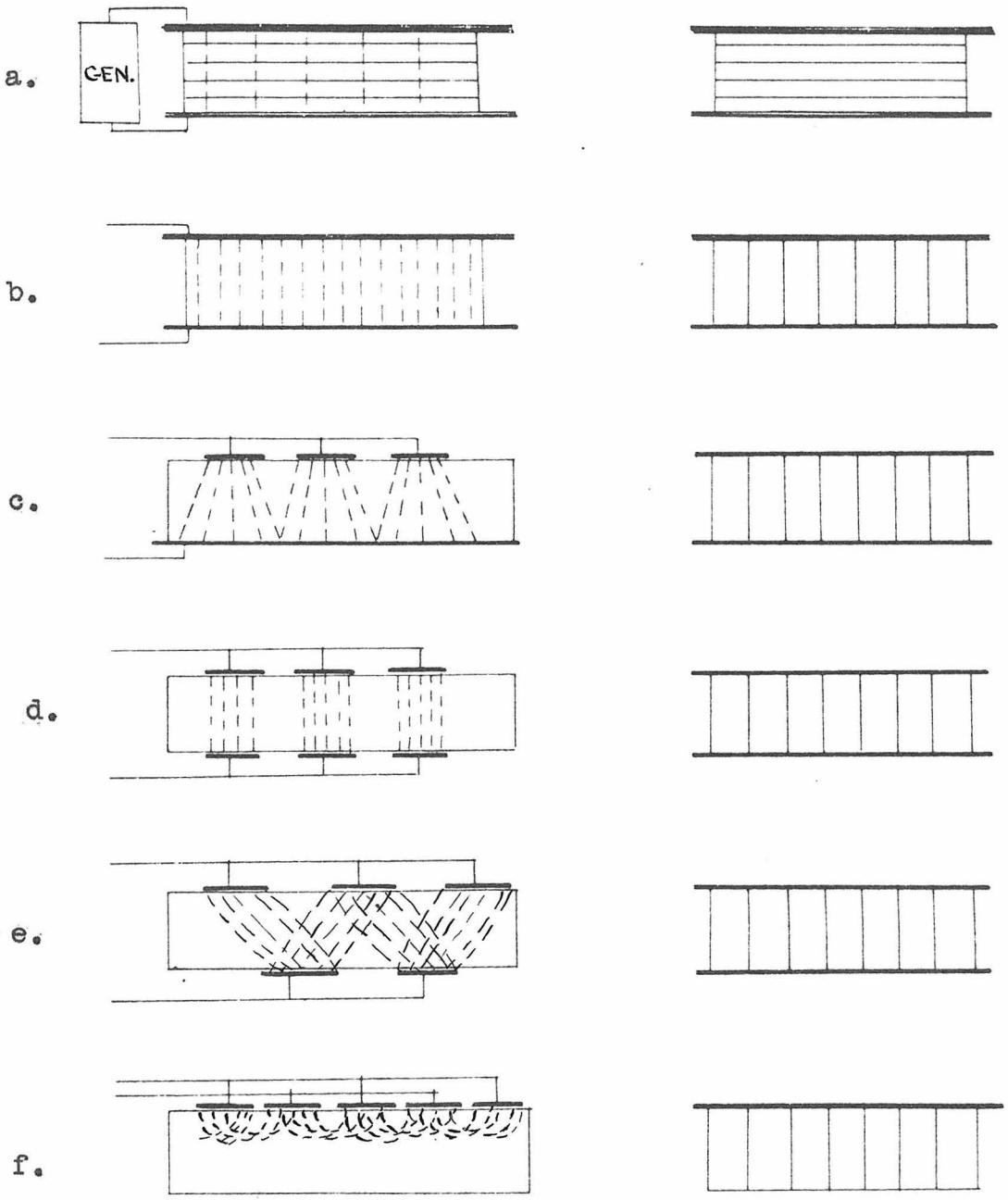
Almost any material known will heat up if an electric current of sufficient intensity is forced through it. Relatively good conductors, i.e., metals, require comparatively low voltages to pass direct or low frequency current. Poor conductors, such as wood or glue, have very high resistances to the passage of direct current or low frequency current. The voltage that would be needed to cause a 60 cycle current to pass through these would be entirely impractical. For example, if it is desired to heat 50 cubic inches of spruce 200°F in 2 minutes, it would require 4,200,000 volts to produce the required current. Therefore, the reason for using high frequency in dielectric heating is that resistance of poor conductors decreases almost inversely as the frequency is increased.

The greater the density or conductivity of the material, the greater is the heat generated in a given time. Thus, when a material of nonuniform density or moisture content is subjected to high frequency, the dense and moist areas heat more readily. Since the glue line contains a high percentage of moisture, the heat is thus concentrated in the glue line rather than being distributed in the wood.

When materials are placed between electrodes in a dielectric heating application, the results depend upon their relative placements. Figure I-a, on the next page, shows the materials in series with the flow of current. In Figure I-b, they are all parallel. Moist glue lines will

FIGURE I

Electrode arrangements for core gluing and resulting pattern.



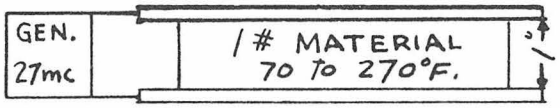
heat much faster than the wood when the arrangement is parallel. The rate of temperature rise depends upon the factor KPF/HD, for materials in parallel. The numerator KPF is known as the loss factor of the material, K being the dielectric constant and PF, the power factor. The denominator is a product of H, the specific heat, and D, the density of the material. When the material is in series, the entire mass must be heated, therefore, the dielectric constant is not directly effective. The heating rate is thus proportional to only PF/KHD.

Electrode arrangements, as shown in Figure I-c,d,e, and f on page 23, provide various patterns and setting percentages of glue lines. Each pattern fulfills certain requirements. The "Z" pattern, for example, has the advantage of setting the greatest percentage of a glue line for a given time period.

The minimum time needed for a given weight of various materials to be heated through the same temperature rise without flashover, is given in Table III-A, on the next page. Wood that has a considerable percentage of moisture can be heated so rapidly that the wood explodes, because of the vapor pressure forcing the water out. Most woods can be heated through a 200°F rise in ten seconds without flashover.

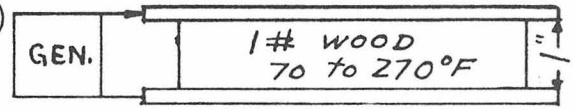
The significant effect of frequency is to set the minimum time in which the work can be treated without

TABLE III



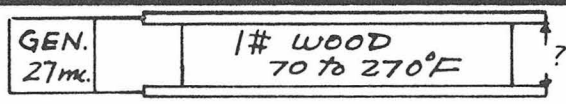
MATERIALS EFFECT

MATERIAL	HD KPF	MINIMUM HEAT TIME TO AVOID FLASHOVER	TRANSFER EFFICIENCY %	POWER REQ'D 1 min. HEAT
WOOD (60% H_2O)	0.1	0.9 sec.	98.2	3.1KW
PYRALIN	0.5	4.2 "	95.5	1.3 "
WOOD (seas'd)	1.1	9.6 "	94.9	2.0 "
LUCITE	9.0	1.3 Min.	68.0	—
MICALEX	26.4	3.7 "	28.6	—
MICA	191.0	26.6 "	6.2	—
POLYSTYRENE	284.0	39.6 "	5.5	—



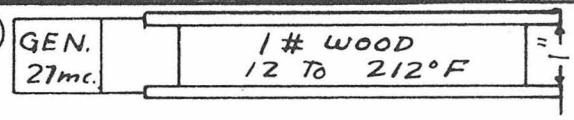
FREQUENCY EFFECT

GEN. FREQUENCY	MINIMUM HEAT TIME TO AVOID FLASHOVER	TRANSFER EFFICIENCY %	POWER REQ'D 1 min. HEAT
2 mc.	68.6 sec.	96.8	—
14 "	15.8 "	95.5	2.0 KW
27 "	9.6 "	94.9	2.0 KW
100 "	3.8 "	93.4	2.1 KW
200 "	2.3 "	92.5	2.1 KW



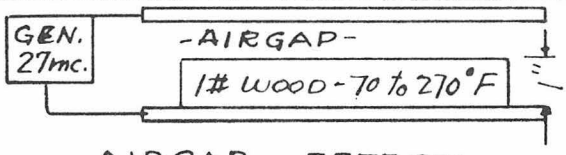
THICKNESS EFFECT

THICKNESS OF MATERIAL (IN.)	MINIMUM HEAT TIME TO AVOID FLASHOVER	TRANSFER EFFICIENCY %	POWER REQ'D 1 MIN. HEAT
0.0004	FOREVER	94.9	—
0.004	0.2 sec.	"	37.7KW
0.008	0.3 sec.	"	9.5 "
1/16	1.4 "	"	2.0 "
1/4	3.6 "	"	2.0 "
1	9.6 "	"	2.0 "
6	33.6 "	"	2.0 "
24	1.5 min.	"	—



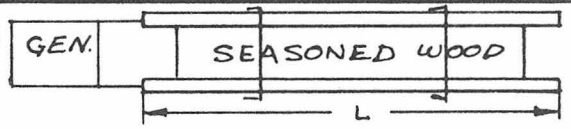
MOISTURE EFFECT

MOISTURE % DRY WEIGHT	MINIMUM HEAT TIME TO AVOID FLASHOVER	MAX. TEMP. RATE RISE (°F/sec)	% TRANSFER EFFICIENCY	POWER REQ'D 1 MIN. HEAT
0	41.4sec	4.8	84.5	2.1KW
5	21.9 "	9.1	88.8	2.0 "
10	12.7 "	17.0	92.6	1.9 "
30	2.2 "	89.0	97.3	1.8 "
60	0.9 "	217	98.2	1.8 "



AIRGAP EFFECT

AIR GAP (IN.)	MINIMUM HEAT TIME TO AVOID FLASHOVER	TRANSFER EFFICIENCY %	POWER REQ'D 1 min. HEAT
Contact	9.6 sec.	95.0	2.0KW
0.008	9.6 sec.	94.8	2.0 "
1/16	19.6 "	93.8	2.1 "
1/4	49.5 "	90.5	2.1 "
1	150.0 "	80.0	—
10	11.4 min	32.0	—



MAXIMUM ELECTRODE LENGTH

GEN. FREQUENCY	MINIMUM ELECTRODE 'L' WITHOUT SPECIAL PROVISIONS	STUB SPACING
2 mc.	28.0 FT.	28.0 FT.
14 "	3.8 "	3.8 "
27 "	2.0 "	2.0 "
100 "	6.2 in.	6.2 in.
200 "	3.1 in.	3.1 in.

THESE CALCULATIONS WERE MADE PUBLIC BY THE ELECTRONIC ENGINEERS OF THE RADIO CORPORATION OF AMERICA.

R.Y.

flashover. This is shown in Table III-B. In general, the effect of raising the frequency reduces the time needed for curing by a reciprocal of the raised amount.

The effect of the thickness of the material to be heated on the time cycle is shown in Table III-C. Table III-D, on the other hand, shows the effect of moisture upon required minimum heating periods. Moisture means an increase in the density, which therefore, results in longer cycles of heating. For maximum speed and efficiency, air spaces between the electrodes are not to be used unless the heated material is of irregular shape. Table III-E, shows the increased time needed if the electrodes are off the work.

Nonuniform heating in the glue line is undetected unless it is severe. When the length of the electrode becomes large in comparison to the wave length of the frequency being used, a phenomenon known as "standing wave" results, which causes the nonuniform heating. The use of stubs on the electrode can correct unequal heat distribution. Table III-F, shows the length of electrodes recommended for a variety of generator frequencies.

Shielding of high frequency generators is necessary for two reasons. The first of these is the safety of personnel. The generator uses high alternating and direct voltages that must be enclosed and inter-locked. The radio frequency voltages in the press do not produce a shock, but will result in severe burns. The second reason for

shielding is to prevent radiation which may cause interference with radio-communication channels. Public Notice #84900, issued September 25, 1945, states that the following frequencies may be used for commercial heaters and diathermy machines.

13.66 mc ± .05%
27.32 mc ± .5 %
40.98 mc ± .05%

Government action up to date has been taken only when a machine happens to interfere with some aircraft, FM, communication or television station. Public notices usually become law within a few years, and it is expected that a government inspection, in regards to shielding, will have to be anticipated.

The initial cost on installation to date is best shown by a graph. The dotted line in Figure II on page 28 shows average initial costs, according to available price quotations. These are only average, because engineering costs were necessary in some cases. The upper solid line indicates the average cost per kilowatt at various powers, and this total cost is broken down into tube cost, amortization cost and power cost. This information was made available by the Westinghouse Electric Corporation. As usual, the cost per kilowatt is higher for small size generators than for larger generators. This is because of the higher cost of equipment and tubes. Operating costs were analyzed by the Westinghouse electronic division and the results are shown

FIGURE II

POWER COST

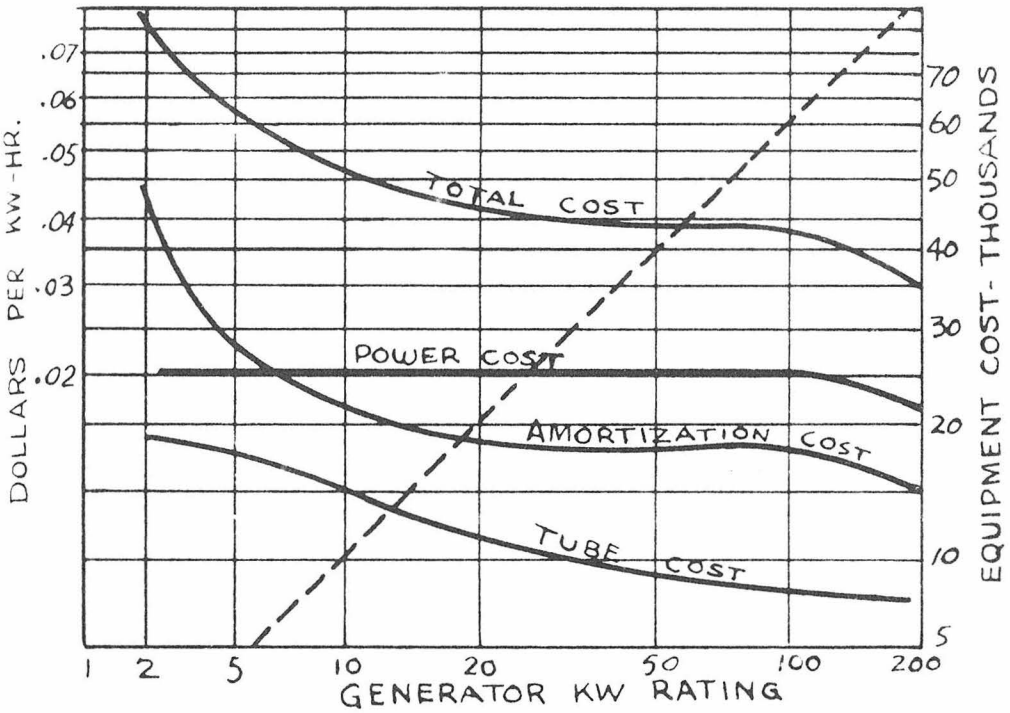
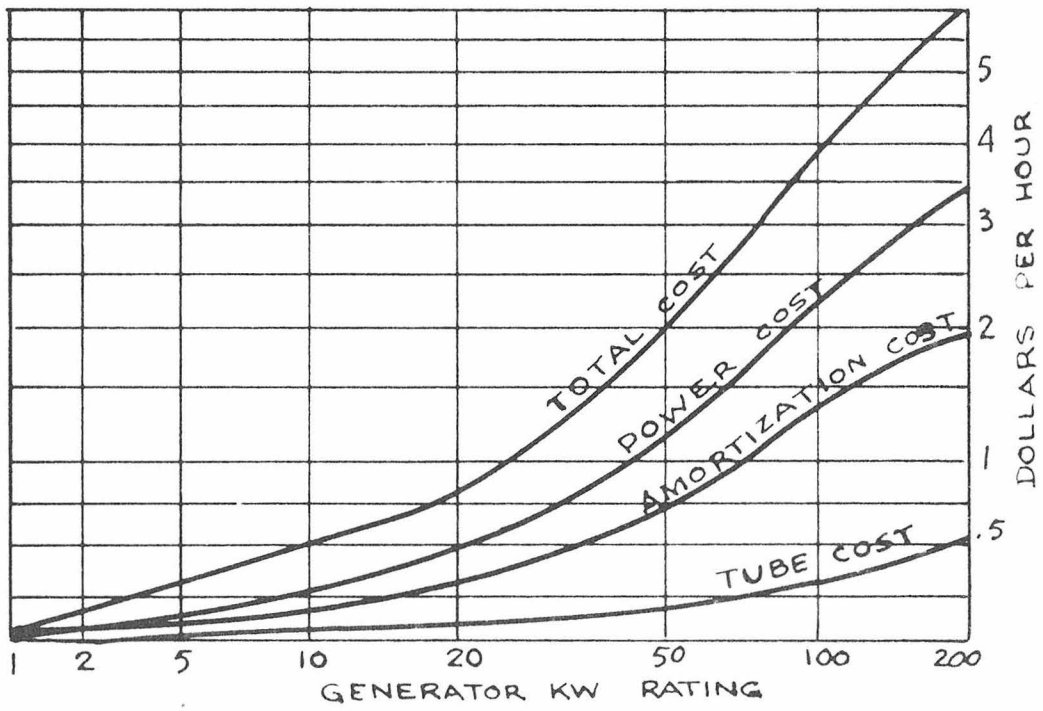


FIGURE III

OPERATING COST



in Figure III on page 28. Power and tube replacements are the main costs, but, these figures today are constantly changing, due to improvements and an increasing market.

There are some obvious advantages to high frequency gluing that no other method has today. Instantaneous and uniform heating is provided throughout the material. The heating starts at the center of the material regardless of its thickness. In the steam-platen method, the heating time varies as the square of the thickness of the material. The steam heated platen method requires fifteen minutes or more to raise the temperature of one inch stock 270°F, while the platens are heated to 300°F. Thus, the layer of wood next to the platens is 300°F, while the center is at best 270°F. The moisture in the wood migrates to the center which is often 15 per cent, leaving the outside section containing about 3 to 4 per cent. The result is locked-in strains and stresses that lead to warping. This excessive drying of the outer layer causes "case hardening". In the case of gluing any considerable thicknesses, no other method but electronic gluing is economical. Besides the cycles being greatly reduced, and the temperature controlled closely, there are numerous minor advantages which vary with the work. There is no uncomfortable heat radiation, also, the heat can be turned off instantly.

Depreciation and Obsolescence

An annual depreciation charge is made to cover the decline in value of any asset, and it is a fact that in common practice 20 years is the average write-off period for machinery. A small depreciation figure is favored by most companies, because it means greater earnings; by the government, because it means higher tax returns.

Obsolescence of machinery is approximately within seven years. Obsolescence should be looked upon as a factor of depreciation. Depreciation is made up of three factors. The "work factor" is the consideration of the extent of the machine's operation. This is on what most of the companies base their entire depreciation, at a rate of 5 per cent. The "wear factor" is ever present, but not realized as much as it should be by the financial men in the company. This factor depends upon the kind of job, the operator, and the maintenance of the machine. The rate of depreciation can be raised 10 per cent by this factor. The third part of depreciation is "obsolescence", which is measured by the relative productivity of the machine. This is an elusive figure, for it is entirely governed by the comparative productivity of a newly perfected machine that will do the same job faster, cheaper, and better. In normal times an allowance of 12 1/2 per cent for depreciation is considered conservative.

Some companies look upon purchasing a new machine as

an equipment that has a life of 25 years. It will serve efficiently for 8 years, probably 12 years and possibly 20 years. The depreciation, in this case, is figured on a 15 year basis. This system is based on book value financial thinking, rather than on constant consideration of the machine's operating value.

Trademarks

The use of trademarks plays a prominent part in protecting machines against competition. Since this is the first machine for this company, the correct selection is most important. To get a trade name established as soon as possible is preemptory. New federal trademark laws will be effective July 5, 1947. The main reason for this is to bring these laws up to date. The new Lanham Act, provides for two types of registers in the patent office, one called "Principal Register", for registering coined and suggestive marks, and the other called the "Supplemental Register", for holding any trademark symbol, label, package, configuration of goods, name, work, slogan, phase, surname, geographical name, numeral, device, or any combination of any of the foregoing. However, such marks must be capable of distinguishing the applicant's goods or services. Another important provision of the new act is that it contains a "graduation clause", whereby a mark, even though it be descriptive or geographically descriptive when registered supplementary, may be subsequently reregistered in the

principal register, provided that the mark has become distinctive through use in the trade for five years. A "concurrent use" clause is also enclosed in the new act. This provides the use of a mark by each of the parties in different localized parts of the country. A nation-wide protection is given when the mark is registered in the principal register. The assignment of trademarks is also possible now by dividing the business geographically or different types of products. When the mark has been registered, the new act requires the owner to give notice that his mark has been registered by the use of: "Registered in the U.S. Patent Office", or "Reg. Pat. Off.", or the letter R enclosed within a circle.

DESIGN

Since the success of a machinery design project depends on engineering and industrial designing knowledge, there are great possibilities in this field for persons who have these qualifications. The problem of designing an item just out of the first stages of development, is a different problem from redesigning an advanced design. When the Gillespie High Frequency Gluing Machine was selected as the problem, this machine had been considered as designed, and was being presented to the market. The manufacturer knew the machine was an answer to the woodworking industry's production needs, but he did not know the extent of the competition or the reactions of the consumers in regards to their specific needs and desires.

The High Frequency Gluing Machine that is being sold today to the woodworking industry, had been developed during the war at the Gillespie furniture manufacturing plant. The Pico Machinery Corporation is now manufacturing the machine. The plant includes a machine shop and steel fabricating shop. The machine shop is equipped to handle any production the rest of the plant can attain. The fabricating shop has heavy shears and welding and acetylene cutting equipment capable of handling steel plate up to one inch in thickness. A minimum of pipe shop equipment is available as well as a 5 ton press.

Redesign Problem

The redesign problem itself was to correlate the factors accumulated from the completed survey and research into an effective design. The limitations were economy, manufacturer's restrictions, and the extreme variety of applications required.

Redesign Elements

1. The operating units were to be assembled for ease of maintenance, simplification of design, and to eliminate recognition of unit manufacturer's commercial R.F. generator model.

2. The conveyor had to travel variable distances in order to accomodate the variety of stock that is used in the industry.

3. Since the loading area is only six feet long, an extension was needed to handle lengths up to 15 feet.

4. Many plants do not have the amount of air pressure required by the clamping medium. This necessitates, in existing installations, the additional purchase of an air compressor. This delay in installation and additional investment for separate units had to be remedied.

5. The various controls were scattered and the arrangement was only for the convenience of installation rather than for accessibility and use.

6. The variation of panel sizes to be glued in the machine was acommodated by the use of a series of temporary

boards. A problem always existed in their attachment and their storage.

7. The machine had been designed to handle the widest stock that was used in the furniture industry, but it failed to adapt itself to the possible production with the popular dimensions.

8. The construction was very rigid and heavy, but the same results could be accomplished by simpler methods.

9. Safety features and government regulations had not been given the required consideration.

10. The ease of inspection, maintenance and repair needed incorporation.

11. The appearance of the present machine has been associated with airplanes, and does not distinguish itself.

Results and Recommendations

The principle of gluing that is used in this machine was accepted, by the trade, more readily than any other known today. Therefore, this was continued in the new design. The limitations put on by the manufacturer were that the design was to be adaptable to their plant capacity, no radical changes were to be made in regards to the materials or the basic construction, and that the present electronic equipment was to be retained, as well as the cold electrode conveyor system.

The first step toward the new design was to take the separable parts and study them individually in regards to

the machine as a unit. In order to produce a functional design, it was necessary that all phases of the design problem be dealt with simultaneously. The resulting form is a composite answer to the subsidiary problems.

Cabinet-

The old machine had the cabinet that housed the electronic generator on the working side of the machine. The space occupied by this cabinet prevented freedom of operation and ease of observation into the curing area.

The new machine was designed to have a clean and open working area, by having the cabinet a part of the rear of the machine. The cabinet is large and incloses not only the electronic parts, but also the eight side pistons and the new hydraulic equipment. The ease of installation and maintenance of all this equipment is provided for in the design. The electronic parts are mounted on removable panels. The power tube, that needs replacement more often than anything else in the cabinet, is positioned very conveniently at the very edge. The drawing on page 62 shows the possible arrangement of the electronic apparatus, as well as the construction of the cabinet. There is space for any necessary rearrangements or additions.

Figure IV on page 37 shows some of the improvements of the new machine over the old one. Simplification of construction was developed. The channels that are formed to make the frame for the mounting of the vertical pressure

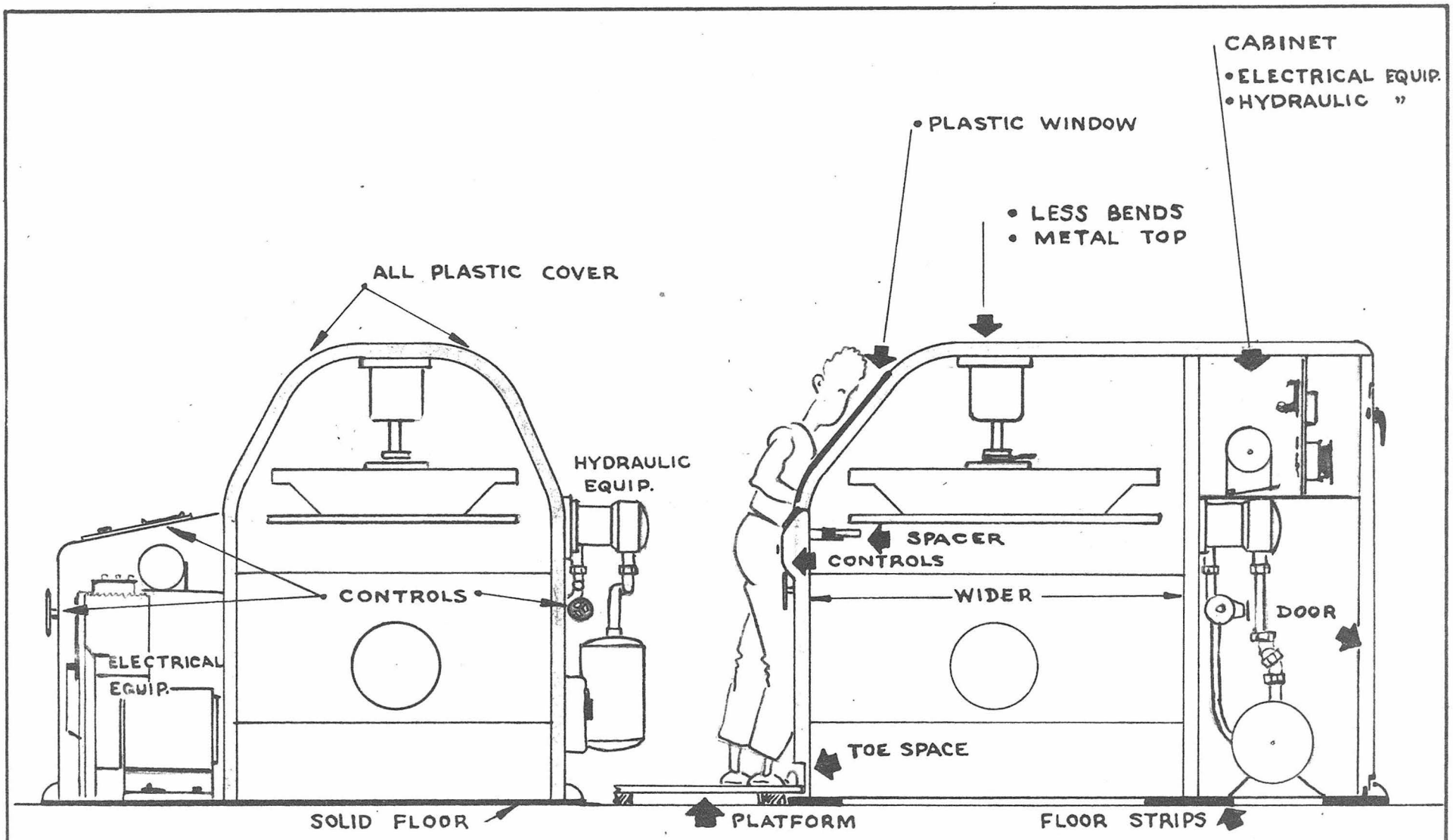
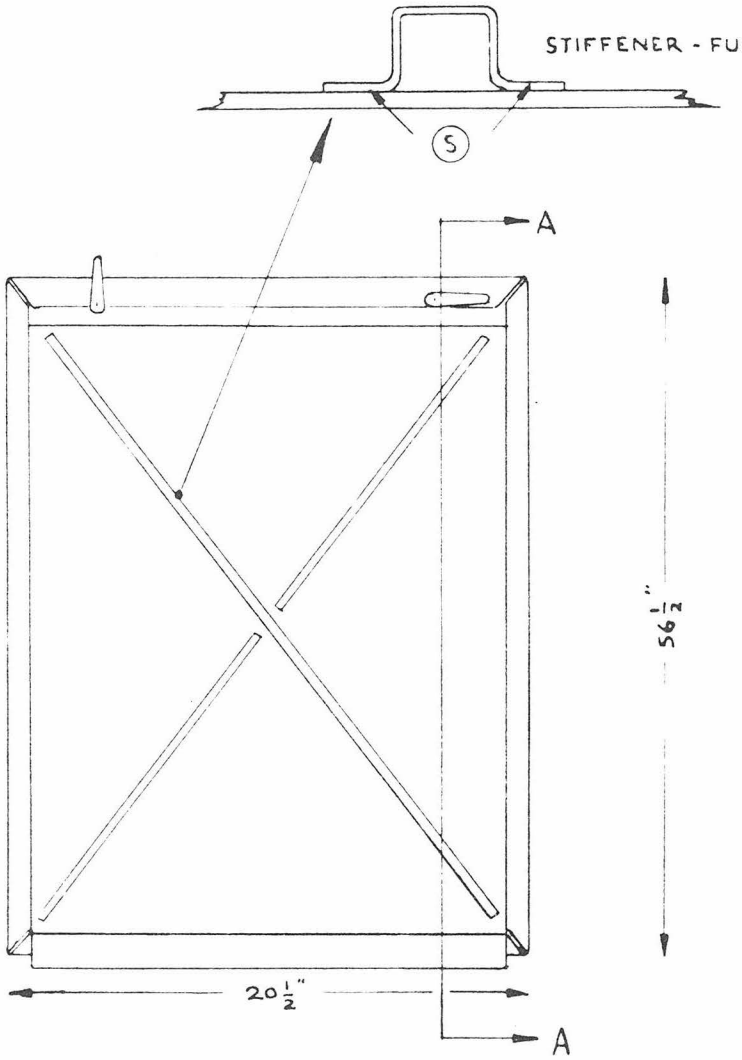


FIGURE IV

P. YANKAUSKAS

pistons need only be bent half as much as they were originally. The new cabinet is simpler and more accessible than the previous one. A safety feature is incorporated in the doors of the cabinet to shut off the high voltage when the doors are opened. Ventilation is provided at both ends of the cabinet to dissipate the heat. The doors on the cabinet have been designed for ease of handling; the bottoms set into slots, and the top parts are maneuvered by the two handles which act as grips at all times. The doors were designed to be removed rather than swing on hinges because this required the minimum of space to open them. This is the more economical construction, also. The doors are constructed of mild sheet steel (14 gage) with spot welded reinforced edges and diagonal stiffeners as shown in Figure V on page 39. The previous covers, secured by bolts, were made of one quarter inch steel plate and weighed 123 pounds each.

The new design not only relieved the working area and improved the general construction, but it also added the desired bulk and balance to the appearance of the machine. The bulk creates psychological value that the product needed, as the survey showed. Distinguishing the machine from any association with a radio frequency generator that is sold as a separate unit, was also gained by this new arrangement. No additional floor space was used to obtain these improvements.



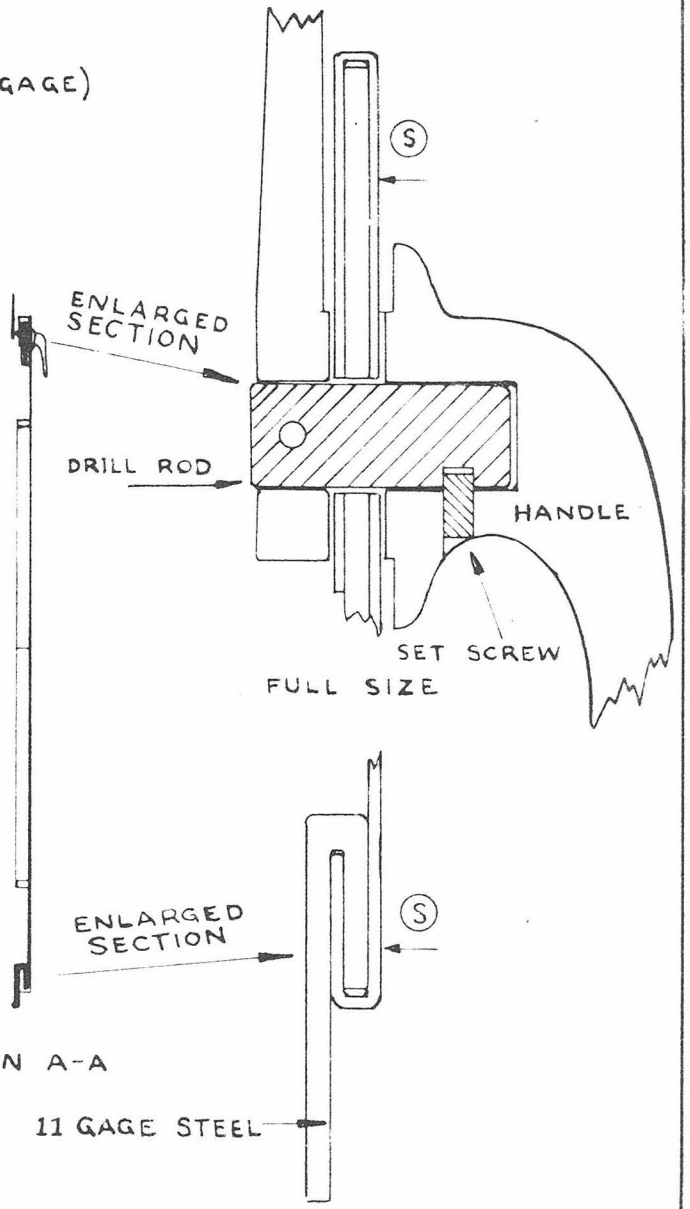


FIG. V

- DOOR - 14 GAGE STEEL
- EDGE REINFORCED WITH 11 GAGE STEEL
- (S) = SPOT WELDED

CABINET DOOR

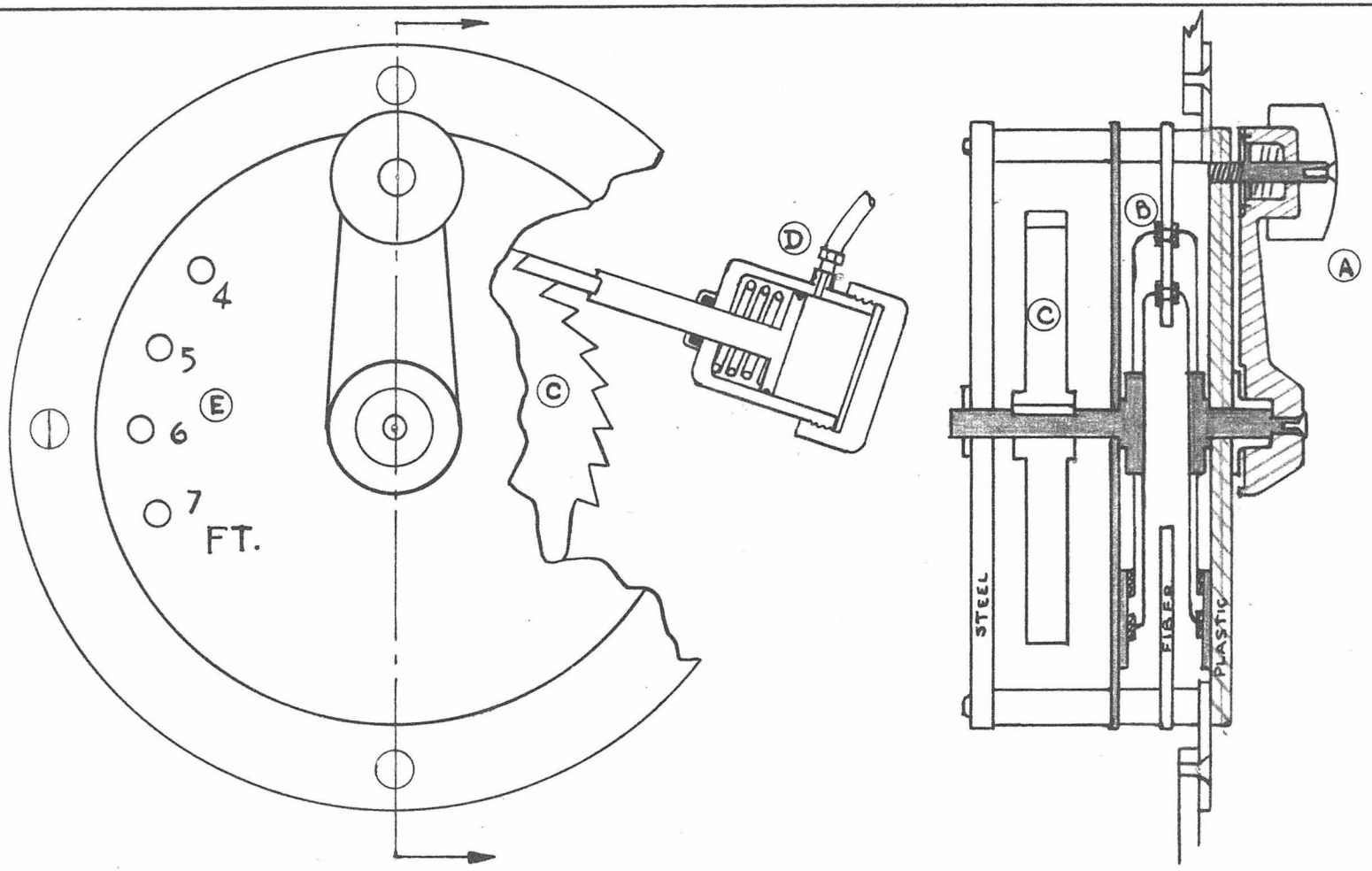
The new design was extended to include less expensive materials. The cellulose acetate plastic windows were made simpler and only required half the original amount of panes. Rather than having four windows on one side, the design was changed to two windows, in order to simplify their appearance, manufacture, and assembly. This doubling the area of windows is possible since only one very slight curve is used in the new design.

Conveyor-

The original conveyor moved a quarter of its full length every time a cycle occured, this meant it travelled seven and one half feet.

The length of travel of the new conveyor is now selective. The construction of the selector is shown in Figure VI on page 41. This was suggested and worked out with the company's engineers. The operation of the selector is first to offset electrical contacts equivalent to a number of teeth on a gear, which represents the number of electrodes that are required to travel. As the cycle takes affect, the electrodes on the conveyor strike a cam that releases the gear one tooth at a time, until the contacts match again and the conveyor motor is thus shut off.

The selection of length varies from as few as eight electrodes (3 feet) of travel, to twenty electrodes (7 1/2 feet) which is more than the full capacity of the gluing area. The gluing area is six feet long. This improvement



— CONVEYOR SELECTOR —

(A) SCREW-IN POSITION (AL) KNOB
(B) CONTACTS THAT ARE OFF-SET BY SELECTOR KNOB
(C) GEAR THAT IS OPERATED AS ELECTRODES PASS A HYDRAULIC CAM.
(D) SMALL PISTON THAT IS OPERATED BY THE CAM TO MOVE THE GEAR
(E) ENGRAVED FIGURES ON PLASTIC PLY DISC.

Scale - ½ 5-28-47 P. YANKAUSKAS -

FIG. VI

makes it possible to glue any length of stock completely automatically. There is no longer any need to push the panels back into the machine to cure the parts that had not been cured. A length, as for example, of twelve foot boards, can now be set to travel six feet every cycle and thus cure in 2 cycles. The original conveyor would move the boards seven and one half feet after the first six feet of cure, thus necessitating the foot and one half of excessive travel of boards to be pushed back into the machine, or it would not be glued.

Extended Loader-

There is no provision in the early machine for lengths over 7 feet. The new design includes an extensible lay-up table that can be used for lumber up to fifteen feet in length. This is a specific requirement in a large percentage of the industry, and an added sales feature for the others. Channel irons were used for stiffness and strength. The roller on the end is a closed pipe with a heavy neopreme covering. The extension has a positive stop when it is drawn out the full length. The design of this feature had the compactness and unity that was required to be in accord with the over-all theme. The drawing on page 62 shows the construction and operation of this unit.

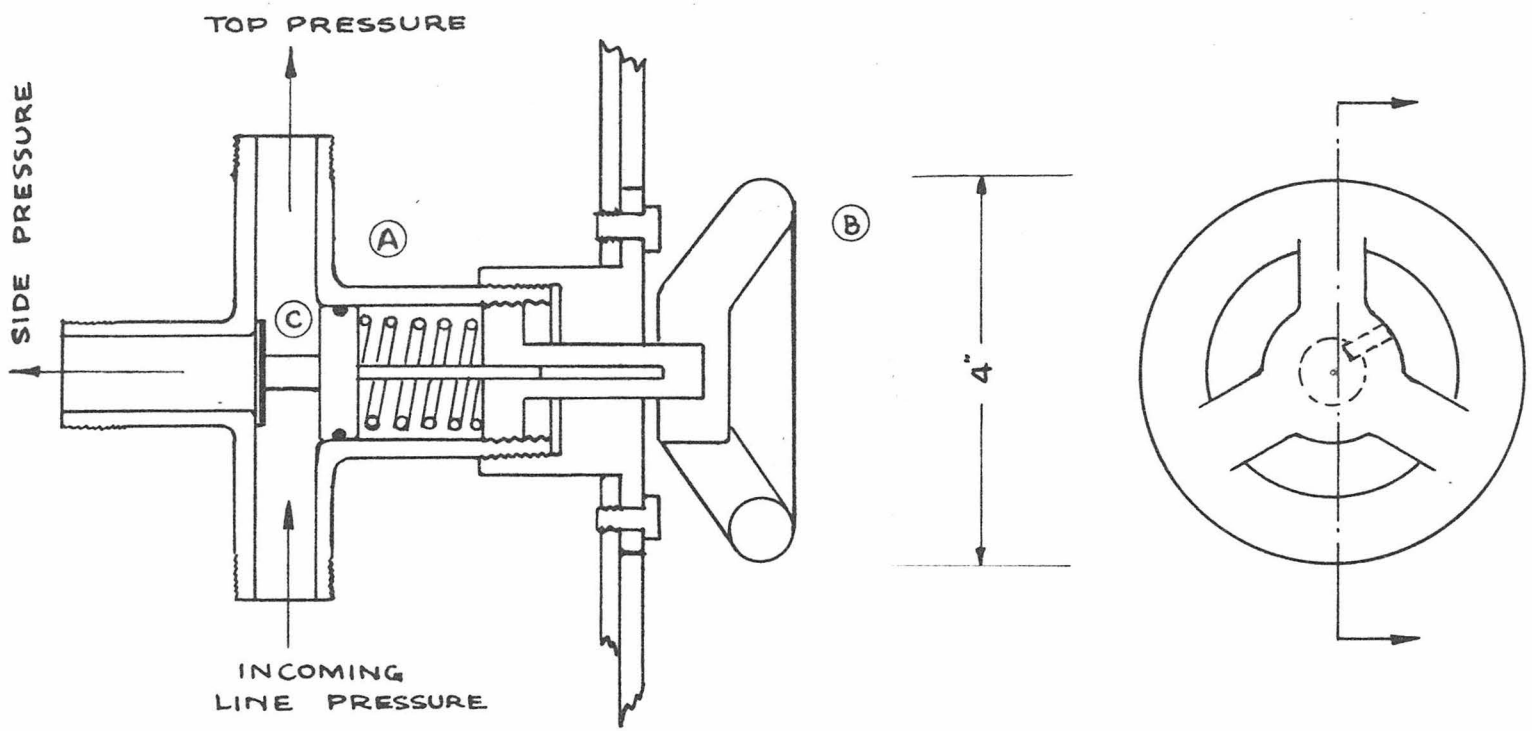
Pressure-Medium-

The previous machine had an air hydraulic medium for pressure application. The air pressure that is used in an

average woodworking plant is not enough to operate this pressure system. Some consumers had to buy compressors with 20 HP motors.

To solve this installation problem and not have the consumer dissatisfied because of the need of additional purchases, the new design has recommended a complete hydraulic system. The layout of this system is shown by the drawing on page 63. The new principle is to have a 5 HP motor on a six vane pump (Waterbury pump) that can deliver 50 gallons of oil per minute. The pump takes the oil from the sump tanks and pumps it into the 13 inch pipe that is used as the backbone for the machine. It was found by trial that air cushioning was needed here in order to have pressure on the fluid without filling the whole tank. Electrical valves function with the cycle to open pilot valves that operate the Roos diaphragm valves to conduct the flow in the proper channels. The Roos valve deflects to pass the oil to the sump tank. A valve was designed to regulate the pressure for the variety of woods. The valve is shown in Figure VII on page 44. This valve is brought out to the control panel for the convenience of the operator. The valve when set, determines what pressure is initially used to close the vertical pistons to align the wood to be glued before the side pressure is applied.

In addition to having a means to regulate the amount of pressure, as well as the desired sequence of its administration,



PRESSURE REGULATOR VALVE

(A) VALVE HOUSING IS CAST & MACHINED

(B) PLASTIC (PHENOLIC) HANDLE

(C) STEEL PISTONS (USE O-RINGS)

Scale = ½ SIZE 5-30-47 P. YANKAUSKAS

FIG. VII

progressive side piston action is also recommended. Trials in the field have revealed that progressive application of side pressure produces joints with greater strength. A very small progressive change in the size of the liquid inlet ports accomplished this. This change involved no comparable additional cost in manufacturing. The change is not in the hole of the piston housing casting, but in the short pipe connection entering the casting. The change only involves forcing different sleeves in the pipe. This means that the man who makes the installation will have full control of proper assembly. Since the system has to drain through the same line it was applied, the sequence of operation will repeat itself as the pressure is removed from the lumber. This method of applying the side pressure will be a decisive advantage when warped stock is glued. The prolongation of only a few seconds of the cycle is estimated because of this new procedure.

Controls-

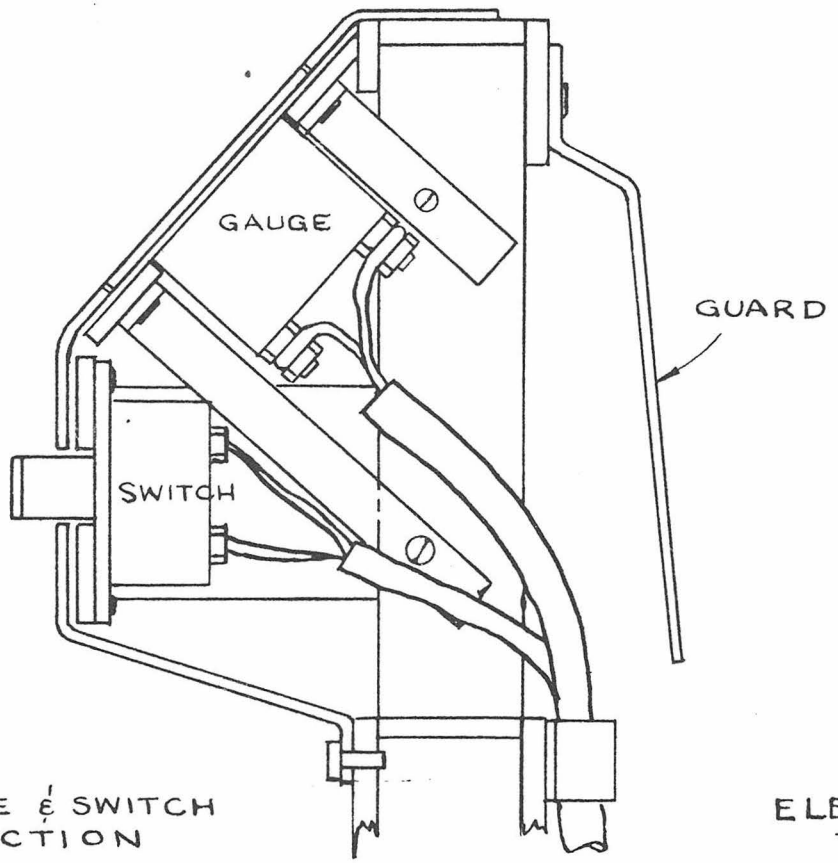
The controls of the old machine were all separated. The electrical controls were four feet away from the operator. The pressure regulator was at the back of the machine. No voltage regulator was provided, therefore, the operator had to go inside the machine and take different taps off the transformer to get the workable voltages.

The new machine has the controls designed for the convenience in their use. The location of the panel was of

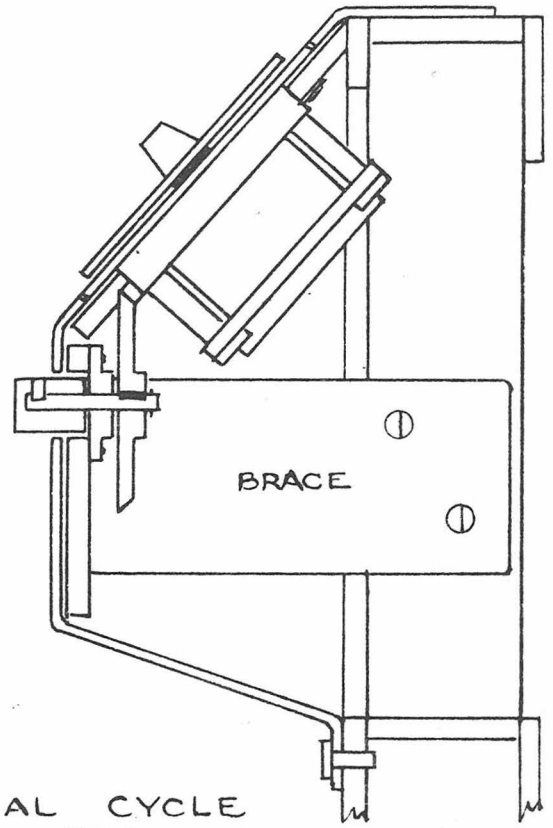
prime consideration. The arrangement of each individual control was dictated by its use. Color was used to aid the operator in distinguishing the desired controls. Conventional red plastic was used for the emergency switch and the stop button. An illustration of the panel is on page 61. The remaining controls are made of black phenolic plastic. All the controls are commercial items. The control panel was positioned to the right of the immediate working area, in order to keep it clean of glue and not have the worker operate the controls accidentally as he moves about his work.

The controls have all been brought together to this one area. This results in some additional cost of material and installation, but not enough to make a difference in the selling price. The added sales feature of having organized controls on the machine, obviously warrants this change. In purchasing, the controls of the machine are next in importance after performance. The controls were designed so that a man can operate them with glue covered hands and be able to clean the controls easily. The operation of the controls must not only be simple, but also have the appearance of ease in operation. The dials were positioned at the top and sloped for ease of observation.

The controls that are used constantly are the frequency knob and the "start" and "stop" buttons which are positioned immediate to the operator. They are always within arm's



GAUGE & SWITCH SECTION



ELECTRICAL CYCLE TIMER SECTION

CONTROL PANEL SECTIONS

Scale - ½ Size

5-28-47
P. YANKAUSKAS

FIG. VIII

reach of the worker. The remaining controls are only used at the beginning of the run and can be reached by one step. All of these are located in the sequence of their use.

The construction of the control panel is shown in Figure VIII on page 47. Mounting the controls on one-eighth inch steel plate permitted the use of 18 gage steel sheet in forming the cover with the five ton press available. The smooth hard lacquer finish was recommended in place of the wrinkle finish used on the old panel, because it can be cleaned easier and it stays cleaner. The conveyor selector dial is to be made from a laminated plastic sheet with the engraved selections in feet so that the operator will have an easy means of knowing the travel length. The plastic sheet is black on the surfaces, and white through the center, so that on cutting through the surface of black the figures are left in white.

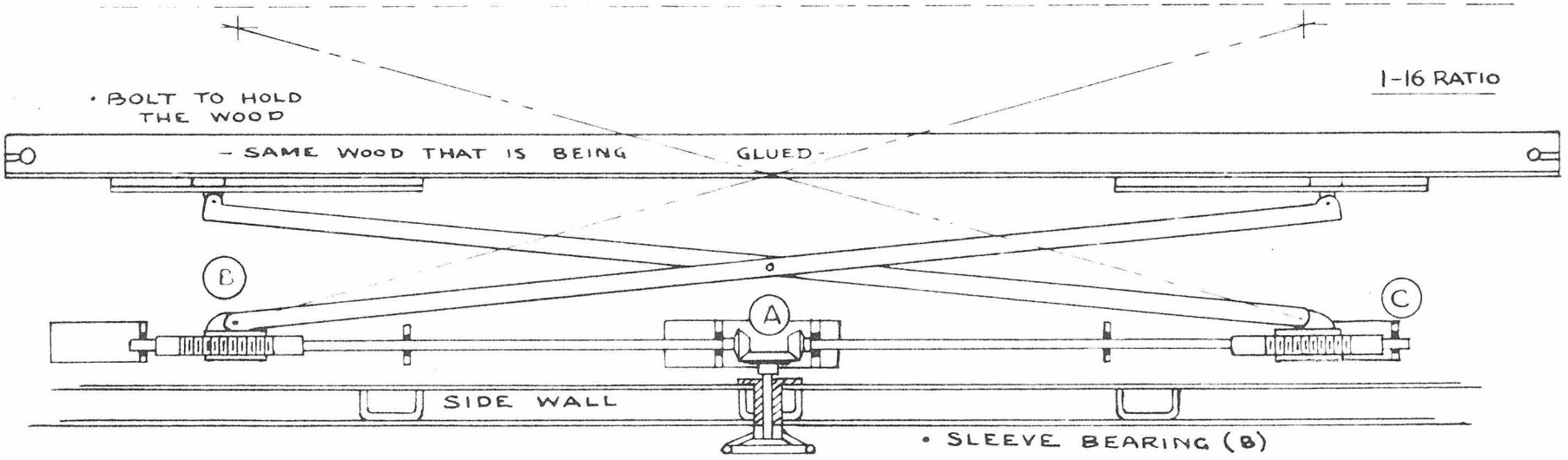
Panel Variation-

The old method of handling panels of less width than 30 inches was by placing various compensating board spacers in the machine. Anything over 30 inches was reached by the pistons that have six inches of travel. The new design has incorporated in its controls a handle that operates this needed spacer effect. The design is that of a scissor arrangement as shown in Figure IX on page 49. The lead on the acme thread that operates the arms is multiplied sixteen times at the pressure bar. This necessitates very little

(A) BEVEL GEARS - DIAMETAL PITCH = 10
GEAR - 30 TEETH, 3.089" O.D.
PINION - 15 TEETH, 1.679" O.D.
STEEL (.08C - .25 Si - .40 MN - 5.0 Ni) HARDEN 1500°F.
"

(B) AMERICAN STANDARD ACME - SIZE 3/4, MAX. D. = .7500, PITCH D. = .667, 6 THREADS PER INCH.
NUT = MAX. D. .7700 PITCH D. - .684 (B1 STEEL)

(C) SPACING OF BEARINGS (BALL) = $\sqrt[3]{D^2 \times 6.3}$ = 1.2 FEET.



PANEL VARIATION ADJUSTER

SCALE - 1/8
P. YANKAUSKAS

FIG. IX

adjustment to get considerable spacing in the machine. Simplicity and economy was gained in the construction of this feature, by the use of simple bevel gears, welded members and ball bearings. The bevel gears are so arranged that only right handed acme threads are needed on both shafts. The pressure bar is designed to hold a 3 inch strip of the same wood that is being glued, so that the pressure would not crush the wood being glued.

Production-

The old machine was designed to handle all the dimensions of stock that were used in the manufacture of furniture. The use of the 36 inch width is very rare, but panels that are 18, 20 and 22 inches wide are very popular. The new design offers to double the production of the popular size panels. The new machine is able to glue material up to 45 inches in width. This wider machine will not only be more productive for the regular users, but will also open a new market in the plywood industry, which makes the standard panel of 4 by 8 feet.

The construction of the machine is not changed on account of the widening, other than making the cross bars nine inches longer.

Construction-

The basic construction of the old machine was to be followed as stipulated by the manufacturer. The new design uses the basic methods of construction, but the enclosed

prints and figures will show the following major improvements:

a. Four edges were eliminated.

b. The amount of bending required on the upper structure was reduced to half.

c. Nine rounded corners were excluded

d. Simpler and half the amount of plastic windows in the new design.

e. Removable plates are held by quarter turn Shakeproof fasteners.

f. The one-quarter inch steel plate floor was removed.

g. Corner insertions were designed where the three-quarter cut pipe edges met.

h. The big pipe through the machine was shortened on the loading end of the machine.

Safety and Government Regulations

The present machine had not observed the shielding ordinances, or provided proper safety for the worker.

The new machine has a safety shut-off switch in conjunction with the doors of the power cabinet. A foot switch is provided at the working area so that the operator can shut off the machine even if his hands are loaded. A second set of interlocked "start" and "stop" switches are placed at the unloading end of the machine, in case a man is used to unload the machine rather than some mechanical means as recommended.

The redesign of the machine has also included the

shielding of the transmission of radio frequency waves. The steel top of the cabinet was made to continue over the top of the gluing area and drop down along the curves of the channel frames for four inches. Authoritative persons have stated that this cover will prevent about 80 per cent of the transmission, if there is any. The remaining amount of transmission can be shielded by enclosing a wire screen between two layers of plastic used for the windows. However, this is not needed since there is very little detectable transmission by this machine. The consumers all ask for the shielding because they have all been impressed by the government restrictions.

Inspection and Maintenance-

The new design has provided for the ease of maintenance by the use of the following features:

a. All the surfaces are smooth and plain
b. Removable covers are held on by commercial quarter turn Shakeproof fasteners, which are attached to the covers.
c. Two rows of "zerk" fittings are built in the front of the machine. One series of fittings at each end of the machine lubricates half of the machine.
d. The cabinet doors are easy to handle and have the safety feature of turning off the power when the doors are opened.
e. A coverplate provides a simple access to the

refilling plug of the hydraulic system.

f. All the controls are removable in part or as a whole in order to facilitate repair or cleaning.

g. Both ends of the machine have covers which provide admission to the conveyor and its drive motor.

h. Besides the "zerk" fittings, and the control panel, the remaining parts that require frequent access are in the cabinet.

Appearance-

After the function was fulfilled in the new design, the appearance was given consideration. The visual aspect is, no doubt, a very potent factor in present day selling, although performance is the greatest selling factor. A machine with outstanding design in appearance suggests excellence in performance, easy maintenance and high quality. Greater care is given by the operator if the machinery is trim and efficient. This results in greater production and longer life of the equipment. The new machine is clean and simple in form, which provides a business like "functional" appearance. The arrangement of the dials and a large locked cabinet suggests value and confidence in its performance.

In addition to having this very smooth, simple, plastic appearance to distinguish this machine from others, additional features that are uncommon in the industry, have been introduced. Most machines usually have wood platforms built around them sooner or later, thereby destroying the correct working

height for which the machine was designed. The recommendation here is to build a special platform to go with the machine. The platform is to be of phenolic base resin impregnated maple sections that are mounted on channel irons and secured by means of metal separators that are bolted to the channels. The toe space designed in conjunction with the platform is for the convenience of the operator. The worker has to constantly lean over the machine to get close to the work, therefore, the toe space is important. This toe space designed by the use of a channel iron, is less expensive than the construction of the previous base.

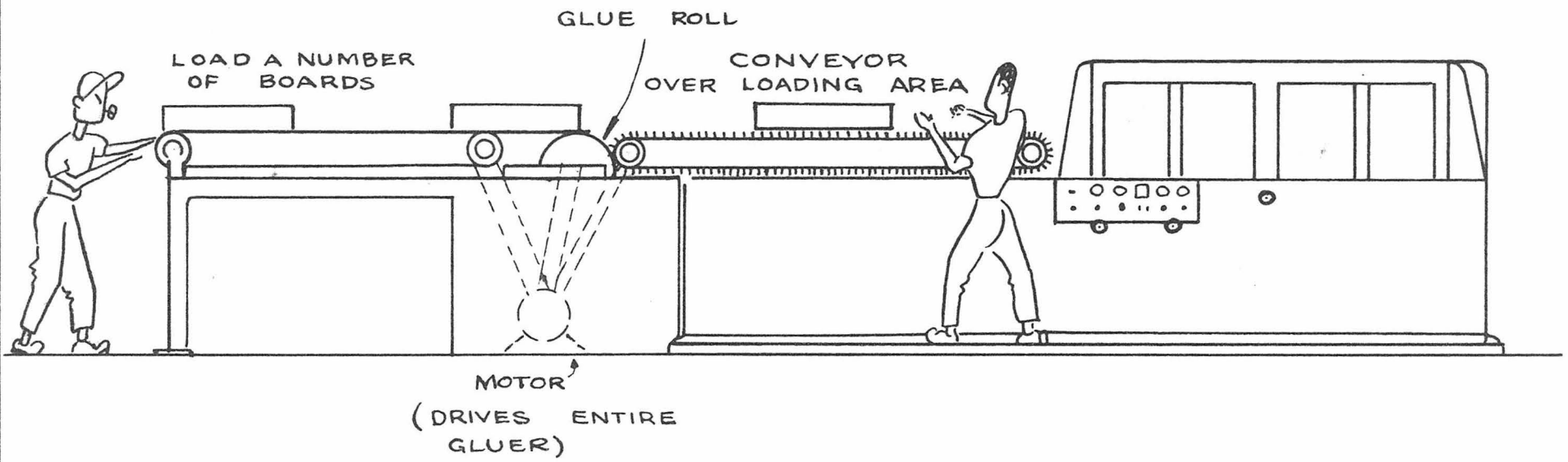
Color improves the appearance and encourages proper maintenance. But the real reason for color is to assist in seeing and calling attention to danger areas. The body of the machine is best painted in a quiet color of medium light reflectance. The "Production Gray-Blue" from the Fuller Paint Company is recommended for the machine, because it is pleasing to the eye and is an excellent change from the dull gray, or black used on most machinery. For areas that are to be high-lighted, the use of blue green is recommended.

Recommendations to be Considered-

The need for a quick method of loading the machine was realized and studied. On account of the machine's varied use, no solution was arrived at that would be applicable

to all applications. Before the loading problem can be solved, the method of glue application to the stock must be studied. Up to the present time, there is no universally accepted method. Figure X on page 56, shows a design that can be very easily made to go with the machine for most general purposes. The application of glue is made by means of a powered steel roll and the excess glue is scraped off by a spring steel blade that has V's cut into its edge. A conveyor carries the lumber to the worker over the loading area. The cost of this addition would amount to about $200.00.

The study of existing radio frequency generators and the improvements being made on the equipment indicated changes that should be considered for the present generator. The present unstabilized type of generator could be supplied with crystal control for an added cost of $1,000. A substantial increase in the gluing speed could be realized by increasing the frequency to 27.3 mc. This change would not involve a redesign of anything except the main coil and feed system to the electrodes. To stabilize the frequency of the generator would involve only additional equipment in the cabinet. The needed apparatus costs between one and two thousand dollars. The addition of a heat integrator circuit will automaically very the power output or the time that the glue is heated in such a manner that uniform gluing is obtained regardless of extreme conditions.



A PROPOSED GLUE APPLICATION

FIG. X

P. YANKAUSKAS

CONCLUSION

As a result of the approach, based upon the major consideration of the consumer's use of the product, the consumer is offered a machine with maximum utility, as well as visual appeal, and the producer is given a product with greatest consumer acceptance, and economy in manufacture.

The market research indicated that there are 5,000 possible buyers of a wood edge gluing machine, mainly in the south and northwest areas of the United States. The competition of this machine is not serious, at this time, but it is necessary to keep up with the progress being made in radio frequency and gluing.

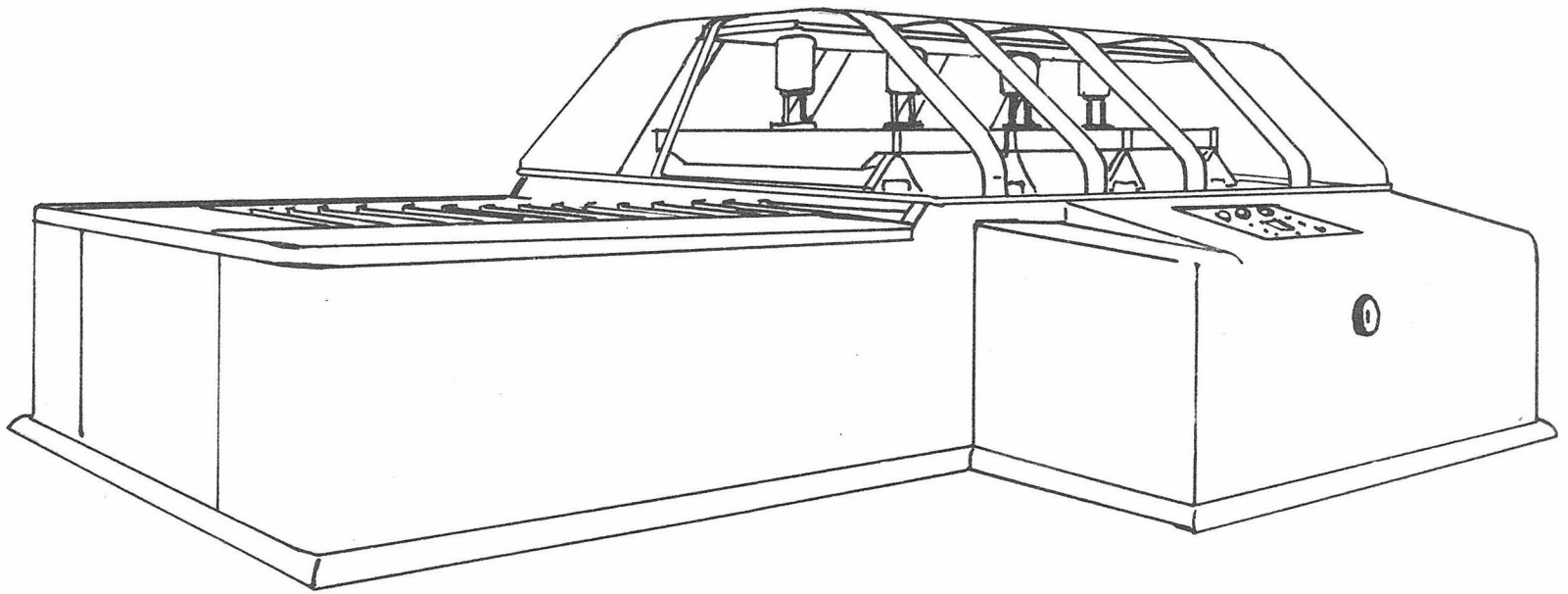
The consumer research exposed a slow and cautious buyer who had a wide variety of requirements. There is a need to educate and convince him in regards to the advantages of this new application of radio frequency.

The distribution of the machine should now be handled by a reputable machinery dealer. The manufacturer having completed an initial selective distribution, with personally supervised installations, now needs a large group of well trained salesmen to cover the industry and close the sales.

The new design has added productivity, greater adaptability, and the desired economy in manufacturing. The major problems of installation have been solved, and the appearance has been greatly improved. Some of the added features of the new machine are: selective conveyor travel,

extensible lay-up table, spacer arrangement for variable panel widths, a locked cabinet for all the electrical and hydraulic equipment, centralized and functionalized controls, and simplified construction that leads to ease of maintenance.

The new machine is unmatched in today's competition and has the maximum consumer appeal, visually as well as functionally. Progress of electronic applications have just begun, and therefore, to be ahead of the competitors, one must keep up with the progress every day, by designs that fit tomorrow's needs.



OLD MACHINE

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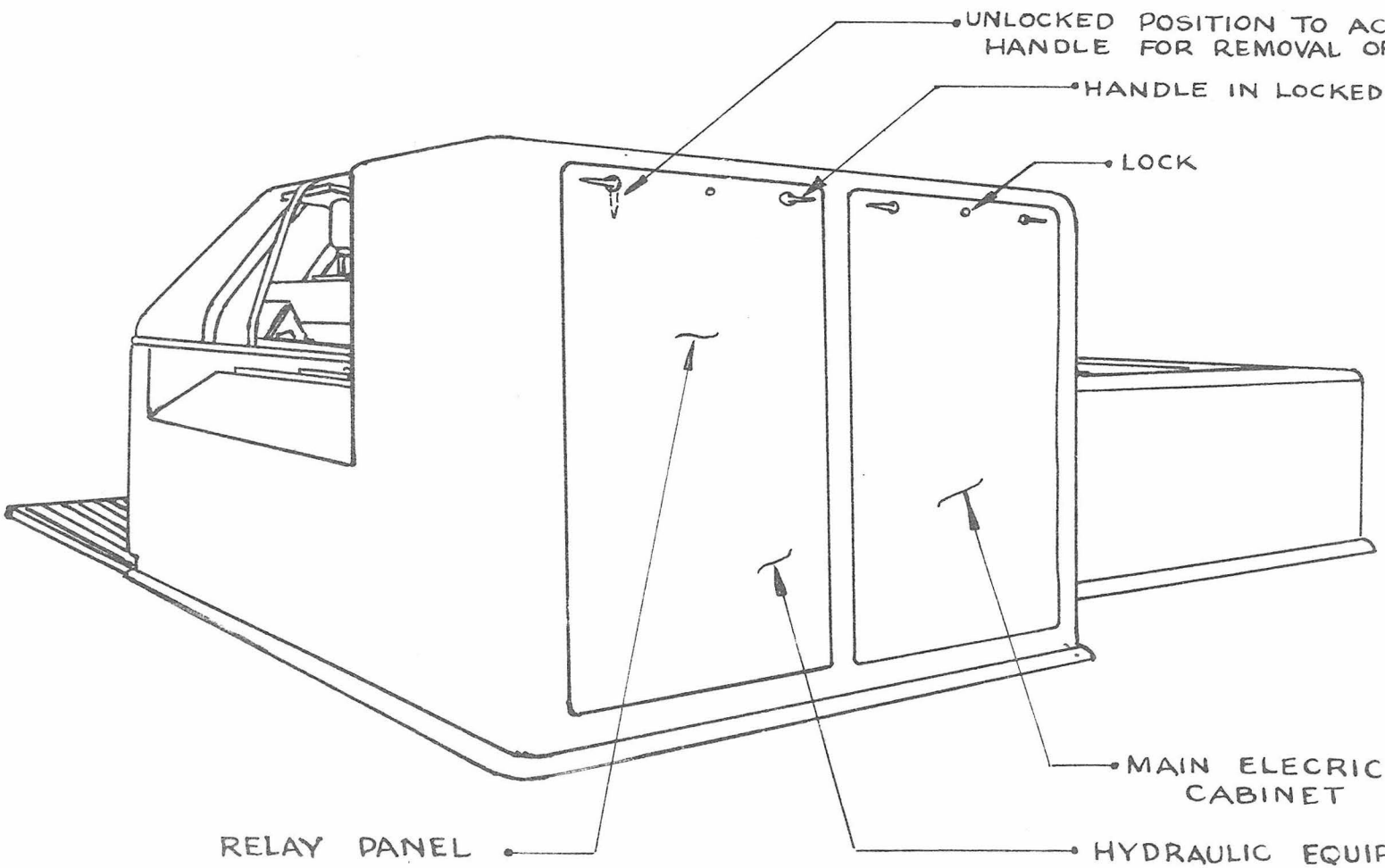

NEW MACHINE
(REAR VIEW)

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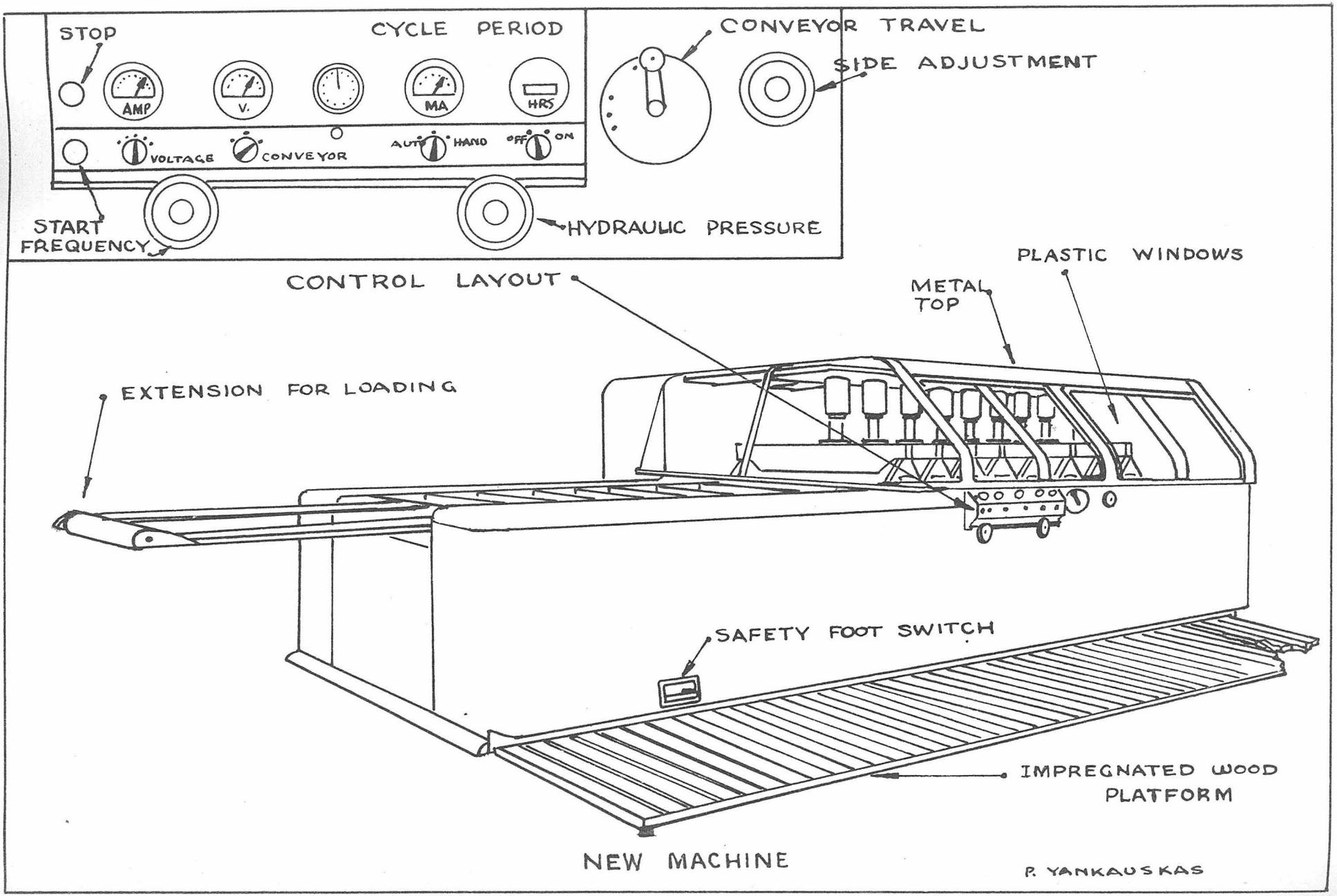
STOP
CYCLE PERIOD
AMP
V.
MA
HRS
VOLTAGE
CONVEYOR
AUTO
HAND
OFF
ON
START
FREQUENCY
CONVEYOR TRAVEL
SIDE ADJUSTMENT
HYDRAULIC PRESSURE
CONTROL LAYOUT
PLASTIC WINDOWS
METAL TOP
EXTENSION FOR LOADING
SAFETY FOOT SWITCH
IMPREGNATED WOOD PLATFORM
NEW MACHINE
P. YANKAUSKAS

APPENDIX

MATERIALS COST ESTIMATE

New Items

Cabinet		
Channels (1/4 X 1 1/2 X 3)		10.65
Angle (2 X 2 X 1/8)		4.15
Doors (gage 14 steel)		8.78
Roof (gage 11 steel)		7.80
Handles	at .75	1.50
Loader Extension		
Channels (1/2 X 1 1/2 X 3)		2.60
Shaft (1/2 steel)		1.50
Plate (gage 11)		1.65
Pipe (4" O.D.-.24		30.00
Control		
Sheet steel (gage 14)		1.56
Plate steel (gage 11)		1.09
Plastic (1/8" sheet)		3.00
Width		
Plate (gage 11)		4.60
Aluminum casting		7.00
Hydraulic		
Pipe (1" O.D.)		30.00
Pipe (2" O.D.)		36.00
couplings		46.00
Roos valve		75.00
Tank		58.00
		$ 329.88

Items Eliminated

4" Pipe	40.00
13" Pipe	14.00
Plastic Covers	46.50
Air-hydraulic tanks	19.50
Channels	3.75
Floor Plate (gage 11)	56.50
	$ 180.25

Additional cost for materials in new design is $ 149.63

Persons Interviewed

North Central

Ed Roos Company, 7329 W. Harrison, Forest Park, Illinois

Mr. Ed Roos - President

Plycor Company (Engineers), 154 E. Erie, Chicago

Mr. H.K. von Maltitz - President

W.W. Kimball and Company, 2611 S. California, Chicago

Mr. Walter Kimball - President
Mr. Sill - Manager

Butler Specialty, 8200 S. Chicago, Chicago

Mr. Harry Bergman
Mr. Marty Forman

Southern

Inman Furniture Company, 2817 W. Broadway, Louisville

Mr. Frank Hinklebein

Girdler Corporation, 224 E. Broadway, Louisville

Mr. Dawson - In charge
Mr. Harry Smith - Research
Mr. B.R. Hopkins - Sales Manager

Mengels, Fourth and Colorado, Louisville

Mr. W.T. Green
Mr. E.A. Skonberg
Mr. H.T. Riggs - Works Manager
Mr. K.E. Deal - Plant Engineer

Gamble Brothers, 4601 Almond, Louisville

Mr. C.D. Dosker - President
Mr. Moser - Manager

Eastern

Hayward Wakefield Furniture Company, Gardner, Massachusetts

Mr. Greenwood - President
Mr. Hendrickson

Western

Arts and Crafts, 429 Auzerais, San Jose, California

Nelson Furniture Manufacturing, 1054 Park, San Jose

Larson Ladder Manufacturing, 28 Moorpark, San Jose

Mr. Larson
Mr. Turnbaum

Mr. Lindquist, 1501 McDaniel, San Jose

Pacific Manufacturing, 2610 The Alameda, Santa Clara, California

Pacific Lumber Company, 100 Bush, San Francisco

Mr. C.L. Thompson - Director of Research

Friedricks Furniture Company, 2169 Falsom, San Francisco

Mr. Baunhefner

Long Bell Lumber Company, Weed, California

Mr. Jude White

Ralph L. Smith Lumber, Klamath, Oregon

C.D. Johnson Lumber Company, American Bank Bldg, Portland

Mr. Ernest Johnson

Engineering Timber, 734 N.E. 55th, Portland

Mr. Bob Johnson
Mr. Fortune

M and M Woodworking, 2301 N. Colorado, Portland

Mr. Michel Pasquier
Mr. Malarky

West Coast Lumber Association, Yeon Bldg. Portland

Dornbecker Furniture, 1100 N.E. 28th, Portland

Mr. Heeley
Mr. Barker

Laminated Products, 2500 S.E. Insley, Portland, Oregon

Mr. Winkel
Mr. Stevenson

Gram Manufacturing, W.8th, Vancouver, Washington

Mr. Taylor

Long Bell Lumber Company, Longview, Washington

Mr. Authur L. Mottet - Research Engineer
Mr. Heppenstal - Research Engineer

Weyerhauser Lumber, Longview, Washington

Mr. R.D. Pauley

M and M Plywood, Longview

Linscott Lumber Company, Centralia, Washington

Mr. Linscott - President
Mr. Ed Frodell - Superintendent
Mr. Marc Burdick - Assistant

J.V. Posey Company, Ontario Street, Hoquiam, Washington

Mr. Stinchfield - President
Mr. Howard Franz

Grays Harbor Chair Company, Hoquiam

Mr. Canauer
Mr. Shuh
Mr. Murray Cole - Superintendent

Wycoff Manufacturing, Aberdeen, Washington
207 16th, Hoquiam
Mr. C.D. Wycoff

Gregory-Butler Furniture, Tacoma, Washington

Mr. Gregory

F.S. Harmon Manufacturing, 801 E. 25th, Tacoma

Mr. Craft
Mr. J.H. Kitler

Carman Manufacturing, 801 E 25th, Tacoma

Mr. Carman
Mr. Lundeen

Northwest Chair, Tacoma

Mr. R.C. Bourdon - Production Manager

Northwest Syndicate, Tacoma

Mr. Russell
Mr. Mann

Forest Furniture Manufacturing, Bellingham, Washington

Mr. Felton

Murray Manufacturing, 1824 Ellis, Bellingham

Burke Millwork Company, N. 34th and Fremont, Seattle

Mr. Burke - President
Mr. Joe Franz - Vice President

Monsanto Chemical, Seattle

Mr. Garlick
Dr. Hubert

Casein Company, Seattle

Tallman Machinery, 2057 15th Ave., West , Seattle

Mr. Hartnell

University of Washington, Seattle

Dr. Schrader

Timber Structures, First Street, Seattle

Biles Coleman Lumber, 401 S. 5th, Omak, Washington

Mr. McNett - President
Mr. Source

Deerpark Lumber Company, Deerpark, Washington

Diamond Match Company, Newport, Washington

Western Pine and Sash Company, E 315 Jackson, Spokane

Mr. Carmen

White Pine and Sash Company, E 4005 Broadway, Spokane

Mr. K.H. Klopp - President
Mr. Sampson

Potlatch Forests, Potlatch, Idaho

Potlatch, Lewiston, Idaho

Mr. R. Bowling
Mr. John Harom

Ralph L. Smith Lumber Company, Canby, California

Mr. Carpenter

Ralph L. Smith Lumber Company, Alturas, California

Angelus Furniture Company, Los Angeles

Mr. Joe Siskin

Forest Furniture Manufacturing, Los Angeles

Mr. Mariot

L.A. Chamber of Commerce

Mr. Eliason

L.A. Period Furniture, Los Angeles

Mr. Bill Dillman
Mr. Morry Renier

Correspondence

Correspondence was carried on with 15 other firms regarding the subject.

Books in Reference

" The theory and Practice of Radio Frequency Measurements"

by E.B. Moullin

"Induction Heating"

by H.B. Osborn Jr.
P.H. Brace
W.G. Johnson
J.W. Cable
T.E. Eagan

"Electronic Laboratory Manual"

by Westinghouse Electric and Manufacturing Company

"Consumer Engineering"

by Roy Sheldon
Egmont Arens

"Introduction to Electronics"

by Ralph G. Hudson

"How to Conduct Consumer and Opinion Research"

by Albert B. Blakenship

"Industrial Design"

by Harold Van Doren

"Wood Handbook"

by U.S. Department of Agriculture

" Machinery's Handbook"

by Erik Oberg
F.D. Jones

"Art and the Machine"

by Cheney

Reference was made to various reports of conferences, pamphlets, booklets and publications pertaining to the subject.

I wish to express my gratitude to the many who have helped me to accomplish this thesis.

To the client

Mr. Forrest Gillespie

To the faculty members of the California Institute of Technology

Mr. J. Paul Youtz

Dr. D.S. Clark

Mr. David Welch

Mr. Beverly Morant

Mr. Salvatore Merendino

Mr. Harry Greene