

EXPANSION AND REVISION OF THE
PRODUCTION AND MANAGEMENT FACILITIES OF THE
ROYER FOUNDRY AND MACHINE COMPANY

by

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May 16, 1949

Professor Joseph S. Newell
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Dear Sir:

In accordance with the requirements for graduation, I herewith submit a thesis entitled Expansion and Revision of the Production and Management Facilities of the Royer Foundry and Machine Company.

I am indebted to Mr. William E. Ritchie of the Department of Business and Engineering Administration for his advice in its preparation.

Respectfully submitted,

Stanley S. Davies

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INTRODUCTION

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Purpose: The purpose of this thesis is to develop a plan for expanding the production and management facilities of the Royer Foundry and Machine Company; to increase the production efficiency by replacing the present overcrowded work area and congested layout with a well-planned orderly layout in an area adequate for comfortable and efficient operation; and to adapt this planning to the particular area designated for expansion by the management of the company. It is also the purpose of this paper to develop in the above plans a degree of flexibility which will make further expansion possible without completely upsetting the production layout, as will be necessary in the application of this proposed expansion.

Scope: No attempt is made to go beyond the physical aspects concerning the expansion and modernization of the facilities of the Royer Foundry and Machine Company other than the facts which lead up to and warrant the expansion. The greatest emphasis is placed on plant layout in an effort first, to locate all the departments in such a manner that each one will be placed conveniently near the others with which it has a direct function; second, to arrange each department layout to obtain maximum efficiency within the unit, consideration is given to minimizing materials handling and centralizing the storage of in-process inventory. It is intended that the organized procedure of operations proposed in the following pages can serve as a foundation for a more formal system of production planning and control than is now being used. However, the plant will still be sufficiently small after this stage of expansion to allow the present informal methods to function

as successfully as they have in the past. Hence, no recommendations are made at this point for such planning and control devices as production boards or Gant Charts. The expansion proposed in this paper includes plans for enlarging the office area and shifting the drafting department. An increased and well-organized storage loft is also included in the total expansion of plant facilities.

Limitations: This investigation, analysis, and proposed plan contain the following limitations.

1. The area for the proposed expansion as designated by management, was chosen because management feels it is the next logical area for an addition to the plant, not because an expanded production layout could best be achieved in this particular area. Hence, there is no choice in the direction of the expansion, or the size or shape of the area for the proposed addition.

2. The original building, constructed in 1923, is of light construction and will not support a second floor. Hence, this area is eliminated for possible storage loft space.

3. Management feels the problem is one of inadequate working space and poor layout, not a lack of production equipment. The company believes the present machines and production equipment are quite adequate for increased production volume, if the entire cycle of operation can be better organized and all machines and equipment can be fully utilized. Hence, the machinery available for the expanded production layout is limited to that which is now present in the plant. The plan is not to include additional machines or machines of a different type.

4. The additional area needed for assembly is based wholly on an estimate by the president, general manager, and foreman. A new market is being developed which will call for increased assembly of small machines; a new machine has been developed which needs considerable room for assembly. But, no concrete market data has been obtained to indicate what volume of sales might be expected, hence, the assembly area necessary is a rough estimate at best.

5. The present production procedure is lacking in regularity and uniformity of material flow. Hence, it is difficult to trace an average flow of materials or determine an average time for materials storage between operations. Flow process charts of present operations are at best a rough estimate and are, therefore, very limited in their use either as a graphic picture of the present situation, or as a scale for measuring the increased efficiency of the proposed layout.

Conduct of Investigation: This paper is based first on a familiarity with the Royer Foundry and Machine Company, the writer having worked in the shop for six months. A week was recently spent in the plant reviewing the present layout, tools, and equipment, the present production problems, and the area available for expansion. Many hours of discussion were held with the president and general manager regarding the needs which the expansion and new layout must fulfill. Some of this discussion was augmented by use of templates on the floor plan of the proposed expanded plant. Later, templates were extensively used in developing the detailed layout.

SUMMARY

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Conclusions: In the analysis of the present situation of production and management facilities of the Royer Foundry and Machine Company, the writer believes he has presented substantial proof that a revised plant layout is not only advisable, but most necessary for continual progress of the company. The following deficiencies have been realized:

1. There is very little relation between the present orientation of the various operating departments and the production cycle, resulting in excessive transportation of materials.

2. Operating departments are not accurately defined and many overlap, creating areas of congestion.

3. The total shop area is insufficient for number of production operations, storage, and assembly required by the present stage of production.

4. The overall layout is very crowded and lacking in organized storage space for in-process inventory.

5. In-process inventory travels much too far, often needlessly backtracking.

6. The present assembly area will not be able to handle the assembly of the new machine now being introduced, due to lack of sufficient area.

7. The cramped quarters of the belt department are far from being conducive to comfortable and efficient work.

8. Location of the steel rack is poor in respect to its related operations, such as welding. Excessive transport of material is the result.

9. The welding shanty is too small, and it is in no way related to any of the surrounding departments. Again, excessive transport is involved.

10. Transportation of materials is often inhibited by narrow passages between machines and restrictions due to storage of in-process inventory.

These deficiencies are the growing pains of a gradually expanding small business. The writer believes the point has been reached when they can no longer go unattended, and a major revision seems to be the only certain way of achieving a truly satisfactory operating layout, productive and efficient.

Recommendations: The following recommendations are made for expansion and complete revision of the production and management facilities to increase the working area, minimize materials handling, regulate materials flow, organize storage in all stages of production, and alleviate the crowded situation in the office areas.

1. Construct a two story addition as proposed in figure 1.
2. Locate a storage area for in-process inventory in the center of the machining operations. (Fig. 4, 5, and 6.)
3. Move the belt department into the wing now occupied by the steel racks. The area is large and still convenient to the foundry. (Fig. 3 and 11.)
4. Locate the steel racks as indicated in figure 3 and 11 for accessibility to incoming steel.
5. Locate the welding shanty adjacent to the steel rack for accessibility of incoming stock. (Fig. 3) Also, enlarge the welding shanty to alleviate congestion.

6. Assign the main portion of the new addition to assembly for ample working area and complete accessibility to all finished and purchased inventory. (Fig. 8.)
7. Place stock bins for finished machined parts on the border between the assembly and machining areas for direct routing. (Fig. 7.)
8. Locate tool and jig storage adjacent to the drill presses. (Fig. 3 and 11.)
9. Center the shipper between the assembly and crate departments for accessibility to both and to the finished inventory. (Fig. 9 and 10.)
10. Store finished machines adjacent to the new trucking door for convenient shipping and good appearance to front entrance of shop. (Fig. 3, 9, and 11.)
11. Store all heavy purchase goods in the second floor of the new addition for accessibility to assembly. (Fig. 13.)
12. Expand second floor office facilities into the area now used as loft storage over the crate department. (Fig. 13.)
13. Construct a private office for payroll and other confidential matter. (Fig. 13.)
14. Move the drafting office to the first floor for accessibility to front office and ship. (Fig. 11.)
15. Expand the front offices to include the present tool room. (Fig. 11.)
16. Relocate the shop lavatory and washroom in the area now used as a stockroom.

These sixteen recommendations are the major steps which must be taken to develop the proposed situation which is discussed in detail in this text. A graphic picture of the final result is presented in

figures 11 and 13. The layout as illustrated in figures 1 through 14, and developed in the discussion of the proposed situation is the complete recommendation of the writer as his solution for meeting the present need for expansion and revision of the production and management facilities of the Royer Foundry and Machine Company.

BODY OF REPORT

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History: The Royer Foundry and Machine Company was started by Mr. George Royer. Mr. Royer was an inventor of considerable genius, but as is so often the case with men of his aptitude, he was handicapped for many years by lack of the financial backing necessary to put his ideas into production. After developing a governor for mine elevators and a train coupling (to mention only two of many projects, none of which he had been able to capitalize), he contrived a machine for preparing foundry sand. At this point his entire shop was contained in an old wooden garage. Though his facilities were nil, his product looked promising to several bankers and established business men, and the Royer Foundry and Machine Company was founded in 1922.

The following year the plant was constructed. Funds were limited, and it was constructed as inexpensively as possible. The result was a building with 60 feet of street frontage, 150 feet deep, two stories in the front for offices, and a small foundry in the ^{rear} room. This building which was constructed with a light I-beam frame, but it is not believed to be sufficiently strong to support a second floor or much in the way of any heavy overhead load, is the main section of the present plant.

The Royer had the usual difficulties common to every enterprise having an unknown name which attempts to introduce a new product. Gradually a nationwide distribution was developed through agents of the foundry industry. Once machines were finally introduced into most foundry centers, they began to sell themselves and the business grew. With the growth of sales volume, came an expansion of the sales line.

The basic design of the machine remained the same, but it was produced in many different sizes. Constant improvements were made and finally it was included in a large scrape remover which contained a Royer shakeout. At one point the sand preparator was mounted on a caterpillar tractor with scraper, screw feed, and bucket line in front. This machine was designed to travel down long windrows of sand after the castings had been removed, and leave behind it a long windrow of the same sand completely prepared for remolding. However, this model proved to be too large and unweildy for all but a few of the very largest foundries, and the idea was abandoned until last year. The demand still remained for a machine which could travel down a windrow and prepare the sand as it went along, so a new model was developed. The plow, screw feed and bucket line still remain, but the sand preparator is mounted on wheels and is controlled by an operator who walks along side. The entire unit is much smaller and more compact than its predecessor and considerably more manueverable. At present the company is introducing this machine by trial in a large midwestern foundry. The development of this machine and the anticipation of its success is one of the major factors which prompts the company to expand its facilities, particularly the assembly area, since considerable work and space are involved in its assembly.

Two other applications have been found for the machine which was basically designed to prepare foundry sand for molding. It is now used by sewage disposal plants to handle sludge, a heavy, dry caked material which is rapidly processed to tobacco consistency by the Royer and bagged as fertilizer. This market is very slow, however, since most sewage disposal plants are municipally owned and operated

and, hence, are very inhibited in regard to the purchase of equipment. The other new market, the compost market, is very promising. The machine has been operated with great success by greenhouse men, nursery men, mushroom growers, and the peat moss industry. It is also used to prepare soil for public parks and gardens, golf courses, and cemeteries. Until last year this large, but very dispersed market was handled as a sideline by the same agents who dealt with the foundry industry. Needless to say, this gave a very inadequate coverage. The past year has been spent establishing a separate distribution network for the compost market. The outlook is very promising and is another factor which prompts expansion. Again the expansion emphasis is on the assembly department, since the compost market calls for many small machines.

The accumulation of machinery and equipment at the plant has paralleled growth of production as would be naturally expected. During the pre-depression years the new business could not afford new machinery and most of the large tools were purchased second hand. The tools included heavy drill presses, light standing drill presses, lathes of various sizes, a large planer, two millers, and three medium punch presses. Only in the past ten years have additional machines been purchased as new machines. Today the three old heavy drill presses are still doing satisfactory service and are the only heavy drill presses in the plant. The bearings have been replaced several times, but the company believes it can maintain them for several years to come. The same story applies to the planer, the two millers, two of the small standing drill presses, the three punch presses, and two of the lathes—though old machines, they are still doing satisfactory service due to careful maintenance. To this collection of antiques

have been added in the past years, four new lathes and several new light model drill presses.

The five belt machines now in operation are an interesting feature. They were designed and built by Mr. Royer when the plant first began operations twenty-seven years ago. They still provide the most satisfactory method for making the Royer belt. Mr. Royer also designed a small automatic machine for making the special staples needed in belt construction. Two of these machines are still in satisfactory service.

As tools and equipment have accumulated in the twenty-seven years the Royer Foundry and Machine Company has been in existence, and as production has gradually increased, a rather confused production layout has developed until today a very crowded condition exists and it is very difficult to draw a line where one department stops and the next begins. In-process inventory crisscrosses back and forth across the shop and is often stored in any vacant corner available between operations. Some of the machines are much too close together, making the transport of materials difficult in many spots. This situation is perhaps the most pressing factor for expansion of the plant working area. A new layout, which seems mandatory at this point, could not be satisfactorily achieved with the present number of machines in the limited plant area which now exists.

The Product: Royer sand separators and blenders are made in ten standard, stationary and portable models and specials to suit the needs of foundries large and small for conditioning backing, facing, and core sand. The same models are available as compost and sludge machines. All portable models are mounted on rubber tires; the foundry models are all electrically powered, while the compost and sludge

machines are often powered by gasoline engines, depending on whether operation is to be indoors or out. The basic design of all Royer models is the same, and the heart of this design is a rapidly rotating wide combing belt which runs over two pulleys so arranged that the belt gives a flat surface moving upward at 45 degrees. This combing belt consists of staggered rows of heat-treated chrome molybdenum sprigs or teeth mounted on a belt of rubber composition backed with heavy fabric. Over the combing belt is mounted a sheet steel hopper which guides the sand, compost, or sludge to the belt. The rapidly moving sprigs comb the material fine, it drops into the pockets between the sprigs and travels forward to be discharged out the front. At the upper end of the hopper is a retarding sweep flush with the belt for holding back foreign matter and material which is not completely reduced. The lower end of the hopper is a movable retaining plate for holding in the material load and discharging scrap and foreign matter. The entire machine is mounted on a welded steel frame. It can be fed manually or mechanically.

Manufacturing Processes: To describe in detail the manufacturing process of every part of the Royer machine would involve endless detail unnecessary for the purpose of this paper. Therefore, the manufacturing processes will be grouped in such categories as cast parts, cold rolled steel, sheet steel, belts, frames, assembly and miscellaneous.

The two large pulleys of the Royer machine are each mounted on a heavy steel shaft. These shafts begin their machining tour in the steel rack where they are stored in the form of cold rolled steel stock. The first operation is to cut to proper length the number of shafts designated in the lot order. An average lot might call for

twenty shafts. The shafts are cut by a power crosscut saw, a rather slow operation. From this point they move to the heavy grinder where the burrs are removed, and then they proceed to the lathe operation. On the lathe, the shafts are centered, the ends are squared, four cuts are made on each end, and a set of threads for a lock ~~nut~~^{nut} are also cut in each end. Drilling oil holes is the next step. Light drill presses are used; long small holes are drilled in both ends along the axis of the shaft and tapped for plugs. These holes are connected to holes perpendicular to the axis of the shaft which lead out through the bearing surface. The final operation is one of milling keyways at one end of the drive shaft for locking on the drive pulley. The shafts then go to stock bins of finished parts to await assembly with the long hallow pulleys. The entire process may be performed by three different operators. The first man may perform all operations from the steel rack to the lathe; all lathe operations are performed by lathemen, a third man will do the drilling, tapping, and milling. The ~~lot~~ is transported from one operation to the next by any one of the three operators, there is no uniform practice in this respect. From start to finish the lot may be temporarily stored between any or all of the operations, and storage space may be any empty corner of the shop where they can be piled.

Bearing mounts, pulley heads, wheel mounts, rear pulley slides, and sweep handles are all cast in the foundry. The risers and sprues are knocked off and rough edges are ground down in the foundry. The sweep handles require two single drilling operations and then proceed to finish stock bins. The wheel mounts, and rear pulley slides must first have their contact surfaces planed flat, the next and final

operation is drilling holes for mounting bolts. They then pass on to finished inventory. Bearing mounts, and pulley heads must first have their contact surfaces turned down by lathe operations, several cuts are required. The pulley heads are then completed with a drilling operation. The bearing mounts require both a planing operation and a drilling operation to reach completion. With each part described above, drilling, lathe, and planing operations will each be done by different operators, any number of storages may take place during the cycle of operations, and again, as with the steel shafts, storage space might be anywhere in the shop. They all eventually land in the finished stock bins except in the case of full bins, then they are stored in the shop wherever room is available, preferably near assembly.

Hopper sides, sand deflectors, and pulley guards are all purchased in their finished form. Though they are light, they are quite bulky and require considerable storage space. The sand deflectors and pulley guards require only a drilling operation for mounting holes, while the hopper sides require the additional operation of riveting steel strips along the bottom edges. The drilling operations take place on the light drill presses, the riveting is performed at a work bench. Since little precision is required to drill and rivet the parts, the job is generally reserved for unexperienced men who are being broken in.

Motor mounts are heavy rectangular sheet iron $3/8$ inches thick. These pieces are cut to size on the secator, and the rough edges are then ground down. To these pieces are welded flat and angular pieces for mounting. The next operation is that of planing the contact surfaces which is followed by drilling various mounting holes. The

drilling operations take place on the heavy drill presses because the size and weight of the motor mounts make them too unwieldy for smaller presses.

The Royer frames are constructed of welded angle iron. The angles are stored originally in the steel rack, are cut to length on the crosscut saw, and edges ground before they proceed to the welding shanty. Once welded together, a trimming by a portable grinder completes them for assembly.

Completely unrelated to all other operations is that of the belt department. The belt stock of rubber composition is purchased finished to size; the sprigs must be manufactured in the plant. Sprig steel is $3/16$ inches thick, one inch wide, and comes in large rolls weighing about 75 pounds. Operation one is to rewind a roll of steel onto a spool. The spool is then mounted on a punch press which automatically punches out flat sprigs 8 to 20 inches long depending on the setting. The sprigs have teeth every half inch. These flat sprigs then proceed to the bending press where a right angle is formed the full length of the sprig. They are next tempered in the foundry, then stocked in the belt corner for mounting. The belt machine is of very intricate construction, designed by Mr. Royer. The belts are placed on rollers as it moves along, the sprigs are stapled in place in much the same manner in which a sewing machine operates. The staples used are also manufactured by two small automatic machines in the belt corner. The finished belts are then dipped in a deep tub of a special heavy, tough black paint and then hung over the bin to dry, dripping back into the paint tub. This completes the belt and it proceeds to storage.

Assembly is performed in lots of one to as many as six, depending

on the size of the machines and the number needed at the time. The assembly man collects all parts needed from finished inventory, purchased inventory, and motors from the storage loft. One man carries the complete assembly from start to finish and usually paints the machine also. In the case of the large scrap removers, they must be constructed near the welding shanty. Two or three men are required to construct this machine which measures nine feet in every direction. The frame is built of heavy four-inch angle iron, which supports a huge hopper. The frame is welded together right on the assembly floor, after which the separator, shakeout, and controls are installed. The foreman usually supervises such construction. These machines are only made on order and are shipped out upon completion. The volume of production is only four or five per year.

The Royer Foundry and Machine Company also does much outside work. They will generally take on any machine shop job from repairing mine pumps to turning out rollers for the presses of the Wilkes-Barre Record. They have made many pieces of special equipment for the Planters Peanut Company, including the mechanism for a twenty-foot mechanical peanut man, and have also made special machines for one of the large local bakeries. These jobs are always supervised by the foreman. He is an ingenious mechanic and machinist. Many jobs he will do himself; others are handed out to the better machinists. The jobs are assigned to any vacant machine. In case of a rush job, it will replace the regular Royer production if proper machines are not otherwise available.

Consideration of Present Layout: The ills of the present layout of production facilities of the Royer Foundry and Machine Company stem from two sources. First, the working area available for production has not kept pace with the growth of production volume and subsequent growth of production equipment. The result is an overcrowded condition which makes it cumbersome to move material from operation to operation, makes direct routing of material difficult sometimes impossible, and leaves little or no space for an organized system of storing in-process inventory in a manner convenient to the successive operations. The result, beyond congested working conditions, is an excess of materials handling and a flow of materials too irregular even for a job-shop plant, which is fundamentally the classification of this company. Second, the gradual growth and expansion this plant has undergone in the past twenty-seven years has brought about the condition so common to growing small plants. In the beginning operations were small enough to be classified all under one department. Machines were few enough that their location one to another was not all-significant. As production increased and one machine was added to another, the production area expanded and various elements of the manufacturing cycle grew to a point where each should be organized as a separate unit. However, as machines and tools were added, too often they were located in any space which was available, and their location did not always coincide with their phase of the operating cycle in which they were to function. The resulting situation which is present today is that of various departments overlapping--it is difficult to draw distinct lines of demarkation between them--and location of departments incongruous with the cycle of operations. Figure 2 shows the approximate location

of departments as they are located today, but the lines of demarkation as illustrated are a rough estimate at best.

The belt department is probably the most critical point of overcrowding. The five belt machines, three heavy presses, two staple machines, a small lathe and work bench are crowded into an area of approximately 850 square feet. The machines are so close together that it is difficult to walk between them. The congestion of this area is increased by storage of belts, sprigs, and a rack for comb-bar stock. The flow of belt stock, which is bulky and combersome, is a clumsy situation at best, and operation of the belt machines is restricting and far from comfortable in view of the loading and unloading of belt stock on the machines in an area with so little freedom of movement. As belts come off the machine, they must either be carried one by one to the nearest available place for storage to await painting, or they pile up by the machine obstructing the limited passage space between machines. Crowding is the only major deficiency of the belt department; the location is good. It is next to the foundry where the sprigs must be heat treated. The sprigs have a minimum distance to go from the presses to heat treating and back to the belt machines.

The assembly department is as satisfactorily located as possible under the present location of finished inventory, purchased inventory, and shipping. However, this relationship could be improved by better orientation of these sources upon which assembly must draw. The difficulty anticipated for the assembly department is one of insufficient floor area in the very near future. At present the area is used to its fullest capacity, but sales of the new machine will bring the immediate problem of area in which to assemble them. Also, it is

expected and hoped that the new compost market will mean a greater number of assemblies of small machines, again calling for an increase in floor space for the assembly department.

In considering any form of expansion or new layout of the present facilities, the location of storage must hold a high priority particularly in a job-shop where in-process inventory often has many long waits between operations. The present situation in the Royer plant calls for both expansion and re-orientation of all storage facilities, finished parts, in-process inventory, purchased parts, and purchased small stores. In-process inventory, for example, is scattered throughout the plant, sometimes stored near the machine of its last operation, or the machine of its next operation, or very often in any out-of-the-way corner. In any case, it is difficult to keep track of the in-process stock; it often piles up and congests the working areas and passageways, and it usually moves twice the distance necessary before it completes its cycle of operations. Very few areas are designated for storage of a particular part. An area where pulley mounts are stored one week may contain pulley shafts or hopper sides the next. In the past the foreman has been able to keep track of the in-process inventory in his head, but now the point has arrived when he should be relieved of this task by some form of organized storage system. As for purchased parts, wheels, motors, and drive pulleys, most are found in the second floor loft over the crate department. The location is good for incoming material, since it can be unloaded and hoisted directly to this area from the outside where deliveries are made. On the other hand, it is a long haul to the assembly department. Some motors are stored in the balcony loft which is much more convenient to assembly

and equally accessible to delivery. Purchased stores such as nuts, bolts, springs, and bearings are in the best possible location in view of the present layout. However, finished machine parts, which are fabricated right next to the assembly area must move off to the storage bins then back to assembly which is not minimizing materials handling. Also many finished parts are stocked in other parts of the shop for lack of space in the finished stock bins. Though many of these outside stock piles are convenient to assembly, it would simplify matters if finished parts could be placed in one designated area. If production continues to grow, the necessity for ever tighter record and control of inventory will also grow, and centralized storage will eventually be mandatory. It would be an asset at this present stage of production.

The storage of tools and jigs is a function which is related almost entirely to the operations of the drill presses and millers. At present the storage area is quite far from the area where the jigs and stored tools (drills and cutters) are actually used, which necessitates excessive transporting between the two. The present location does have the advantage of being conveniently located in respect to the foreman's office, since he must continually check on the condition and supply of small tools and does what work the jigs require in the way of repair or redesign. Its present location also allows a tight check on this equipment, which is advisable in the case of any small articles of value which might otherwise become scattered and lost.

The problem of the steel rack and its accessory tools (saw, cut-off, and secator) is mainly one of accessibility to delivery of steel which comes in the form of long stock, heavy and unwieldy. Its

present location has an entrance to the yard where trucks arrive to deliver material, but the location of the entrance is such that it is a mean job to get the long steel bars from the truck into the racks. Also, the location is quite out of the way in respect to the two operating areas to which it is most closely related, the welding shanty and lathes. All stock from the steel racks must cross the shop diagonally to both of these areas. As for the welding shanty itself, here again is an area which suffers both from a poor location and cramped quarters. The welding shanty must function with the steel rack, as mentioned above, and assembly. It is not near either. The assembly of large scrap removers, at present, is not done in the assembly area where it should take place, providing room allowed, but these machines must be constructed in front of the welding shanty for accessibility to welding—a major assembly operation of the large scrap remover. The new machines which are now coming into production, also require the presence of welding equipment on the site of assembly, which makes it mandatory that assembly and welding be moved to adjacent positions for future operations. The welding shanty has the task of constructing all the machine frames from welded angle iron. This is a cumbersome operation which requires considerable room in which to move about. The present facilities are much too small and congestion arises when many frames are in the process of construction. The shanty should be enlarged to enable welding of the new machine to take place within the shanty to eliminate the flash from the rest of the shop. The present setup is too small for this practice.

The last productive department, which is the heart of production, is the machining department. It includes all operations of lathes,

drill presses, millers, shapers, and the planer. Its general location is all right, but its layout is rather scattered. The lathe arrangement is good. The other tools are not organized to any particular pattern of materials flow. The greatest difficulty in this area is that of a total lack of designated storage area for material in-process, as was discussed in the section on storage. Congestion often arises from storage around the machines and materials handling is excessive when the congestion is relieved by storage outside this area. Orientation of any layout should begin with this area and it should be so located as to allow proper orientation of all other departments in relation to it. At present, the steel rack, tool and jigroom, and finished inventory are all poorly arranged in respect to the machining department, and storage of in-process inventory does not exist in an organized form. Expansion of this area is only necessary to the point of including proper area for storage of material between operations. Materials handling could be reduced somewhat by a more organized layout of the tools in this area, centered on some pattern of material flow.

The remaining plant floor space is engaged by the crate department. This area alone has both ample floor space and proper location. It is most accessible to incoming material, which in this case is lumber and nail bags, and the exit of finished crates is near the finished machines, which is as it should be. The only deficiency is the fact that one corner of this area has been designated as the paint locker. All paints are stored here and much of the painting takes place in this area. The deficiency is the fire hazard produced by the presence of paint storage adjacent to the storage of lumber. These two departments should most certainly be separate for the sake of safety.

As production grows, the management of production also must increase, and its facilities must likewise expand. The situation on the shop floor also holds true for the management facilities, they too are now inadequate. The increase in production calls for office work requiring more room than is now available. Increased government control over the past years brings still more pressure for expansion of office facilities. As for the layout of office facilities, two difficulties are now encountered. First, the only private office is that of the president and general manager. The secretary in charge of the payroll, which is confidential, does not have sufficient privacy to be able to work on it during regular office hours. The result is several nights of work every two weeks in making out the payroll so that sufficient privacy can be had for this business. This seems to be a rather unfortunate situation, the relief of which calls for a private office for this work. Such an office can only be had by expansion of the total office area. The second deficiency is that of the drafting room. There is only one draftsman, and he also has the responsibility of purchasing and following up orders. These tasks keep him in the front offices of the first floor, which are already overcrowded. He has one small drafting table on the first floor, while the main portion of his equipment is on the second floor. For any degree of efficiency this man should have his facilities located in one area, preferably on the first floor in view of the time he must spend there with his responsibilities other than drafting. Also, the drafting at this stage is done in close cooperation with the foreman, who works out the details for new developments in his first floor office and on the shop floor.



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Page 24 has been omitted due to a pagination error by the author.

Again this is a problem of both expansion and layout.

Proposed Situation: As emphatically indicated in the above analysis of production and management facilities, a revision of the present layout seems mandatory. This could not be achieved successfully in the present limited plant area. Therefore, the following solution is proposed.

Management has designated the area indicated in figure 1 as the logical area for the next plant addition. In the proposed situation this area will be fully utilized for construction of a two story addition to the present plant. This structure should be so designed that it will be capable of withstanding the stress of heavy floor loads on the second floor, an area which will be discussed later in terms of storage. In regard to the actual structure of this addition, savings may be had by removing all windows and frames of the present outside walls which the addition will enclose, and using these windows and frames in the new construction. The present window area which will be applied to the addition will be sufficient to furnish the entire new first floor and part of the second floor with the material at hand. The street entrance of this addition will have a double with door rolling overhead to utilize the space which would otherwise be reserved for clearance of doors swinging on a vertical axis. The second floor will have a similar door area, the street front for entrances of material by an overhead hoist. However, the overhead rail eliminates the overhead door, so two doors will be used which swing inward on vertical axes. Three of the present wall areas will be eliminated to allow additional passage into the new area. These three cuts may be seen in figure 11, one on the left side of the tool room, one as an exit to

the welding shanty, and the third to be the cut in the south wall of the present building as an new shop entrance for some of the incoming goods and an exit for all shipping. This entrance must have a sliding door, since again the overhead rail for hoists makes a rolling door impossible. All these cuts come in wall areas which now contain windows, hence, none of the present I-beam structure must be altered or reinforced. Windows will be cut in the left hand wall of the area proposed for the belt department. At present this wall is blank, and the light will be necessary for operation of the belt machines as well as for the sake of good environment. The only other construction detail which will be mentioned is the consideration of the light construction of the original building which the addition will contact on the south side of the proposed assembly area. This side of the new structure will not be supported by the old building, but will rest on its own I-beam supports erected flush with wall of the old building. All other contacts of the addition and the present building will be with the later wings which are of sturdy structure and able to support the addition.

The revision of the plant layout will begin with the machining area, since this is the heart of the production cycle and, hence, the logical starting point. The new south entrance reduces the present lathe area. The basis for the location of this entrance is a straight passageway and rail for overhead hoist directly from the entrance to assembly. If the entrance were to be moved one bay nearer the front offices the overhead rail would be eliminated by the present storage balcony. In determining the location of the machining department, lighting is a prime factor, for the most precise work is done on the

lathes. The windows of the south wall offer the best lighting, and this area, as indicated in figures 3 and 11, is of ample size for the new tool layout. The lathes and planer receive first priority on natural light and are so located; next are the millers and shapers in that order. Another factor was also considered in placing the planer. The proposed new south entrance will be a source of cold air in the winter, whenever the door must be opened. This could well be a discomfort to any operator forced to work near this entrance. The planer is the one machine in this area which is used the least, and also the one machine which places its operator farthest from the entrance. Should this solution not be complete enough, there is ample room between the lathes and planer to move them all farther from the entrance and erect a protecting panel perpendicular to the entrance.

Four considerations determine the location of the drill presses. First, there are the last machines in this area in priority for natural lighting. Second, all drill press operations require the use of jigs and access to tool storage (drills), and hence should be placed as near the jig and tool room as possible. The proposed layout not only realizes this desired feature, but in so doing also gives the tool and jig room an optimum location in regard to its combination with stock bins of finished parts and hence allows the view of one man to control both. The third consideration is the fact that drilling operations are the final operations in the production cycle of each part which passes through the machining department. It is logical then that this final operation should take place at the point nearest the destination of finished parts (stock bins of finished inventory and assembly). The final consideration was to arrange the machining tools

in a circular manner centered about a storage area for in-process inventory to minimize materials handling. This too was brought about by the proposed location.

One overall advantage of the proposed location of this department is its direct access to the foundry, the source of all cast parts which must be machined, and to incoming purchased parts which must be completed (hopper sides, pulley guards, and sand deflectors). These two sources account for about 70 per cent of the material which flows through the machining department. The one weakness of this location is that factors determining the location of the steel rack made it impractical to locate it adjacent to the machining department. Hence, the source of stock for pulley shafts is not as near as the ideal situation would have it. However, this factor becomes negligible in view of the advantages already discussed. An added feature is the spur overhead rail branching from the main line and passing over the planer and two large lathes. This will greatly assist in transporting and setting up heavy outside jobs which are often done on these machines.

By far the greatest asset attained in the layout of the machining area is the radial location of machines centered about the storage bins of in-process inventory. Figure 4 illustrates the central location of this storage area in respect to incoming material flows, and the exit of finished parts. Storage of materials in any phase of a production cycle is always to be minimized and eliminated wherever possible. The ideal state is continuous flow. However, this situation is reserved for a moving production line, while the job-shop must recognize that the very nature of a job-shop production system breeds

storage at the end of nearly every operation. The task, therefore, is to organize this storage to minimize materials handling and transportation, and maximize the accessibility of inventory for each succeeding operation. The detailed layout in figure 11 and the charts of material flow, figures 5 and 6, will illustrate graphically how this desired situation has been achieved. Figure 11 shows that no operator is more than several steps from his course of supply. Figures 5 and 6, which indicate the storage areas designated for each classification of material in each stage of production, further emphasizes the accessibility of material to each operator. It is not intended, of course, that the material will be drawn piece by piece--material will continue to move in lots, but the distance will certainly be minimized. Figure 5 traces the flow of cast parts. The different parts are not differentiated, but the route to every type of operation is indicated. This chart also traces the direct route, storage and operations of the purchased inventory (hopper sides, pulley guards, and sand deflectors). Figure 6 traces the other two major material classifications, steel shafts, and welded bases. When figures 5 and 6 are aligned and pressed together the entire floor situation can be seen at one time.

It should be pointed out that material does not have to return to the bins following the completion of each operation. Whenever the completion of one operation coincides with the availability of machine and operator to perform the succeeding operation, the material, of course, will flow directly to the next operation, by-passing the storage bins; unfortunately this sort of timing is more often the exception than the rule. The system outlined here may be regarded as a buffer or governor. It will absorb an excessive inflow of material at any

point without congestion, and it is a pool of inventory on which to draw when the inflow at any point is slack. Between any two operations these stock bins will be absorbing every surge and extending in time of slack. Erratic material flow is characteristic of job-shop production. However, this proposed buffer system continually assures available stock for each operator. Another advantage of this centralized storage is its use as a rapid indicator of the inventory situation. One glance at the bins will give a complete picture of the inventory level.

Second in importance to the machining operations are those of the belt department. The fabrication of belts is the most independent phase of the overall production cycle. It need only be coordinated with the foundry for the function of heat treating sprigs. The remaining area which is adjacent to the foundry is nicely suited both in area and shape to house the belt department (see figures 3 and 11). The following factors determine the arrangement of machines as illustrated. First, the belt machines staple machine and three presses are not individually powered, but rigged for overhead pulley drive. This fact points to an arrangement of machines as nearly in one straight continuous line as is possible within the area limitations. The long narrow space available here allowed this to be achieved. One overhead drive shaft will extend from the bending press to the furthestmost belt machine, and all machines will be powered from this shaft. Measuring in a direction perpendicular to this drive shaft, it may be found that the staple machines and bending press are too far aside from the center line, placing their drive belts at such an angle as to greatly reduce the desired overhead clearance above the passageways. Should this be

the case, the main overhead shaft will be displaced slightly to the left (toward the staple machines and left punch press), and a short drive shaft will be mounted parallel to it and centered over the bending press and rear punch press. This auxiliary shaft will be powered by a horizontal belt to the main line.

The second factor which determines the proposed layout of this department is the order of operations performed in the manufacture of springs. With coiled spring steel stocked in the indicated area, it passes in order through the winder, punch press, and out to the foundry. The smaller punch press on the left is not utilized in the manufacture of belts, but it is operated by the belt department. Also, it must be located where overhead drive is available. It is used to punch out comb-bars for the Royer shakeout, a small operation independent of every other plant operation. This function can be nicely absorbed by the belt department. The press is located in the manner illustrated because the comb-bars are five feet in length and considerable clearance is required in both front and rear of the press. Comb-bar stock is small and will be stored next to the press. Shakeouts are made only to order, so finished bars will go directly to welding for the final pre-assembly operation—no storage will be involved.

The third consideration is that of spring and belt storage accessible to the operators of the belt machines. A limited supply of springs will be placed in a receptacle above each belt machine, at a height that can be easily reached by the operator while remaining in a sitting position. The main storage of springs, upon return from the foundry, will be stored in shelves along the wall as indicated. There

will also be sufficient storage area along this wall for an ample supply of belt stock. The main storage of belt stock will be located in the loft over assembly and will reach the belt room by being lowered through the trapdoor just outside the belt room entrance.

The final factor which must be included in this department layout is the facility for maintaining the machines. The head belt operator is in charge of maintenance of the entire department and requires a small lathe, grinder, and workbench. These items fit nicely along the left wall as indicated, completing the layout, which gives ample room for comfortable operation, movement of materials, and storage. The finished belts pass on to the painting tub adjacent to the belt room, then move across the aisle to final storage in the assembly area.

Location of the steel rack must have the next priority. Its access to incoming steel is a factor which cannot be compromised. The location designated in figures 3 and 11 satisfies this need completely, and also gives the added advantage of proper orientation with two other departments with which it must be coordinated, the welding shanty, which requires most of its stock, and assembly. As mentioned in the discussion of the machining department, the steel rack is not in an ideal location as a source of shaft stock for the lathes. However, at this end of the line, also, this single disadvantage becomes negligible in view of the advantages realized by this proposed location. Layout is no problem in this area. The saw requires a long clearance area behind it for the stock which is fed in through the rear. The cutoff needs similar clearance plus a location against an outside wall to simplify piping out the fumes it exhausts. The secator handles sheet metal and requires average clearance on three sides. All of these

requirements are easily met by the proposed arrangement of tools.

The welding shanty must be closely coordinated with the steel rack. An adjacent location is most desirable since the entire flow of material which must undergo a welding operation comes directly from the saw and secator of the steel rack area. Such an adjacent location has been managed as is illustrated. Additional improvements in the proposed welding shanty are: 1. An increased area which enables all frames to be welded within the shanty with the exception of the large scrap remover; 2. A location adjacent to the assembly department negating the distance finished frames must travel, and making possible the assembly of the scrap remover in the assigned assembly area by virtue of immediate access to welding equipment, which can be rolled out on the assembly floor; 3. A separate entrance and exit which enable a continuous single direction flow of material through the shanty, eliminating congestion, and; 4. The location of a grinder between the entrance and exit. Burrs from the saw must be ground down before material undergoes a welding operation, and many welds must be trimmed following the operation. The location of this single grinder accomplishes both tasks. Storage of finished frames is immediately adjacent to the exit of the welding shanty, actually on the assembly floor, and directly under the eye of the shipper who is also in charge of finished inventory. Welded motor mounts require planing and the planer is within a reasonable distance of the shanty exit with a direct aisle route between them. Neglecting the other factors, the ideal situation would of course reduce this distance.

Finished inventory falls in an ideal location. The stock room for machined parts lies on the border between the area of machining

operations and assembly, which is as direct and short a route as possible. These bins are so located as to be under the direct observation of the shipper who is responsible for finished inventory. Small purchased inventory (nuts, bolts, springs, and so forth,) are also the responsibility of the shipper and are located in the same convenient area for this supervision as is the finished inventory. An additional advantage to the location of these purchased stores is their proximity to the point of arrival--they come directly up the passageway from the south trucking entrance and are checked in at the office of the shipper. Figure 7 gives a graphic picture of advantageous position of these stock bins. At the present scale of production a record for checking inventory in and out of these can operate adequately on a clip board hung at either entrance to these bins. This record will serve two purposes. 1. To keep track of small parts which otherwise might easily become scattered and lost. 2. To enable a rapid spot check on inventory without the necessity of actually counting hundreds of small parts. Fencing this area in could serve only one purpose; that of discouraging pilferage--a condition non-existent in this plant due to its superior grade of personnel and excellent personnel relations.

The final stage of production is assembly. The previous stages of layout development have all been directed toward this end, which makes the orientation and planning of this department all important and perhaps in some respects the measure of worth of the overall plan. The plan for the assembly department, as illustrated in detail in figure 11, is determined by the following factors. 1. Orientation in respect to the inflow of all finished inventory. 2. Accessibility to welding facilities. 3. Location in respect to the shipping department.

4. Needed floor area for present assembly, anticipated increase due to the development of the compost market, additional area needed for assembly of the larger machine now being placed on the market, and sufficient area to enable construction of large scrap removers on the assembly floor. 5. Demand for ample work bench space. 6. Need for access of small drill presses and grinders.

The proposed layout incorporates all of the above factors. Figure 8 illustrates graphically the flow of all finished and purchased parts which enter the assembly area from three sides and surround the assembly operations in their various storage areas. The storage of finished belts, hoppers, sand deflectors, pulley guards, and welded frames and motor mounts will not require the procedure of a written system for checking parts in and out. These are all large bulky parts which will not be mislaid or lost, and they are stocked in relatively small numbers, enabling a rapid visual count for spot checking inventory. A checking system such as will be maintained in the finished and purchased inventory bins would not warrant the effort and detail involved. Motors, wheels, pulleys, and pulley belts drop into the center of the assembly area from overhead trap doors in the second floor storage loft. From the standpoint of accessibility of finished and purchased parts for assembly, this layout could not be more exact. The paint locker has been included in this department, eliminating the fire hazard which exists at present with the paint and lumber storage adjacent, and enabling finished machines completely painted to roll out of assembly, past the office of the shipper into the area designated for storage of finished machines. The spur of the overhead rail which branches out across the area assigned to assembly of large machines

will make an electric or chain hoist available along the entire area to assist in assembly of heavy parts.

Beyond the responsibilities of inventory control, shipping and receiving goods, the shipper is also responsible for the crate department. Figure 10 illustrates the visual vantage point of his central location. His position grants him full view of the three areas of control under his responsibility. The design of the shipper's room is to consist of a desk near the entrance and storage shelves on three walls. The shelves are under the window viewing assembly are waist high to afford vision of assembly and finished inventory, and to provide bench area for boxing repair parts. The same shelf design will be used on the shelves directly opposite to obtain a similar view of the crate department. The remaining shelves will be at least head high. In this office will be stored a quantity of all small parts and bearings which are commonly demanded as replacement parts. Flat cartons will also be stored here. The equipment will include a scale for weighing boxed parts. The function will be that of boxing and shipping repair parts, plus the previously described functions of the shipper. The central location of the shipper also commands the vantage point of being at the junction of the flow of finished machines and crates—an ideal location for coordinating the two. This situation is illustrated in figure 9. Actually finished machines will be lined in the area designated in figure 11, and will not be crated until ready for shipping. The storage of finished machines in this particular area will present an attractive front to all visitors approaching through the main entrance. This area also enjoys the advantage of being adjacent

to the shipping exit, the logical area for storage of finished products.

This completes the layout of ship facilities. All operations are orientated in respect to the cycle of operations. Materials handling and transport are minimized, and ample working area is allowed for each operation. All passageways between machines are at least four feet in width. Wider arteries for transportation extend from the trucking entrance to assembly, and from the foundry to the front offices. The main overhead rail from trucking to assembly will assist in transporting heavy material, aid in crating, and loading crated machines. The spur rail to the overhead balcony is strictly for transport of heavy material assigned to balcony storage. As for the manner of transporting inventory between operations, the distances involved are too short, and the loads too light to warrant elaborate equipment such as fork trucks, which would be much too cumbersome in a plant of this size. Conveyors would not be economical for such erratic material flow and would not be applicable to this job shop layout. Wheeled pallets and handtrucks will serve the purpose well.

The overall need for plant expansion is as pressing in the area of management facilities as on the shop floor. By utilizing the second story of the proposed addition for all loft storage, the present loft storage will be vacated and available for expansion of office facilities. An entrance will be cut into this area as indicated in figure 13. The floor level of the present storage loft is three feet above the floor level of the present office, which will necessitate the addition of several steps. The office of the president and general manager is to remain the same. Its location is satisfactory and the space is ample. The present office area is to be partitioned as indicated

in figure 13, providing a lobby, two private offices, and a sizable ladies' lounge with lavatory. One of the proposed private offices is to be assigned to the secretary in charge of the payroll and other confidential matters, thus eliminating the present unsatisfactory situation of night work for the sake of privacy. The other private office may be assigned to the company treasurer. The additional office area will be arranged in the manner indicated in figure 13. It features ample room for files, a storeroom for ice supplies, and sufficient desk area for an expanded secretarial force. The desk area has the advantage of good natural lighting. The men's lavatory will not be located in the new office as indicated in the proposed plan, but will be located in the lobby area opposite the one in the president's office. This change is made for obvious reason. The entrance between the proposed office addition and the new storage loft already exists in the form of an entrance now used for hoist access for present loft storage. No wall must be cut, but the present opening will be reduced to normal door size. This access to the proposed storage loft will be a convenience to management for inspecting the loft inventory situation.

Revision and expansion of first floor office facilities is proposed to fulfill the following needs. 1. To provide the draftsman with a separate office large enough to install complete drafting facilities, convenient to the second floor for consultation on design, to the shop and foreman for construction details, and to the front office in conjunction with the draftsman's added responsibility of purchasing and tracing orders. These needs may be satisfactorily met by utilizing the area which is now the shop lavatory and washroom. This area is ample, it has natural lighting from two sides, and is the only

area readily accessible to both the first floor front office and the second floor. This access will be enhanced by addition of an entrance at the foot of the stairwell as indicated in figure 11. The area of the front office must also be enlarged. This is easily achieved by including the present area used for the storage of tools and jigs. The displaced lavatory and washroom may be located in the area now used as the stock room. This location will entail minimum plumbing, since installation of the new second floor lavatory will be directly over this area allowing a single line to service both lavatory facilities.

The expansion and revision of management facilities is a rather straight forward business in respect to the intricate relationships which must be developed to achieve the maximum benefit of a properly orientated production layout. However, both phases of the business venture must keep in pace. The present deficiencies of the production situation seem more vital at this point than the needs of management. But, the proposed addition and revised production layout offer a prime opportunity to relieve the congested condition in the office areas also. It therefore seems logical, and perhaps most economical, to combine both proposed expansions into one move. This operation should not be considered solely in the light of a venture into an era of greater production. Granted the proposed move will increase the productive capacity of the plant considerably, but many of these changes should be incorporated regardless of whether or not anticipated sales increase actually materialize.

APPENDIX

ROYER FOUNDRY & MACHINE CO.
PLOT
CONTAINING 29,698 SQ. FT.

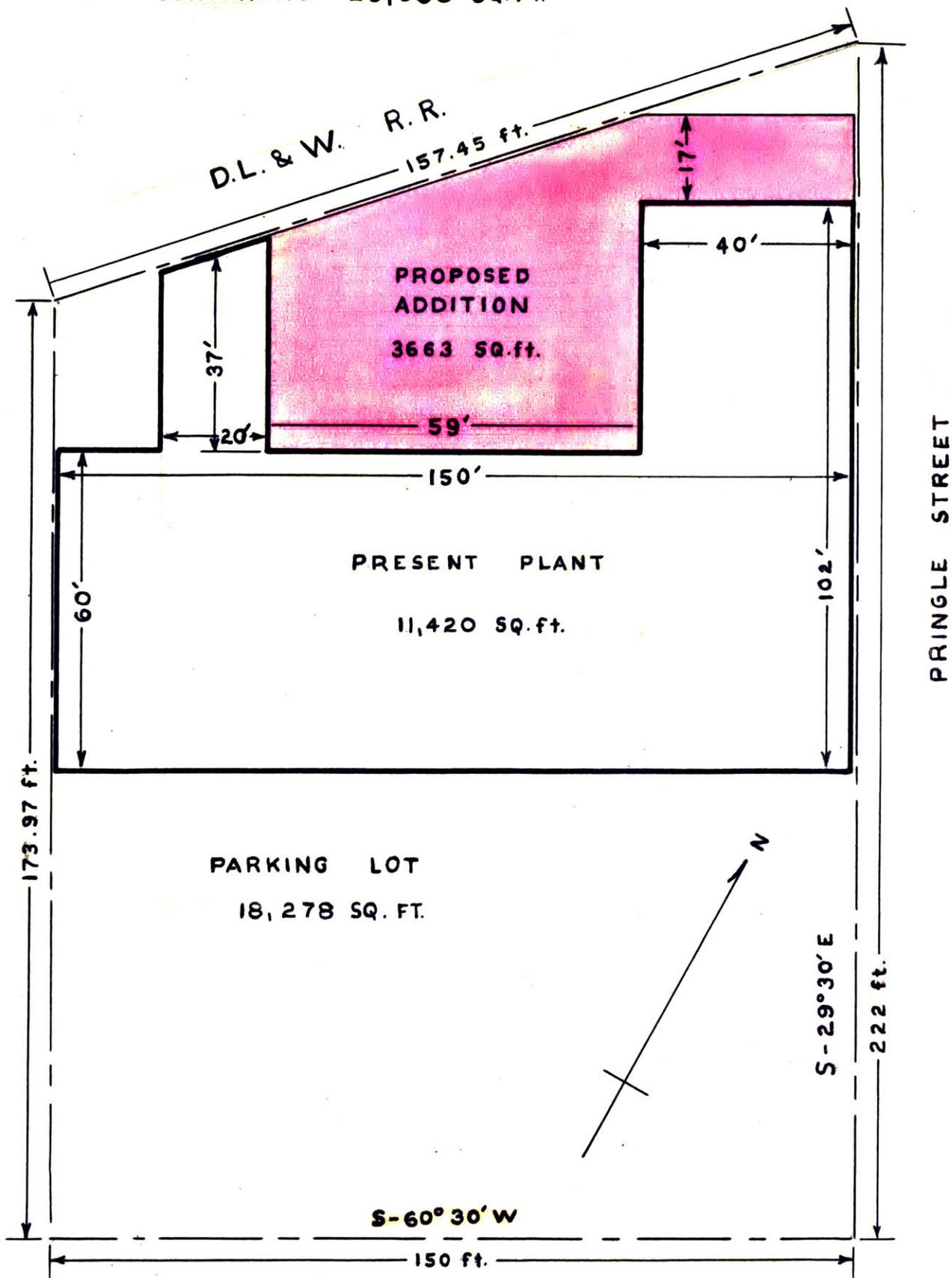


FIG. 1

PRESENT LOCATION
OF
DEPARTMENTS

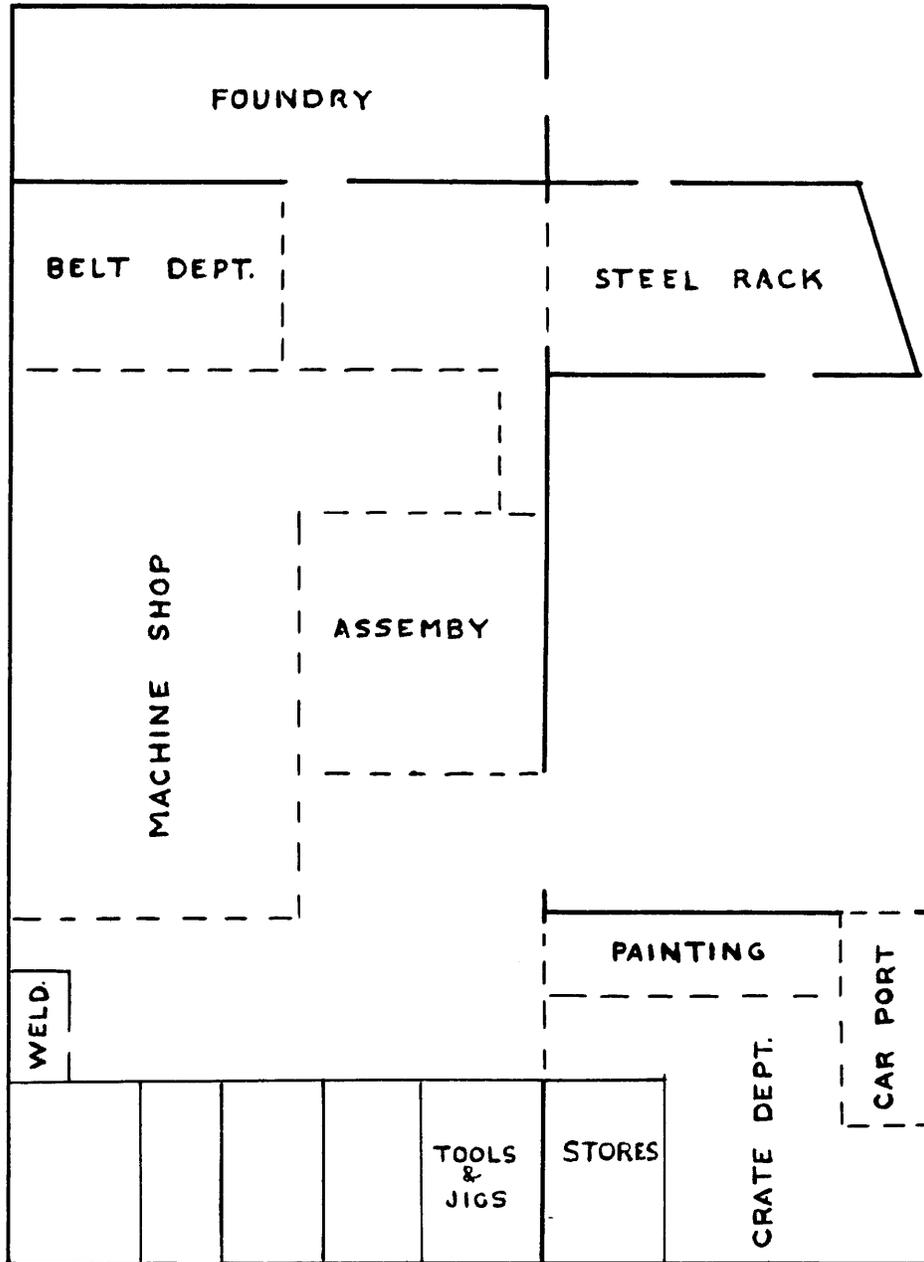


FIG. 2

PROPOSED LOCATION
OF
DEPARTMENTS

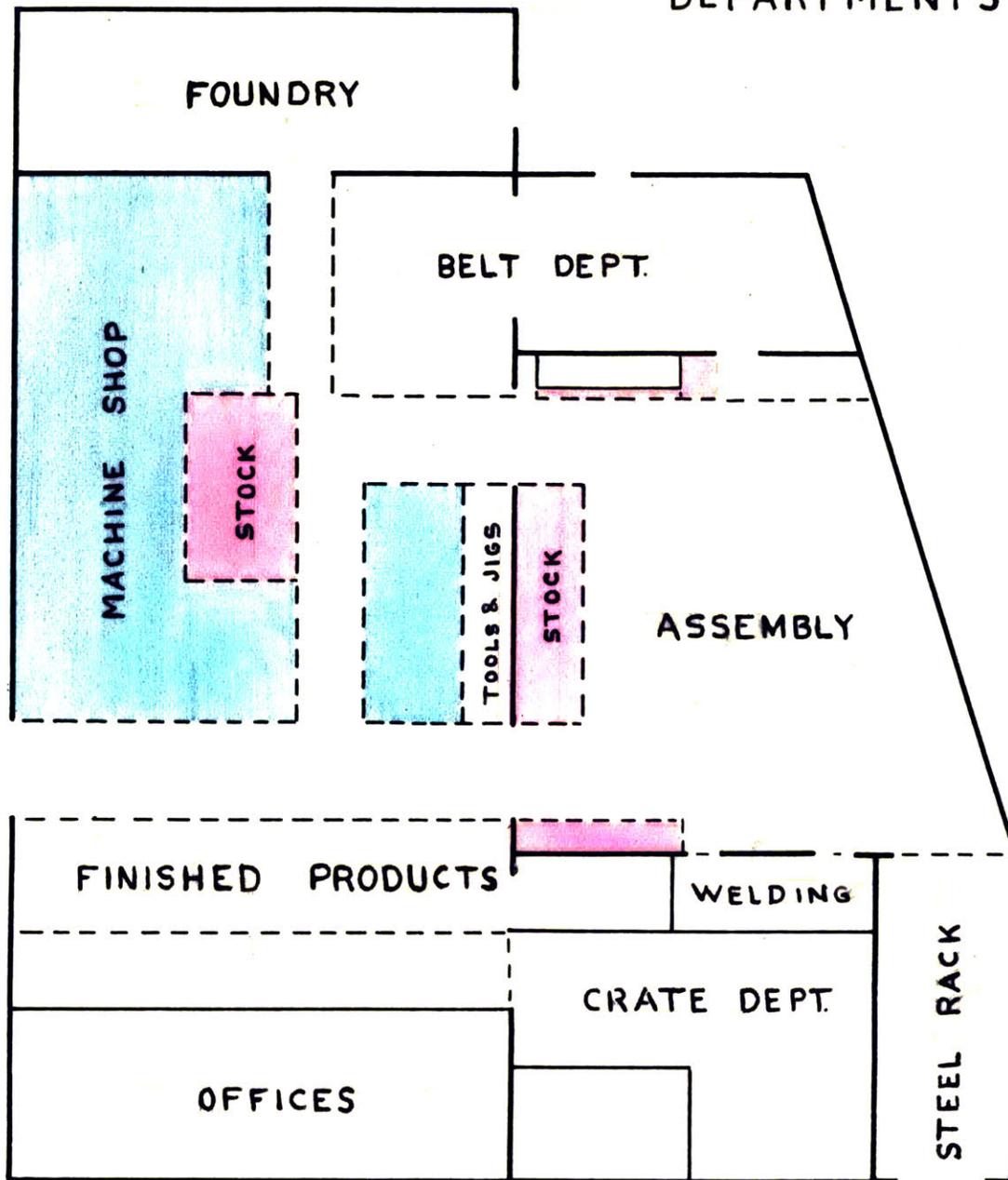
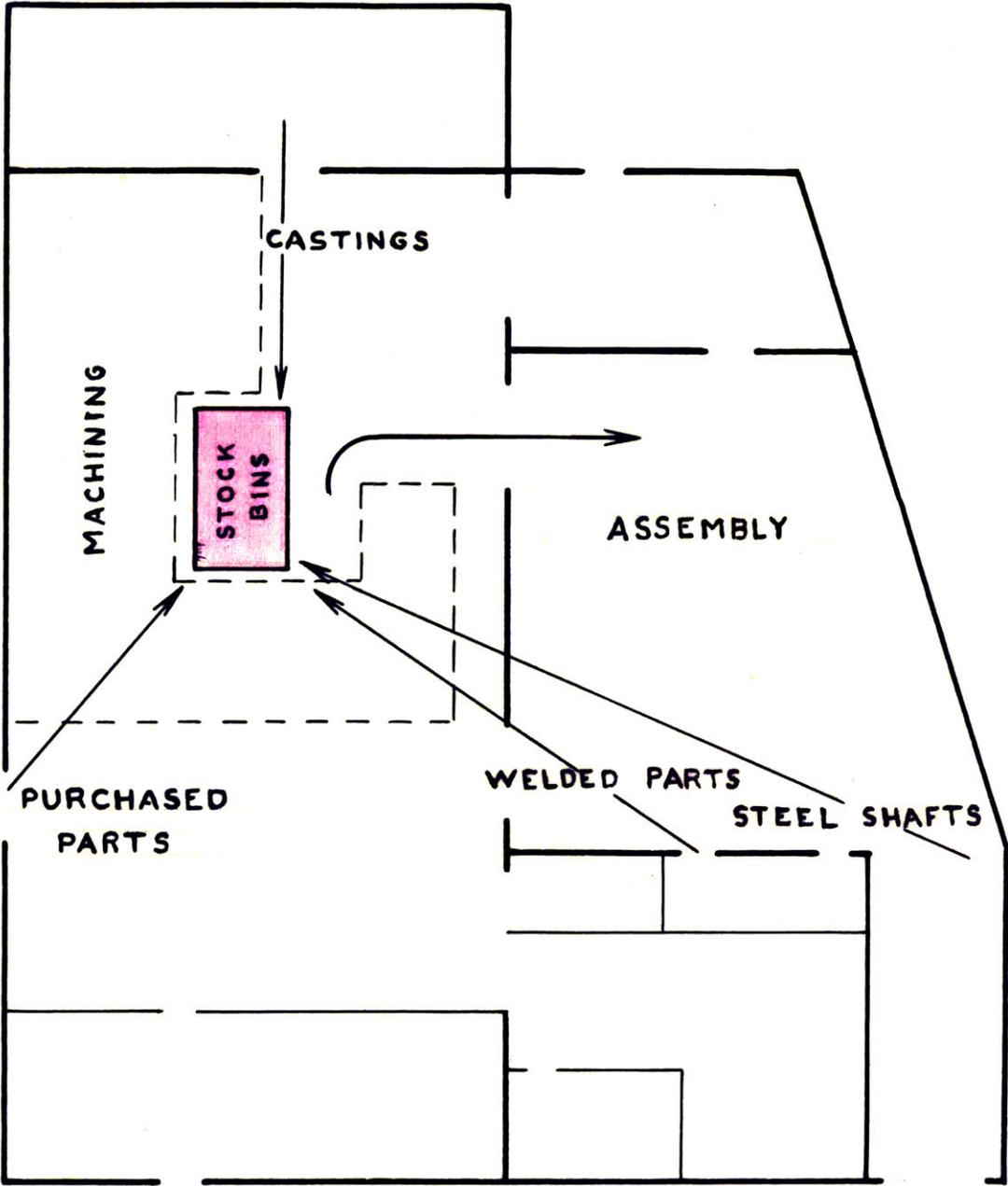


FIG. 3

IN-PROCESS
INVENTORY



STOCK BINS FOR IN-PROCESS INVENTORY CENTRALLY
LOCATED FOR BOTH INCOMING MATERIALS AND ALL
MACHINING OPERATIONS

FIG. 4

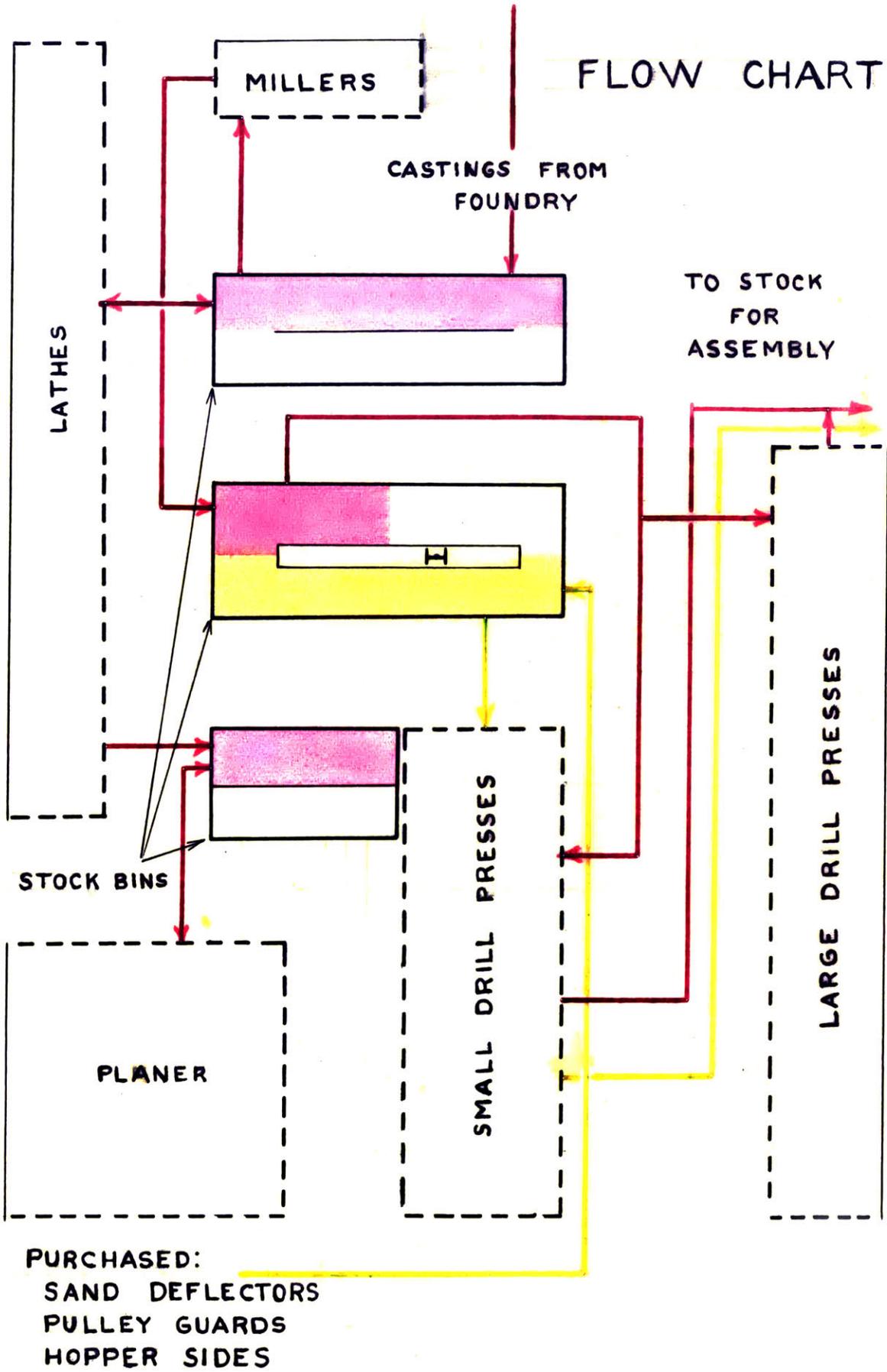


FIG. 5

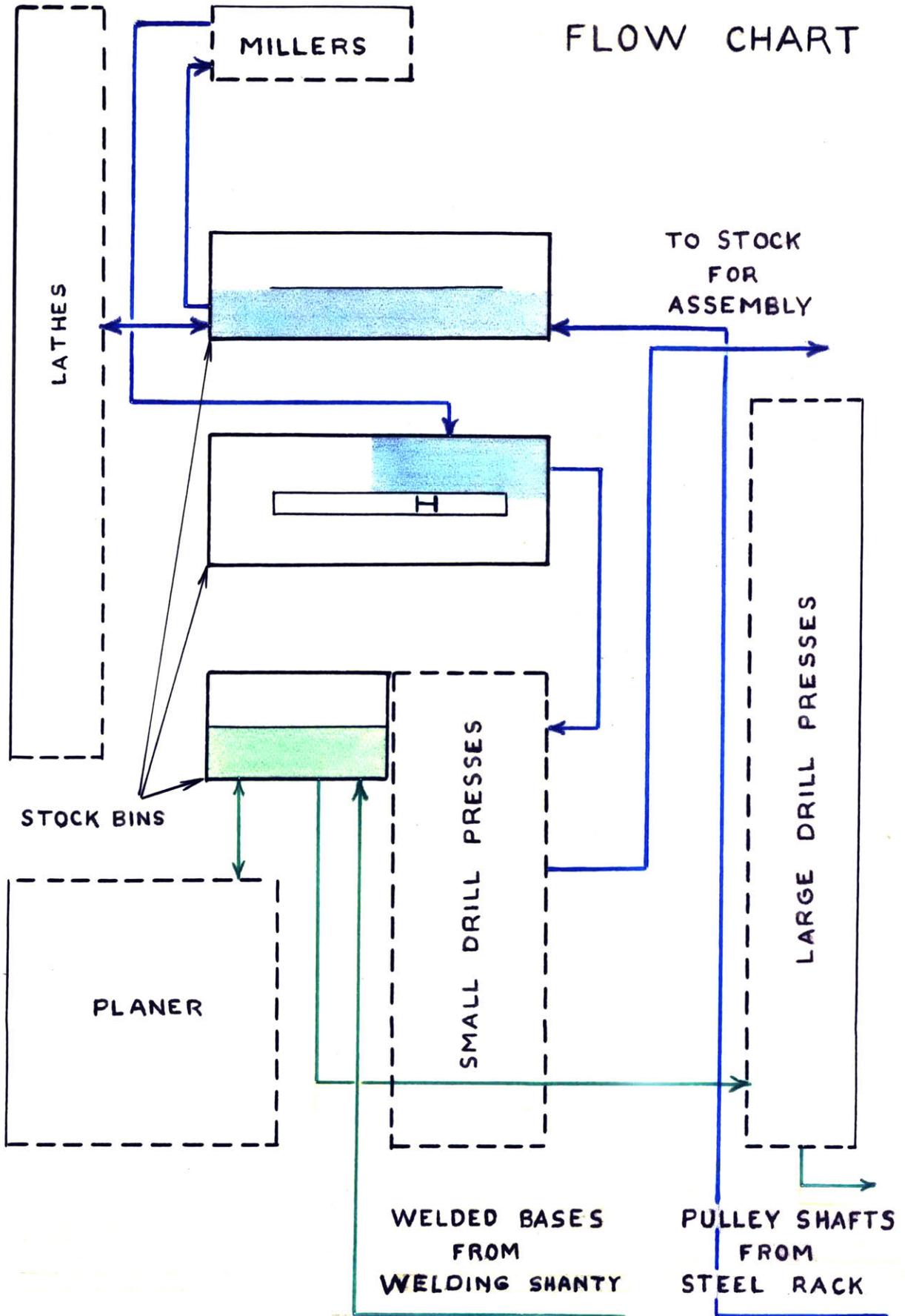
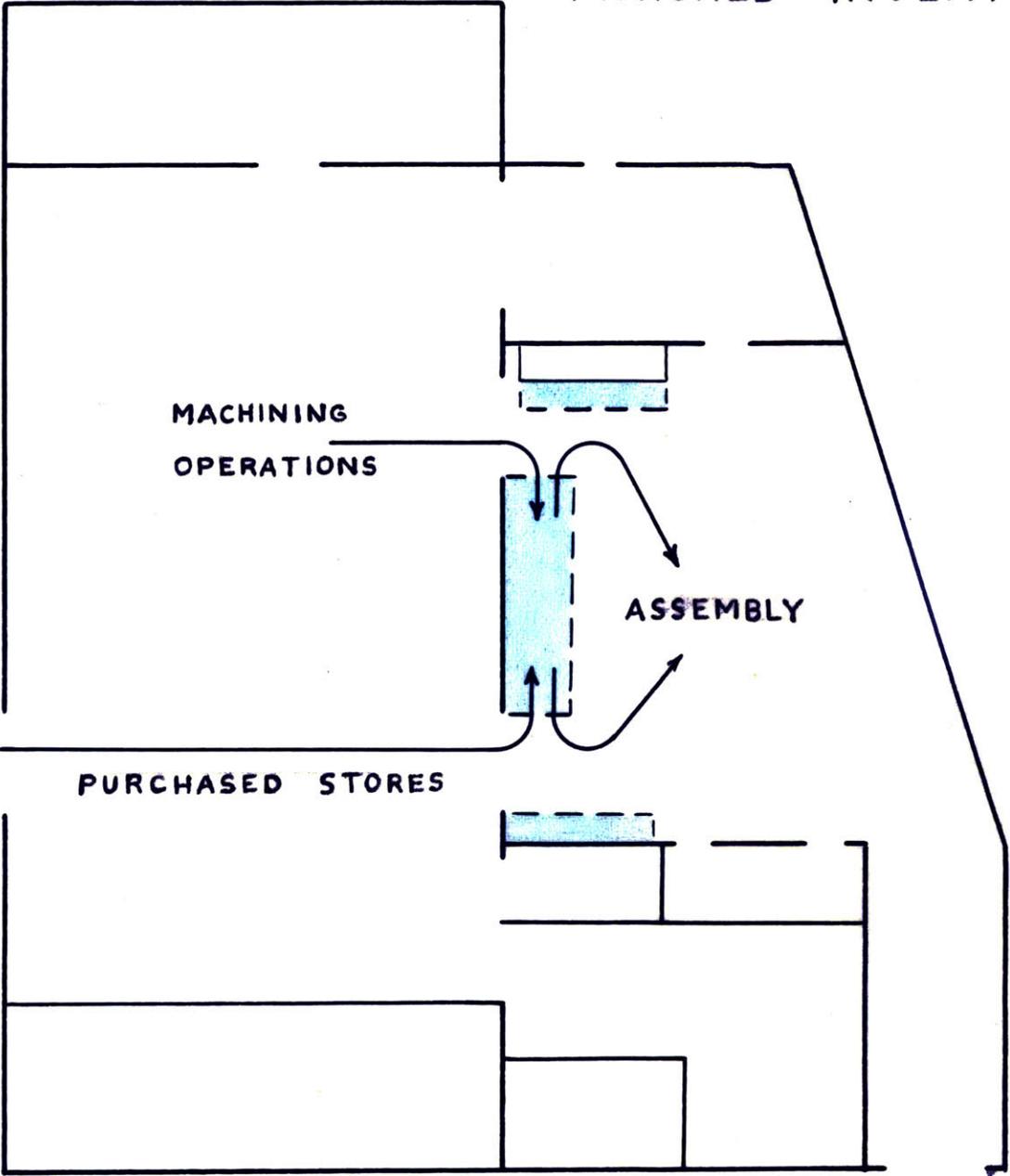


FIG. 6

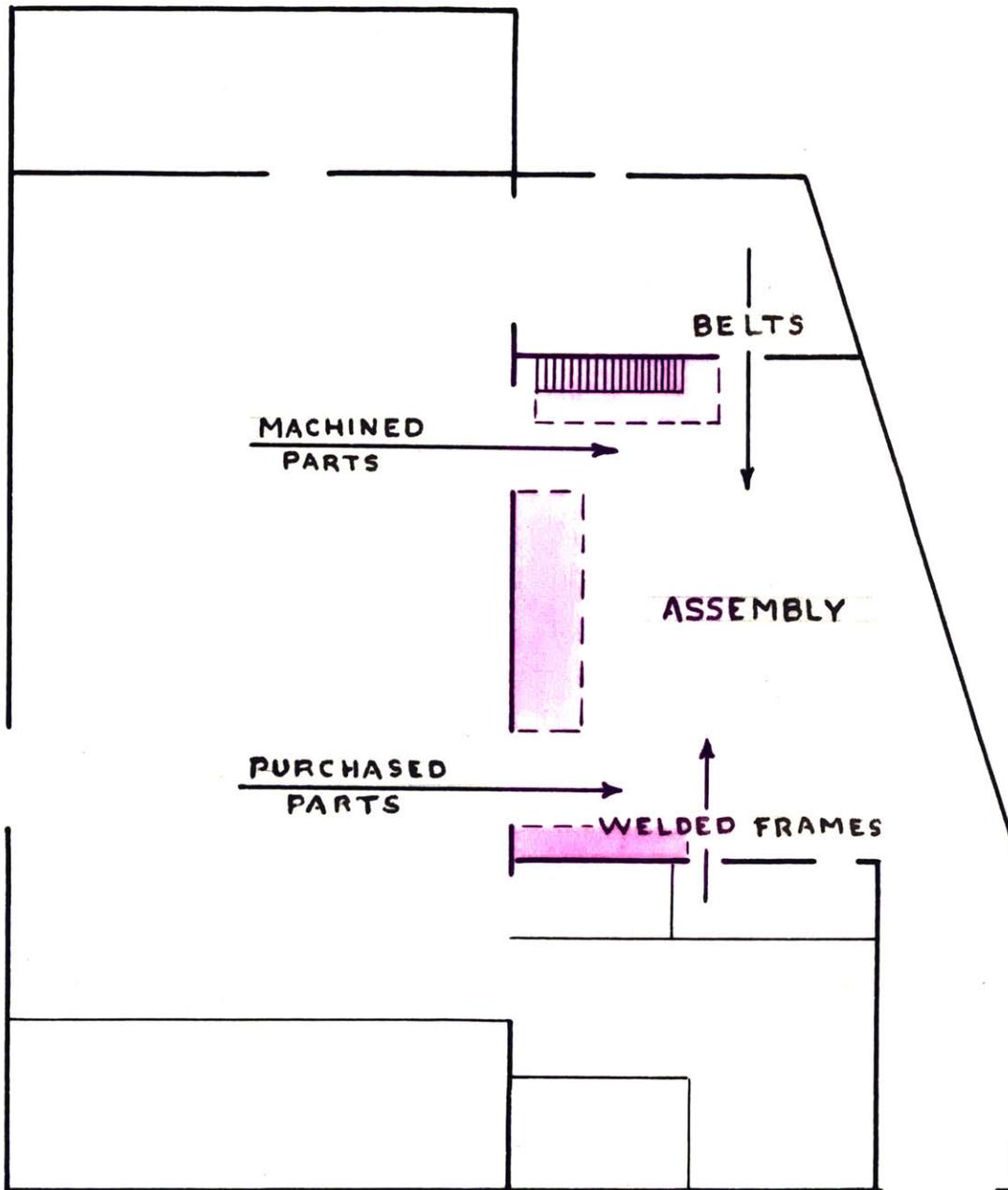
STORES AND
FINISHED INVENTORY



STOCK BINS FOR MACHINED PARTS AND SMALL PURCHASE ARE CENTRALLY LOCATED BETWEEN THE SOURCE OF STOCK AND ASSEMBLY.

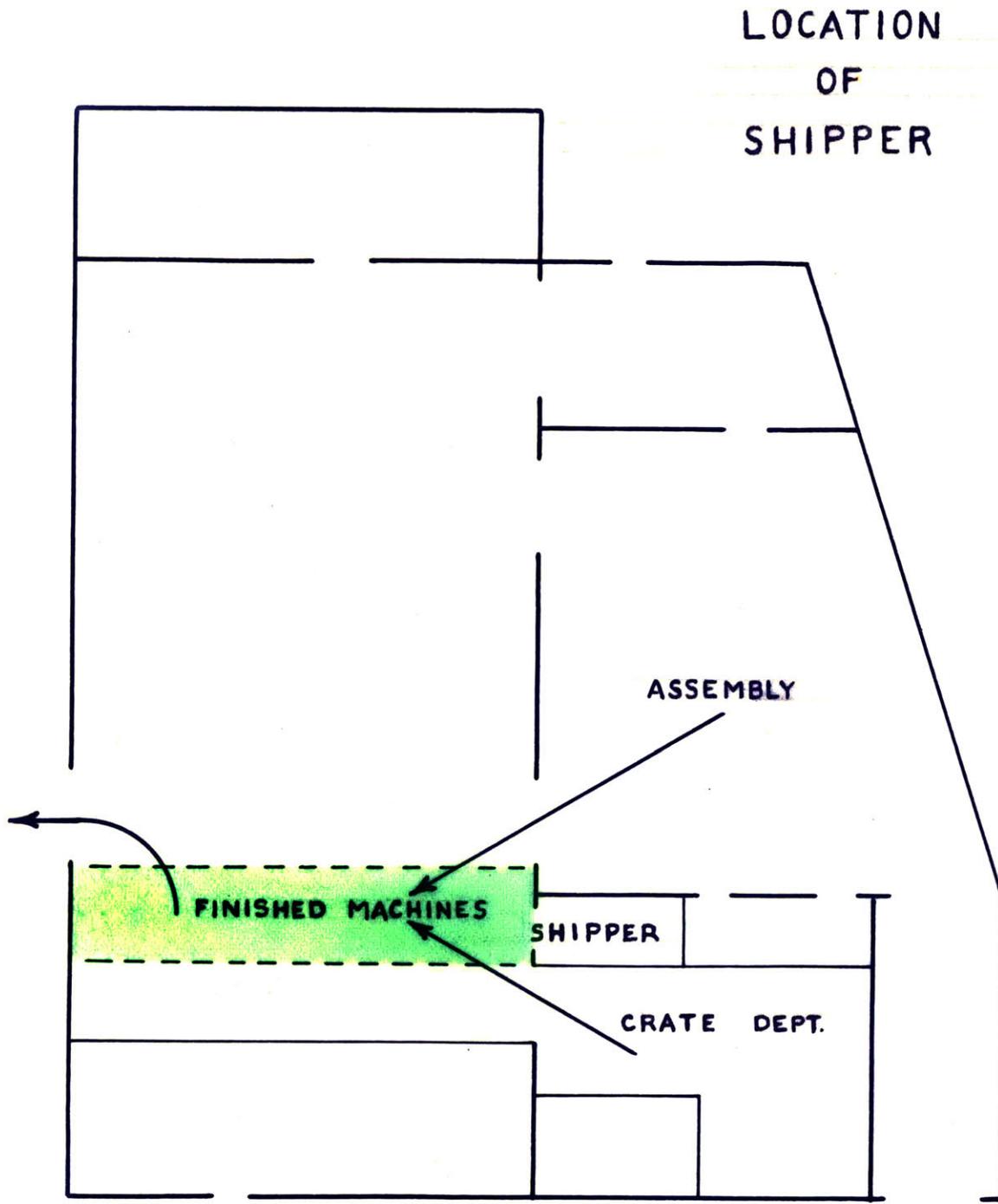
FIG. 7

ASSEMBLY DEPARTMENT



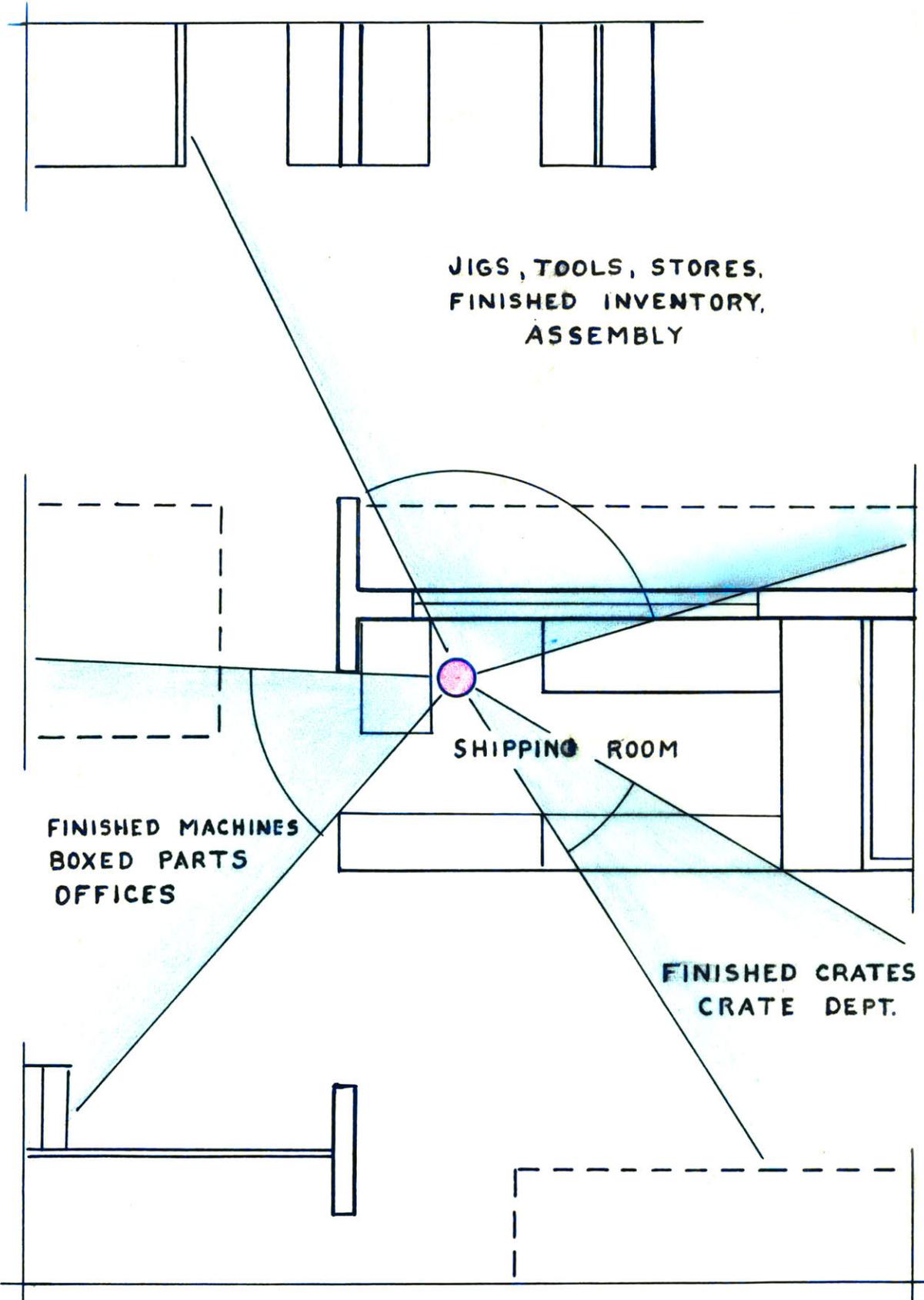
MOTORS , PULLEYS , AND WHEELS ARE DROPPED FROM 2ND FLOOR STORAGE OVER ASSEMBLY. ASSEMBLY AREA IS SURROUNDED ON THREE SIDES BY STORES OF FINISHED PARTS.

FIG. 8



SHIPPER CENTRALLY LOCATED FOR FLOW FROM ASSEMBLY AND CRATE DEPT., AS WELL AS EXIT OF CRATED MACHINES.

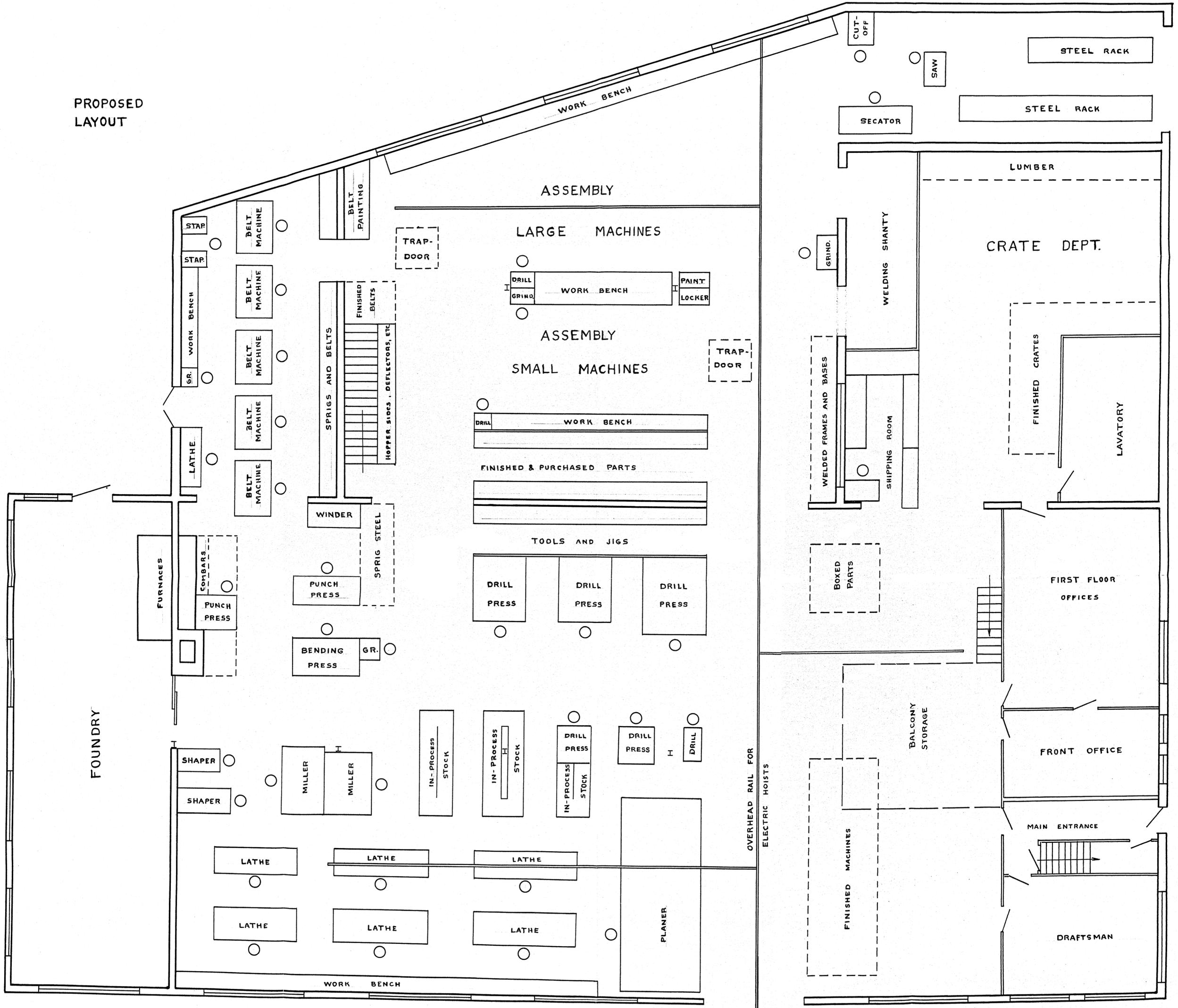
FIG. 9



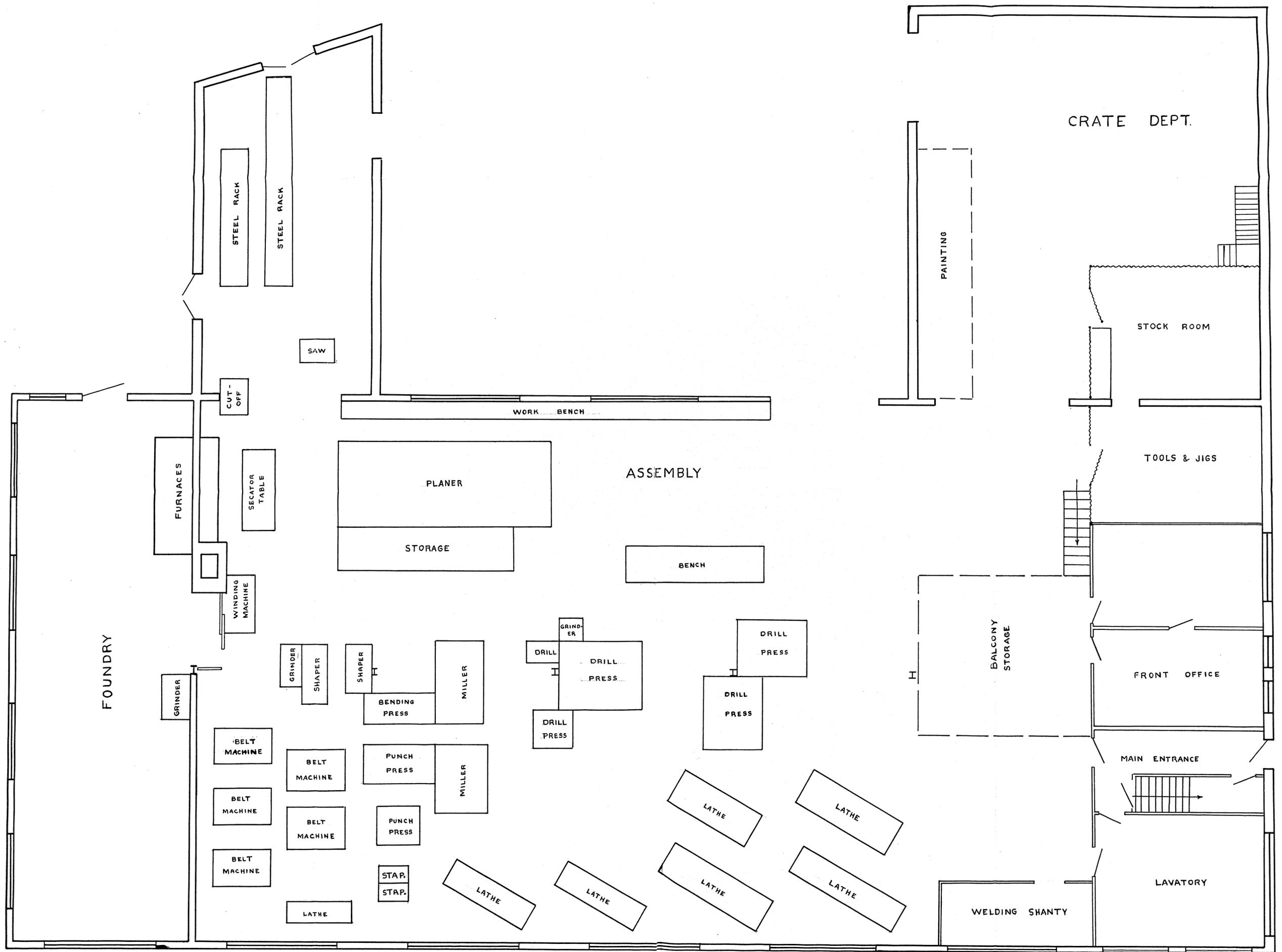
VISUAL VANTAGE POINT OF SHIPPER

FIG. 10

PROPOSED LAYOUT



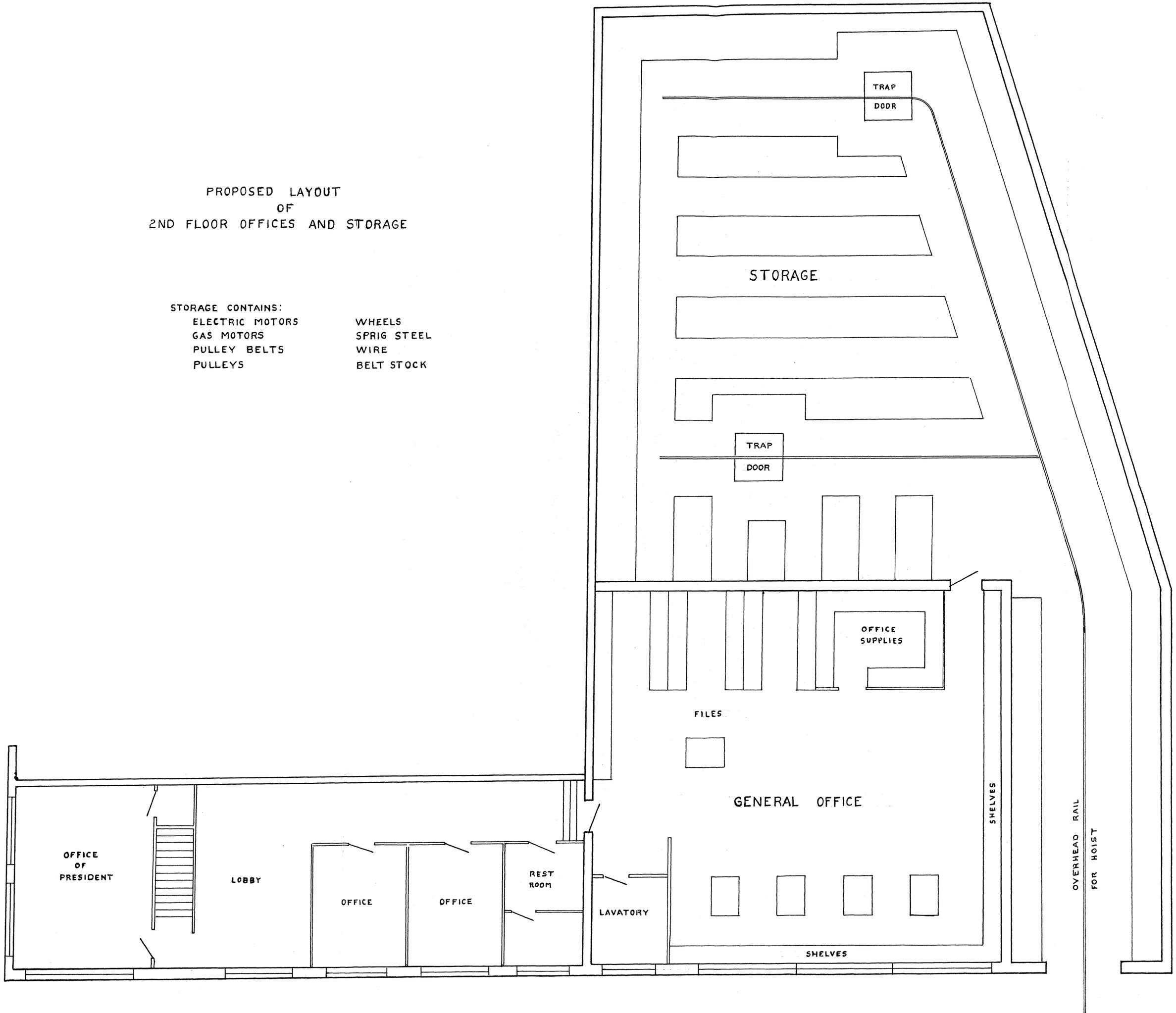
PRESENT LAYOUT



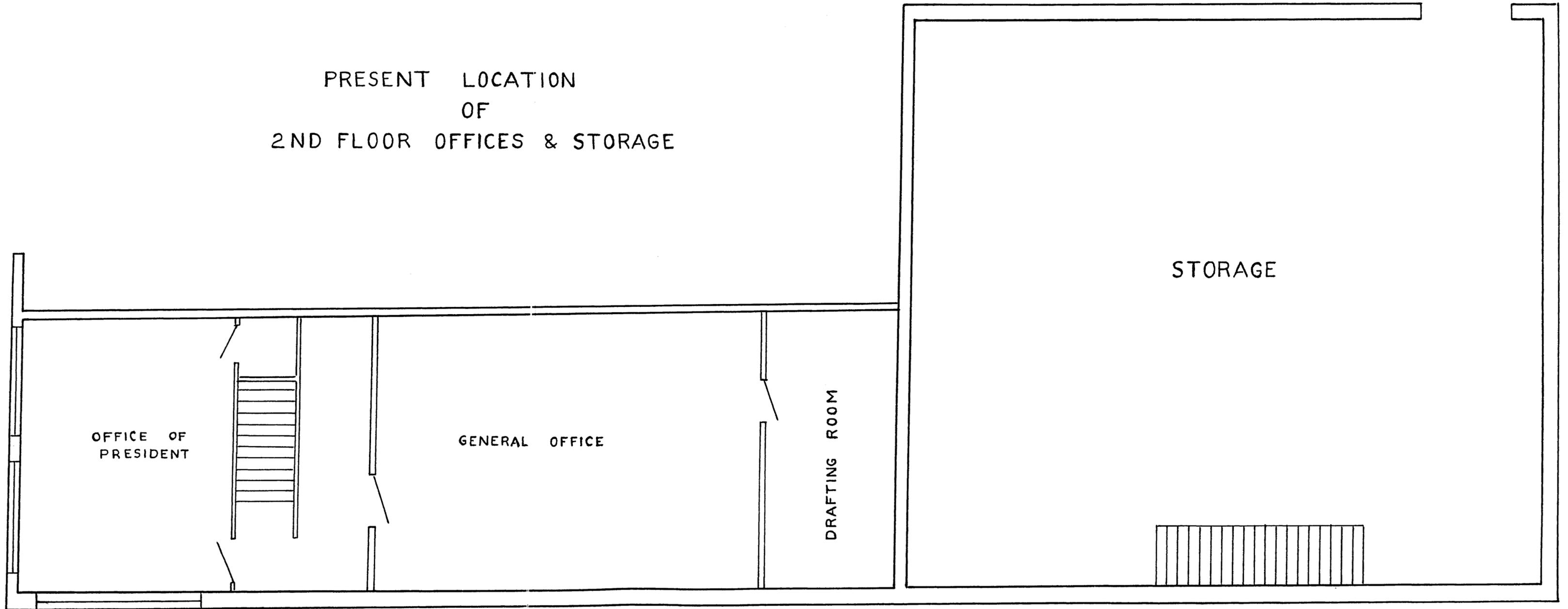
PROPOSED LAYOUT
OF
2ND FLOOR OFFICES AND STORAGE

STORAGE CONTAINS:
ELECTRIC MOTORS
GAS MOTORS
PULLEY BELTS
PULLEYS

WHEELS
SPRIG STEEL
WIRE
BELT STOCK



PRESENT LOCATION
OF
2ND FLOOR OFFICES & STORAGE



OFFICE OF
PRESIDENT

GENERAL OFFICE

DRAFTING ROOM

STORAGE