NATIONAL BUREAU OF STANDARDS REPORT

10 262

LIVE LOAD STUDIES OF CONVEYOR SYSTEMS AND POSTAL FACILITIES

Interim Report II

I–Story Facilities

for: Post Office Department

NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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I-Story Facilities

by
J. O. Bryson
and
L. E. Cattaneo

for: Post Office Department

June 1970

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1-STORY FACILITIES

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1. Introduction

The study of live loads on conveyors and postal facilities being conducted by the National Bureau of Standards is essentially an investigation of the occupancy loads imposed on the building due to the mail handling processes. The occupancy loads are the live loads resulting directly from the activities and types of equipment employed by the user. The main objective of this study is to survey the loads in a representative sample of mail handling facilities to develop comprehensive information on the magnitude and distribution of actual loads imposed on facilities. This information would then serve as the basis for engineering recommendations concerning the appropriate structural live loads to be used in the design of future postal facilities.

In order to develop an adequate program for investigation of loads imposed on postal facilities, it was necessary to gain a

thorough understanding of all of the features of mail handling operations, processing equipment and building layouts. Consequently the initial phase of the work was devoted to studies of POD Engineering Design Standards and drawings, meetings and discussions with POD officials and mechanization contractors, and field visits to selected facilities for on sight orientation. Following this initial work the conditions under which the survey would be conducted and the factors most significantly affecting the loads were used in formulating the program of investigation and study.

It was decided early in the planning of the program to study the loads in highly mechanized facilities of modern construction and, where possible, in those representing different regions of the country. Selection of the sample of facilities was influenced to a great extent by a conclusion drawn from the preliminary studies that the number of stories in a mail handling facility is an important factor for live load evaluation. Consequently, facilities to be surveyed were chosen to represent categories of one, two, and multi-story structures. The facilities are being surveyed in groups according to their number of building stories in order to accommodate the data reduction and evaluation, and reporting.

This report presents an analysis of the results from field surveys of three 1-story facilities (Greensboro, N. C., Chicago AMF, Illinois, and Buffalo, N. Y.). The results are evaluated from the standpoint of design loads.

2. General

2.1 Building Facilities

The buildings that are being surveyed for loads in this investigation are classed by the POD as "Major Postal Facilities." A major postal facility is one that has a work floor area greater than 50,000 sq. ft.[1/] The space provided in these facilities is divided generally into four major areas:

1. Workroom area
2. Mail handling support services areas
3. Platform or docking areas
4. Administration, personnel, and public services areas.

The workroom is a large open bay floor in which the mail processing activities are centered. The floor area is lined with regularly spaced structural columns which superficially divide the floor space into "grid squares". The other areas serve to support, in different ways, the activities on the workroom floor.

The workroom floor is divided into designated work areas to accommodate specific mail processing activities. The work areas are of different sizes, depending on amount and type of activity, and usually cover a number of grid squares.

1/ Postal Space Standard and Equipment Layouts Vol. I, POD Publication 37

Within the work areas the activities and types of equipment employed for processing the mail toward its destination are the principal factors which affect the characteristics of the occupancy loads.

2.2 Building Occupancy Loads

The loads that are imposed on the structure due to the mail handling processes are defined as follows:

(1) Mail load - all types of mail in various containers being processed or stored within the facility.

(2) Fixed mechanization load - load due to the weight of mail processing equipment either anchored to the ceiling or bolted to the floor (i.e., bulk mail-conveyors, parcel and sack sorting machines, letter sorting machines, etc.)

(3) Mobile mail handling and miscellaneous operating equipment - items that are used to contain the mail that is being processed or stored on the work floor; also different types of maintenance equipment (i.e., baskets, hand trucks, tables, bag racks, motorized sweepers, etc.)

(4) People - the weight of the maximum number of people assigned to a specific area.

These loads are ordered into two groups according to the manner in which they are supported by the structure. They are ceiling

supported loads and floor supported loads as follows:

I. Ceiling Loads

1) Fixed mechanization (ceiling suspended conveyors)

2) Mail

II. Floor Loads

1) Fixed mechanization (floor mounted conveyors) and workroom equipment

2) Mobile mail handling and miscellaneous operating equipment

3) Mail

4) People

The ceiling loads and floor loads in a 1-story facility are basically free and independent of each other. However, in a multi-story facility consideration must be given to the combined effect of the ceiling loads of one story and the floor loads of the story above it.

2.3 Factors Influencing the Survey Procedures and Evaluative Approach

The survey procedures and data handling techniques are described in detail in NBS Report 10141, "Live Loads Studies of Conveyor Systems and Postal Facilities, Interim Report, Preliminary Results for Survey at Greensboro, North Carolina."

Many factors having to do with building layouts and activities within the building were considered in developing the survey procedures and evaluative techniques for this study. However, the following considerations and conditions had the greatest influence on the manner in which this program is being conducted.

The occupancy loads in the workroom area of a facility are in a state of constant change. The total mail load fluctuates with the input - output movement of the mail; and the specific (discrete) loading within the facility changes as the mail is transported from one point to another in the normal processing operations. The total load fluctuations are significant only in considering seasonal peaks (Christmas mail, etc.) and even then the information is of little or no use for engineering design purposes unless it can be conveniently converted to a distribution within the facility.

The collection of loads data had to be conducted from the standpoint of a limited sampling approach because of the need to cover facilities of different sizes and in diffернt regions of the country within the overall time span allotted for the program. Also, the restriction on the field survey activity during the "Christmas rush" period, when mail load is assumed to be highest, greatly influenced the sampling approach.

Consequently, it was decided that the sampled data would have to support broad projections of the information in order to cover variations beyond the sampling conditions (i.e. seasonal fluctuations).

3. Results

It was stated earlier that it is the mail processing activities and consequently the types of equipment employed for processing the mail within the workroom which are the principal factors affecting the characteristics of the occupancy loads. The workroom floor is divided into designated "work areas" for specific mail processing activities. For the purposes of this study the activities were covered by 10 work area categories designated as follows:

Area #1 Culling, Facing & Cancelling - Activities in this area center around initial or preliminary processing of incoming mail--for the most part, mail made up of mixed letters, flats and circulars. Equipment in this area relates to dumping, segregation, cutting, culling, facing and cancelling and usually includes such characteristic items as portable conveyors, hopper-feeders, powered facers and cancellers as well as a variety of general equipment (utility carts, canvas baskets) found in many work areas of a postal facility.

Area #2 Letter Distribution - The letter distribution operation was taken to include all letter handling activities, whether involving outgoing, incoming, stated or mixed letters. For the main part the

area title was used to cover letter distribution activities, whether manual or automated, but was applied also to areas containing similar and related activities such as registry and lock box sections. Equipment encountered in these areas was predominantly letter sorting cases, mail transporting containers (utility carts, hampers, mobile tables, trays, tray carts), and, where used, letter sorting machines (LSM's). In the case of registry sections there were some unusually heavy items, such as safes.

Area #3 Main Office Carriers - The activity in this area was limited to that of letter carriers sub-sorting their assigned mail load by use of letter sorting cases labeled at the city-block or street address level. Primarily, these areas contained letter sorting cases, throw-back cases, and hampers plus general types of associated mail handling equipment.

Area #4 Flats Distribution - Like its 1st class equivalent, area #2, this area was devoted mostly to mail sorting, but of flats and circulars. All sorting, however, was done manually and the activity description was used to include handling of newspapers. Characteristic equipment included

sorting cases for flats and circs, portable paper-tables, or special containers for flats and circs, again together with various types of support equipment.

Area #5 Pouching - The work area in which the main activity was pouching, was so designated without regard to the category of mail being placed into sacks. Such areas were characterized by the presence of banks of pouch or sack racks. Auxiliary equipment varied among mobile containers and nutting trucks.

Area #6 Sawtooth Platform Area - Characteristic of these areas were the large sawtooth-perimeter platforms used for sorting sacks onto nutting trucks.

Area #7 Outgoing Parcel Post - The operations in this area were mostly concerned with the sorting of loose parcels into sacks for different destinations. As such, the area contained many pouch racks, nutting trucks, and hampers.

Area #8 Incoming Parcel Post - The activity in this area was involved with the handling of parcels in sacks entering the facility for further destination assignment or for shaking out and sorting for local distribution. Nutting trucks and hampers were prominent in these areas.

Area #9 Outgoing Non-preferential - When indicated, this designation was assigned to an area used in processing outbound 3rd class mail. Activity and equipment in this area was similar to that in area #4. In the final analysis it may be desirable to incorporate areas #4 and #9.

Area #10 Temporary Storage - The description of this area was applied in a broad sense in that the temporary storage which was truly short term was of a wide variety of items which included mail awaiting further processing as well as temporarily idle mail sorting cases, containers of empty bags, and other equipment.

The three 1-story facilities surveyed for loads are located at Greensboro, North Carolina, Chicago (AMF), Illinois and Buffalo, New York. Floor plans for these facilities, showing the workroom floor divided into work areas, are presented in Figures 1, 2 and 3. Table 1 presents the area breakdown for the three facilities in terms of amounts of floor space occupied by the various work areas.

The data collected at the facilities pertain to two general categories of loads: (1) Ceiling loads; and (2) Floor loads. The reader is again referred to NBS Report 10141 for details

of the techniques and procedures used in surveying loads and for the data reduction.

3.1 Ceiling Loads

The ceiling loads are divided into two groups. They are bulk mail loads on ceiling-suspended conveyors and dead loads from the suspended mechanization system.

For the varying load of bulk mail acting on a conveyor the data is reduced to obtain information on the magnitudes and variations of distributed loadings over various lengths of the conveyor, and for the forces induced in the conveyor suspension rods. The objective is to determine the loading spectrum for the resolution of the mean and upper limit extreme values and the relationships between the two.

After examining the data collected at the facilities, it became apparent that an inadequate sample of information was being obtained since a higher percentage of upper limit values is expected to occur during the "Christmas rush" and possibly other peak periods for which no data has as yet been collected. Consequently, only the maximum values observed during the surveys are significant for judgments on design loading.

The maximum loading recorded on a 10 ft section of conveyor (the standard length) was 25 psf and the maximum loading recorded over the full length of a conveyor was 12 psf.

The field data for suspended mechanization loads were recorded in the form of dimensions and types of construction materials for selected sections of conveyors and other processing machinery. The area occupied by a mechanization section and its location within the plan of the building were also recorded. Sections were selected which represented the different types of conveyor units and different combinations of units in a common area. These data were reduced to total weights of sections located within specific horizontal areas. Calculations were made to determine values for the total load equally distributed over the horizontal area for each mechanization section. In addition, the hanger loads for conveyor suspension rods were calculated for two different support arrangements: (1) with suspension rods located at the four corners for small conveyor sections; (2) with suspension rods supporting large conveyor sections every 5 ft. in a rectangular coordinate grid. The four-corner support calculations were made for conveyor sections with areas of 75 sq. ft. or less (the smallest section examined was 5 ft. by 5 ft. = 25 sq. ft.). The 5 ft. rectangular grid support

points were choosen since they conform to the POD specification for the arrangement of insert anchor points for the support of suspended mechanization systems.

The type and location of suspended mechanization sections measured for weight estimates at the three field locations are indicated on the plans in Figures 4, 5, 6, and 6A. In both Greensboro and Chicago, a wide variety of mechanization sections and subsections were included in the measurements. The data collected from these facilities were reduced to ceiling loads for the mechanization sections investigated and are presented in Tables 2 and 3 for Greensboro and Chicago, respectively. However, in Buffalo the weights of all of the mechanization units located in an area of highly concentrated mechanization were recorded. The area covered two adjacent grid squares (C5 and D5) where three layers of conveyors come together in a multiplexity of systems. This concentrated mass of mechanization required additional support from extra structural steel members installed inside the building. The data collected from Buffalo were reduced to uniformly distributed loads for each grid square. They were 48 psf for grid square C5 and 53 psf for grid square D5.

The ceiling loads at Greensboro, presented in Table 2, are values of uniformly distributed and concentrated loads caused by conveyors and their structural support. The locations of

these sections are shown in Figure 4. At a given location (encircled on the floor plan) the labeled overall section referred to is marked by heavy straight lines bounding the conveyor system. This area was further subdivided for more specific consideration of included loads. The subscript letters of area designations refer to cardinal directions, (F_W=F, Westerly).

In area A (Figure 4), the easterly portion A_E contains a crossover area involving twelve conveyors, TSS-1 thru 5, SS-1 thru 6, and S-5. The sub-areas A_1 thru A_6 in A_W are each take-up roller sections for conveyors SS-1 thru 6, respectively.

In area B, B_N contains conveyor SP-1 and its traveling deflector; area B_S contains the tail ends of conveyors SPS-1 thru 5. A slide area between areas B_N and B_S is totally supported between them and its weight is so apportioned. The following areas are conveyor corners or junctions and contain conventional conveyor, support, walk, and mechanical construction for the indicated conveyors:

Area	Conveyors
C	S-5 to SS-7
D	S-6 to S-7
E	S-3 to S-4
F	S-9 to SS-8
G	RRD-9 to RRD-10

Area H contains a typical section of a 4-track over-under carrousel parcel sorter PSM-1 thru 4, together with tail ends of conveyors T-6 and 7. Area K contains a typical section of a 2-track over-under carrousel sack sorter SSM-1 and 2, together with tail ends of conveyors SD-7 and CSS-1. It is to be noted that values for uniformly distributed loads (UDL) were computed for dead weights of mechanization sections alone (UDL) and for mechanization sections with design live load added on to the conveyor belt areas where they would occur (UDL_2). The design live loads (mail) used are those currently specified by POD (30 psf). The computed hanger rod loads for the 5 ft-spaced coordinate grid support points is based on the minimum number of support points in a 5 ft grid system which fall within the plan area of the mechanization.

The mechanization sections in the Chicago AMF which were selected for examination are indicated by heavily outlined areas on the conveyor plan shown in Figure 5. The estimated dead weight data in terms of uniformly distributed loads and concentrated loads for these areas are given in Table 3. In addition, ceiling loads in these areas have been estimated and tabulated for the condition of dead load plus live load.

Area A contains the horizontal take-up loop of the horizontally returning carrousel-type sack-sorting machine SSM-1. The westerly portion of the take-up loop A_W contains the transmission and drive motor; A_E refers to the easterly portion of the take-up loop, exclusive of the drive mechanism. Since this part of SSM-1 is within the return leg of the loop where its trays are always empty, no values which include live load are listed. It was noted that this take-up loop section experienced considerable vibration when SSM-1 was operated at the travel rate of 60 trays per minute. Concern over the effect of this vibration on the safety of the system seemed to be a general feeling among the personnel involved with the operation and maintenance of SSM-1.

Area B contains a typical straight section of SSM-1 (including a walkway). This, also, is in the empty tray, return leg of the loop, but live load conditions are listed for general application of a typical section. Area C includes a length of SSM-1 on the mail-carrying north side of the carrousel which contains junctions with the tail ends of conveyors D-1, D-2 and D-3 and with Chute - 7. Area D is at the head-end of conveyor D-4 which discharges into a spiral chute. The westerly portion D_W contains the drive mechanism and platform area; the easterly side D_E includes the head end and take-up pulley section of conveyor D-4. Area E contains only the take-up pulley and frame of conveyor D-3. Area F is at

the head end of conveyor D-3; the westerly part F_W contains the end of conveyor D-3 which discharges into a spiral chute; and the easterly part F_E contains the drive motor and platform of conveyor D-3.

Area G, at the southeast corner of the building is at the junction of conveyor A-8 with the induction point of carrousel SSM-1. The northerly portion G_N contains the deflector of conveyor A-8, the deflector track, and a coinciding length of conveyor A-8. The central portion G_C is within G_N and contains the drive pulley end of conveyor A-8. The southerly portion G_S contains the drive motor and platform section of conveyor A-8. Total area G also includes a walkway parallel to conveyor A-8.

3.2 Floor Loads

The weights and approximate locations of all items on the workroom floor were recorded during the survey. Floor plans of the building were used to note work area layouts and locations. A further breakdown of the floor area was made by defining the areas bounded by column lines as grid squares. The grid squares were then divided into 1/2-span mid-strips and 1/4-span column-strips corresponding to the structural strips considered in bending moment design of a two-way flat slab (see Figure 6). The overlapping of the strips in the two directions formed a pattern of grid area sectors which provided a general location scheme. In cases where the boundary of work area did not coincide with a column line, the work area then contained partial grid squares.

The determination of the loads in the survey involved either direct weighing of items or estimation of the weights. An estimate of the weight for any item is based on the known empty weight plus an estimate of the amount of content in the item. Contents were categorized as (1) letters, (2) flats and circulars, or (3) parcels. These contents were estimated either in terms of percent of volume capacity or in terms of linear feet of stacked letters or flats. Specific items had previously been load-calibrated for 100 percent

capacity or for weight per unit length. Very helpful information and data on mail weights were provided by post office officials at the facilities visited.

The data for the floor loads part of the study was reduced and evaluated with a computer program which was designed to provide information on the loads related to work activity and the geometry of the structure. The computer prints out tables and graphs of principal information and data relationships. From these printouts the maximum values of loadings occurring on floor areas of different size divisions are presented in Table 4. These were chosen to show the upper limits of loadings occurring in the three facilities at the time of surveying.

An important factor in the study of floor loads is the relationship between discrete loads and their areas. There were many different types of load items encountered in the survey, and they varied widely in weight and in size. The weight of a given item divided by the floor area that it occupies is defined as its discrete unit load. It follows that items of different weight may produce the same discrete load on the floor depending on the respective item size. The sum of the floor area occupied by load items is defined as the loaded area. Figures 8 through 10 show the relationship

between loaded area and discrete load values for the workroom area in each of the three facilities surveyed. The area supporting discrete loads greater than a specific value is given as a ratio of the total loaded area on the vertical axis and the values of discrete load are given along the horizontal axis. Therefore, these plots indicate the fraction of the loaded area which supports loads greater than a particular value of discrete load.

Table 5 gives the percentage of space occupied in each work area for each of the three facilities. Only in storage areas is it expected that the occupied space might exceed 60 percent. This is because the maneuvering space needed for people and mobile equipment in activity associated areas is often found to exceed 40 percent and is occasionally found to be 80 percent or more. Storage areas, however, do not require as much free space for maneuvering.

3.3 Analysis of Data

In analyzing the loads data, emphasis was placed on determining characteristic uniformly distributed loads and high load concentrations. However, sight was not lost of the fact that a structure must be designed to safely support all loads that it will be subjected to during its life time. In this regard a great deal of attention was devoted to upper limit values of loadings for both ceiling loads and floor loads.

The floor areas on which the loads are applied are divided into two categories: (1) Activity associated areas; (2) Structurally significant areas. The activity associated areas are the work areas. The structurally significant areas are the grid square and grid sector areas.

When there is a change in basic activities on the work floor area of a facility the characteristic loading changes as well. The grid square represents the basic floor and ceiling element that the characteristic loading relates to in terms of first order design loads. Therefore, the loadings within work areas have been evaluated in terms of their effect on grid squares (floor or ceiling structural panels).

The occupancy loads on the ceiling are the suspended mechanization loads combined with bulk mail loads on conveyors. As stated earlier, the data on bulk mail loads recorded at the facilities may very likely not include the most severe loadings that are imposed on storage conveyors. The maximum average loading recorded on the full length of a storage conveyor was 12 psf. The maximum average loading recorded on a 10 ft section of a storage conveyor was 25 psf. The design load specified by POD for storage conveyors of all types is 30 psf. It is this value of loading that is used in this report for live load on conveyors.

The suspended mechanization loads (UDL), presented in Tables 2 and 3, varied over a wide range of values. These values ranged from a low of 19 psf to a high of 234 psf. A plot of the uniformly distributed loads (UDL) for the mechanization sections versus the plan areas of the sections is presented in Figure 11. In general the high load values are found where the section plan areas are less than 50 sq ft. A curve was drawn to represent the assumed upper limit boundary load values based on the data collected thus far. It is noted that the sections covering areas larger than 50 sq ft impose loads that are less than 100 psf. In fact, the pronounced change seen in the slope of the upper limit boundary curve occures near the 100 psf value. The areas covered by the

grid squares for the three facilities are 1,089 sq ft, 1,066 sq ft, and 1,944 sq ft for Greensboro, Chicago, and Buffalo, respectively. The values of uniformly distributed load on the upper limit curve which correspond to the grid square areas for the three facilities are 80 psf for Greensboro, 80 psf for Chicago, and 70 psf for Buffalo.

The floor loads data from the surveys include information that is area associated in terms of activity divisions and structural divisions. The data presented in Table 4 show the maximum floor loadings found on different size areas. This tabulation shows very clearly that as the area gets smaller the loading approaches the maximum discrete load value which by definition is the limit. The maximum loading recorded was 87 psf on a grid sector in Chicago. However, the grid square stands as the most structurally significant area for studying design loading. Consequently, the data need to be analyzed from the standpoint of a probable maximum loading on grid squares. The curves giving the cumulative fractions of loaded areas for discrete load values by work areas can be conveniently used for this analysis. These curves are composed of surveyed loads and their respective areas set up to show the variation in discrete loads on the loaded area. Within a work area, there are different types of

items used in the mail processing operations. The weights of the items that contain mail vary from some minimum to a maximum value depending on the amount of mail being carried. Therefore, in a work area where there are different sizes and types of items containing different amounts of mail, the discrete loads range over a wide spread in values. The fractions of the loaded area corresponding to discrete load values in a work area are indicative of the relative loading characteristics in terms of magnitudes and distributions.

The cumulative curves of discrete loads for each of the work areas from all three facilities were used to obtain a load profile to be applied on a grid square area. The load profile used effectively optimizes the loading on the panel for maximum bending moment. This means that the maximum values of actual loadings recorded during the field surveys of the facilities were arranged to impose the most severe bending moment effect on a grid square area. In this way actual loadings were used to arrive at values for the maximum loadings likely to occur from the various activities being conducted in each of the work areas.

Figure 12 illustrates the procedure used in applying the load values from cumulative curves to grid square areas for

maximum loading effect. The curve used in the example here is for work area 1 in Greensboro. The total area for work area 1 is 8512 sq. ft. and the loaded area is 1741 sq. ft. or approximately 21 percent of the total area. It is this loaded area (1741 sq. ft.) that is represented by the vertical axis (ordinate) for the curve. The area for the grid square in Greensboro is 1089 sq. ft. which is 62 percent of the loaded area for work area 1. The portion of the cumulative curve from 0 to .62 area ratio is equal to the grid square area size. This lower portion of the curve also includes the heaviest discrete loads encountered in the work area. These loads are ordered according to weight along the horizontal axis and according to relative area covered, along the vertical axis. Figure (a) of 12 shows how the areas for the respective discrete loads are arranged on a grid square panel for maximum effect on bending moment. The panel is next considered as a 1-way simply supported slab and the load profile on a 1 ft. wide strip through the center of the panel is constructed as shown in (b) of Figure 12. The maximum moment caused by this loading arrangement is computed, and from it an equivalent uniformly distributed load (EUDL) is determined by use of the following relationship,

$$\text{EUDL} = \frac{8M}{\ell^2}$$

where,

M = maximum bending moment

ℓ = span length

The values of EUDL for the work areas in each of the facilities surveyed are presented in Table 6.

3.4 Comments

The overall plan for this study of loads on postal mail handling facilities was designed to have the data from each phase of the investigation be applicable to all phases of the study. This is to say that, although the investigation was generally divided into groups of facilities according to their number of stories, the final results would need to be based on data from all facilities in order to broaden the sample information for any one group sufficiently for design load analysis. The rationale is that characteristics of loadings within work areas (i.e., loadings caused by specific activities) are independent of the number of stories in a facility. The same can be said for bulk loads on conveyors. Consequently, the results presented here are considered preliminary and will be re-evaluated each time additional data are acquired.

The main reason for believing that the loading might be different as the number of stories changes, is the rule of thumb

decision limiting work floor areas to 100,000 sq. ft. per story, and the fact that the operational layout or mail flow must of necessity change with number of stories. It follows that, as the number of stories change between facilities so will the arrangements and distributions of work areas which will directly affect the loading by floor level.

Areas of high discrete loads were encountered during the floor loads survey. Notable cases of such loading conditions are shown with photographs in Figures 13, 14, and 15. Figure 13 is a photograph of closely spaced nutting trucks filled with sacks of letters, flats or papers. Figure 14 shows piles of sacked mail (letters, flats, or papers) stacked directly on the floor. Figure 15 shows a utility cart filled with letters. Although full grid squares of such loadings were not observed in one-story facilities at the time of survey it was apparent that grids which are otherwise unoccupied, might be filled by such loads during peak periods of fluctuating mail volume. (Such cases were observed in later surveys of 2-story facilities). Filled nutting trucks weigh as much as 2200 lbs, or more, and can develop a discrete floor load of about 130 psf. The same mail stacked directly on the floor to the same depth produced a floor load of approximately 110 psf on the area that it covered. Observations of work floor activities suggest that a floor load of 40 to 50

psf is very likely to develop over a complete grid square by utility carts filled with mail and covering the entire grid square area.

Summarizing the information developed from loads in 1-story facilities thus far the following preliminary values were determined:

(1) For bulk mail load on storage conveyors -- 30 psf

(2) For suspended mechanization loads -- 100 psf

(3) For live floor loads -- 100 psf

The value of 30 psf for bulk mail (live load) on storage conveyors should be considered from two points of view. First, from the standpoint of the design of the conveyor, and secondly, from the standpoint of its contribution to the suspended mechanization ceiling loads.

For the design of storage conveyors, the present indications are that the value of 30 psf for live load is reasonably proper. This conclusion is based on consideration of the maximum value observed on a 10 ft section (25 psf) as compared with the presently specified design load of 30 psf. The spread between the two values is 5 psf. The likelihood of the occurrance of loads exceeding 25 psf is judged to be strong, because the value of 25 psf was observed under

rather limited sampling conditions, as discussed earlier. The design value of 30 psf is apparently at a level high enough for satisfactory performance of a conveyor.

The suspended mechanization load of 100 psf includes dead weight values for mechanization sections combined with a live load value of 30 psf for bulk mail applied over the transporting surface of the system. The 100 psf for mechanization loading is the value of loading derived in relation to a grid square (ceiling panel) area of 1000 sq ft or more and practically square in shape. When considering an area the size of a grid square, a value of 30 psf for live load is considered very conservative. This is because the data from the survey show that the loading on conveyors decreased as the belt area (length) increased. It is noted that the maximum average loading recorded on a 10 ft section of a storage conveyor was 25 psf while the maximum average loading on the full length of a storage conveyor was 12 psf. It is this element of the loading that might be reduced after additional data is evaluated.

4. Tables and Figures

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Work Area Code No.	Activity Description	Approximate Area, sq. ft.		
		Greensboro (Grid = 33'x33' = 1089 sq. ft.)	Chicago AMF (Grid = 35'x30' =1066 sq. ft.)	Buffalo (Grid = 36'x54' =1944 sq. ft.)
1	culling, facing, & cancelling	8,512	10,917	11,178
2	Letter distribution	7,392	18,727	27,702
3	Main office carriers	10,806	------	1,944
4	Flats Distribution	9,315	4,329	32,562
5	Pouching	2,069	4,046	------
6	Sawtooth Platform area	11,298	------	------
7	Outgoing Parcel Post	12,306	3,923	31,590
8	Incoming Parcel post	8,671	3,265	21,384
9	Outgoing Non-preferential	14,535	------	28,188
10	Tempo storage (outside parcels and equipment)	1,650	5,820	6,804
Total Workroom Area Surveyed		86,554	51,027	161,352
Gross Workroom Area		98,000	51,200	162,810

TABLE 1 Distribution of Workroom Floor Space in 1-Story Facilities

Mechanization Section	Total Material Weight (lb)	Plan Area of Section (sq. ft.)	Gross* UDL. W/O L.L. (PSF)	Gross UDL2 Incl. Conveyor L.L. @30 PSF (PSF)	Hanger Load, Assuming 4 - Corner Support: W/O L.L. (lb/hanger)	Hanger Load, Assuming 4 - Corner Support: with conveyor L.L. @30 PSF (lb/hanger)	Hanger Load, Assuming Support at 5 Ft. Co-ord Grid Pts.: W/O L.L. (lb/hanger)	Hanger Load, Assuming Support at 5 Ft. Co-ord Grid Pts.: with conveyor L.L. @30 PSF (lb/hanger)
A	68,000	1780	38	67	-	-	880	1560
A_w	40,400	990	41	64	-	-	820	1280
A_e	27,600	790	35	73	-	-	790	1640
A1→6	3,750	32	117	142	940	1150	-	-
B	21,000	590	36	51	-	-	750	1070
B_s	12,100	240	50	72	-	-	670	970
B_n	8,900	200	44	62	-	-	560	780
C_s	3,300	25	130	150	820	950	-	-
C_n	2,700	35	80	100	680	870	-	-
D_w	3,300	35	95	116	830	1010	-	-
D_e	3,500	30	150	170	1110	1270	-	-
E	5,800	120	50	65	-	-	580	860
E_n	1,400	30	47	68	350	510	-	-
E_e	3,300	60	54	75	830	1130	-	-
E_s	1,100	30	38	-	280	-	-	-
F	6,500	110	59	75	-	-	650	820
F_w	2,300	35	66	87	580	750	-	-
F_e	2,700	35	77	98	670	850	-	-
G_w	1,800	25	73	90	460	560	-	-
G_e	1,300	25	54	70	340	430	-	-
H	16,600	360	46	61	-	-	690	920
K	11,400	140	80	88	-	-	950	1040

*UDL = Uniformly Distributed Load; L.L. = Mail Live Load

TABLE 2 Ceiling Loads from Suspended Mechanization Sections - Greensboro, North Carolina

Mechanization Section	Total Material Weight (lb)	Area of Section (Sq. Ft.)	Gross UDL, w/o L.L. (psf)	Gross UDL$_2$* Incl. Conveyor L.L. @ 30 PSF (psf)	Hanger Load Assuming 4 - Corner Support		Hanger Load, Assuming Support at 5-ft. Co-ord. Grid Pts.	
					w/o L.L. (lb/hanger)	With Conveyor L.L. @ 30 psf (lb/hanger)	w/o L.L. (lb/hanger)	With Conveyor L.L. @ 30 psf (lb/hanger)
A	14,000	513	27	---	---	---	470	---
A_W	2,700	40	68	---	680	---	---	---
A_E	11,800	513	23	---	---	---	400	---
B	3,100	192	16	19	---	---	170	200
C	8,500	288	30	35	---	---	360	420
D	3,100	40	78	88	---	---	520	590
D_W	900	20	45	---	230	---	---	---
D_E	2,200	20	110	131	550	---	---	---
E	2,500	12	208	234	620	700	---	---
F	2,300	25	92	105	---	---	380	440
F_E	1,300	13	100	---	330	---	---	---
F_W	1,000	12	83	109	250	330	---	---
G	15,600	399	44	53	---	---	600	740
G_N	8,400	195	43	60	---	---	470	650
G_C	1,300	25	52	---	320	---	---	---
G_S	4,600	126	37	---	---	---	390	---

*UDL = Uniformly distributed load; L.L. - Mail live load

TABLE 3 Ceiling Loads from Suspended Mechanization Sections - Chicago AMF, Illinois

Facility	Work Floor				Work Area				
	Total Load kips	Area sq.ft.	UDL psf	Occupied Space %	Code	Total Load kips	Area sq.ft.	Maximum UDL psf	Occupied Space %
Greensboro	563	86,554	6.5	22.4	10	15	1650	9.2	30.9
Chicago	353	51,027	6.9	24.1	4	39	4329	9.1	31.3
Buffalo	1390	161,352	8.6	27.0	3	25	1944	12.7	27.1

Facility	Grid Square					Grid Sector					
	Code Grid sq. (work area)	Work Area UDL psf	Area sq.ft.	Maximum Grid UDL psf	Occupied Space %	Code Sect or (Gr. sq.) (Work Area)	Work Area UDL psf	Grid Square UDL psf	Area sq.ft.	Maximum Sector UDL psf	Occupied Space %
Greensboro	C-10 (3)	7.9	1089	15.9	41.3	3-4 (k-5) (6)	6.9	10.8	68	53.9	97.0
Chicago	E-1 (2)	7.4	1066	14.5	32.2	1-2 (E-1) (2)	7.4	14.5	67	86.7	58.2
Buffalo	E-14 (2)	11.1	1944	13.9	33.4	1-2 (A-4) (7)	6.9	12.4	121	54.7	81.0

TABLE 4 Maximum Loadings on Floor Areas of Different Size Divisions

GREENSBORO POST OFFICE

Work Area	PERCENTAGE OF OCCUPIED SPACE	OCCUPIED AREA(SQ.FT.)	TOTAL AREA(SQ.FT.)
1	20.5	1740.9	8512.0
2	28.0	2069.8	7392.0
3	20.8	2249.1	10806.0
4	25.0	2326.1	9315.0
5	24.7	511.3	2069.0
6	18.2	2055.1	11298.0
7	25.1	3088.3	12306.0
8	22.1	1920.3	8671.0
9	19.9	2888.6	14535.0
10	30.9	509.8	1650.0
BDG.T.	22.4	19359.2	86554.0

CHICAGO AMF POST OFFICE

WORK AREA	PERCENTAGE OF OCCUPIED SPACE	OCCUPIED AREA(SQ.FT.)	TOTAL AREA(SQ.FT.)
1	16.3	1781.6	10917.0
2	24.3	4556.2	18727.0
3	.0	.0	.0
4	31.3	1355.3	4329.0
5	25.2	1018.8	4046.0
6	.0	.0	.0
7	32.4	1271.1	3923.0
8	20.3	664.2	3265.0
9	.0	.0	.0
10	28.2	1639.6	5820.0
BDG.T.	24.1	12286.8	51027.0

BUFFALO POST OFFICE

WORK AREA	PERCENTAGE OF OCCUPIED SPACE	OCCUPIED AREA(SQ.FT.)	TOTAL AREA(SQ.FT.)
1	18.5	2062.6	11178.0
2	30.2	8365.7	27702.0
3	27.1	526.0	1944.0
4	33.5	10912.5	32562.0
5	.0	.0	.0
6	.0	.0	.0
7	24.7	7805.5	31590.0
8	17.8	3806.9	21384.0
9	27.9	7862.2	28188.0
10	32.2	2189.8	6804.0
BDG.T.	27.0	43531.3	161352.0

TABLE 5 Percent of Work Area Space Occupied by Load Items

	Equivalent Uniformly Distributed Load (EUDL) psf		
Work Area Code	Greensboro	Chicago	Buffalo
1	61	93	61
2	54	72	76
3	57	--	35
4	68	65	68
5	38	63	--
6	68	--	--
7	36	53	89
8	53	42	75
9	71	--	104
10	33	100	54

TABLE 6 Equivalent Uniformly Distributed Loads (EUDL) Derived from Optimized Loadings on Grid Square

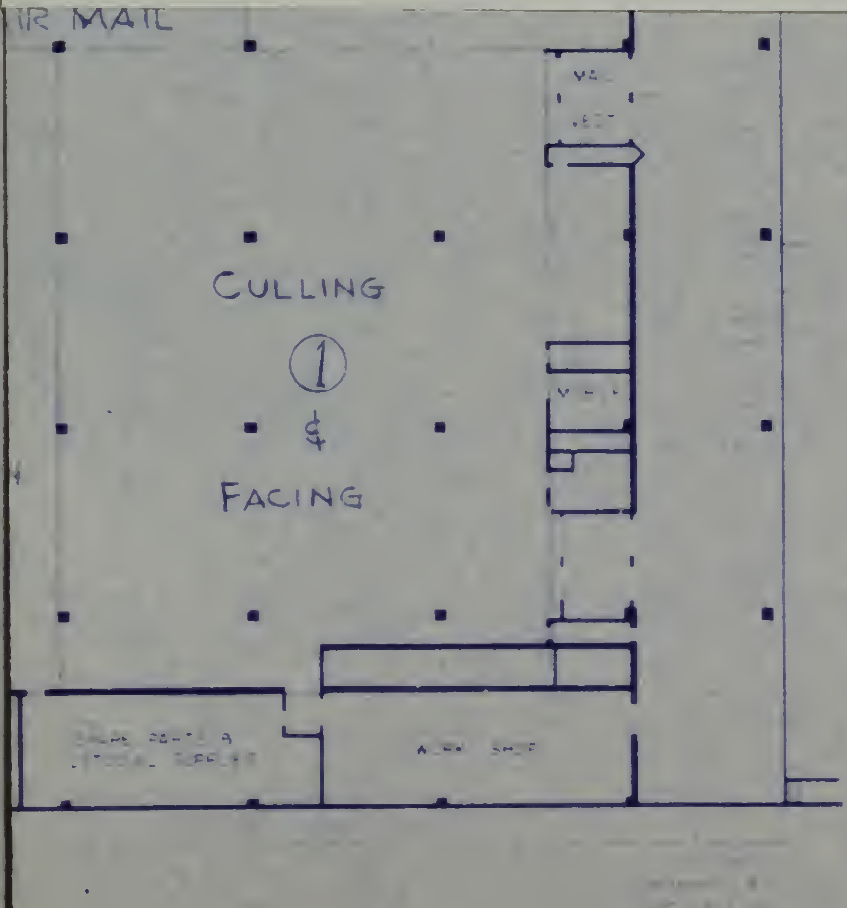


FIG. 1 - GREENSBORO POST OFFICE FLOOR PLAN SHOWING DESIGNATED WORK AREAS.

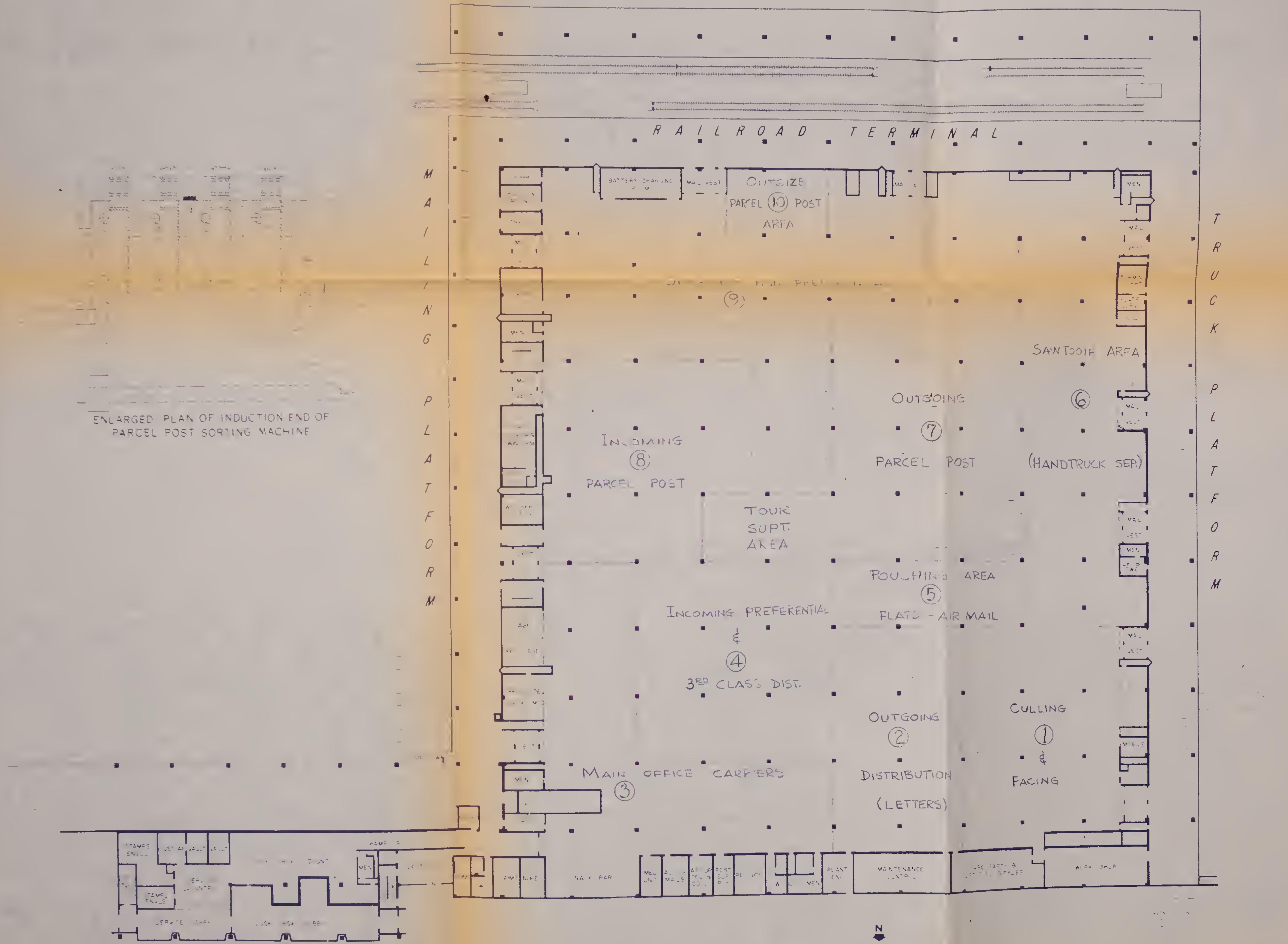
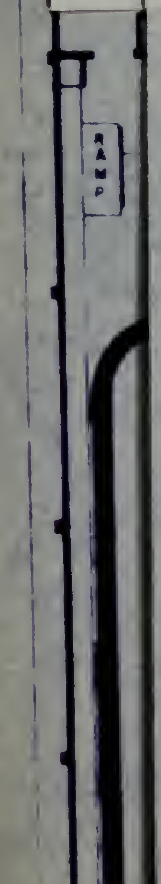


FIG. 1 - GREENSBORO POST OFFICE FLOOR PLAN SHOWING DESIGNATED WORK AREAS.



G. 2 - CHICAGO POST OFFICE FLOOR PLAN SHOWING DESIGNATED WORK AREAS.

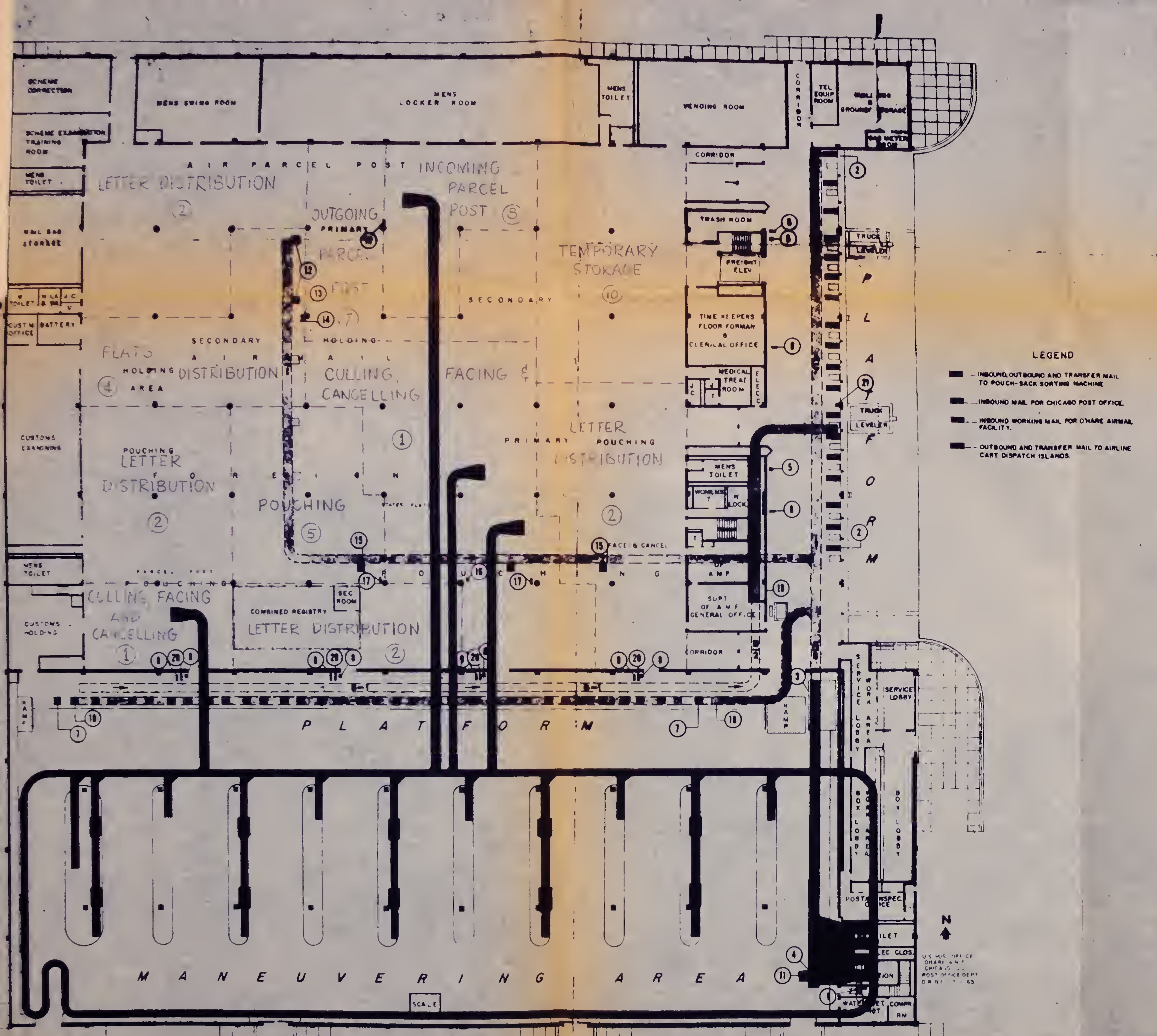
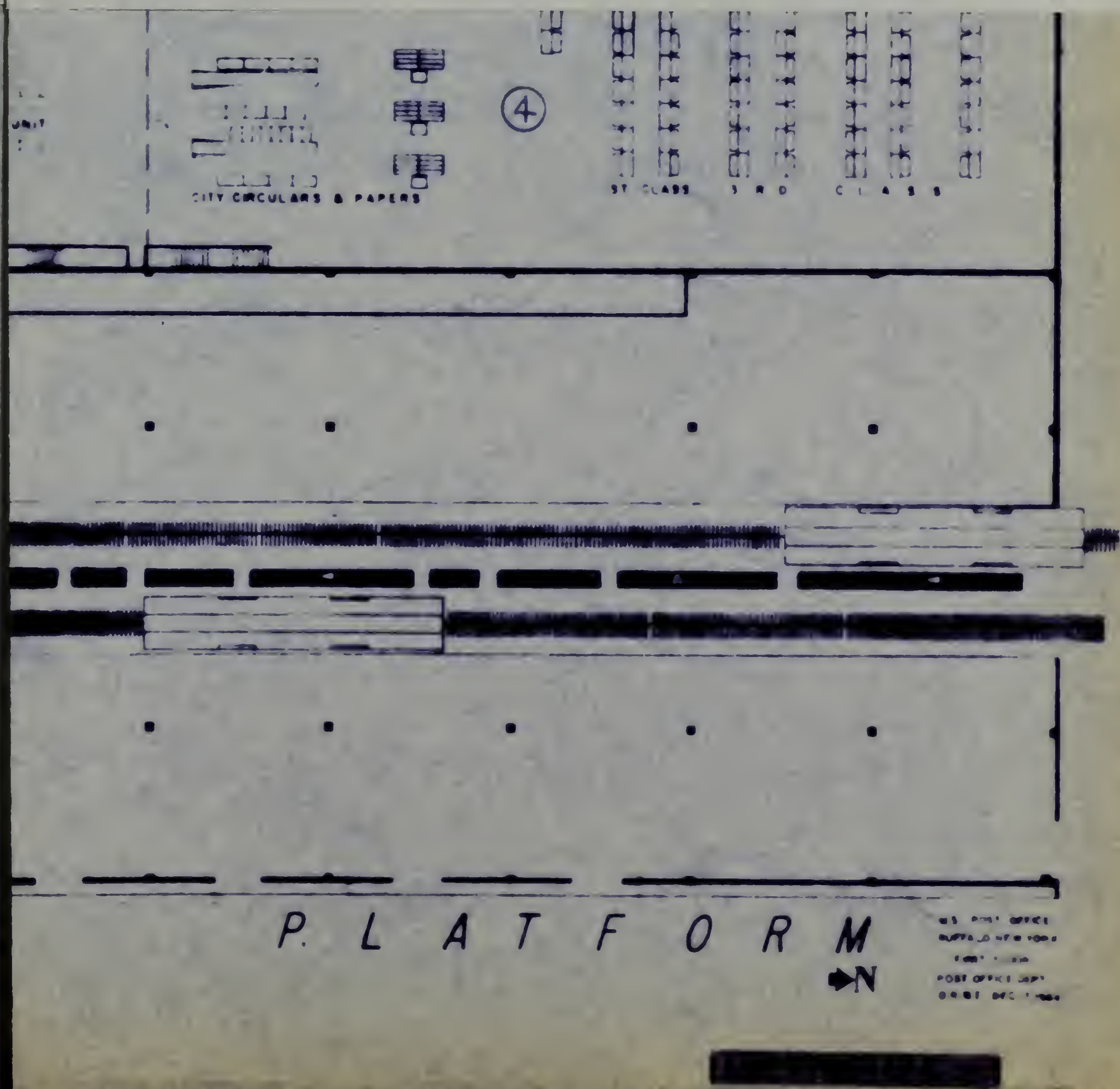


FIG. 2 - CHICAGO POST OFFICE FLOOR PLAN SHOWING DESIGNATED WORK AREAS.



3 - BUFFALO POST OFFICE FLOOR PLAN SHOWING DESIGNATED WORK AREAS

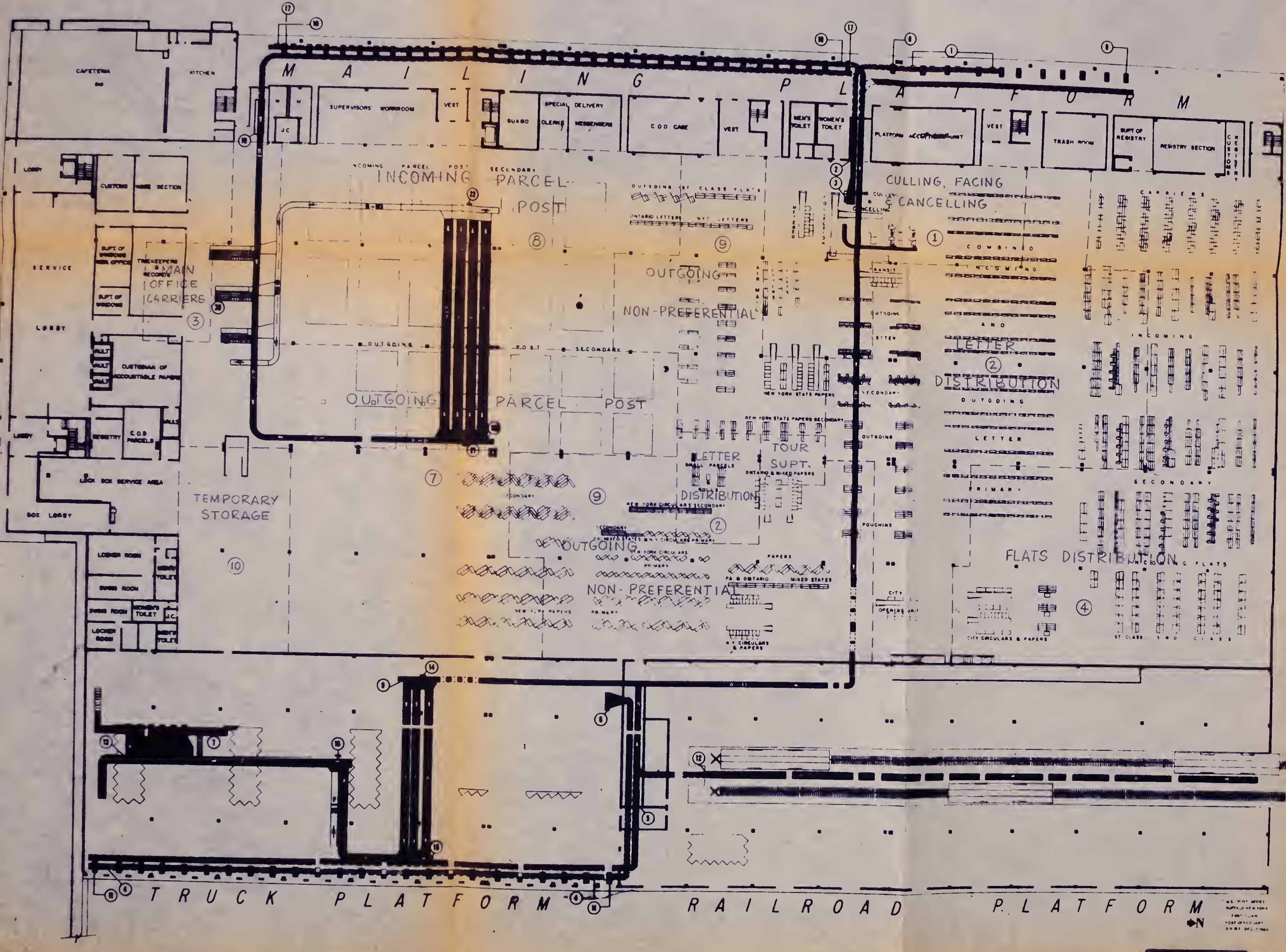


FIG. 3 · BUFFALO POST OFFICE FLOOR PLAN SHOWING DESIGNATED WORK AREAS

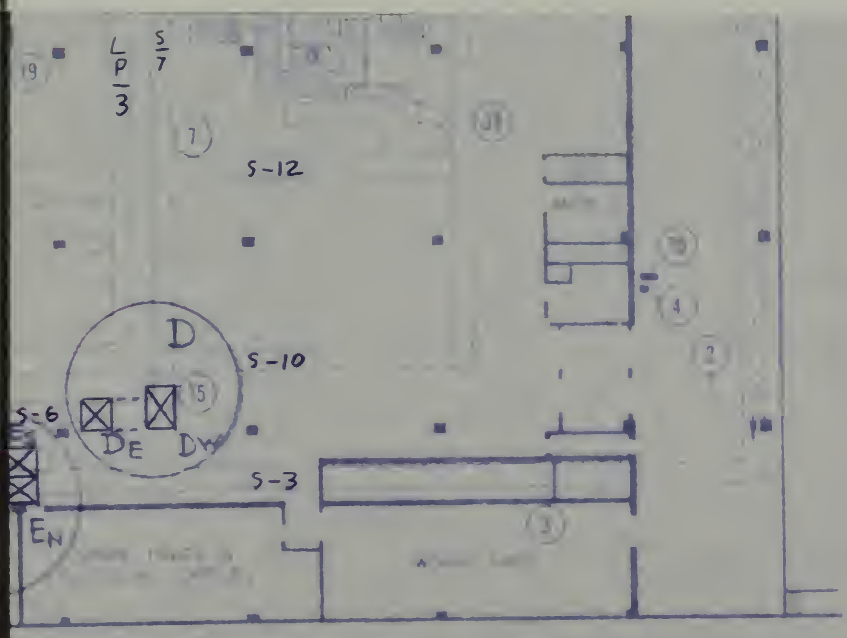


FIG. 4 - MECHANIZATION SECTIONS AT GREENSBORO SELECTED FOR DEAD WEIGHT DETERMINATION.

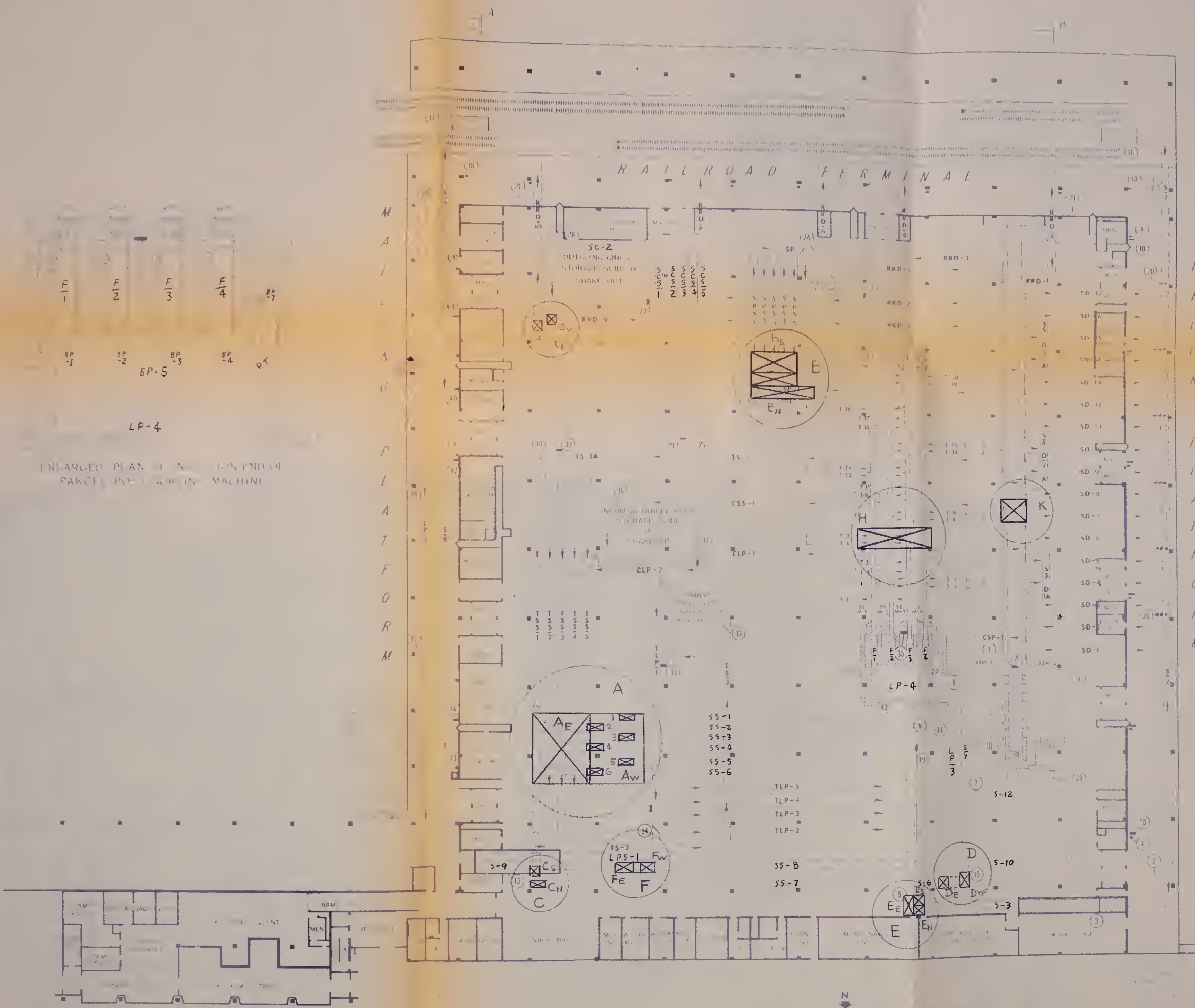
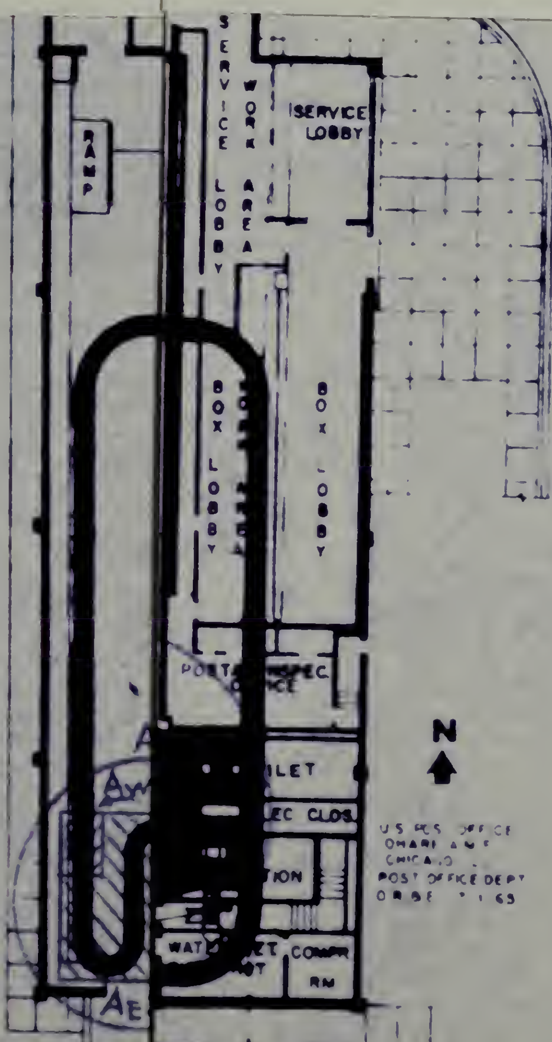


FIG.4 · MECHANIZATION SECTIONS AT GREENSBORO SELECTED FOR DEAD WEIGHT DETERMINATION.



ECTIONS AT CHICAGO SELECTED FOR
ERMINATION.

[redacted]

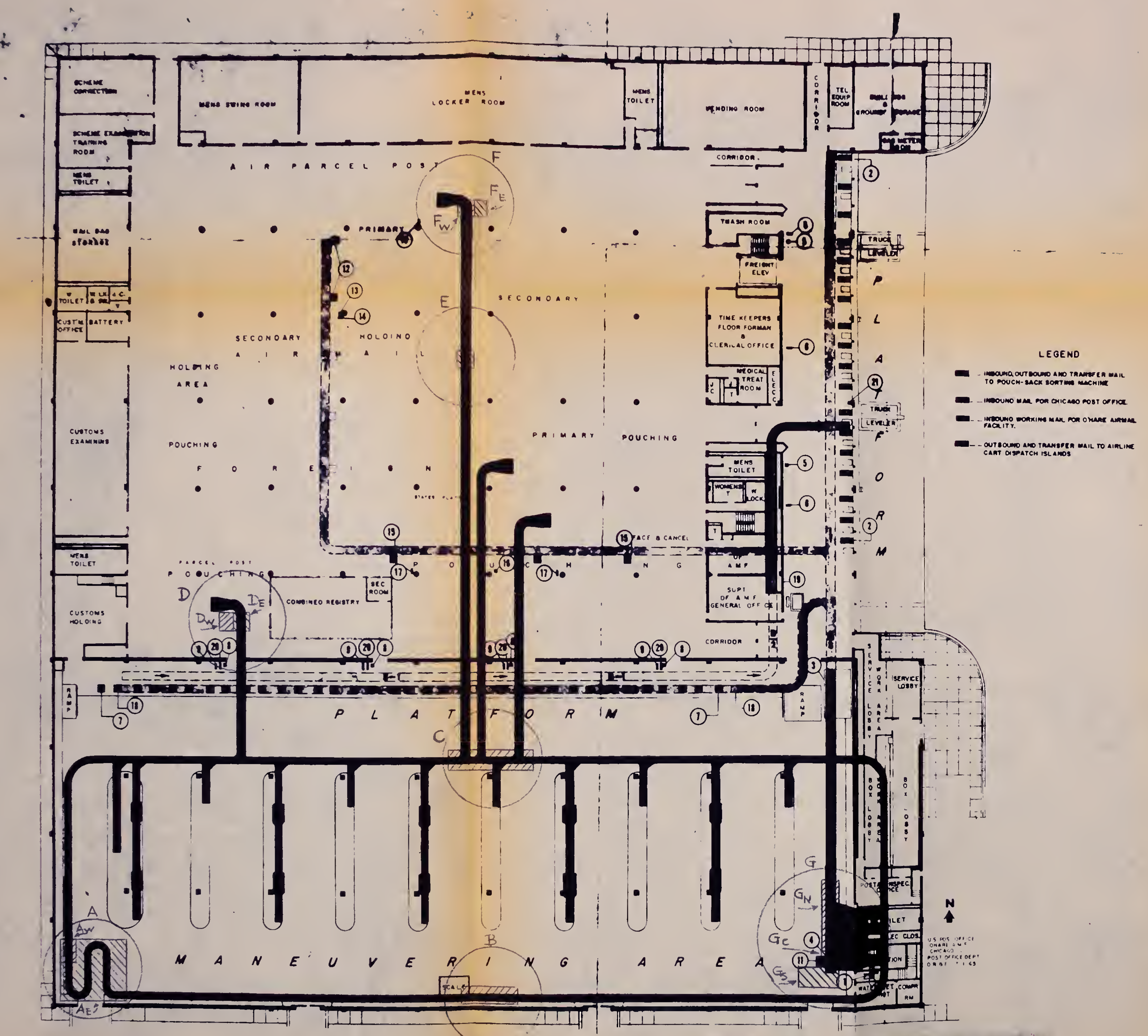


FIG. 5 - MECHANIZATION SECTIONS AT CHICAGO SELECTED FOR DEAD WEIGHT DETERMINATION.

[redacted]

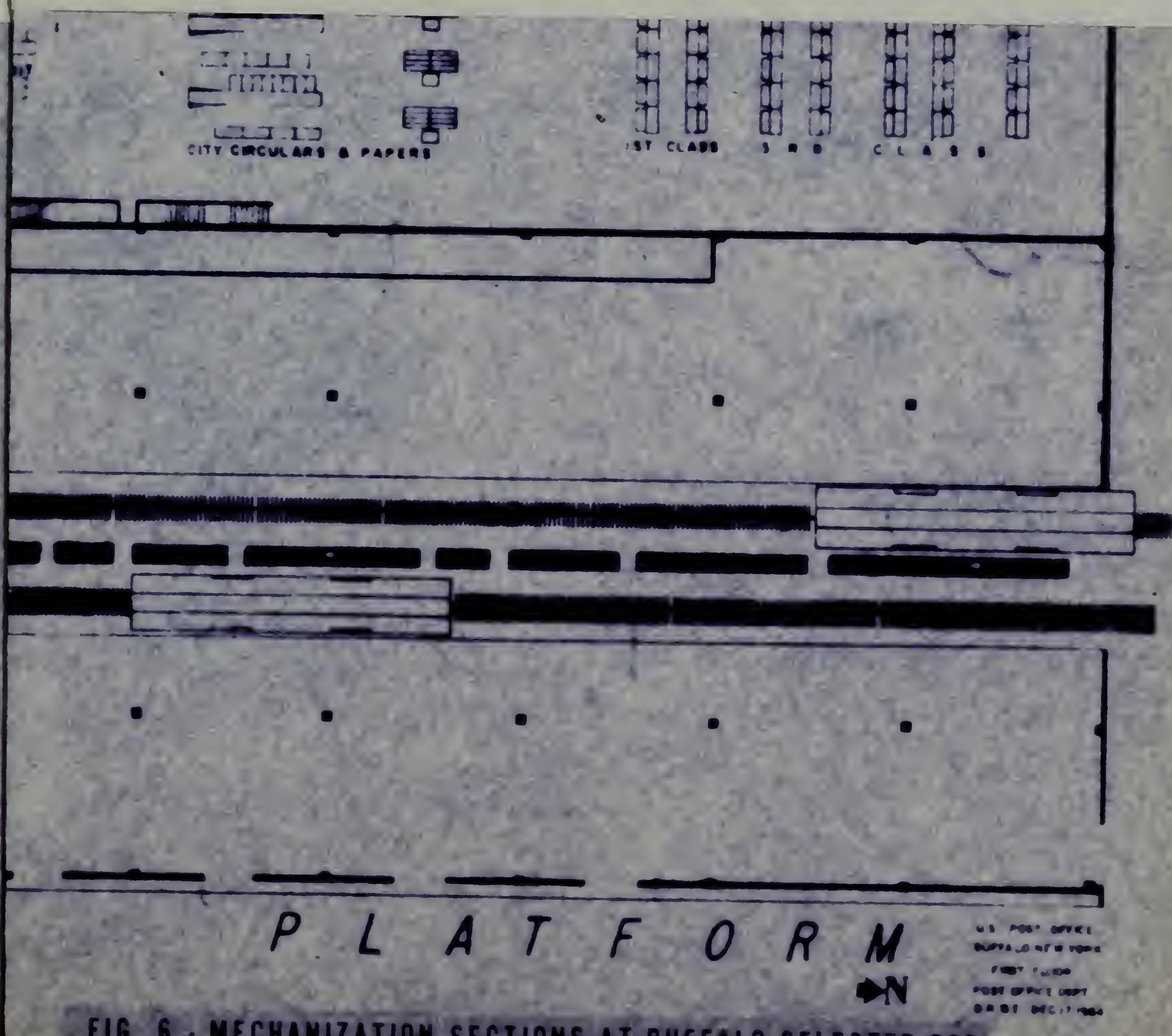


FIG. 6 - MECHANIZATION SECTIONS AT BUFFALO SELECTED FOR DEAD WEIGHT DETERMINATION. [redacted]

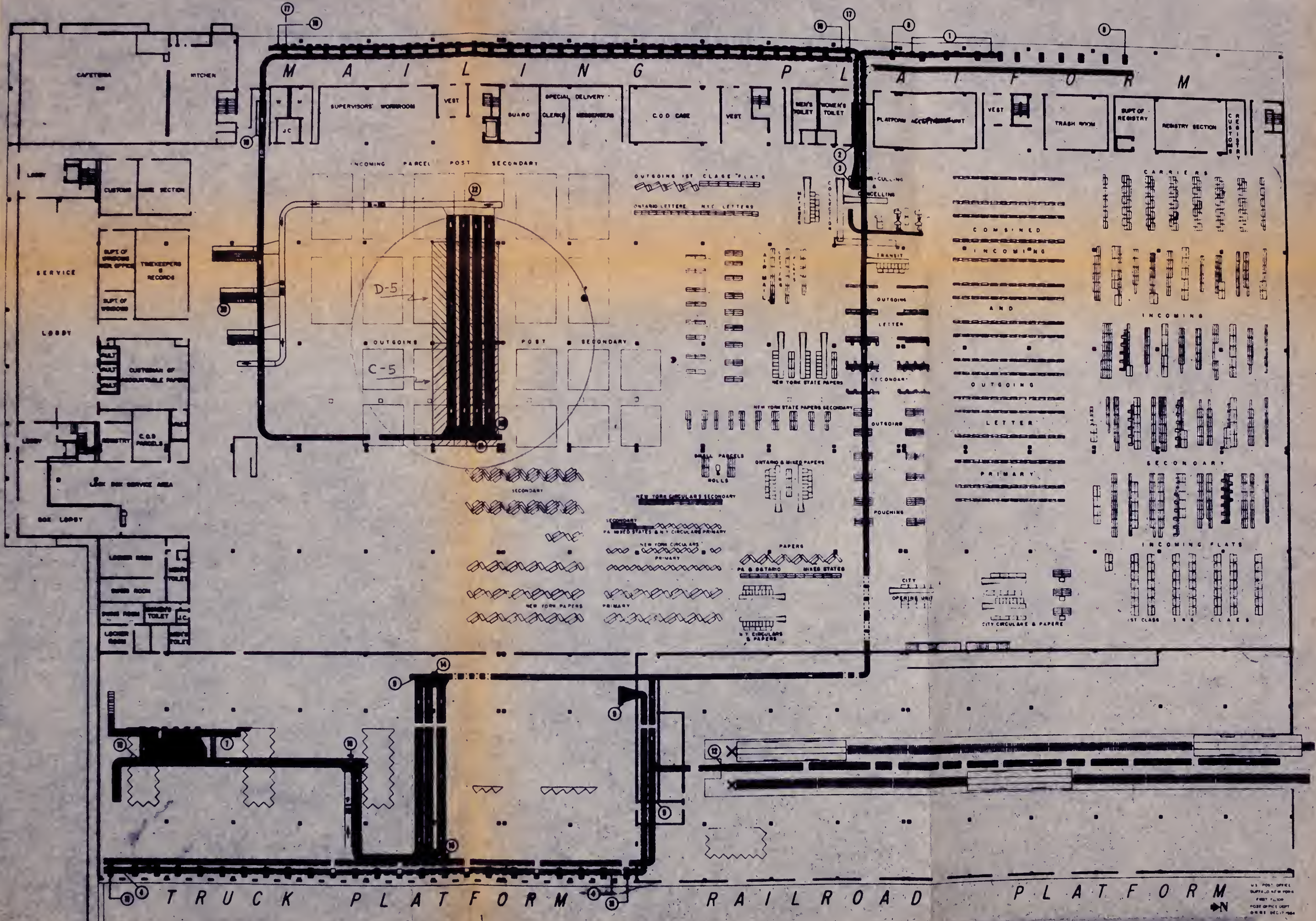


FIG. 6 - MECHANIZATION SECTIONS AT BUFFALO SELECTED FOR DEAD WEIGHT DETERMINATION.

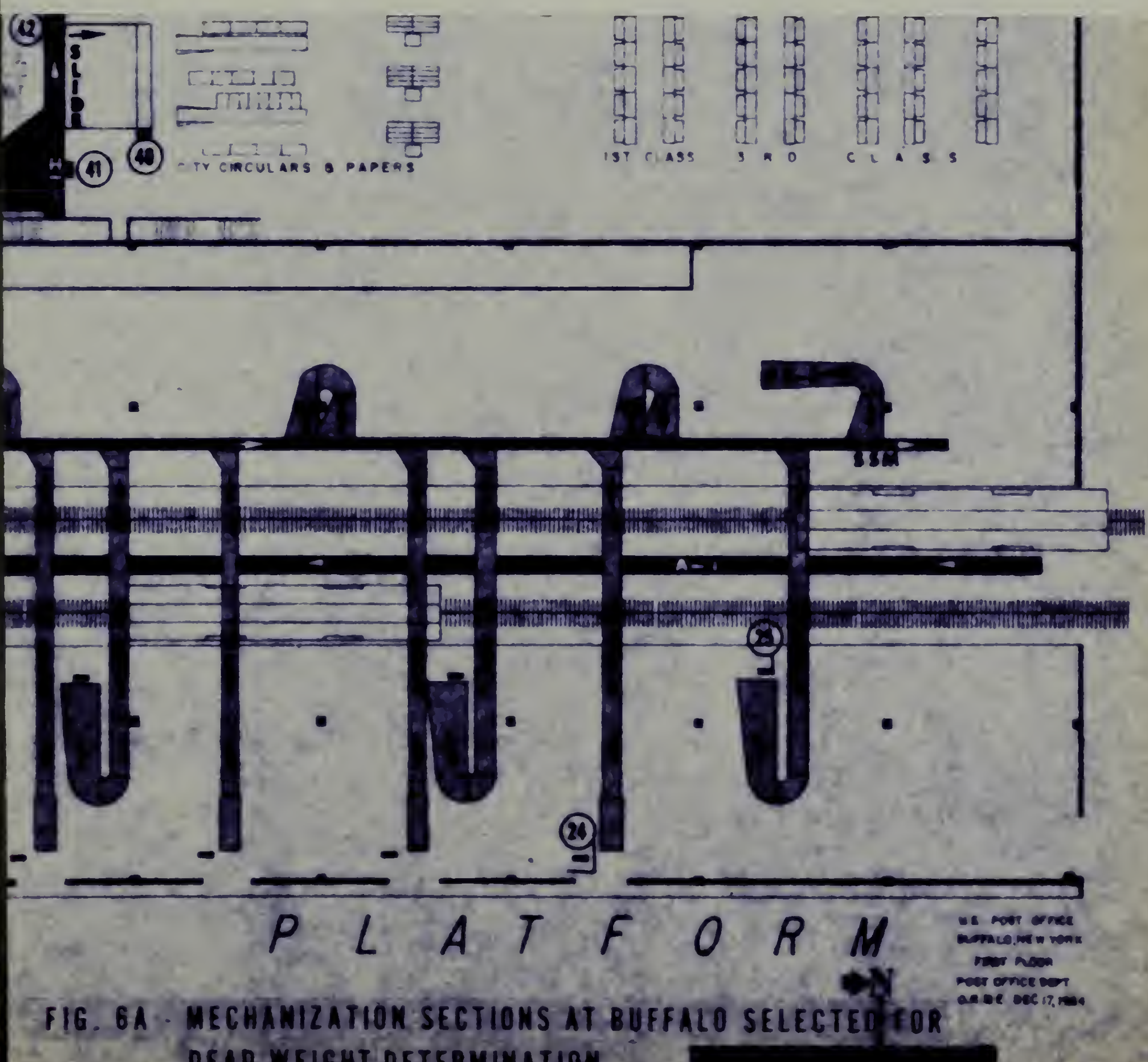


FIG. 6A - MECHANIZATION SECTIONS AT BUFFALO SELECTED FOR DEAD WEIGHT DETERMINATION.

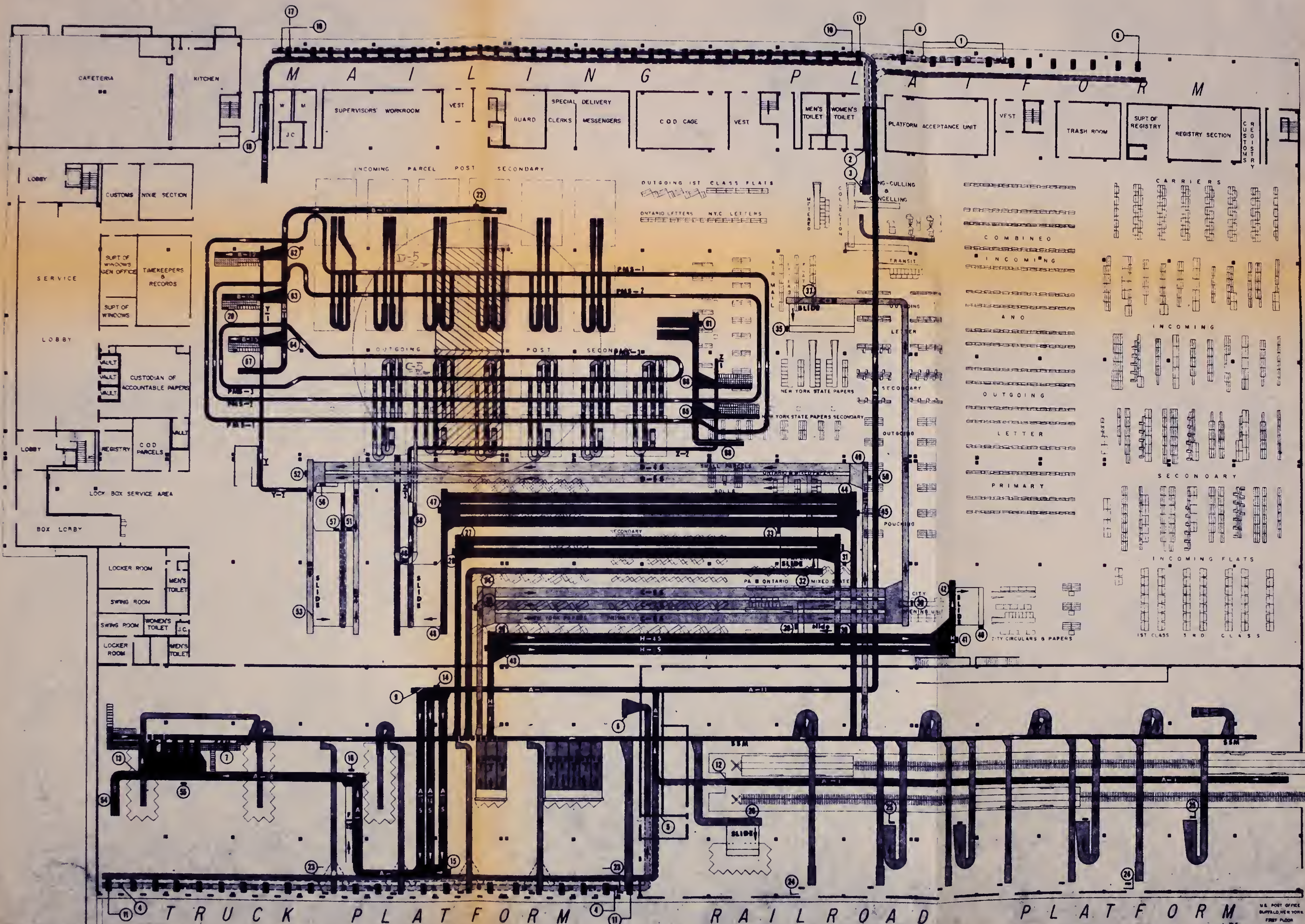
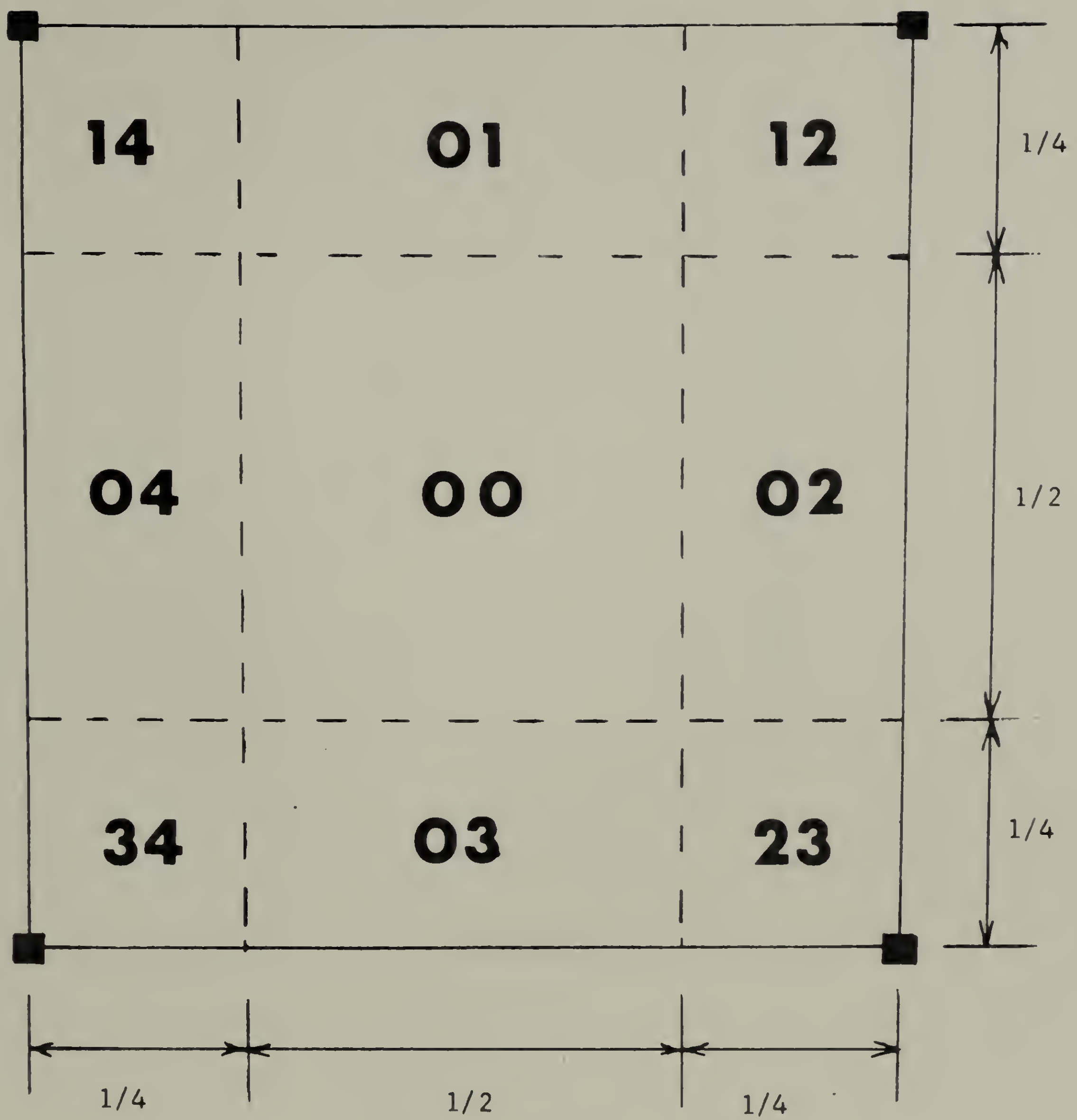


FIG. 6A MECHANIZATION SECTIONS AT BUFFALO SELECTED FOR DEAD WEIGHT DETERMINATION



Code number is related to an actual direction, e.g.:

00 = Central

01 = North

12 = Northeast

02 = East

23 = Southeast

03 = South

34 = Southwest

04 = West

14 - Northwest

FIG. 7 - GENERAL SCHEME FOR LOCATING ITEMS ON FLOOR OF POST OFFICE WITHIN A COLUMN GRID SQUARE.

CUMULATIVE FRACTIONS OF LOADED AREA CARRYING LOADS GREATER THAN A DISCRETE VALUE, WORK AREA, BUG.T.
TOTAL AREA= 86554.0 SQ.FT.
LOADED AREA= 19359.2 SQ.FT. = 22.4 % OF TOTAL AREA
ZERO LOAD= 67194.8 SQ.FT. = 77.6 % OF TOTAL AREA
U.D.L.= 6.6 FOR TOTAL AREA

GREENSBORO POST OFFICE

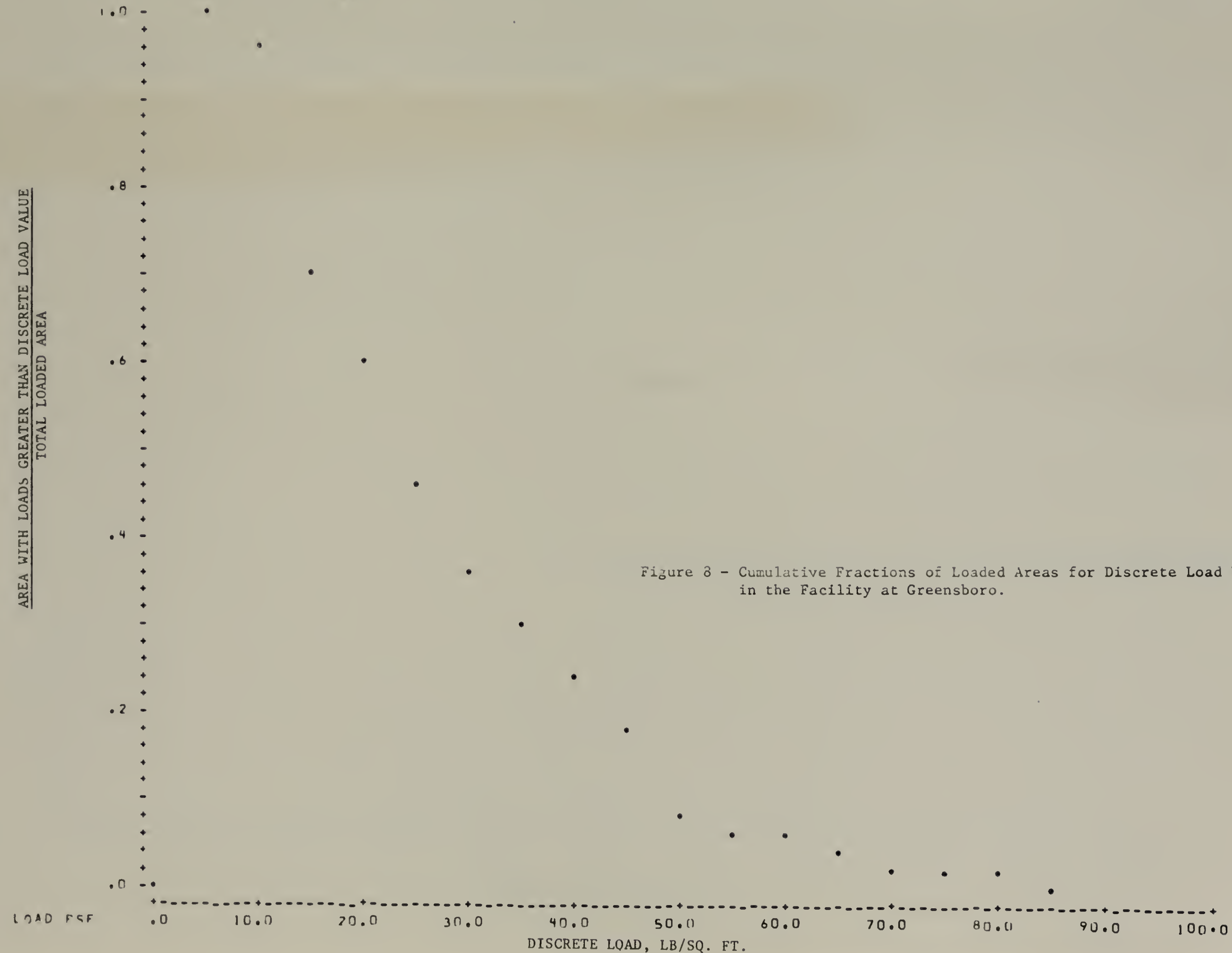


Figure 8 - Cumulative Fractions of Loaded Areas for Discrete Load Values in the Facility at Greensboro.

TOTAL AREA = 51027.1 SQ.FT.
LOADED AREA = 12286.9 SQ.FT. = 24.1 % OF TOTAL AREA
ZERO LOAD = 38740.2 SQ.FT. = 75.9 % OF TOTAL AREA
U.C.L. = 7.9 FOR TOTAL AREA

CHICAGO AMF POST OFFICE

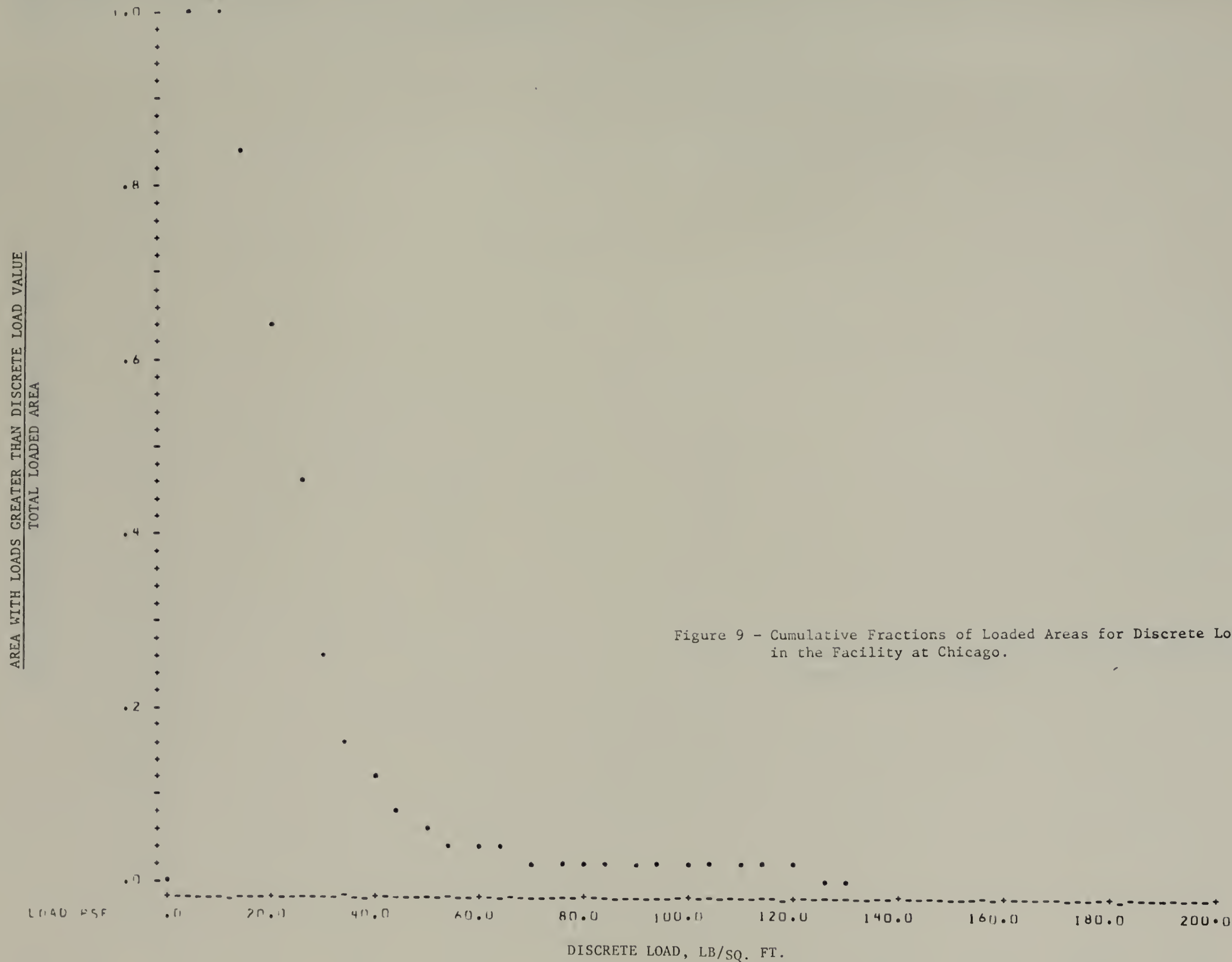


Figure 9 - Cumulative Fractions of Loaded Areas for Discrete Load Values in the Facility at Chicago.

CUMULATIVE FRACTIONS OF LOADED AREA CARRYING LOADS GREATER THAN A DISCRETE VALUE, WORK AREA, BDG.T.
TOTAL AREA= 161352.0 SQ.FT.
LOADED AREA= 43531.3 SQ.FT. = 27.0 % OF TOTAL AREA
ZERO LOAD= 117820.7 SQ.FT. = 73.0 % OF TOTAL AREA
U.D.L.= 8.6 FOR TOTAL AREA

BUFFALO POST OFFICE

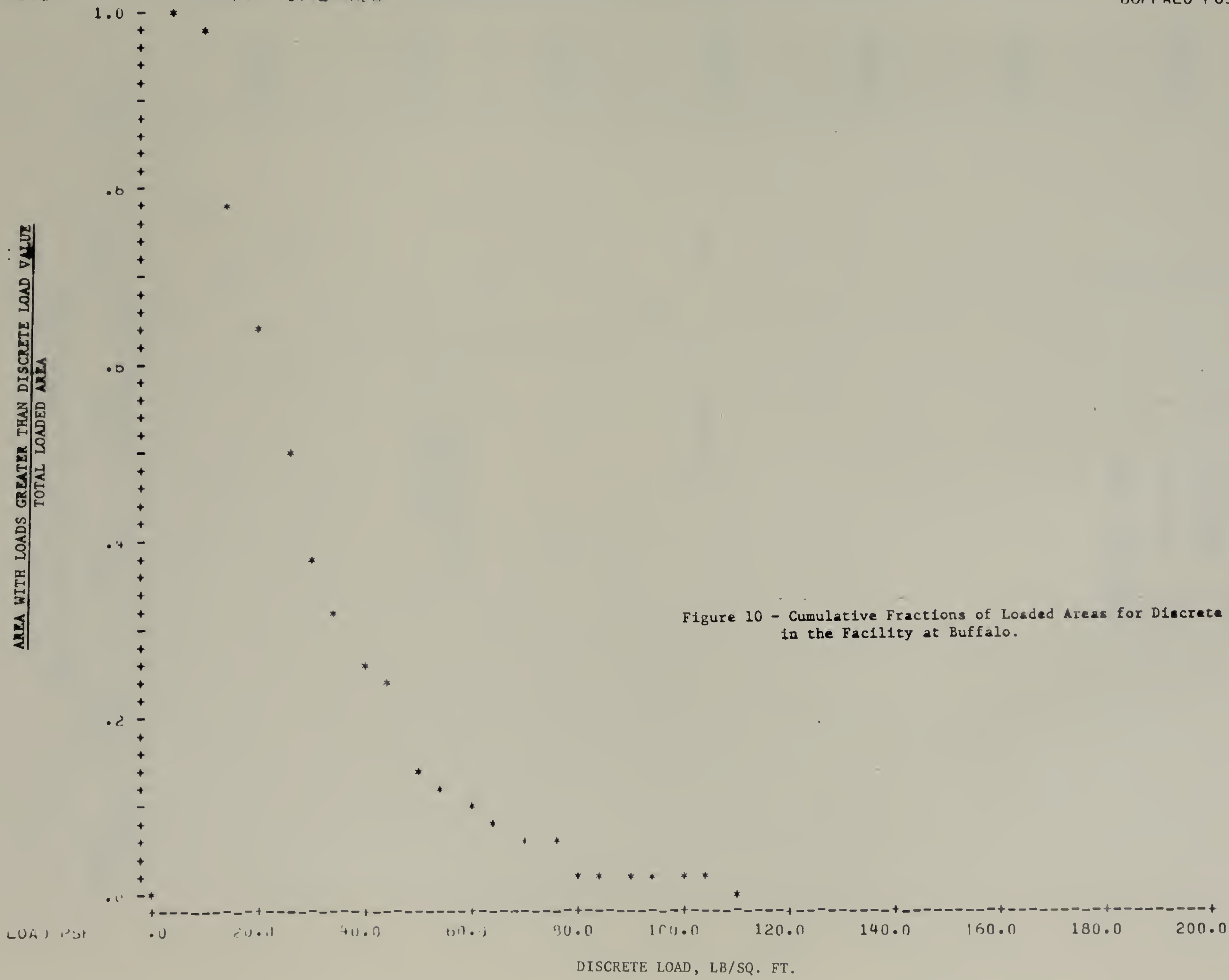
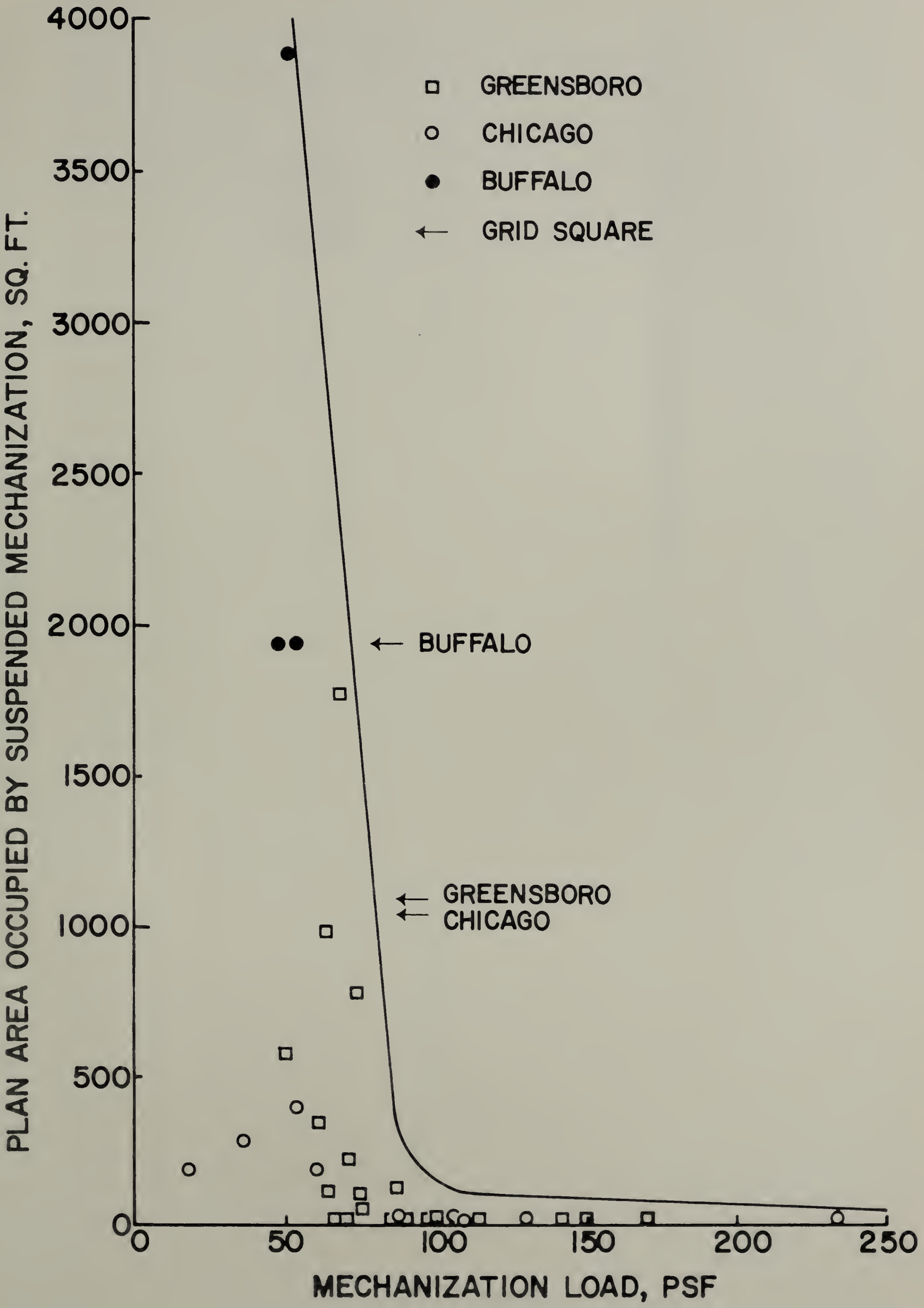


Figure 10 - Cumulative Fractions of Loaded Areas for Discrete Load Values in the Facility at Buffalo.



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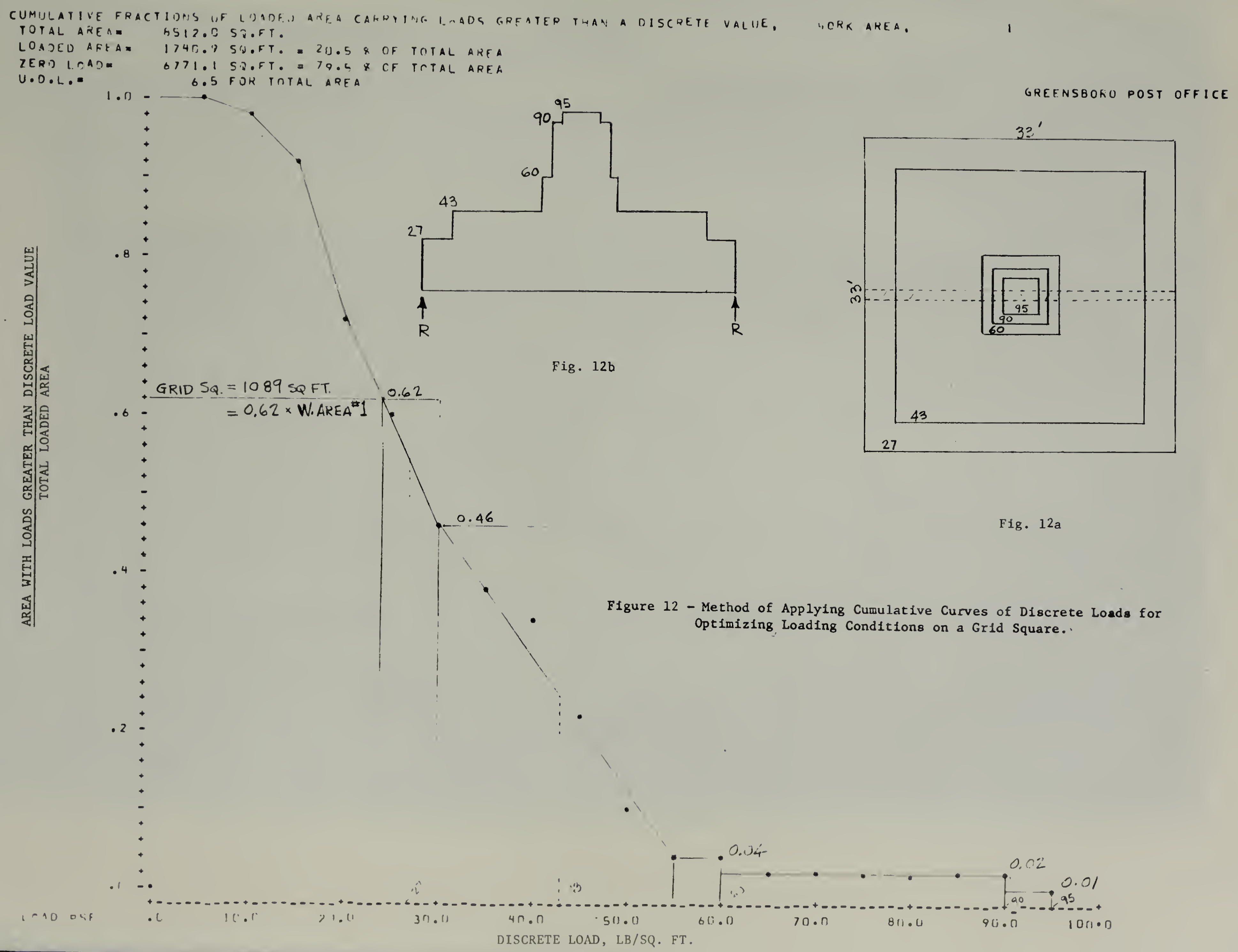

Figure 12 - Method of Applying Cumulative Curves of Discrete Loads for Optimizing Loading Conditions on a Grid Square.

FIG. 13 - LOADED NUTTING TRUCKS CLOSELY SPACED ON WORKROOM FLOOR.

FIG. 14 - FILLED MAIL SACKS PILED DIRECTLY ON WORKROOM FLOOR.

FIG. 15 - FULLY LOADED UTILITY CART.

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