THE FACTORS AFFECTING THE LABOR EFFICIENCY OF EGG COLLECTION

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

William J. Toleman

1963

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.

DATE DUE	DATE DUE	DATE DUE
FEB 3 0 o 1[illegible] 1 02		

ABSTRACT

THE FACTORS AFFECTING
THE LABOR EFFICIENCY
OF EGG COLLECTION

by William J. Toleman

Egg collection has become the most time consuming chore on wholesale egg farms. The proportion of time spent collecting eggs on wholesale egg farms has increased from 30% in 1948 to 80% in 1963.

Time and motion studies were made on twenty-one Michigan egg flocks. Four egg collection systems were evaluated: cage-belt, cage-carrier, floor-belt, and floor-carrier. Samples of eggs were candled from twenty-two flocks immediately after collection and before any further processing took place.

In this study the labor efficiency of egg collection was greater with belt egg collection systems than with carrier egg collection systems.

With the average cage-belt collection system the time required per 1,000 hens per day to collect eggs was 14.0 minutes. The most efficient 30% of the farms in this system required 9.5 minutes per 1,000 hens per day.

With average floor-belt collection systems the time re-

quired per 1,000 hens per day to collect eggs was 17.2 minutes. On the most efficient 30% of the farms in this system the time required was 12.3 minutes.

With the average cage-carrier collection system the time required per 1,000 hens per day to collect eggs was 24.4 minutes. On the most efficient 30% of the farms in this group the time required was 21.0 minutes.

With the average floor-carrier collection system the time required per 1,000 hens per day to collect eggs was 23.4 minutes. On the most efficient 30% of the farms with this system the time required was 17.0 minutes.

Within the floor-carrier collection system with roll-away nests the time required per 1,000 hens per day to collect eggs was 14.95 minutes and with conventional nests, 24.84 minutes.

The difference in collection time between floor-belt collection systems and the cage-belt collection system was three minutes per 1,000 hens per day. This was the time needed to collect floor eggs in the floor management system.

Floor egg collection time was determined more by the number of collections than by the percent of floor eggs.

Egg breakage was 3.8% with basket collection and 1.1% with molded fibreboard tray or plastic flat collection.

With conventional nests, the percentage of cracked eggs was 2.9%, with rollaway nests, 1.5%, and with cages, .5%.

Different combinations of collecting unit and nest type had a marked effect on the number of cracked eggs.

THE FACTORS AFFECTING THE LABOR EFFICIENCY OF EGG COLLECTION

By

William J. Toleman

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Poultry Science

1963

Table of contents

List of Tables

List of figures

List of appendices

Introduction

Michigan is an egg deficit area. Eggs have to come into the state from other areas in order to supply the population. In 1959 Michigan had 4.5% of the population in the United States, while in 1960 Michigan produced 2.6% of the nation's eggs (1). In order to supply Michigan's population with Michigan produced eggs, Michigan poultry farmers would have to almost double their output of eggs. However, production of eggs in Michigan has remained almost steady since 1945.

The total national egg production has been fairly consistant at 1.6 million dozen since 1945 but a change in producing areas has taken place. Exemplifying the change is the fact that California replaced Iowa in 1959 as the largest producer of eggs, a position Iowa had held since 1930. Comparatively new egg production areas have developed in the southern states, particularly North Carolina and Georgia. A decline in egg production has occurred in the North Central states, particularly Minnesota and Iowa. We may conclude that Michigan has done well to maintain a steady egg production in the last ten years.

Specialization and commercialization of Michigan's flocks have brought many changes. Until recently, few changes have occurred in egg handling from the standard method of picking them out of the nest and putting them into wire baskets. Recent innovations which have affected egg collecting are: 1) plastic flats, 2) vacuum egg lifts, 3) large volume washers, 4) wider use of cages for laying hens, and 5) automatic (motor driven belt) collection. These innovations are changing the method of egg collecting.

The farm operator is faced with a choice of egg gathering methods. He can hand carry the baskets of eggs. Probably due to the large amount of travel, this method has been decreasing in importance recently. One of the replacements is the carrier, either on a monorail next to the nests or a cart. The cart may be pushed between rows of cages or down a central collection aisle. Either of these carriers reduces the time spent traveling back and forth. They illustrate a basic principle of time and motion study - move a group of items together.

Both floor systems and cage systems can now have belt collectors installed. Do these belt collectors cut egg gathering time? Some companies claim that they will reduce the gathering to 20% of the time presently spent collecting eggs. Some producers report that they can collect eggs as fast or faster by walking through the house as by standing at a table waiting for the eggs to come to them. Certainly a machine will pace the job. Machine pacing is another time and motion technique used by industry to increase output. The pace may be beaten by a man in a hurry but who is going to hurry day after day? Which method takes the least time?

Is gathering onto plastic flats or molded fibreboard trays faster than gathering into wire baskets? There is an assumption that less eggs are broken in flats than in wire baskets, but no proof. Less cracked eggs could pay for adoption of flats - if there is less breakage. Plastic flat or molded fibreboard tray egg collecting units are adapted for handling eggs with a vacuum lift onto a washer or candler. Eggs from baskets must be lifted out by hand. It is obvious which will prevail in the long run, but many farmers could presently benefit from the use of flats if it were known for sure whether or not they reduce egg breakage and thereby increase income to pay for the new investment.

With this situation in mind, it was decided to determine the efficiency of and the factors affecting the following methods of egg gathering:

(1) Floor-carrier, the monorail system with floor housing.

(2) Floor-belt, motor-driven belt from rollaway nests with floor housing.

(3) Cage-carrier, a cart pushed down the aisle between cage rows.

(4) Cage-belt, motor-driven belt collection from cages.

The study was also devised to evaluate the influence of the type of nest, the type of collecting container and the age of the laying hen on the incidence of cracked eggs.

Review of Literature

Time and motion studies of egg collection are limited. Time and motion studies of egg handling have been mainly concentrated in the egg packing plant.

Earle (2) found that egg gathering averaged 30% of all chore time on New York farms in 1948. Filling and cleaning waterers took 14% of the chore time, feeding took 23.2%, and walking between buildings took 13%. The balance of the day was spent on maintainance, record keeping, or waiting.

Earle's study showed 14.9 to 40.2 minutes were required per 1,000 hens per day to collect eggs. The average egg collecting time was 24.4 minutes per 1,000 hens per day. This time was only slightly more than that determined in an unpublished study at Michigan State University by Davidson in 1950 (3). Davidson's data showed 23.8 minutes per 1,000 hens per day were required to gather eggs. The common method of egg collection in both of these studies was into wire baskets from conventional nests in litter houses. Earle thought the amount of travel was important. The distance traveled per 1,000 hens per day ranged from 573 feet to 1,274 feet with an average of 916 feet. He concluded that nesting rooms would reduce the amount of travel and thereby reduce the amount of egg collection time. Nesting rooms have never become popular among poultrymen, but a method to reduce the amount of travel, the monorail carrier next to the nests, has been developed.

Unpublished data collected by Snyder (4) at Pennsylvania State University in 1960 indicated that an average of 26 minutes per 1,000 hens per day was required to collect eggs. This was the average time for all systems studied. The striking fact was that Snyder's data indicated that egg collection time had not been reduced over the twelve year period since Earle's study, even though Snyder's study included operations with the newest in automatic egg collection equipment. The Pennsylvania study, which was conducted on large commercial farms, yielded the following data:

Total egg collection time per 1,000 hens

Type of collection	Annual Manhours	Minutes per day
Cart with basket in a central aisle	129	21.3
Conventional nest into basket carried manually	187	30.7
Floor-belt into filler flats	117	19.2
Cage-cart into baskets	103	16.9
Floor-belt into baskets	121	19.9
Cart with flats in central aisle	162	26.6

Bartlett (5) of Pennsylvania State University analyzed Snyder's data. He indicated that gathering and moving eggs into carts which carry the flats or the baskets takes 38% less time than hand collecting into baskets and carrying them manually. The carts reduced the travel time by moving the egg baskets in units rather than individually.

The most efficient time in Snyder's study was with hand collection from cages into carts. This required 16.9 minutes per day per 1,000 hens. Mechanical collection required 19.2 minutes per 1,000 hens per day.

Jewett (6) reported from Maine that floor-carrier collection saved four minutes a case over hand carrying each basket with floor systems of flock management. This agrees with Snyder (4). In Maine, floor-belt collection into filler flats reduced collection time 30% over a floor-carrier system. The Maine results indicate Snyder's (4) figures for mechanical collection time may be high.

Gunderman (7) reported that the annual labor cost for hand collection from a given flock of 6,000 layers was about $2370. The total annual cost of collection after installing a mechanical collector was about $685. This value included five year amortization of the $1400 first cost ($280), interest on the investment ($50), and labor ($355). He reported that the time saved was about 1080 hours per year which was 85% of the labor required for hand collection. These results are highly questionable on the basis of the information obtained by Snyder and Jewett.

Miller et al (8) surveyed farm factors affecting egg breakage on Ohio farms. They found the type of collecting container influenced the percentage of cracked eggs. When eggs were collected in a split wood basket 2.2% were cracked and when eggs were collected in a wire basket 2.8% were cracked. They reported that the number of nests supplied per 100 layers and the type of nesting material had very little, if any, effect on egg breakage.

According to Hauser (9), Sauter and Black showed that a ration containing 3.0% calcium caused hens to lay eggs with heavier shells than a ration containing 2.5% calcium. They also reported that shell weight as measured by specific gravity was inversely related to the age of the layers.

Hauser (9) reported a large difference in the percentage of cracked eggs which was related to the age of the layers and shell thickness. The hens were divided in two groups: 11-14 months of age and 17-20 months of age. Two and six-tenths percent of the eggs from the younger birds had cracked shells when the egg shells were .0140 inches or more in thickness, while 17.0% of the eggs had cracked shells when the shells were less than .0140 inches in thickness. Four and six-tenths percent of the eggs from the older hens had cracked shells when the egg shells were .0140 inches or more in thickness, while 21.7% of the eggs had cracked shells when the shells were less than .0140 inches in thickness. He reported that by proper selection of breeding stock, poultry breeders can increase shell thickness.

Experimental Procedure

Twenty-one Michigan poultry houses on thirteen farms were visited during the winter of 1962-63. Two of the farms were visited twice in order to complete observations. The number of layers involved was 174,348. They were all commercial egg laying strains of White Leghorns or Leghorn-type hybrids. A layout of each egg collection system was made and distances measured on each house studied. The layouts are in the appendix. Operator travel distance was recorded for each farm. The time spent collecting nest eggs and floor eggs was measured with a stop watch. The number of hens in the house at the time of the observations was estimated from the housing and mortality records of the operator. The age and strain of the birds were taken from farm records. The number of eggs collected was recorded and the percent production calculated.

Egg collection was classified into the following types:
(1) Floor carrier system with the birds housed loose on the floor. A carrier was pushed by the operator in front of the nest on a rail fastened to the ceiling. The eggs were taken from the nests and placed in baskets or on trays in the carrier.

(2) Floor belt collection. Rollaway nests caused the eggs to roll on to a belt which delivered them to a central point

where they were placed in wire baskets or on to trays. Birds were housed loose on the floor.

(3) Cage carrier collection. Birds housed in cages had their eggs taken from a rollaway tray and placed on a cart. The cart was pushed past each cage by the operator. He took the eggs from the rollaway trays and placed them in wire baskets or trays.

(4) Cage belt collection. The eggs rolled out of the cage on to a belt which delivered them to a central point where they were placed in baskets or flats.

One farm was observed as a check farm. This is Farm A in the appendix tables. The collection system on this farm consisted of conventional nests from which the eggs were gathered into wire baskets and manually carried from the pen. There were approximately 2200 birds in each of four pens. The layout may be observed in the appendix.

Trays in this study refer to molded fibreboard trays or to plastic egg trays. The trays have 30 cells arranged five across and six long.

To study the incidence of cracked eggs, 17,574 eggs from twenty-two flocks were candled. Random samples consisting of 500 eggs in each of two flocks, 666 in one flock, 1260 in one flock, 1248 in one flock, and 1,000 eggs in each of the rest of the flocks were taken. The number of cracks was recorded.

The number of egg collections, the collecting unit (flats or wire baskets), and the type of nest were observed and recorded. The types of nests were classified as follows: (1) cage, (2) rollaway wire bottom in floor operations, or (3) conventional nest.

Somer operators who collected onto flats placed a few dirty eggs in baskets. These eggs were not considered in the egg breakage part of the study.

An attempt was made to collect information on the cost of equipment in the four different systems. Generally the farm managers had either forgotten or had bought the system in a "package" and were unable to separate the cost of the collection equipment. Since a wide variation is to be expected, depending on the bargaining power of the manager, it was decided to calculate the comparative value of the investment from the man hours saved.

The time required to collect eggs was totalled and expressed as minutes per day per 1,000 birds and as minutes per day per case of eggs collected.

The amount of time required to collect floor eggs was separated from other collecting time by stopwatch observation to determine the effect of floor eggs on the time per 1,000 hens per day. The floor egg time is normally included as part of the egg collection time for the floor systems of housing birds.

Forms for farm observations and recording of data are shown in the appendix.

Observation and Discussion

The average time to collect eggs with the cage-belt collection systems was 14.0 minutes per 1,000 hens per day. The range was from 9.5 to 22.0 minutes per 1,000 hens per day.

The average time to collect eggs with floor belt collection systems was 17.2 minutes per 1,000 hens per day. The range observed was from 11.6 to 26.5 minutes per 1,000 hens per day.

Egg collection on the check farm with hand carrying of eggs in baskets taken from litter nests required an average of 19.5 minutes per 1,000 hens per day.

The average time per 1,000 hens per day to collect eggs with the cage-carrier system was 24.4 minutes. The range with the cage-carrier system was 21.0 to 29.3 minutes.

The average time required to collect eggs with the floor-carrier system was 23.4 minutes per 1,000 hens per day. The range with the floor carrier system was from 16.5 to 28.7 minutes.

It was observed that practically the same number of minutes was required for an egg collection within any given type of system, whether 1500 eggs or 2500 eggs were collected. With belt collection systems the amount of time for a collection was determined more by the length of the belt and the rate of movement than by the number of eggs. With carrier systems the time of an egg collection was determined more by the distance the operator had to travel and the type of nests than by the number of eggs. An extreme of egg numbers, either very high or very low, did affect the length of collection time; however, this situation was involved in a minority of the collections. When 1500 or 2500 eggs were collected in the same amount of time the measurement of minutes per case of eggs collected indicated a wide difference while the measurement of minutes per 1,000 hens was affected only very slightly. Because of this the measurement of egg collection time as minutes per 1,000 hens should probably be weighted more heavily than the measurement, minutes per case of eggs.

The average number of minutes required to collect eggs per case of eggs per day was 8.6 minutes for the cage-belt egg collection system. The range of the observations was from 5.7 to 14.3 minutes per case of eggs per day.

The average number of minutes required to collect eggs per case of eggs per day was 10.4 minutes for the floor belt egg collection system. The range of the observations was from 6.3 to 15.5 minutes per case of eggs per day.

The average number of minutes required to collect eggs per case of eggs per day was 13.4 with the cage-carrier collection system. The range observed was from 10.2 to 17.0 minutes per case of eggs per day.

The average number of minutes required to collect eggs

Table I. Labor efficiency of the egg collection systems used with twenty-one Michigan flocks.

	Cage-belt	Cage-carrier	Check farm	Floor-belt	Floor-carrier
Average Minutes per 1,000 hens	14.0	24.4	19.3	17.2	25.4
Range of Minutes per 1,000 hens	9.5 - 22.0	21.0 - 29.3	19.3	11.6 - 26.5	16.5 - 28.7
Average Minutes per Case of eggs	8.6	13.4	13.6	10.4	16.1
Range of Minutes per Case of eggs	5.7 - 14.3	10.2 - 17.0	13.6	6.3 - 15.5	13.2 - 20.2

per case of eggs per day was 16.1 with the floor-carrier system. The range observed was 13.2 to 20.2 minutes per case of eggs per day.

On the check farm the labor required to collect eggs was 13.6 minutes per case per day.

The average time required to collect eggs with the cage-belt system was 10.0 minutes per 1,000 hens per day less than the average time with the cage-carrier system. Furthermore, the longest time observed with the cage-belt system was 22.0 minutes per 1,000 hens per day, which is practically the same as the least time of 21.0 minutes per 1,000 hens per day required with the cage-carrier collection system.

The average number of minutes per case of eggs to collect eggs with cage-belt collection systems was five minutes less than the average time per case of eggs required with the cage-carrier systems. The range of time required per case of eggs does not indicate as wide a difference between the two systems as does the range of minutes per 1,000 hens. Birds observed where the cage-belt collection systems were in use averaged 56% production. The cage-carrier collection system birds averaged 66% production.

The average time required to collect eggs with the floor-belt collection systems was 6.0 minutes per 1,000 hens per day less than the average time with the floor-carrier collection systems. The least time required per 1,000 hens per day with the floor-belt systems was 5.0 minutes less than the shortest time with the floor-carrier systems. The longest times required per 1,000 hens per day with both systems were practically the same.

The average number of minutes required for collection per case of eggs with the floor-belt system was 6.0 minutes less than the time required per case of eggs with the floor-carrier system. The upper range of the minutes per case with floor-belt collection systems was close to the lower range of the floor-carrier collection systems. Birds where the floor-belt collection systems were observed averaged 61.8% production. The floor-carrier collection system birds averaged 50.8% production.

Cage-belt collection systems and floor-belt collection systems were more efficient than cage-carrier collection systems or floor-carrier collection systems. The difference in collection time of 3.0 minutes per 1,000 hens per day between cage-belt collection systems and floor-belt collection systems was the time required to collect floor eggs which will be discussed later.

There was only 1.0 minute difference between the average time required to collect eggs per 1,000 hens with the cage-carrier systems and the floor-carrier systems. These average times are very close to Earle's time of 24.4 minutes for hand carry collection in 1948 and Davidson's time of 25.8 minutes for hand carry collection in 1950. The figures indicate that egg carriers enable poultrymen today to be as efficient with large flocks as poultrymen were in the late '40s and early '50s with small flocks. Large flocks enable poultrymen to employ automatic feeders and waterers by spreading the depreciation over large numbers of birds.

Egg collection on the check farm with a system of hand carrying egg baskets from a litter nest system required 19.3 minutes per 1,000 hens per day, whereas the cage-carrier system required 24.4 minutes and the floor carrier system required 23.4 minutes. However, on the most efficient 30% of the farms with floor carrier systems (Table II) this job required only 17.0 minutes per 1,000 hens per day. Thus, the floor carrier system can be more efficient than the hand carry system.

Table II. Labor efficiency of egg collection with the most efficient 30% of observed flocks.

Collecting System	Minutes/1,000 hens	Minutes/case
Cage belt	9.5	5.7
Cage carrier	21.0	10.2
Floor belt	12.3	6.6
Floor carrier	17.0	17.1

On the most efficient 30% of the cage-carrier farms the average time required to collect eggs was 21.0 minutes per 1,000 hens per day. Collection on the cage carrier system farms required more time than was required on the check farm and four minutes per 1,000 hens longer than on the most efficient of the floor-carrier system farms. The results indicate that the cage-carrier system does not offer the same possibility for collection efficiency as does the floor-carrier system.

There are three main reasons why collections utilizing the cage-carrier system required more labor than collection utilizing the floor-carrier system. First, in this study the average distance traveled for cage-carrier collection was more than twice as great than the distance traveled for floor-carrier collection systems (Table III).

Table III. Distance traveled per operator per collection.

Floor systems		Cage systems	
Belt	Carrier	Belt	Carrier
43'	213'	55'	491'

Second, the cage-carrier must be guided by the operator. The cart tends to go off course into the dropping pits if not guided. The floor-carrier on a monorail is guided by the rail, not the operator.

Third, the eggs are spread out in the cage system and the eggs from the birds in each cage are picked up separately, thus the operator must reach to each cage. The cages have spread out the hens and thus the eggs. Floor system nests, on the other hand, consolidate the eggs. The motions of grasp and release are not particularly influenced by the time it takes to gather eggs or by the gathering system. However, the motion of reach tends to slow down with length and repetition. The motion of reach is also more susceptible to worker variation. It would take more refined time and motion techniques than those used in this study to pinpoint the work-station motions of reach. Observations in this study, and time and motion engineering principles, lead to the hypothesis that amount of travel, reach-motion, and carrier guidance all contribute to lengthen the time required to collect eggs in the cage-carrier system over that required in the floor-carrier system.

It is possible that efficient operators with cage-carrier systems could reduce the egg gathering time by half if they could switch to belt collection. This is indicated by the labor efficiency of the best 30% of the study farms where the egg collection time was 9.5 minutes for cage-belt systems and 21.0 minutes for cage-carrier systems. This will be a difficult goal to achieve, since the good cage-belt flocks in this study received very good management and were in houses equipped with very long belts.

In the most efficient 30% of floor-belt systems, 12.3 minutes per 1,000 hens were required for egg collection. This is about half the floor carrier average collection time of 23.4 minutes and one-third below the best 30% of floor carrier systems where an average of 17.0 minutes was required. The minutes per case figures from Table I indicate the same trend.

The type of nest used influences the efficiency of collection where the floor carrier system is utilized (Table IV). The floor-carrier system with rollaway nests required an average collection time of 19.95 minutes per 1,000 hens per day. The floor carrier system with conventional nests required an average of 24.84 minutes per 1,000 hens per day. This is a difference of 4.89 minutes per 1,000 hens per day. The difference is probably due to the fact that the operator with rollaway nests does not have to search under the hens for eggs. The operator can see immediately where the eggs are located when the rollaway nest cover is lifted.

Table IV. Labor efficiency of egg collection as influenced by the type of nest with floor-carrier collection systems.

Minutes/1,000 hens/day	Rollaway	Conventional
Carrier	19.95	24.84
Belt	17.15	-----
Minutes/case eggs/day		
Carrier	13.27	17.44
Belt	10.33	-----

Floor Eggs

The advantage in collection time of cage-belt collection over floor-belt collection is the saving of the time required to pick up the floor eggs. In this study this time averaged three minutes per 1,000 hens per day (Table V).

Table V. Floor egg collection

	Percent of total eggs	Percent of total gathering time	Minutes per 1,000 hens/day
Range	0 - 18%	1 - 48%	.3 - 8.3
Average	5.6%	17.2%	3.0

The information presented in Table V. - A indicates that the percent of floor eggs is not the major influence in floor egg collection time. The major influence appears to be the number of times floor eggs are collected. Increasing the number of collections increases the travel distance, which in turn increases the percent of total egg collection time spent gathering floor eggs.

Table V. - A Factors affecting labor efficiency of floor egg collection.

Number of floor egg collections	Percent of floor eggs	% of total egg collecting time	Average distance traveled per day
1 - 2	2.0	5.7%	726'
3	12.6	*20.7%	1422'
5 - 6	6.9	23.3%	3064'

* Excludes one farm where the number of floor eggs was 3.5 times greater than average. Including this farm in the category raises the figure to 26.0%.

The following provides an insight into economic factors that the farm manager faces in deciding how many floor egg collections to make per day.

Ten thousand birds laying at a rate of 70% produce 583 dozen eggs per day. The average number of floor eggs in this study (5.6%) indicates that 32.6 dozen eggs will be laid on the floor. How many times can the manager economically pick up floor eggs? It was observed on several farms with three floor egg collections that about 10% of the floor eggs were cracked. The average time for one collection was about ten minutes. Considering that one pickup per day will result in more cracks and some lost eggs (smashed and eaten) we can conservatively estimate that 50% of the floor eggs will be cracked with one pick up. The average difference for 1961 and 1960 in the Chicago and Detroit markets between cracked eggs and large white eggs was 8.4 cents per dozen. We will assume a labor cost of $1.25 per hour.

If all the floor eggs were cracked, the gross return would be reduced by $2.73 per day. The loss in dollars from cracks column in Table V - B indicates the expected loss with the different numbers of collections. The dollars saved per collection column indicates the savings possible from additional collections.

Table V - B. Economics of increasing or reducing number of floor egg collections per day.

Number of floor collections	Estimated % crax	$ saved per collection	Loss in $ from crax	Cost in labor @ $1.25/hr.	Net Gain
1	50	------	1.36	.21	----
2	25	.68	.68	.42	.26
3	10	.41	.27	.62	-.21
4	5	.13	.14	.83	-.70

The "guesstimate" shows a net loss for picking up floor eggs three times, as compared to one or two times. It looks like there is no way to make money by collecting floor eggs three times a day! If the number of cracked eggs among the floor eggs amounts to only 25 or 30% for one collection, the manager would profit by collecting them only once. The estimate indicates that floor eggs should not be collected more than twice.

Financial considerations

The actual investment in equipment per farm could not be determined. Most of the farmers had either forgotten the cost of the equipment, or had purchased it as part of a package and were unable to separate the component costs. The analysis herein, then, depends on the difference in labor utilization efficiency between the egg collection systems and the amount of money saved by changing egg collection systems.

Table VI. Comparison of labor efficiency between different egg collection systems.

System	Annual man hours per 1,000 hens	Hours per yr. saved by belt collection	$ saved/yr. valuing labor @ $1.25/ hour	$ saved per 10,000 hens in 5 years
Cage-carrier	148.43	63.27	$79.08	$3,954.00
Cage-belt	85.16			
Floor-carrier	142.35	36.50	$45.62	$2,381.00
Floor-belt	105.85			
Labor efficiency on best 30% of farms				
Cage-carrier	127.75	69.96	$87.45	$4,372.00
Cage-belt	57.79			
Floor-carrier	103.41	28.59	$35.73	$1,786.00
Floor-belt	74.82			

From Table VI, it can be seen that 63.27 man hours per 1,000 hens can be saved annually with a cage-belt system as compared to a cage-carrier system. This can be converted to a dollar difference based on the farm salary scale and should be figured for each farm. One dollar and twenty-five cents was used in the table, since it is the minimum federal wage for industrial workers. The figure of 63.27 man hours converts to an advantage of $79.08 per 1,000 hens per year for the cage-belt collection system compared to the cage-carrier collection system.

The labor saving value of the cage-belt collection system compared to the cage-carrier collection system for 10,000 hens becomes $3,954 with a five year depreciation schedule. The farm manager can figure that he will save $3,954 which must pay for the (1) cost and installation of the belt system, (2) interest on any borrowed money, and (3) maintainance and repair of added equipment. This is approximately 40¢ per bird.

The cage-carrier to cage-belt transition appears to be worth more to a farmer in the upper 30% of efficiency than it is to less efficient operators.

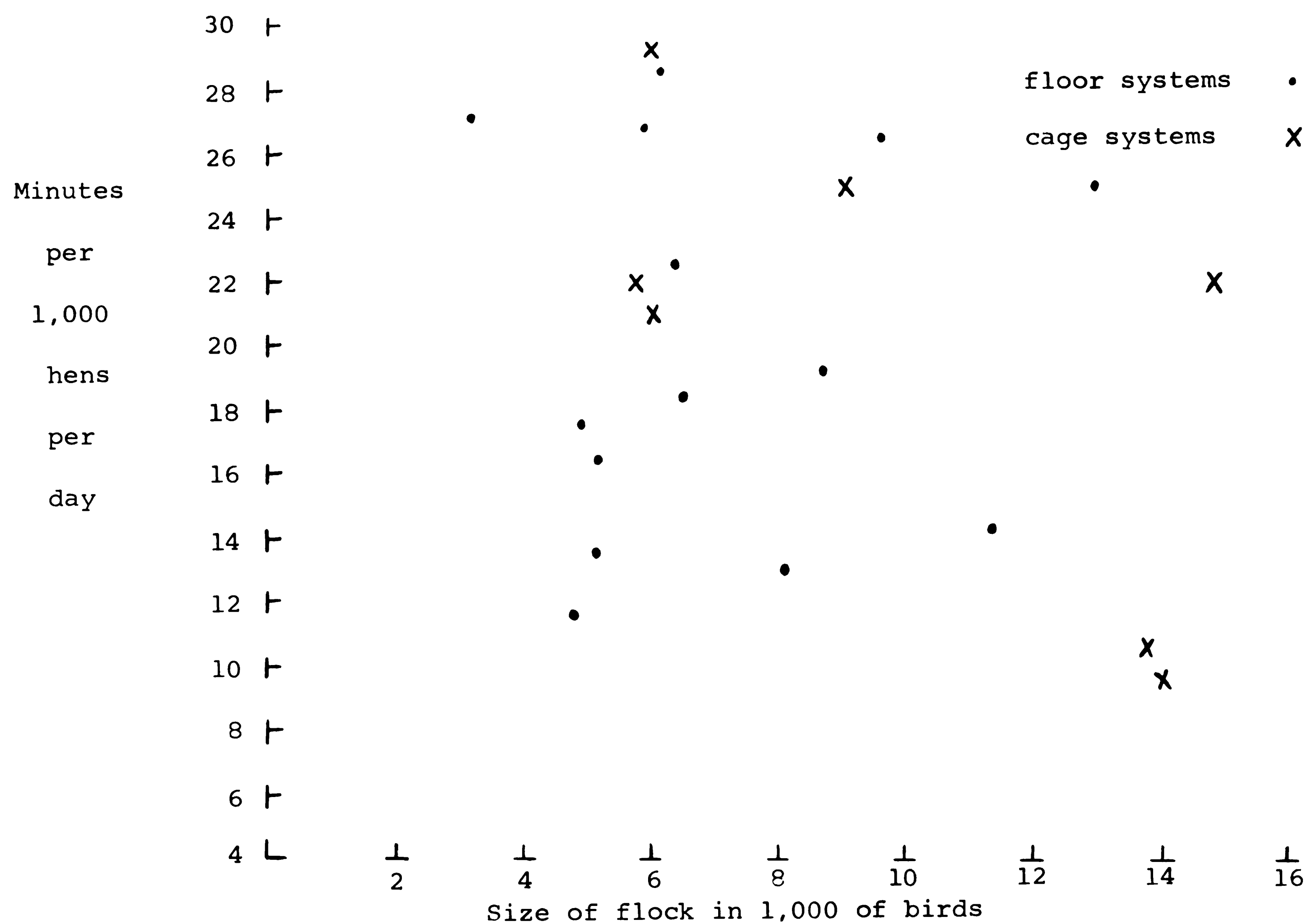
Replacement of the average floor-carrier system with the average floor-belt system saves 36.5 man hours per 1,000 hens per year, or $45.62 per 1,000 hens per year. This difference expands to $2,381 for 10,000 hens with a five year depreciation schedule. The farm manager can figure on saving $2,381 to pay for the change in his collection system.

Based on information from this study, the more efficient floor system farmers would gain less money by changing to a belt collection system than would the average farmer using this system.

Economy of Scale

Figure 1 shows the wide scatter within flock size of egg collecting efficiency. Regression lines were fitted for both cage systems and floor systems. An analysis of variance

Figure 1. Labor efficiency in relation to flock size



for the regression lines indicated that the differences were statistically non-significant. In this study no improvement in labor efficiency of egg collection by increasing the flock size from approximately 5,000 birds to 15,000 birds was shown.

As pointed out previously, it was not possible to study a cage-belt system with 4,000 to 6,000 birds. It was possible to find only one farm with 9,000 or more birds in either the cage-carrier or the floor-carrier systems. Perhaps this is indicative of the economy of scale but the situation makes it impossible to draw any economy of scale conclusions. The variation within the categories indicates that something other than the egg collection system is influencing the labor efficiency of egg collection. This is probably the managerial ability of the farm managers.

Egg Breakage

The percentage of cracked eggs from each flock is shown in Table VII.

In this study, the greatest single influence determining the number of cracked eggs was the type of container the eggs were placed in when gathered. Eggs placed in flats had 1.1% cracks. Eggs placed in wire baskets had 3.8% cracks. The difference of 2.7% was probably due to the combination of weight pressure on eggs in the basket, operator carelessness when placing eggs in the basket, and, finally, a squeeze caused by picking up the full basket after the eggs had

Figure 2. The collection units

Molded Fibreboard Tray Basket

Average egg breakage with baskets was 3.8% and with trays it was 1.1%.

Table VII. The percentage of cracked eggs as related to age and strain of birds, nest type and handling procedure on twenty-one flocks.

		Number of Flocks	% Cracked Eggs
Collecting container	Basket	5	3.8
	Flat	16	1.1
Age	6 - 9	7	1.2
	10-12	5	2.0
	13-15	5	2.7
	16 +	3	2.9
Nest type	Cage	7	.5
	Rollaway	8	1.5
	Conventional	6	2.6
Strain	Hyline	7	1.1
	H & N	4	1.5
	DeKalb	9	1.7
Number of collections	2 - 3	13	1.7
	4 - 6	8	1.8

settled.

Eggs placed in molded fibreboard trays are in individual cells. The weight of the egg is transferred to the tray rather than to another egg. There is no opportunity for the egg to roll against another egg and crack. When a group of trays is lifted, the stress is in the flat rather than in the egg shell.

The age of the bird was the second most important consideration affecting egg breakage. A difference of 1.7% cracked eggs was found between the 6 to 9 month old birds and those over 16 months. The trend shown in Table I is to be expected since thinner shells have long been associated with hens in the latter part of their laying period, according to Romanoff and Romanoff (10).

The type of nest was the third most important factor affecting the percent of cracked eggs. Eggs from rollaway nests showed 1.1% fewer cracks than eggs from conventional nests. Apparently, when the eggs got out from under the feet of the hen the breakage was less. Eggs from cage birds showed the least number of cracks, .5%. The full range of age, strain and number of collections was present in the cage bird classification. The low percentage of cracked eggs from birds in cages was due to the fact that all cages were a rollaway type and the eggs were all collected into molded fibreboard trays.

A small difference in numbers of cracked eggs between strains of chickens was noted in this study. The average percentage of cracked eggs for Hyline was 1.1, for H&N, 1.5, and for DeKalb, 1.7 . Poultry breeders have known for a long time that individuals and families can be developed into thin shell lines or thick shell lines, according to Sturkie (11). The cracking strength is directly related to shell thickness according to Romanoff and Romanoff (10). Thus if there were a difference in shell thickness between the strains in this study the difference in percent of cracked eggs between strains in the study may have been real; however, in the 1962 Report of Egg Production Tests by the U. S. D. A. no significant difference between Hyline, H&N and DeKalb birds in this respect was reported. No importance can therefore be attached to the strain difference noted in this study. All eggs from the Hyline strain were collected into flats and most of the eggs from the DeKalb strain were collected into baskets. Thus it appears that the apparent strain difference is due to the influence of the type of container into which the eggs were collected.

The particular combination on a given farm of factors affecting egg breakage appeared to be important. The percent of cracks from flocks with similar combinations were averaged and the results were as follows:

1) The combination of old age and collection into wire bas-

kets resulted in 5.7% of cracked eggs, the greatest percentage of cracked eggs in this study.

2) The combination of moderate age and conventional nest with tray collection resulted in 3.3% cracked eggs.

3) Wire basket collection combined with rollaway nests and young birds resulted in an average of 2.6% cracked eggs.

4) The combination in the study that resulted in the least number of cracked eggs, 0.6%, was a combination of tray collection from rollaway nests with young birds.

Table VIII. Observed percent of cracked eggs with various egg breakage factor combinations.

Collecting unit	Nest type	Percent of cracked eggs
Flat +	Rollaway	.78
Flat +	Conventional	1.94
Basket +	Rollaway	3.27
Basket +	Conventional	6.00

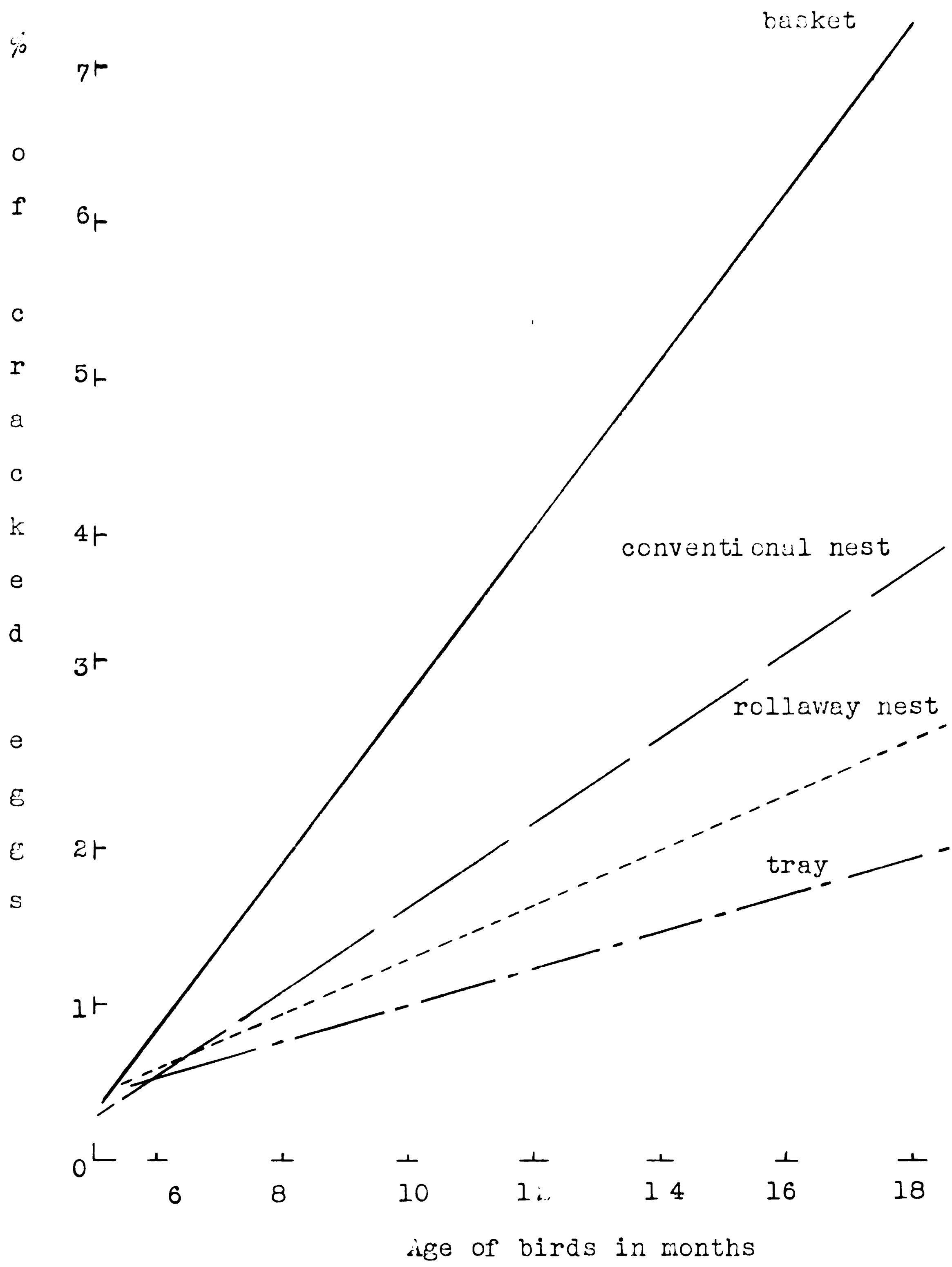
The range of cracks in the individual flocks appeared to be directly related to a combination of the factors in the egg collection system. The various combinations of the type of container and nest type resulted in the averages in Table VIII.

The regression coefficients of age and percent cracked eggs were calculated for wire basket collection, molded fibreboard tray collection, conventional nest, and rollaway nest. The figures proved to be statistically non-significant. The regression lines are plotted in Figure 3 to show the trends encountered on the farms.

The trend toward increasing the percentage of cracked eggs with increasing age is shown in all the lines of Figure 3.

The trends indicated in the regression lines and considered with the actual farm combinations in Table II should be of interest and use to farm managers in budgeting the combination of equipment for a poultry farm. The type of equipment is a factor the poultryman can control. He has to accept the weaker shells of the birds as they go through their laying period. This problem may be overcome in the future through breeding and nutrition but it is a factor the poultryman must live with now. The trends in the study of actual farm conditions indicate that the manager can reduce the number of cracked eggs by adopting flat collection and rollaway nests.

Figure 3. Egg breakage as affected by collection factors



Summary

In this study the labor efficiency of egg collection was greater with belt (automatic) egg collection systems than with carrier egg collection systems.

With the average cage-belt collection system, the labor required per 1,000 hens per day to collect eggs was 14.05 minutes. On the most efficient 30% of the farms in this system the time required was 9.5 minutes.

With the average floor-belt collection system the labor required per 1,000 hens per day to collect eggs was 17.2 minutes. On the most efficient 30% of the farms in the system the time required was 12.3 minutes.

With the average cage-carrier collection system the labor required per 1,000 hens per day to collect eggs was 24.4 minutes. On the most efficient 30% of the farms in this group the time required was 21.0 minutes.

With the average floor-carrier collection system the time required per 1,000 hens per day to collect eggs was 23.4 minutes. On the most efficient 30% of the farms with this system the time required was 17.0 minutes.

Within the floor-carrier collection system with roll-away nests the time required per 1,000 hens per day to collect eggs was 19.95 minutes, while with conventional nests the time required was 24.84 minutes.

The difference in egg collection time between floor-belt collection systems and the cage-belt collection system was three minutes per 1,000 hens per day. This was the time required to collect the average number of floor eggs.

Floor egg collection time was determined more by the number of collections than by the percent of floor eggs. Indications are that more than two collections are uneconomical for the average number of floor eggs observed in this study, 5.6%.

Annual man hours saved by having cage-belt collection rather than a cage-carrier collection system was 63.27 man hours per 1,000 birds for the average farm and 69.96 man hours per 1,000 birds for the most efficient 30% of the farms in this study.

Annual man hours saved by having a floor-belt collecttion system rather than a floor-carrier collection system was 36.50 man hours for the average farm and 28.59 man hours for the most efficient 30% of the farms. There appeared to be no advantage on egg collection efficiency as flock size increased.

The three most important factors influencing the percent of cracked eggs under actual farm conditions were:

1) The type of container. Collection into molded fibreboard trays resulted in 1.1% cracked eggs and collection into wire baskets resulted in 3.8% cracked eggs.

2) The age of the bird. The percent of cracked eggs increased from 1.2% in the 6-9 month old group to 2.9% in the 16 month and older group.

3) The nest type. Rollaway nests resulted in 1.5% cracked eggs and conventional nests resulted in 2.5% cracked eggs.

Combinations of these factors increased or decreased the percentage of cracked eggs. The farm combination resulting in the smallest percent of cracked eggs was collecting the eggs into molded fibreboard trays from rollaway nests.

Bibliography

1. Agricultural Marketing Service, U.S.D.A. (1962) Statistcal Bulletin 306.

2. Earle, W. (1948) A Time and Travel Study of Poultry House Chores in New York. Cornell Farm Economics 165.

3. Davidson, J. A. (1950) Unpublished study of time to collect eggs on a Michigan poultry farm. Poultry Science Department, Michigan State University.

4. Snyder, L. H. (1960) The Relationships and Combinations of Poultry Equipment to Poultry Chores, unpublished thesis. Pennsylvania.

5. Bartlett, H.D. and H.R. Davis (1960) Progress and Problems in Handling Eggs Mechanically. Paper No. 60-312, ASAE Annual Meeting, June 12-15, 1960.

6. Jewett, L. J. Poultry Farm Chores, unpublished study, Dep't. Agr. Eco. University of Maine.

7. Gunderman, W.G. (1959) Progress Report - poultry automation operating study, Poultry Servicement's Clinic, Cornell University, December 9, 1959.

8. Miller, D. P., E. L. Dakan, and R. E. Cray (1951) Amount, Cause and Economic Importance of Cracked Eggs to Ohio Poultry Industry. Ohio Agricultural Research Bulletin 709.

9. Hauser, E. J. (1961) Egg Breakage Studies, Facts for

Handlers, University of California at Los Angeles, August 1962.

10. Romanoff, A. L. and A. J. Romanoff (1949) The Avian Egg, John Wiley & Sons Inc., New York.

11. Sturkie, P. D. 1954 Avian Physiology, Comstock Publishing Associates, Ithaca, New York.

12. Davies, O. L. (1958) Statistical Methods in Research and Production, 3rd Edition. Oliver & Boyd, London.

APPENDIX

Data on farm egg collection systems

Flock	Number Layers	% Production	Collection System	Minutes / 1000 hens	Minutes per case
A	8,764	56.0	Hand-carry	19.3	13.6
B	4,900	48.7	Floor-carrier	17.6	13.3
C	6,450	52.7	Floor-belt	22.7	15.5
D	13,000	51.8	Floor-carrier	25.0	17.2
E	5,964	61.3	Floor-carrier	26.9	15.6
F	4,800	66.6	Floor-belt	11.6	6.3
G	3,207	56.5	Floor-carrier	27.1	17.4
H	11,400	79.4	Floor-belt	14.3	6.5
I	6,560	60.7	Floor-belt	18.4	10.9
J	6,169	51.1	Floor-carrier	28.7	20.2
K	5,180	67.2	Floor-belt	13.5	7.2
L	13,852	63.0	Cage-belt	10.6	5.8
M	8,110	42.5	Floor-belt	13.0	11.0
N	9,600	62.8	Floor-belt	26.5	15.2
O	14,927	45.0	Cage-belt	22.0	14.3
P	9,070	54.0	Cage-carrier	25.5	17.0
Q	14,079	59.8	Cage-belt	9.5	5.7
R	6,042	75.3	Cage-carrier	29.3	14.0
S	5,800	62.0	Cage-carrier	22.0	12.7
T	6,077	73.0	Cage-carrier	22.3	13.2
U	-----	----	Floor-carrier	----	----
W	5,201	35.4	Floor-carrier	16.5	16.8

APPENDIX

Data on Egg Breakage

Flock	Age Mos.	Unit	No. of Pickups	Nest Type	Strain	Cracked Egg %
A	14	Basket	4	Conventional	Babcock	6.0
B	16	Basket	3	Rollaway	DeKalb	5.2
C	11	Basket	3	Rollaway	DeKalb	5.0
D	13	Flat	3	Conventional	Hyline	3.6
E	13	Flat	4	Conventional	H&N	3.0
F	9	Basket	2	Rollaway	H&N	1.7
G	14	Flat	2	Conventional	DeKalb	1.6
H	7	Flat	3	Rollaway	DeKalb	1.6
I	13	Flat	5	Rollaway	DeKalb	1.4
J	16	Flat	3	Conventional	H&N	1.4
K	7	Basket	3	Rollaway	DeKalb	1.2
L	12	Flat	4	Rollaway	Hyline	1.1
M	20	Flat	4	Rollaway	DeKalb	1.1
N	10	Flat	5	Rollaway	Hyline	1.0
O	13	Flat	6	Rollaway	Hyline	.8
P	8	Flat	3	Rollaway	Hyline	.5
Q	10	Flat	4	Rollaway	Hyline	.5
R	10	Flat	3	Rollaway	DeKalb	.2
S	6	Flat	3	Rollaway	Hyline	.2
T	9	Flat	3	Rollaway	DeKalb	.2
U	7	Flat	3	Conventional	H&N	.1
W	6	Basket	3	Conventional	DeKalb	---

Data on Floor Egg Observations

Flock	% of total egg gathering time	Time to collect floor eggs minutes & seconds/day	No. of collections	% of total eggs	Minutes /1,000 hens/day to collect floor eggs
A	5.6	9:45	3	8.20	1.27
C	33.6	37:04	3	----	5.65
D	15.0	21:45	3	----	2.00
E	28.7	36:05	3	12.00	5.85
F	12.0	5:55	1	.24	1.19
G	3.4	3:15	2	7.40	1.10
H	7.9	13:00	2	.46	1.14
I	18.6	19:06	5	7.30	2.90
J	40.0	51:40	6	6.60	8.30
K	47.8	33:55	3	17.74	6.55
M	5.6	5:52	1	2.60	1.24
N	1.0	3:02	1	.004	.31
U	4.3	5:00	1	.004	.96
Range	1-47.8	3-36	1-6	0 - 18	.3-83
Averages	17.2	18.7	2.4	5.6	3.0

Operator travel distance per 1,000 hens per collection

A	321'
B	260'
C	64'
D	145'
E	287'
F	34'
G	235'
H	44'
I	49'
J	195'
K	33'
L	54'
M	31'
N	48'
O	56'
P	457'
Q	54'
R	486'
S	555'
T	467'
U	123'
W	245'

Farm Survey Form

Farm________________________________ Number____________

Address____

Type of Collection____________________________________

Number of Hens________ Strain__________ % Production________

Age of Hens __________

Job Description	Travel	Time	Eggs

Egg candled______________ Totals ______________

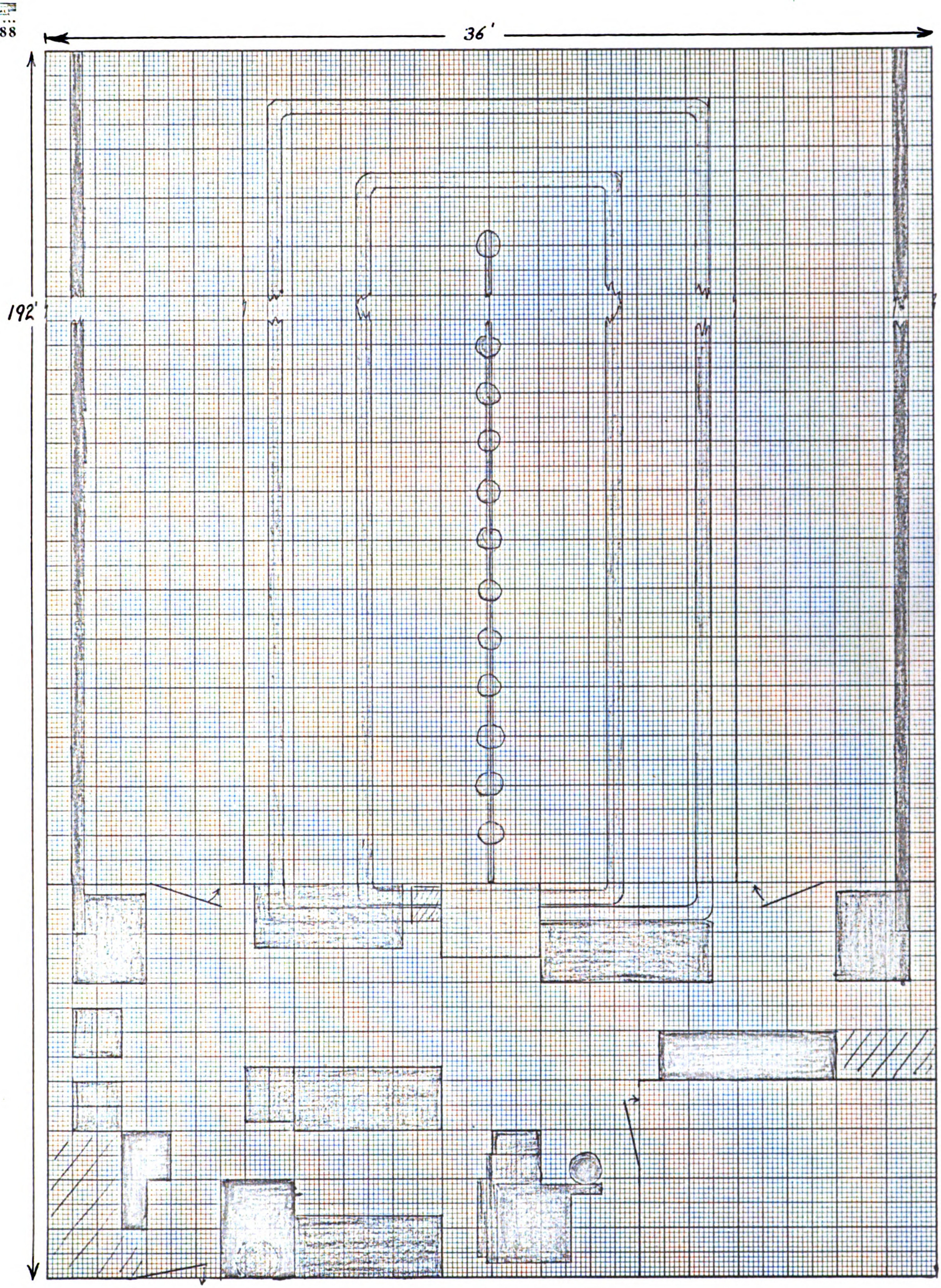
Number cracked___________ Number cases ______________

Percent cracked ___________ Minutes/case ______________

Minutes/1,000 hens _________

Notes:

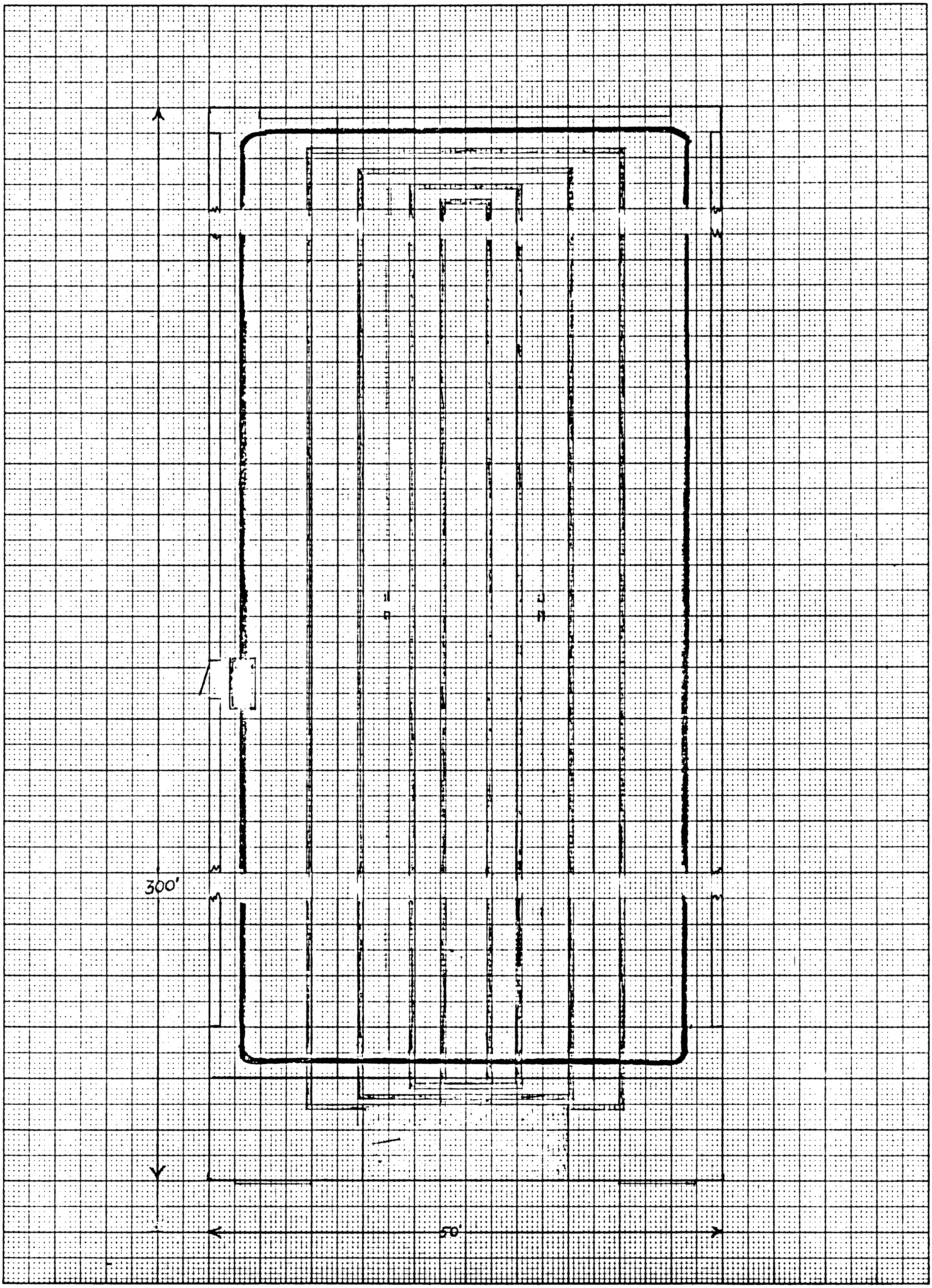
2-188



10 Millimeters to the Centimeter

C

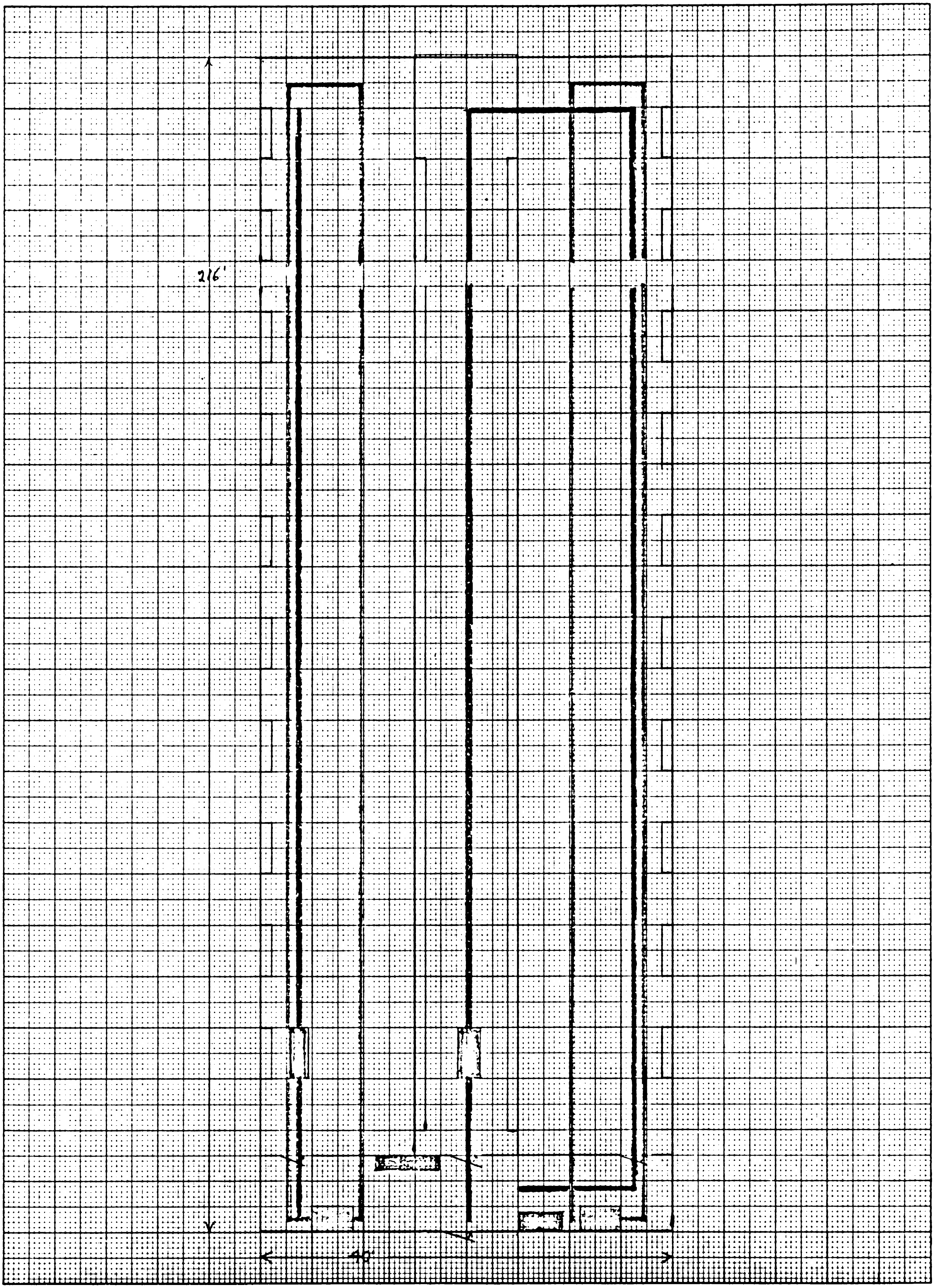
1 cm=2'



) Millimeters to the Centimeter

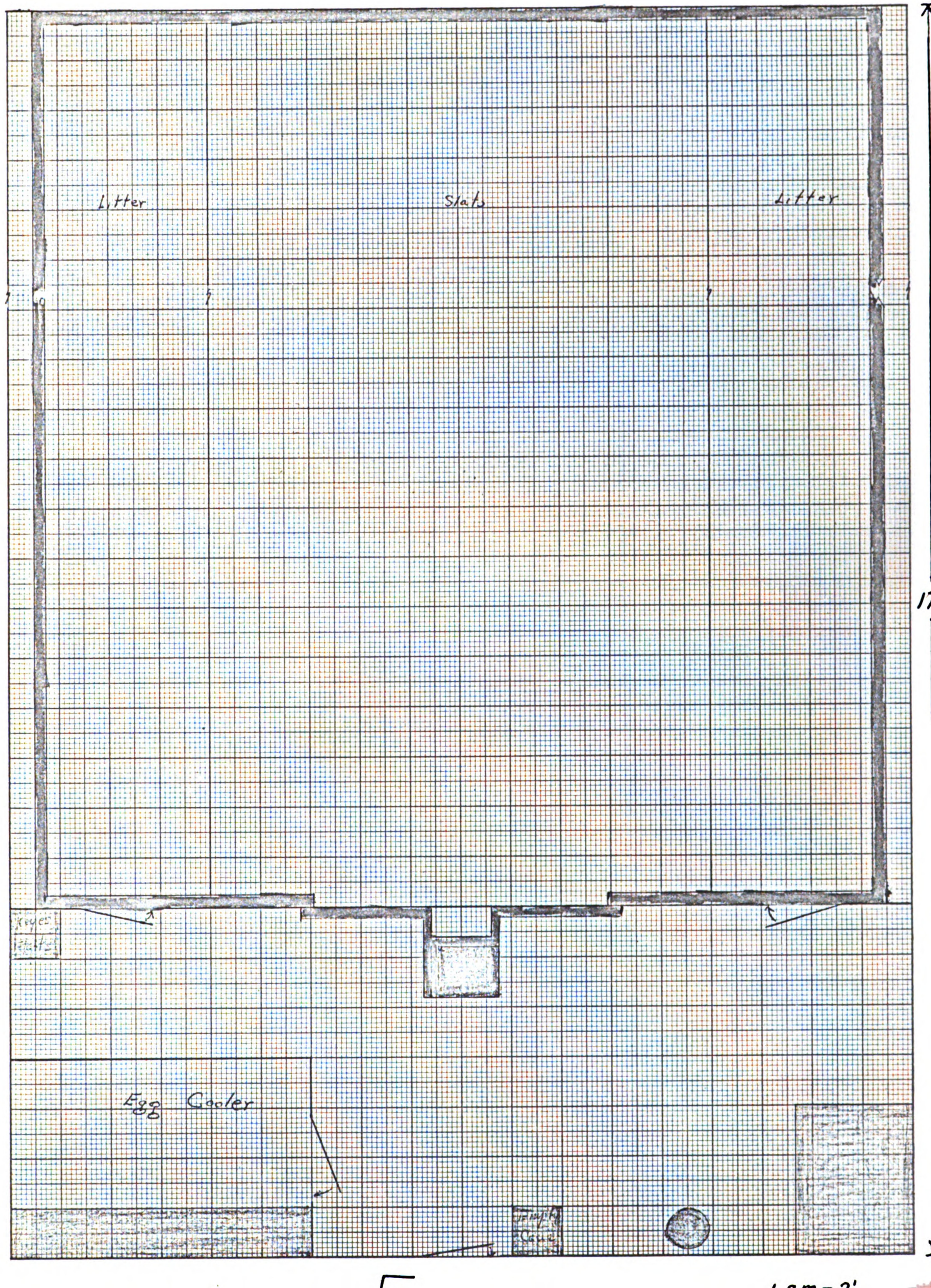
D

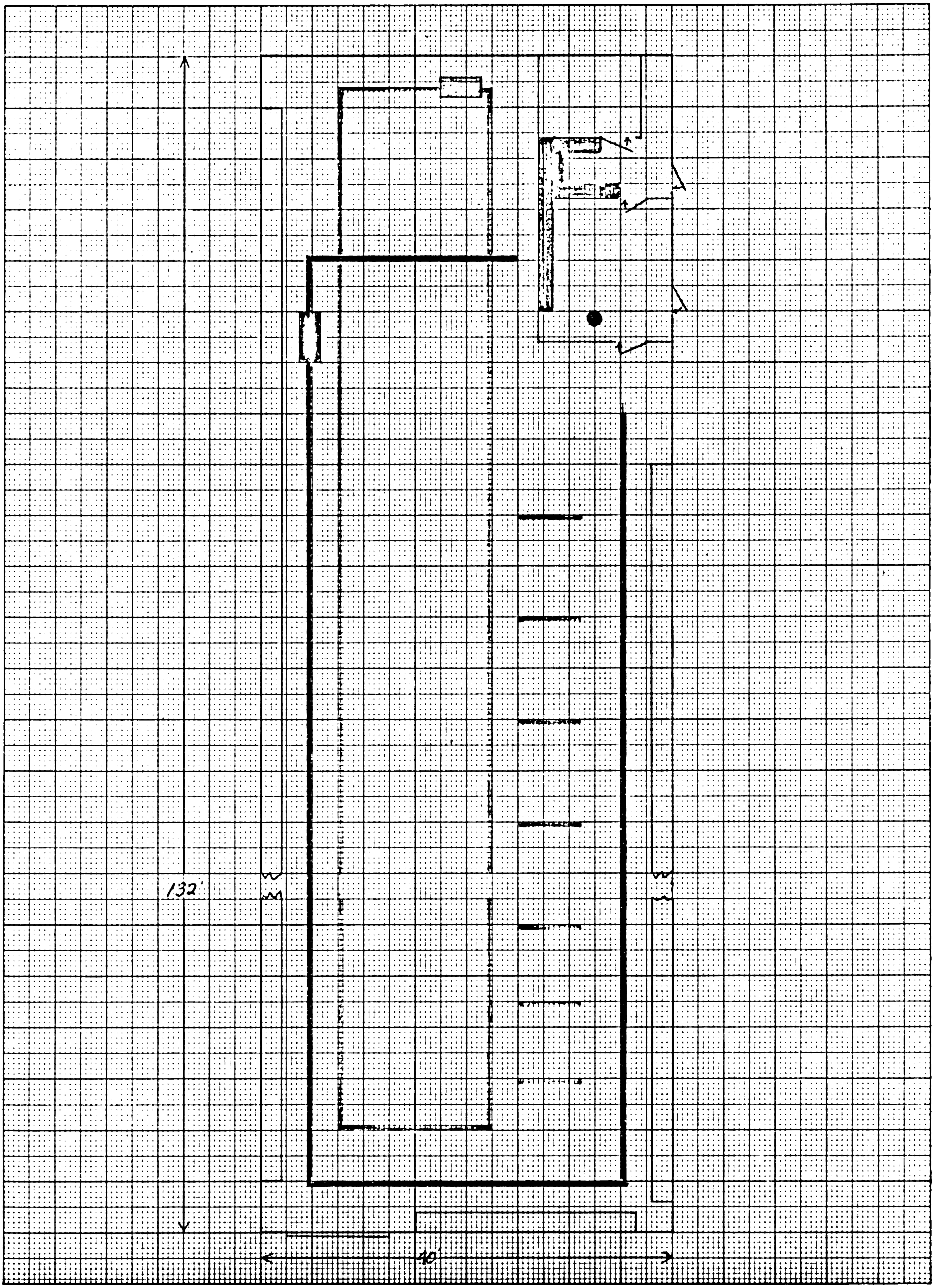
1 cm = 5'



F

1 cm = 5'

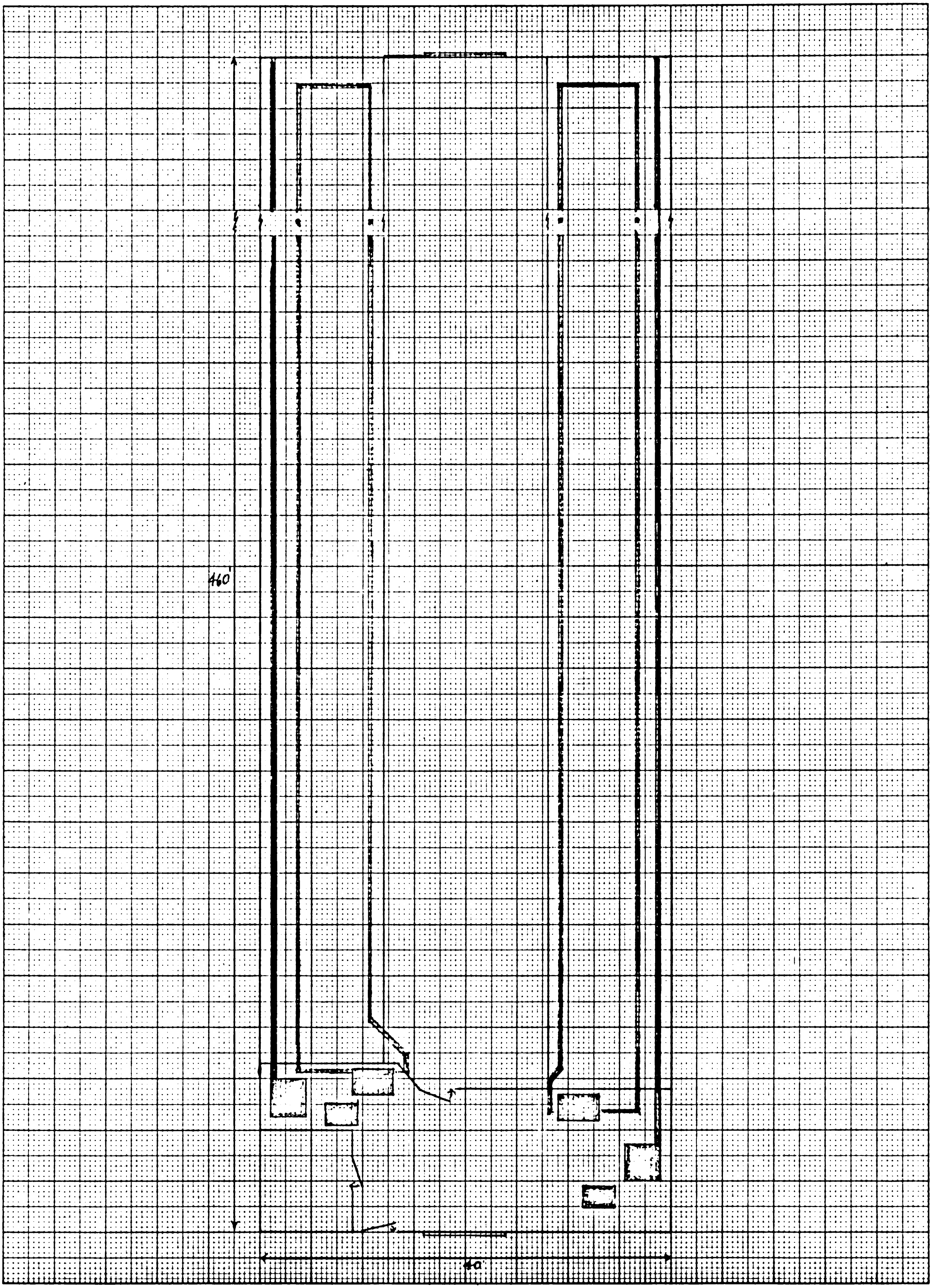

Litter
Slats
Litter
Egg Cooler



10 Millimeters to the Centimeter

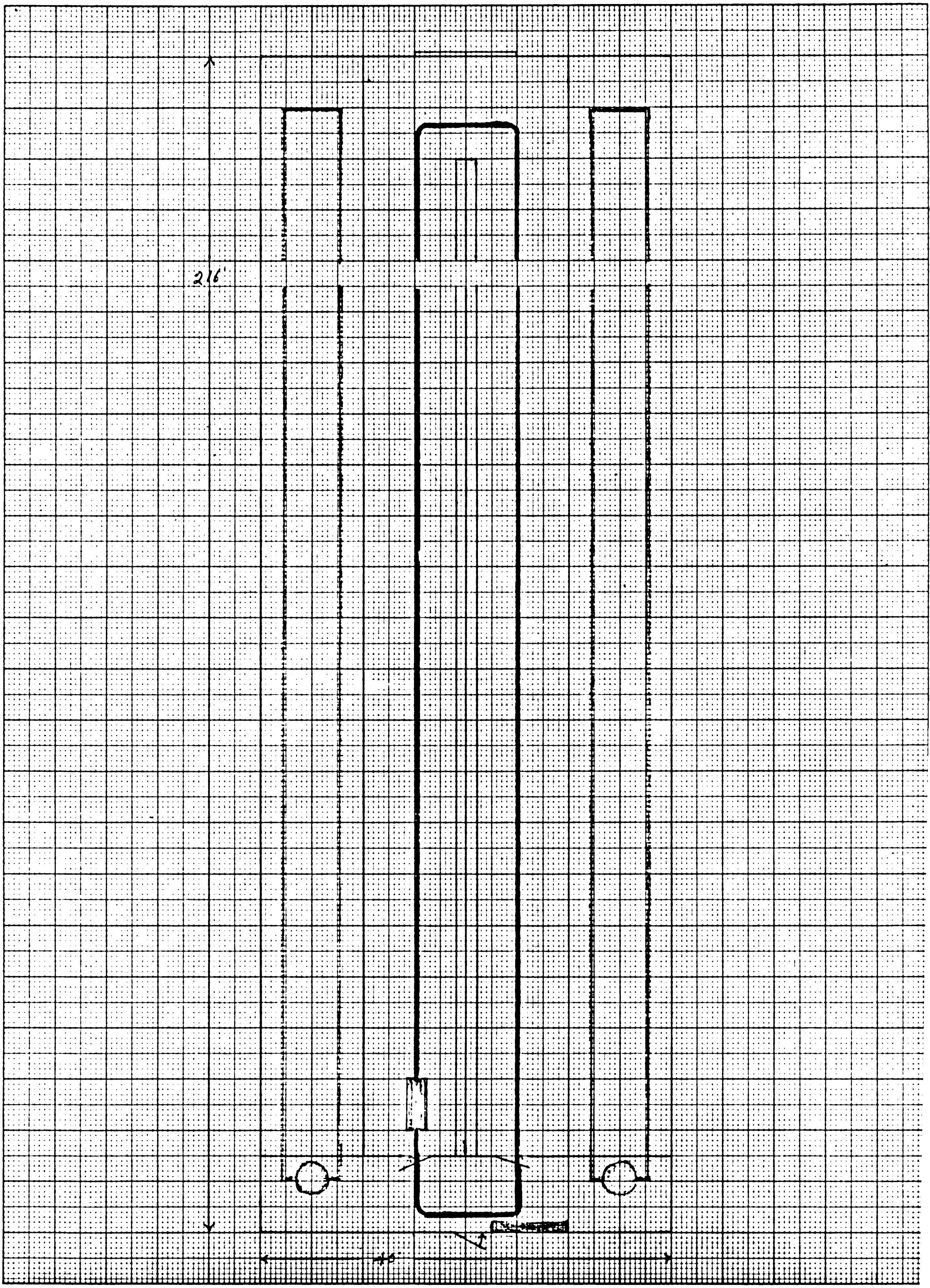
G

1 CM=5'

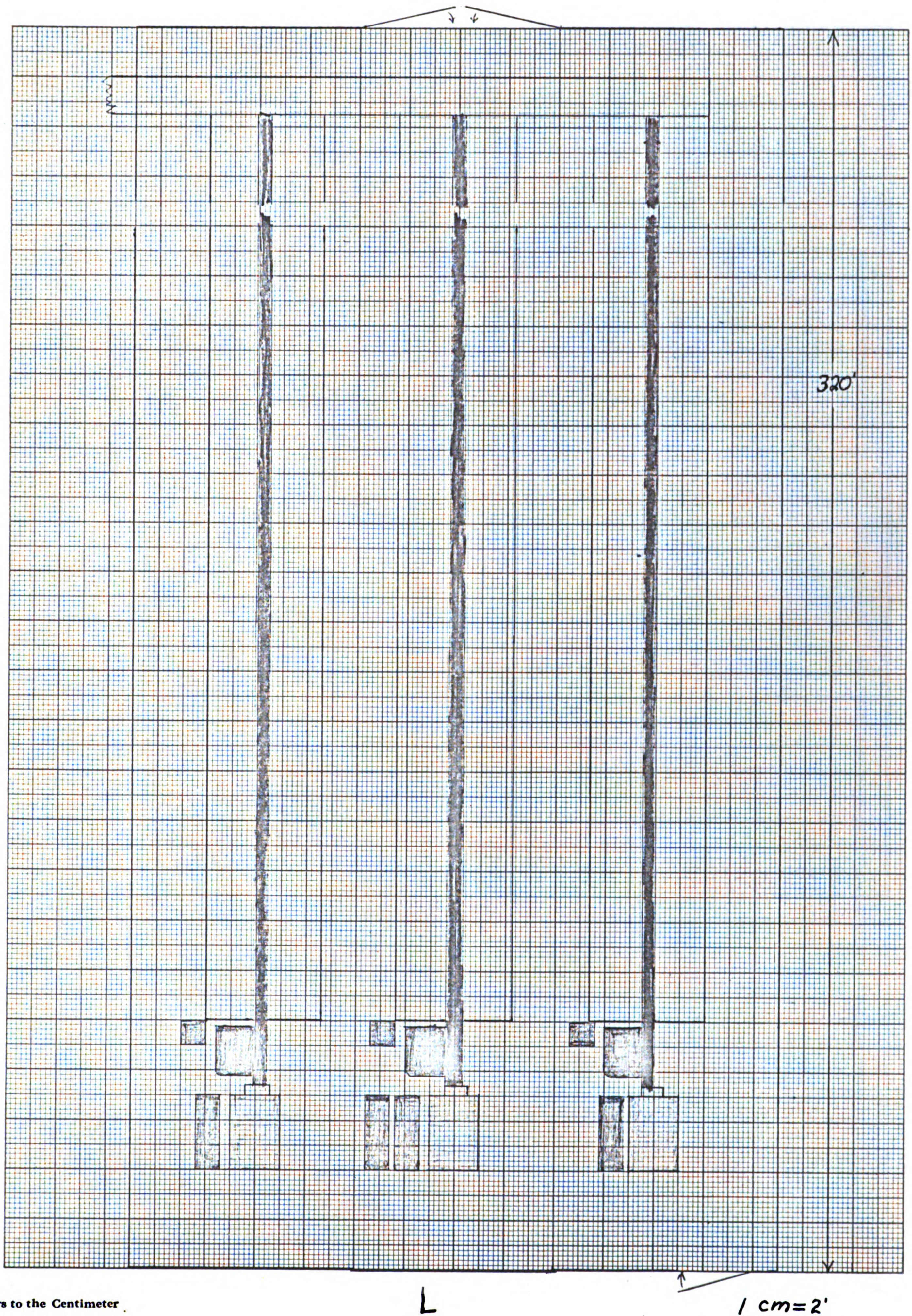


FARM H

1 cm=5'

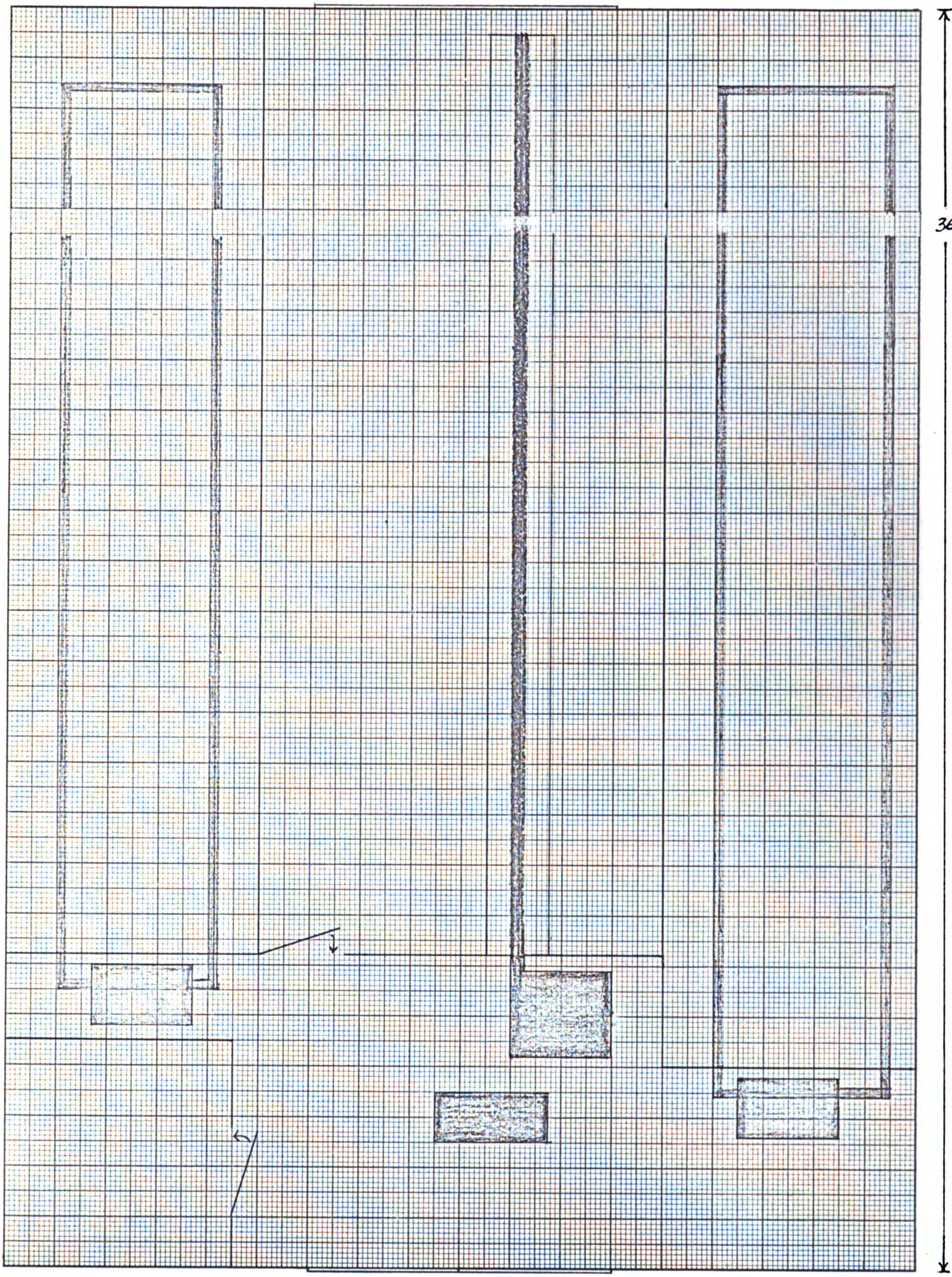


1 cm=5'



0 Millimeters to the Centimeter

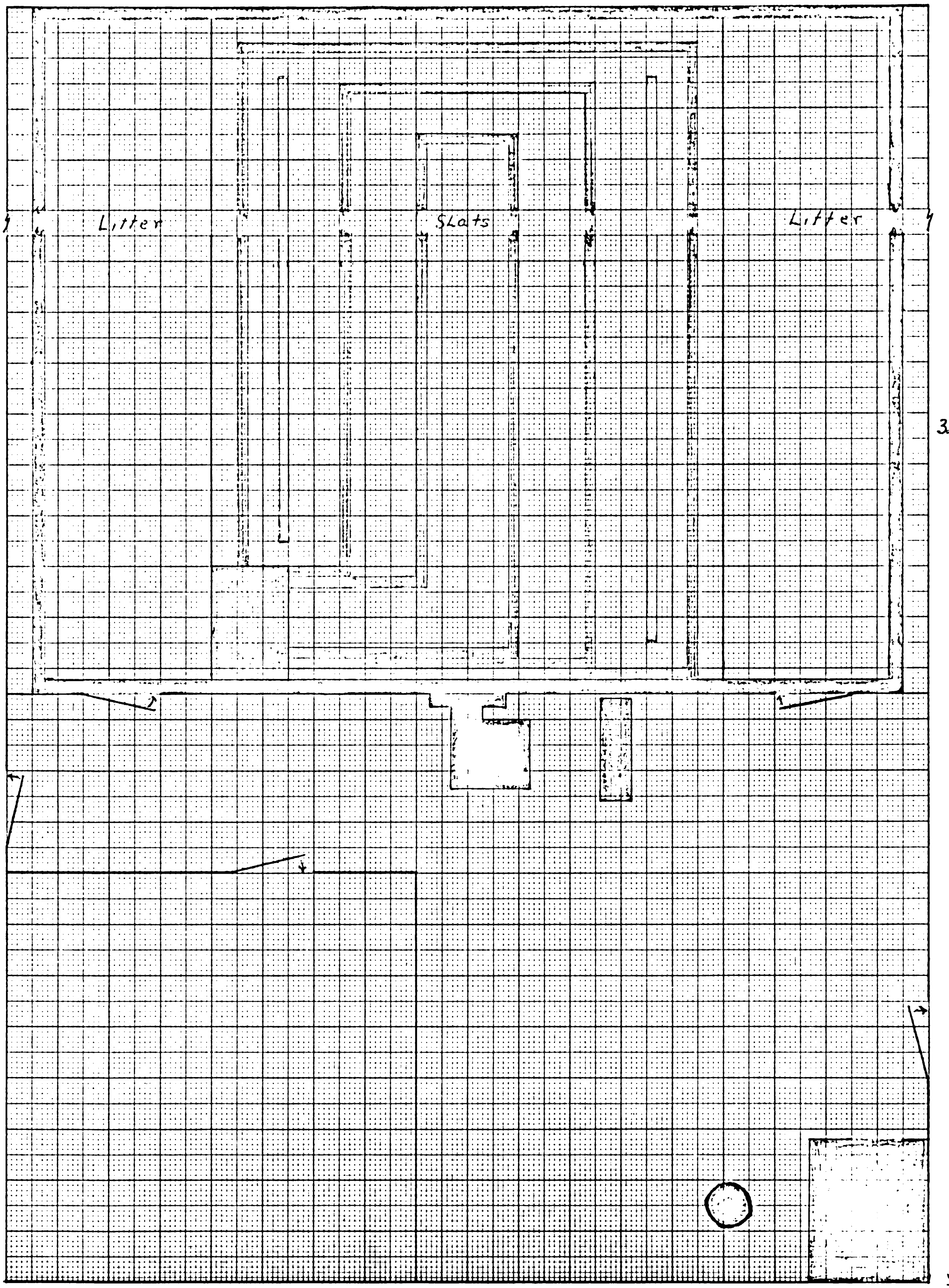
-188



Millimeters to the Centimeter

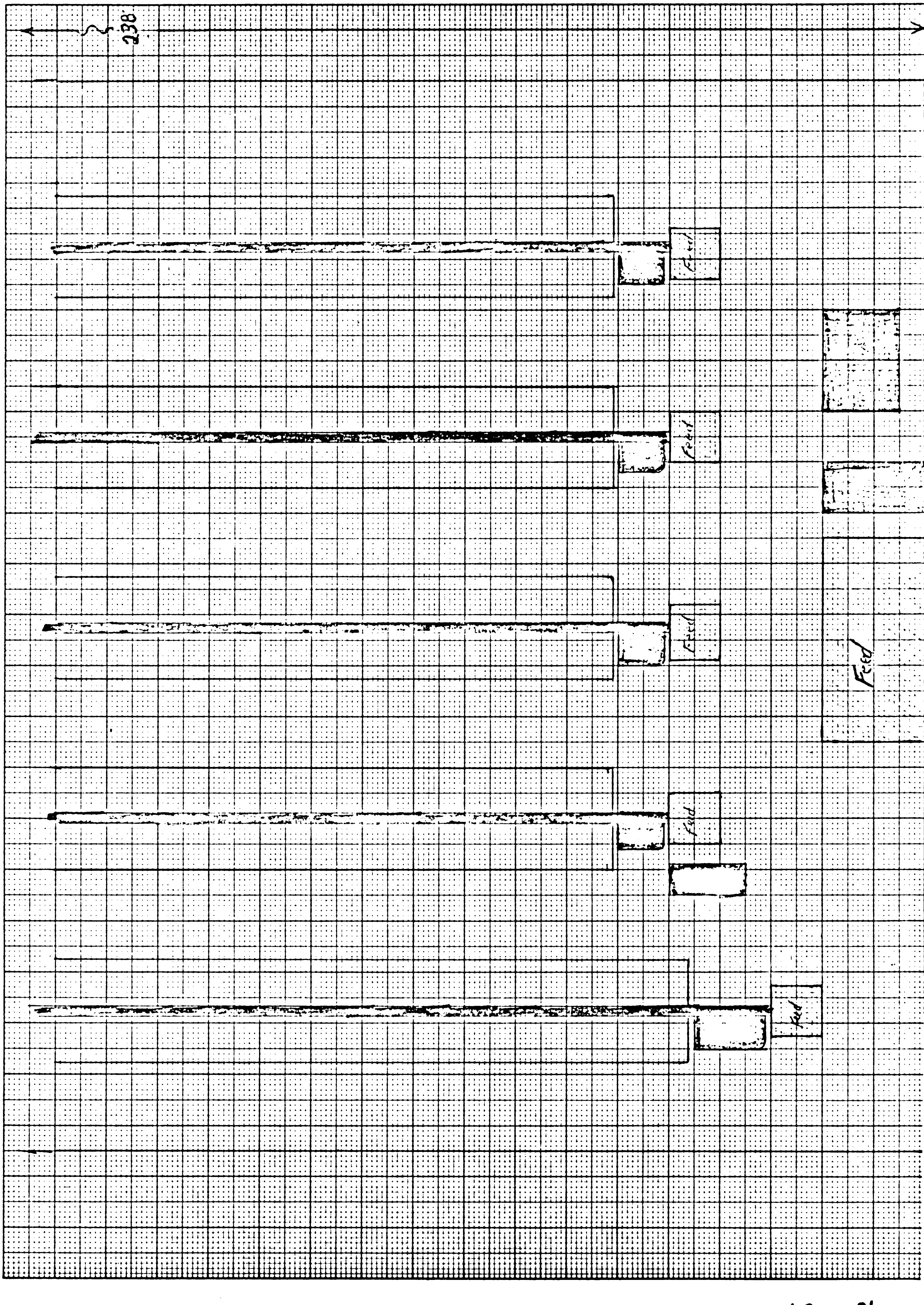
M

1 cm = 2'

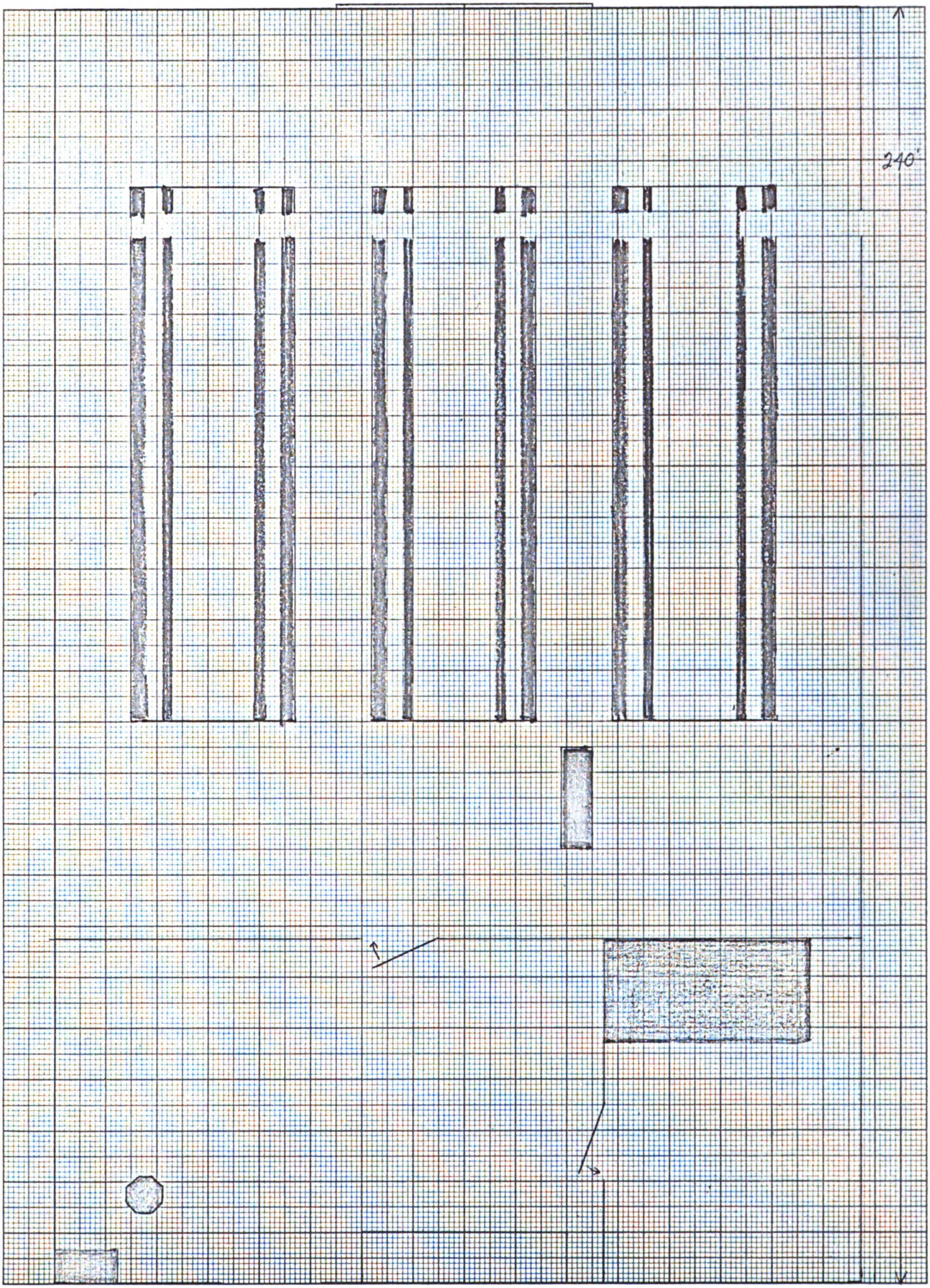


N

1 cm = 2'

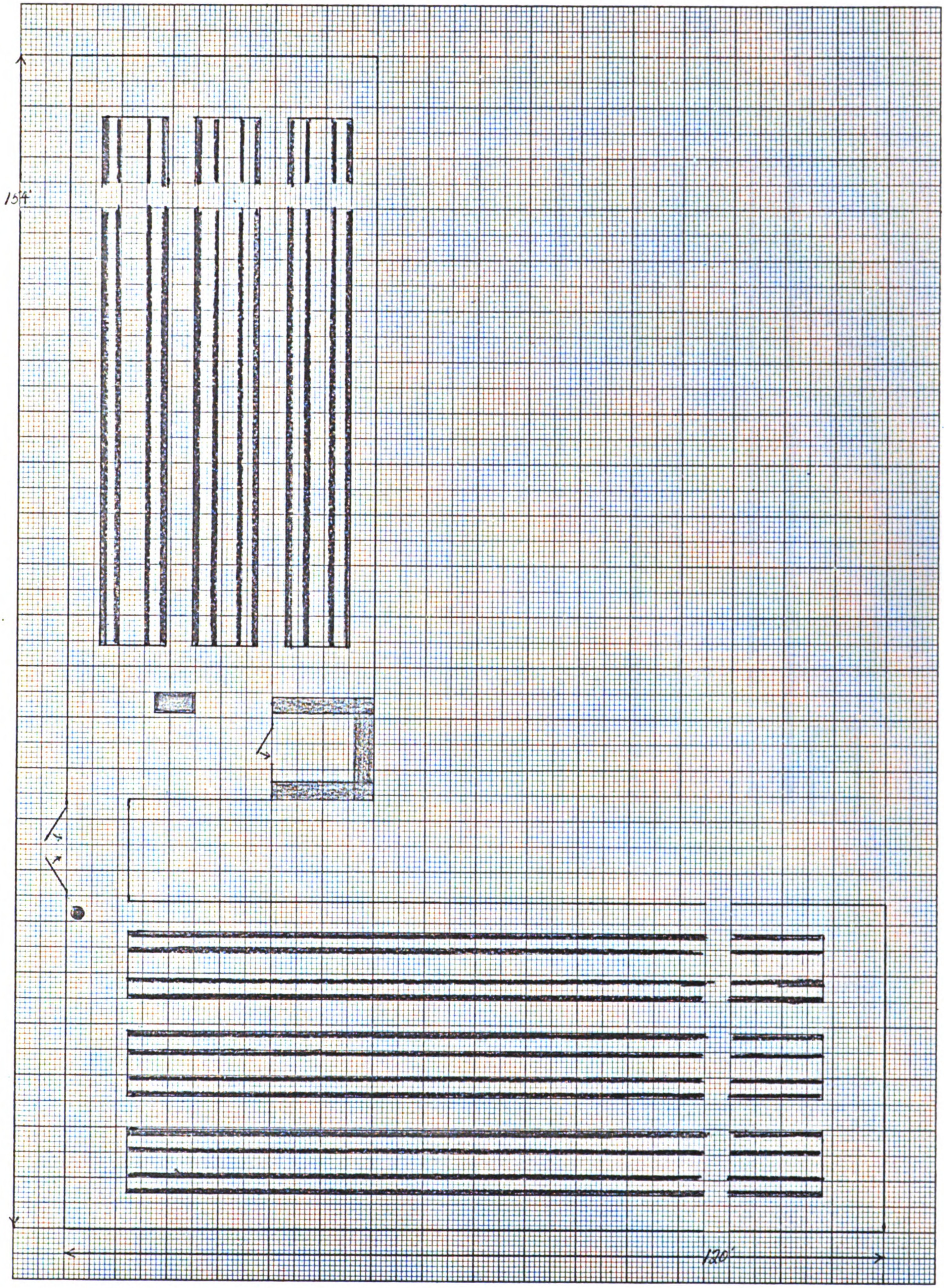


1 cm = 2'



B

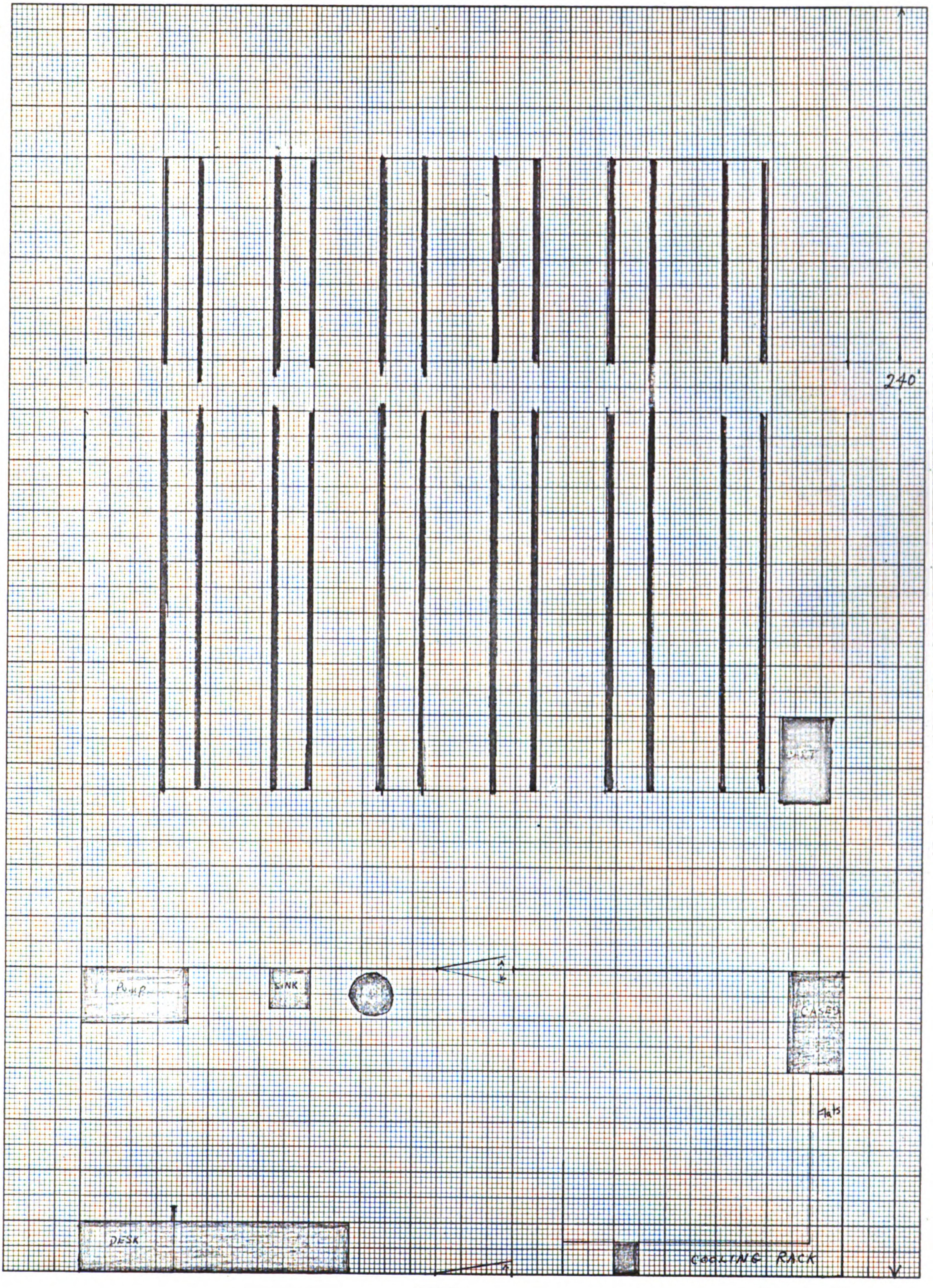
1 cm=2'



S

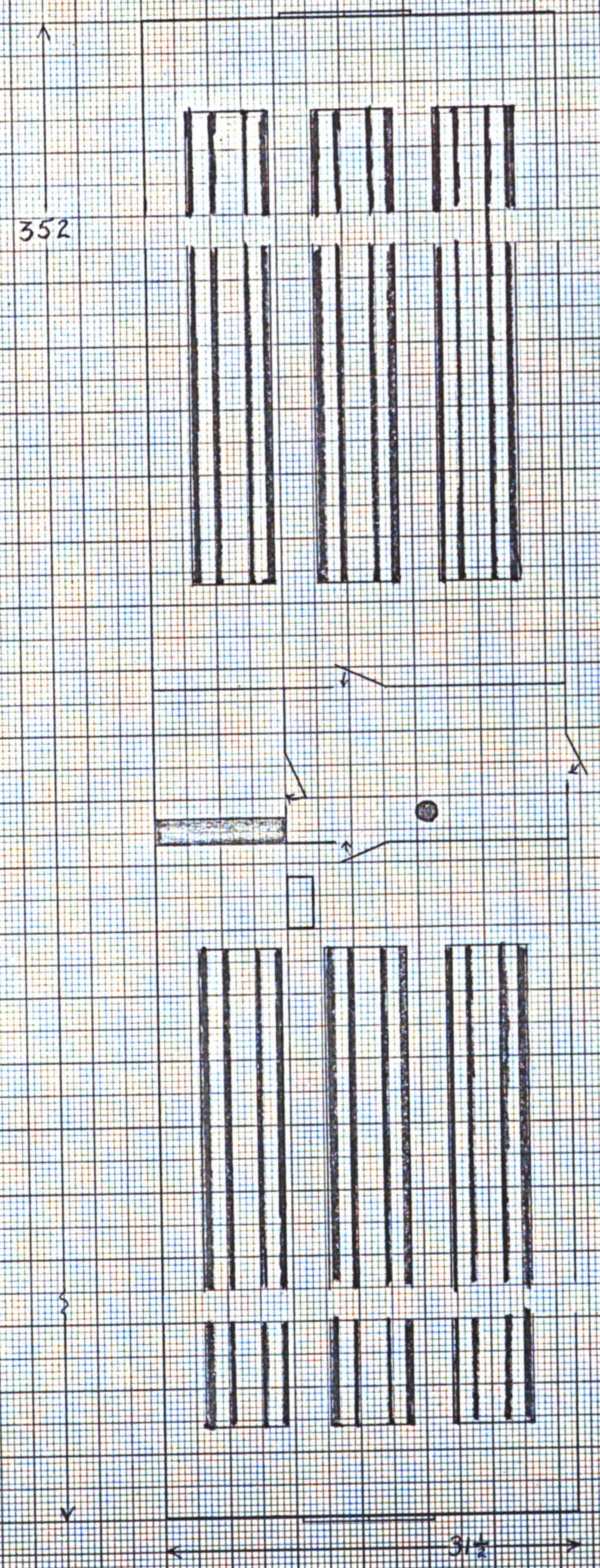
1 cm = 5'

2-188



10 Millimeters to the Centimeter

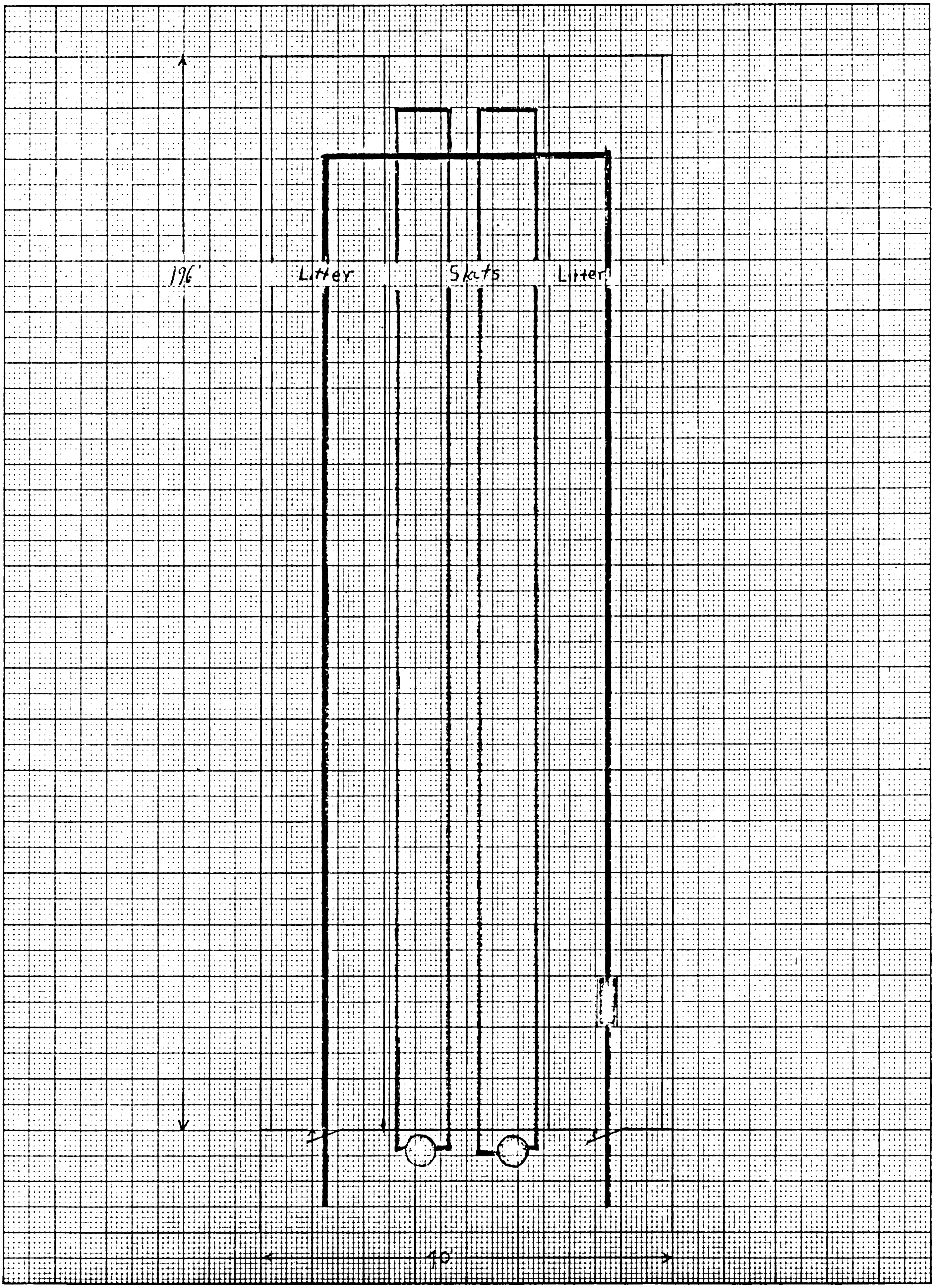
1 cm=2'



P

1 cm = 5'

2-188



10 Millimeters to the Centimeter

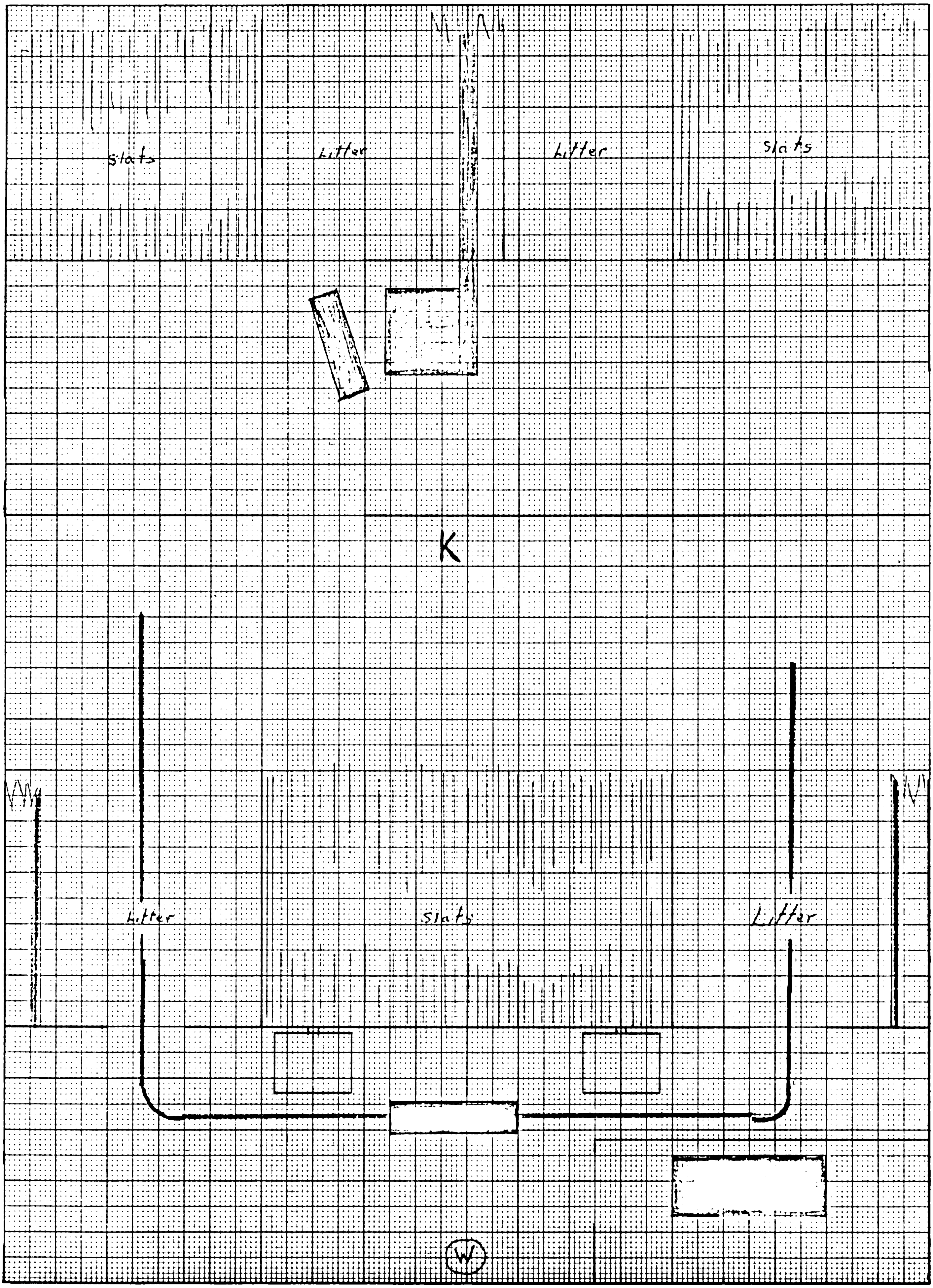
11

1 cm = 5'

2-188

se I

se II



ROOM USE ONLY