HIGHWAY RESEARCH BOARD

Special Report 8

Connecticut Highway Maintenance Production Study

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Special Report 8

Connecticut Highway Maintenance Production Study

Conducted Jointly by the
Connecticut State Highway Department
and the
Bureau of Public Roads, Department of Commerce

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Chief, Highway Cost Section,
Bureau of Public Roads

1952
Washington, D. C.

PREFACE

The report "The Connecticut State Highway Maintenance Production Study" meets one of the basic needs of the highway administrator for facts concerning the performance of the day-to-day maintenance functions. Field work on this pioneer study was completed in August 1951; preliminary drafts of the final report were made available in November 1951. Since this latter date meetings of Department headquarters and field supervisory maintenance personnel have been held concerning improvements of maintenance performance and practices growing out of detailed consideration of the report. By April 1952, through the authorization of Commissioner G. Albert Hill, several obvious improvement needs had been effected; others will require continued study and effort. In many instances there has been a general awareness in the maintenance organization of the need for such improvements. For the first time, however, the facts contained in the report show the magnitude of the problems involved; they also provide a basis for measuring and comparing the results obtained through different practices. This plan of continuous appraisal of field maintenance methods and practices is now (April 1952) established as a routine Department procedure and is one of the most valuable by-products of the study.

A. L. Donnelly,
Engineer of Roadway Maintenance
Connecticut State Highway Department

Hartford, Connecticut
April 4, 1952

PARTICIPANTS IN THE STUDY

This pioneer study of labor and equipment utilization and production rates on state highway maintenance work was a joint undertaking by the Connecticut State Highway Department and the Bureau of Public Roads. For a period of a year, starting in August 1950, detailed observations and time studies were made on typical operations involved in maintaining State highways in Connecticut. The excellent cooperation that existed among the various participants throughout all phases of the study attests to the high degree of interest in this field of basic research.

For the Connecticut State Highway Department, G. Albert Hill, commissioner, Roy E. Jorgensen, former deputy commissioner and chief engineer, A. Earl Wood, deputy commissioner, Warren M. Creamer, chief engineer, and Albert L. Donnelly, engineer of roadway maintenance, provided the incentive that made the study possible. Ellis H. Parker, assistant to engineer of roadway maintenance, handled the many arduous administrative details of the study, and Francis P. Hogan, personnel administrator, managed the difficult task of arranging and scheduling assignments of state personnel to the study. The cooperation of district 1 personnel, Edwin B. Burdick, district engineer, Wells W. Grotta, personnel officer, Roland L. Booth, engineer of maintenance, Howard Dickinson, engineer of maintenance operations, and John Blaney, buildings and equipment inspector, made possible the satisfactory conduct of the study. At the field study level, the excellent cooperation received from state personnel in the Warehouse Point maintenance area is worthy of special comment. James A. "Hockey" Murray, general foreman, was at all times most helpful, offering many observations, comments, and suggestions that were of aid in planning and conducting the field studies. William Malley furnished much information concerning daily operations and considerable data from labor and equipment records of the area. Leon Mullins, garage foreman, and Edward Burns, stock control supervisor, as well as foremen Dewey Rote, Leon Byrnes, Chelsey Parrish, Joseph Barnett, and Julius Stocinis were likewise most cooperative. A similar attitude of cooperation extended throughout the remainder of the organization, including the crew leaders, the equipment operators, and the laborers.

For the Bureau of Public Roads, the interest and cooperation of Leo Grossman, district engineer, and Roland A. Warren, district planning and programming engineer, contributed to the smooth functioning of the study. H. S. Fairbank, deputy commissioner, C. E. Swain, division engineer, and H. C. Headley, division construction and maintenance engineer, participated in original arrangements for conduct of the study.

The study was under the general direction of Fred B. Farrell, chief, highway cost section, Bureau of Public Roads. Morgan J. Kilpatrick, head production cost unit, Bureau of Public Roads, Ferrell M. Bozarth, production cost engineer, and Fred J. Verity, production cost engineer, cooperated extensively in summarizing and presenting the study data and in writing both the progress and the final reports.

Ray E. Pomeroy, Jr., production cost engineer, Bureau of Public Roads, was resident engineer in charge of the study and directed the actual field work.

For the Connecticut State Highway Department, John J. Olshesky was the administrative engineer in charge of the staff of highway department engineers working with the field engineering staff of the Bureau of Public Roads on all phases of the study.

Following is a list of personnel engaged in the studies in the Warehouse Point area for a week or longer during the study period:

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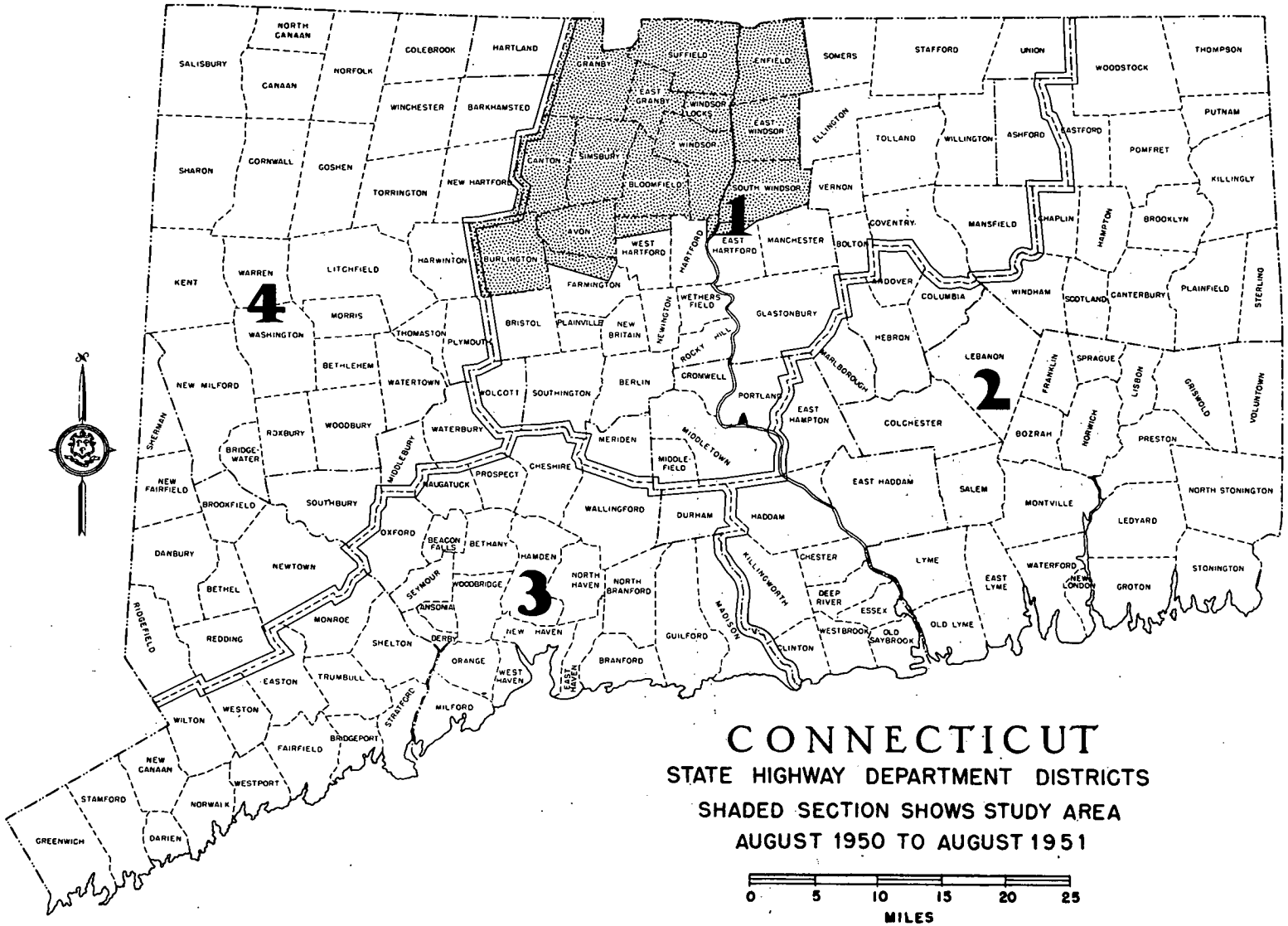
2/ In charge of automatic time recorders
3/ Assistant Supervisor, June 1951-August 1951

Special acknowledgement is made of the thorough detailed technical and editorial review made of the preliminary draft of this report by a general committee composed of the following Connecticut Highway Department personnel:

Albert L. Donnelly, engineer of roadway maintenance
John L. Wright, engineer of roadside development
Edwin B. Burdick, district engineer
Walter T. Schuler, district engineer
Elwood T. Nettleton, district engineer
Edward S. Lawler, district engineer
Roland L. Booth, division engineer of maintenance
Godfrey Pawlikowski, division engineer of maintenance
Louis F. Pike, division engineer of maintenance
Elmer J. Morgan, division engineer of maintenance
Howard E. Dickinson, local operations engineer of maintenance

In addition, many Bureau of Public Roads and other Connecticut Highway Department representatives reviewed specific material and certain phases of the report. A special review committee consolidated and coordinated all comments arising from the reviews. This committee consisted of:

Ellis H. Parker, senior highway Engineer, Connecticut Highway Dept.
William C. Greene, landscape engineer, Connecticut Highway Dept.
John J. Olshesky, junior highway engineer, Connecticut Highway Dept.
Fred J. Verity, production cost engineer, Bureau of Public Roads.



CONNECTICUT

STATE HIGHWAY DEPARTMENT DISTRICTS

SHADED SECTION SHOWS STUDY AREA

AUGUST 1950 TO AUGUST 1951

0 5 10 15 20 25

MILES

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Connecticut Highway Maintenance Production Study

INTRODUCTION

The following report contains the summarized results of a one-year study of maintenance work on 262 miles of state highway in a maintenance area north of Hartford, Connecticut. The objective of this pioneer study is to develop basic facts concerning time utilization and production rates on maintenance operations that have not heretofore been available.

This objective has been achieved. However, it is only one part of the total endeavor involved in developing more efficient and effective patterns of maintenance. Appraisal and interpretation of the study data must next be undertaken in the light of known conditions in the study area and the vast accumulated experience of those concerned with the day-to-day maintenance effort.

The report, in itself, does not tell what is right or what is wrong with any maintenance operation, as observed. It does, however, present certain facts which are necessary for such determinations, and provides the nucleus for a gradually expanding body of facts from which can be developed criteria for maintenance needs, standards of maintenance, and effectiveness of performance.

PURPOSE OF THE STUDY

The purpose of the study was to obtain basic data on maintenance operations with particular emphasis on time utilization and production rates of labor and equipment. Such data are one portion of the total body of needed factual information that has not hitherto been available from any other source.

Interpretation and application of the results are dependent upon many other factors not studied or evaluated as part of this project. The data contained herein do, however, reveal the nature and magnitude of many items which affect productive effort on maintenance work and when interpreted in the light of experience and conditions known to exist, will point directly to certain corrective measures or adjustments that can be undertaken to advantage.

In addition, the further development and extension of the groundwork encompassed by this study can lead to the establishment of units of work and standards of maintenance accomplishment, thus making possible the estimation of labor and equipment requirements to perform the maintenance obligation in a particular area under certain given conditions.

Progress made in this direction will yield many benefits, not the least of which will be the availability of more adequate supporting evidence (a) to accompany the preparation of the maintenance budget, (b) to substantiate requests for meeting needs, and (c) to facilitate overall management of the maintenance effort.

GENERAL

Maintenance is an ever-present problem in the administration of the highway program. It demands continuous attention, day-in and day-out, year-in and year-out. It cannot be suspended indefinitely, nor can it be managed with much degree of success if subjected to haphazard planning or to vague and indecisive policy. Because maintenance work on Connecticut's principal highways and their urban extensions is performed by and under the control of state highway department personnel, any inefficiencies or lack of accomplishment can quickly place the department in a highly assailable position.

The highway administrator is confronted with the task of providing adequate maintenance on the one hand and with the problem of keeping expenditures to a minimum on the other. He needs facts, therefore, concerning routine maintenance procedures and accomplishments, of a kind that will enable sound decisions to be made. But there are great voids in the body of facts so needed, and the administrator has, on frequent occasion, had to make arbitrary decision on matters relating to maintenance requirements.

Errors in making these decisions are expensive. If the maintenance effort is reduced too much, there is the prospect of serious impairment of the highway plant coupled with unpopular reductions in services to traffic; if the maintenance activity is increased beyond justifiable levels, there is the prospect of waste and inefficiency.

A common cycle in the administration of the maintenance program involves alternate periods of build-up and cut-back. Many factors contribute to the perpetuation of this cycle, and it is not always the same ones that bring this about. From 1942 to 1945, for example, there was a period of cut-back caused by war-time restrictions and shortages of labor, equipment and materials. The maintenance program was below minimum needs and the structural integrity of the highway plant was in jeopardy. Following the war came the period of build-up. At that time, there was launched a program of maintenance designed (1) to overcome the backlog of maintenance deficiencies and (2) to meet the rising demand for increased maintenance needs being occasioned by surging increases in motor vehicle travel.

The foregoing pattern of build-up was one experienced in practically all states; but by 1949, the cut-back period was again in prospect in many states, including Connecticut. Proper administration dictated that an appraisal should be made of the degree to which current maintenance needs were being met, and of what steps should be taken in the interest of insuring maximum economy and efficiency of operation. The facts available upon which to base decisions on this matter were meager or lacking. In their absence, a policy of attrition was employed. In Connecticut this was accomplished by placing arbitrary limitations on employment and filling of vacancies.

while such a policy was distasteful to administrative officials, it nevertheless represented one means whereby some control could be exercised over many of those demands by the field maintenance forces which occasionally appeared to lack sufficient justification.

This policy in Connecticut soon gave evidence of dreating as many problems as it solved, the most serious of which was the real danger of curtailing certain essential maintenance activities. Accordingly, in 1949 the top administrative personnel of the Connecticut State Highway Department began to look for ways and means whereby the maintenance situation could be appraised factually. It became apparent however, that the problem was of such magnitude and complexity that a total comprehensive appraisal of maintenance could best be undertaken by means of a series of special studies on specific phases.

One of these phases involved determination of time utilization and production rates of labor and equipment on all types of maintenance operations. In connection with this particular objective, a joint cooperative arrangement was worked out early in 1950 between the Connecticut State Highway Department and the Bureau of Public Roads for a one year study of maintenance operations on a representative portion of the state highway system. In general, the former agreed to furnish personnel, office space, equipment and supplies; the latter agreed to furnish technical guidance and direction in addition to furnishing a limited number of personnel. The Bureau of Public Roads also agreed to supervise preparation of the final reports as well as progress reports during the course of the study.

Pilot field studies were started in June, 1950, and after two months of training personnel in time study procedures, determining study techniques, designing forms, and awaiting equipment delivery, the Connecticut State Highway Maintenance Production Study operated for the 52-week period from August 14, 1950, to August 12, 1951.

MAINTENANCE ORGANIZATION IN CONNECTICUT HIGHWAY DEPARTMENT

The highway commissioner administers the maintenance functions of the Connecticut Highway Department. To assist him in the performance of his duties relative to maintenance, he has a deputy highway commissioner, chief engineer, engineer of roadway maintenance, engineer of roadside development, engineer of bridges, engineer of traffic, and engineer of highway control. In the execution of the maintenance operations, this staff recommends policies, procedures and programs of work to be followed, maintains uniformity of practice throughout the state and acts as consultants to the four districts as required.

Under the general direction of the highway commissioner or one of his staff acting as his agent, each district engineer heading up one of the four operating districts is responsible for the direction and supervision of field engineering, construction and all highway, bridge and structure maintenance in his district. The district engineer has under his direction a division engineer of maintenance. The division engineer of maintenance is responsible for planning and supervising all maintenance activities in a district under a program and policy set forth by the highway commissioner. Each of the four districts is divided, for maintenance purposes, into three areas. Each of these areas, in turn, has a general foreman and is the smallest integral unit under single supervisory control in the maintenance organization. One such area, north of Hartford, was selected as reasonably typical for purposes of study.

The maintenance organization in Connecticut is staffed and equipped to take care of year-round normal maintenance with provisions for supplementing the regular force during the peak needs of winter snow and ice control and summer landscape work. Contractor owned and operated equipment supplement the state forces to meet the peak needs for snow and ice control. Minor highway improvements in stabilizing and modernizing roads, such as additional surface and sub-surface drainage, pavement cross-section work, sight line corrections, short sections of pavement replacement or resurfacing, and landscaping development, and other work of a light construction nature can also be accomplished in addition to routine maintenance during many months of the year. This construction work of a minor nature is programmed and covered by work orders requested by the division engineer of maintenance. During the fiscal year 1950-1951, work order assignment in Connecticut accounted for approximately 20 percent of the total maintenance expenditure. Occasionally, certain classes of work are let to contract and paid for out of maintenance funds when the regular state's forces have too great a workload or when the work is of a specialized nature. On a statewide basis, about 2 percent of the total maintenance expenditures for the fiscal year 1951 was by contract and in the study area covered such items as tree removal, guide rail replacement, major bridge repairs including replacement of pier fenders, storm sewer construction, and hot plant-mix re-surfacing.

The scheduling of routine maintenance is a day-to-day function of the general foreman. Weather and other conditions make it difficult to plan very far ahead. Inspection of the highways, which forms a basis for maintenance planning, is done insofar as possible during travel in connection with other duties and is simply a matter of keeping alert to conditions which

require attention. Each foreman is required to inspect the roads in his area weekly and the general foreman covers the area on a bi-weekly basis. Reports of emergency conditions are frequently telephoned in by property owners and the police. Prior to starting work each morning, each foreman checks in with the general foreman either in person or by telephone for final assignment of the day's work. At this time, any last minute re-scheduling of operations or shifting of personnel or equipment is done. All communication is by telephone or by personal contact.

EMPLOYMENT TRENDS AND PERSONNEL POLICIES

Over the past 14 years, the average number of hourly paid maintenanc personnel on the state-wide payroll has been 1,375. It has ranged from an average of 1,450 in the four pre-war years, 1938 to 1941, to 1,150 during the war years. It then recovered steadily to an average of better than 1,55 during 1948 and 1949. Over the past two years, employment has been somewhat reduced, averaging 1,465 in 1950 and 1,430 for the first seven months of 195

These figures include bridge, roadway, roadside crews, and garage mechanics but do not include foremen or other salaried employees. The numbe of permanent hourly paid employees is slightly higher than in pre-war years. Seasonal variation in employment averages about 10 percent at the present time, which is about one-half of the pre-war variation.

All maintenance personnel are under the Merit System and receive benefits in the form of annual leave, sick leave and retirement. Advancement in the organization is from within. Most equipment operators, crew leaders, foremen and general foremen have been promoted from truck drivers or laborers. Promotion in the higher grades is by examination while promotion in the lower grades is based on demonstrated ability and the foreman's recommendation. No man can be paid for work at a rate higher than that set for his classification, therefore as soon as he has demonstrated his ability to perform work of a higher skill, and the department has need of this skill, he is promoted to a dual classification.

When he works at the higher classification 75 per-cent or more of his time, for a calendar year, he is advanced to the higher classification. If he works more than 50 per-cent of his time but less than 75 per-cent of his time at the higher class, his work assignments are studied, and if in the opinion of his foreman he will be called upon in the following year to perform work at the higher skill for 75 per-cent of his time, he is recommended for reclassification.

The general foreman and the foremen are salaried employees, whereas the highway maintainers are paid at an hourly rate. There are four grades of maintainers for which the hourly pay rates are shown in Table 1. Time and one-half is paid for overtime. The salaried supervisory personnel received 20 percent additional pay during the period from November 15 to April 1 to compensate for overtime activities throughout the year.

Table 1. Hourly pay rates for maintenance personnel

Grade	Starting rate for new help	Rate after ½ year	Rate after 1 year	Rate for promoted personnel starting after ½ year		Description
I	$ 1.03	$ 1.10	$ 1.16			Laborers
II	1.11	1.16	1.21	$ 1.19	$ 1.21	Truck drivers
III	1.17	1.22	1.28	1.24	1.28	Equip. operators
IV	1.22	1.30	1.39	1.34	1.39	Crew leaders and highly skilled men

The maintenance forces worked a 9-hour day and a 5-day week but were subject to call in emergencies. The work day started at the garage at 7:00 AM and ended at the garage at 4:30 PM. At the start of this study, a 9½-hour day (47.5-hour week) was standard for the maintenance forces but a 9-hour day (45-hour week) was started on September 25, 1950. Maintenance personnel, both hourly rate and salaried, earn 15 days leave per year which must be taken so as not to interfere with snow and ice control. All maintenance personnel also earn 15 days sick leave per year with an allowable accumulation to a total of 90 days.

Safety is a paramount consideration in maintenance operations where workmen are exposed to the danger of fast moving vehicles. In the interests of promoting safety, special meetings are held about three times a year at which all foremen, crew leaders, operators and drivers are present. Safe practices are discussed at these meetings which are called and presided over by a representative from the safety engineer's office. Accident prevention policies on all maintenance operations are included in the "Handbook of Safe Practices," which is issued to each employee.

A few of these safe practices which are strictly adhered to and which had certain effect upon the studies are as follows:

1. No riders are allowed on outside of trucks.

2. A man must direct each truck backing up.

3. Except under extraordinary circumstances, all work must be done in right-hand lane in direction of travel.

4. On surface work where the men are working in the traffic lane, a flagman is required to direct traffic past the constriction thus formed.

5. "Men Working" and other warning signs must be placed before starting work, moved ahead as work progresses, and picked up at the end of the day. The effectiveness of the signs depends on the distance at which they are from the work underway. A sign should be at least stopping distance ahead of

the working crew and visible and discernible for a considerable distance beyond that. If signs are too far ahead of the crew, then highway traffic tends to speed up after a cautious quarter-mile and the effect of the signs is minimized. This necessitates frequent moving of signs on a fast moving operation. On dual highways when traffic is channeled into one lane, a series of adequate warning signs placed well in advance is definitely essential so as to guide traffic gradually around the work.

Compensation was paid for lost time resulting from job-related accidents if over a week was lost. Half-time was paid for all work days beginning with the eighth day and continuing until the injured employee returned to work. If the lost time extended beyond the fourteenth day, half-time was also paid for the first week, making the compensation retroactive to the day of the accident. Compensation and medical payments are administered by the office of the attorney general and come from the highway department fund as a self-insured organization. Compensation payments do not appear as a cost of maintenance.

EQUIPMENT ASSIGNMENT AND RENTAL PRACTICES

Connecticut has an investment of nearly $3,000,000, current value, in its maintenance equipment. This equipment is owned by the State Highway Department and is in custody of the Division of Property Control of the Bureau of Business Administration. Each general foreman has a permanently assigned complement of equipment consisting of trucks, other major units, and auxiliary equipment. Certain specialized units such as striping machines, mudjacks, seeding and mulching machines, etc., for which there is only occasional short time use in any one area, are operated on a state-wide basis. Under certain peak loads or emergency conditions, permanently assigned equipment in one general foreman's area may be made available temporarily to another area.

Within each district there are several repair garages, supervised by an equipment engineer and operated by garage foremen and a staff of mechanics. In conjunction with each garage, the Division of Purchases and Stores keeps a supply of spare parts, hand tools, supplies, and materials and keeps a record of all stockpiles of materials elsewhere in the area.

The driver of a truck is responsible for reporting any needed repairs and for seeing that it gets regular maintenance. Crew leaders and equipment operators are likewise responsible for special equipment. Inspection and check up of each truck is made every 1,500 miles. At that time, the driver takes it to the repair garage where he assists the mechanic in checking, lubricating, and making minor repairs. Each repair garage is equipped for major repair work and has a blacksmith shop and paint shop.

The stock room keeps replacement parts so that minor repairs are quickly made. Many replacement parts for the larger pieces of equipment are not kept in stock and since they frequently are not obtainable locally, the down-time is sometimes extensive.

Equipment usage is charged according to uniform hourly rental rates based on depreciation, repairs, equipment maintenance, fuel, housing and insurance but which do not include cost of the operator or any auxiliary equipment not permanently attached, such as snow plows, sanders and so on. Typical rental rates were $1.10 an hour for 3-ton trucks, and $1.35 an hour for 7-ton trucks.

As a general rule, when equipment is out of the garage on routine work, time is charged for the duration of the assignment regardless of whether the equipment is actually used or not. For example, a truck used to transport men to the job site but which may otherwise remain idle is charged for a full day. On operations covered by a work order, however, only the actual working time is usually charged.

ACCOUNTING PRACTICES

All labor, equipment, and materials are charged to various cost accounts by the foreman or crew leader in charge of each crew. For snow and ice control items charges are made only to the appropriate account. For roadside maintenance items (selective cutting and pruning; maintaining slopes and roadsides; roadside mowing; shade tree spraying; maintenance of developed areas; and so on) the charges are also broken down in accordance with "controls". Controls are sections of highway which are relatively uniform with respect to (1) volume and character of traffic and (2) urban and rural development of adjacent property. Controls average about 3.84 miles in length.

Charges for roadway maintenance work such as surface, drainage, guide rails, and shoulders, are broken down still further in accordance with subdivisions within each control which are established wherever an appreciable change occurs with respect to type, width, or age of surface. These subsections are termed "control sections" and average about 1.74 miles in length.

There is another category of work performed by the maintenance crews which involves betterments, replacements, new construction, severe storm damage repairs, and other work of a capital outlay nature. These are covered by special authorizations termed "work orders" for the performance of specified work at specified locations. In making charges to work orders, foreman and crew leaders also indicate the appropriate cost account for the work performed.

The basic charge-out records consist of (1) semi-monthly time reports by the foreman and crew leaders, (2) stores requisitions for materials used from stock and (3) receiving reports for equipment rented and materials purchased directly from the vendor.

For the fiscal year 1950-51, the percentage distribution of expenditures for labor, equipment, and materials was as follows:

Labor	58
Equipment	18
Materials	24
Total	100

Note: The term "control section" as defined above differs from the more common definition employed in other states. In the more common usage, the term applies to a segment of road between each principal intersection and each county line. The average length of a control section under this latter definition will probably average about three times the length of the average Connecticut control section. (See article "Highway Control Sections" by G.D. Gronberg, PUBLIC ROADS, August 1951.)

CHARACTERISTICS OF THE STUDY AREA

As previously mentioned, a general foreman's area is the smallest integral maintenance unit under single supervisory control, and one such area with headquarters at Warehouse Point, Connecticut, northerly from Hartford, was selected as reasonably typical for purposes of study. There are 262 miles of state highways in this area of approximately 394 square miles. As indicated on the map, Figure 1, 11 crews operate in the area: five crews out of the main garage at Warehouse Point and six crews out of five other garages spread throughout the area. These latter garages have no major repair facilities; principally, they are strategically located headquarters for the crews, equipment and tools. Under the jurisdiction of the general foreman and five regular foremen were a total of 84 maintenance men - laborers, drivers, and crew leaders - with a total of 36 trucks and 12 other major pieces of equipment.

The practice in this area, which follows the general plan of operation throughout the state, is to have special crews to do certain operations such as roadside, drainage, and guide rail. Some foremen have more men than others since their operations are not wholly confined to the mileage assigned to them. Occasionally, there are temporary transfers of men or crews between general foremen's areas to render specialized or emergency assistance. In addition, there are specialized crews not assigned to any particular area which do work on a state-wide or district-wide basis. Of the state-wide crews, one is a blacktop crew whose principal work is resurfacing scaled or worn-out portland cement concrete with commercially produced bituminous concrete; two crews operate specialized center-line and guide line striping equipment; and two other crews perform jacking of settled concrete slabs. Bridge maintenance and sign maintenance are performed on a district-wide basis; electrical maintenance is on a state-wide basis.

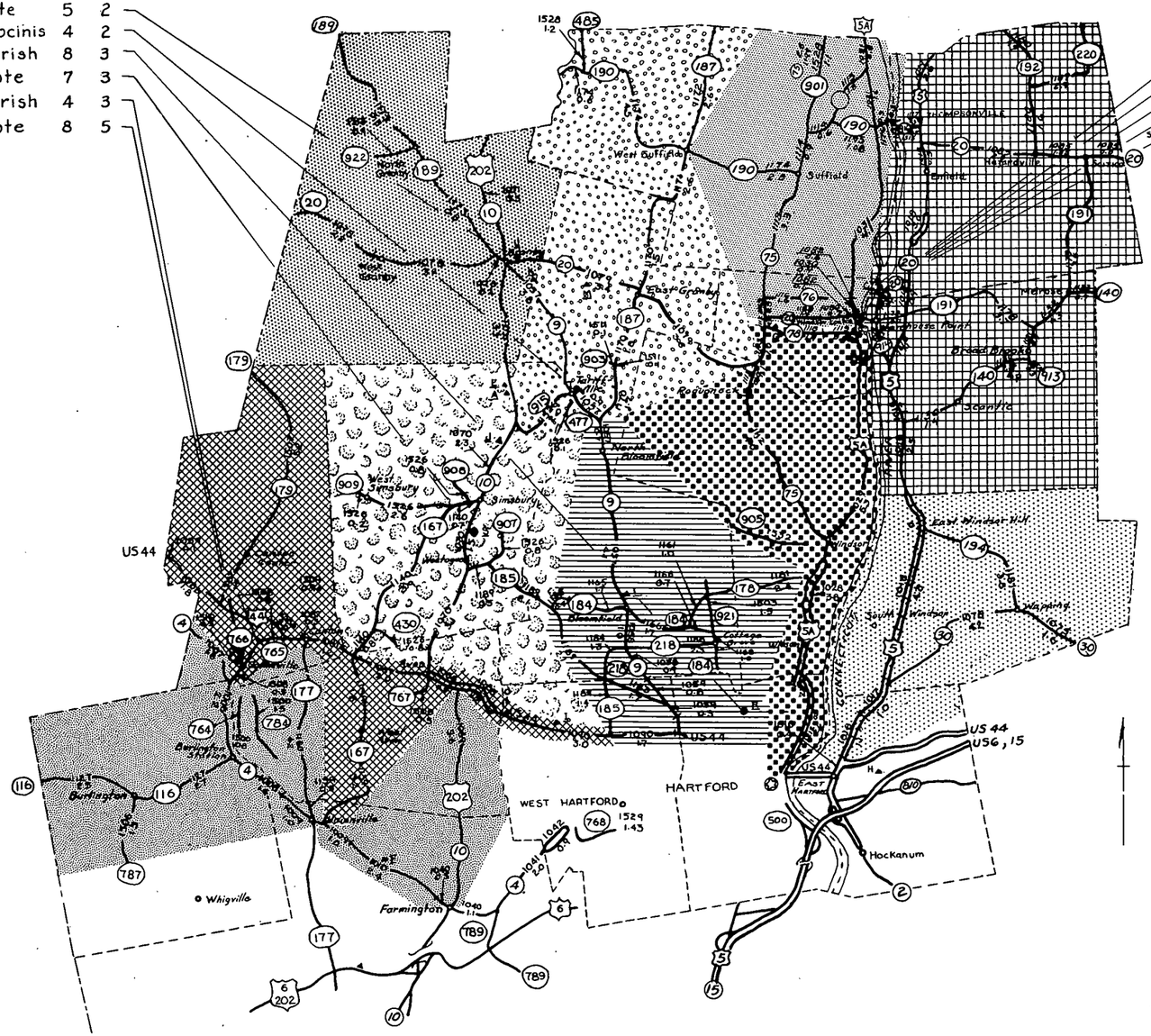
The Warehouse Point area was selected for purposes of study since it contains the wide variety of terrain, traffic, land use, and road types found throughout the state. The comparison of certain factors in the Warehouse Point area with the average for the state's 12 maintenance areas is shown in Table 2.

Table 2. Comparison Between Warehouse Point Area and State-wide Average General Foreman's Area of Various Items Related to Maintenance

Item	Warehouse Point Area	Average for the 12 General Foremen's Areas of the State
1. Area in square miles	394	417
2. Miles of State highway		
a. In rural areas	231	213
b. In urban areas	31	34
c. Total	262	247
3. Lane miles of State highway	560	534
4. Miles of each surface type		
a. Bituminous treated	19	33
b. Armor coat	68	80
c. Bituminous penetration	106	46
d. Mixed in place	7	1
e. Bituminous concrete	21	16
f. Portland cement concrete	41	71
5. Average daily traffic, 1950	2800	3070
6. Average age of surfaces in 1950, years	20.6	21.9
7. Number of maintenance personnel, 1951		
a. Salaried	6	8
b. Hourly rate	93	121
8. Major equipment		
a. Trucks	36	35
b. Other major units	12	14
9. Expenditures per mile for routine maintenance, fiscal year 1950-51	$737.	$1024.

Code	Crew Leader	Foreman	Men	Trucks
	Saunders	Rote	5	2
	Hopkins	Stocinis	4	2
	Sparrell	Parish	8	3
	Vincent	Rote	7	3
	Clark	Parish	4	3
	Munson	Rote	8	5

Code	Crew Leader	Foreman	Men	Trucks
	Zercie	Stocinis	9	3
	Kibbe	Barnett	8	5
	Malley	Byrnes	6	4
	Lees	Byrnes	9	5
	Beck	Byrnes	4	1



Key	Town	Route	Materials	Users
A	Simsbury	10	Sand Pit	Vincent, Saunders, Hopkins
B	Windsor Locks	5A	Sand, Patch, Post, Stone	All
C	Enfield	20	Sand, Fence, Posts, Tables, Garage	Malley, Kibbe, Lees, Zercie, Beck
D	Collinsville	766	Sand, Salt, Trucks, Plows, Garage	Clark, Munson
E	Simsbury	10	Patch, Fence, Posts, Plows	Vincent, Saunders, Hopkins, Beck
F	Farmington	4	Dunning - Sand Pit	Clark, Munson
G	Windsor Locks	78	Roncari - Sand	All
H	East Hartford	15	Sand	Kibbe
I	West Hartford	44	Sand	Clark
J	Simsbury	10	Sand	Vincent
K	Granby	9	Sand	Hopkins, Vincent
L	Bloomfield	9	Town Gar. - Sand, Patch, Fence, Plows	Sparrell
M	East Granby	20	Sand, Brush Burning	Hopkins
N	Windsor	5A	Sand (No. Meadows)	Lees
P	E. Windsor	off 140	Sand & Gravel Pit (Reichle's)	All
Q	E. Longmeadow	Mass.	Christensen - Gravel	
R	Hartford	Martin St	Garage	
S	Simsbury	10	Garage	
T	Tarriffville	9	Garage	
U	Granby	20	Garage	

▲ Stock Pile ● Garage

FIGURE 1

MAINTENANCE PRODUCTION STUDY

DISTRICT NO. 1 - NORTHERN SECT.

JULY 1950
Revised Nov. 1951

SCALE OF MILES

The weather in the study area is approximately the same as at Hartford which is close to average for the State. Weather data are rather sketchy as there are only three weather bureau stations in Connecticut, at Hartford, Bridgeport and New Haven, and a number of cooperative stations scattered about the state. The 46 year means of weather at Hartford and comparative data during the study period are as follows:

Item	46 year average	August, 1950 to July, 1951
Mean temperature	50.1°F	51.2°F
Precipitation	42.1 inches	42.7 inches
Snowfall	40.5 inches	37. 1 inches
Percent of possible sunshine	55%	50%
Clear days	110	74
Partly cloudy days	111	88
Cloudy days	145	203
Days reaching 90° or better	8	7
Days getting below freezing	120	115
Days not getting above freezing	33	17
Days getting below zero	3	1
Days having 0.01 inch or more precipition	127	115
Days having 1 inch or more snow, sleet, hail	11	11
Days having thunderstorms	27	18
Days having heavy fog	48	41

A comparison of the 1950-51 season shows total snowfall to be 37.1 inches which is only slightly below average. The weather in this vicinity is, in general, unpredictable, particularly in the winter because the polar front, the boundary of contact between cold, dry, polar air and warm, moist, tropical air has an average winter position right through southern New England and in the summer has an average position along the Canadian border. Thus, not only is winter weather unpredictable but the snowfall in any one year can and does vary widely from the average. Snowfall is 50% above the average approximately one year in every five.

Sleet storms and glaze ice can cause as much work for the maintenance forces as snowstorms. The number of days per year of sleet and glaze at the Hartford Weather Bureau station for the past 15 years has varied from 14 to 28 with an average of 18. In the winter 1950-51 there were 16 days of sleet and glaze, which is slightly below average.

NATURE OF THE STUDY

Since this was the first study of its kind, a certain amount of preliminary work was necessary in the development of study techniques. Several types of studies were decided upon, as follows:

1. The labor study. This type of study is conducted principally on crew labor operations such as hand mowing, patching, erecting snow fence, and so on. Observers employ stop-watches to obtain a complete record of the time spent by each maintenance man on each individual operation throughout an entire day. A record of the amount of work accomplished is also kept.

2. The equipment study. This type of study is conducted on individual units of equipment principally on operations in which the equipment is the production unit such as on surface treatment work, excavation, stockpiling, eductor operations, and so on. One observer is ordinarily assigned to each piece of equipment and employs a stop-watch to obtain the complete detailed record of waits, delays and working time throughout a day. Records are also kept of work accomplished, travel distance, and so on.

3. The accomplishment study. In this type of study only one or two observers are used to make a generalized time distribution and record of the work performed on a maintenance operation. Such studies do not, of course, break down each small delay and item of work performed, but they do serve as useful supplementary studies of time utilization and accomplishment.

Labor and equipment studies are conducted for an entire working day and occasionally require as many as 7 or 8 observers on one study in order to obtain a complete integrated record of every operation performed throughout the day, sometimes over a distance of several miles. The full-day study has been determined as necessary since a one or two-hour sample during any part of a day's work on maintenance operation is rarely typical of the entire day's work.

For all types of studies, a detailed record is made of the work accomplished. In the case of guide rail work, for example, a record is made of the number of old posts removed, new posts placed, and old posts straightened; on bituminous patching, the quantity of material placed and the area patched are noted; on crack sealing, a record is made of the lineal feet of cracks, quantity of material, length of slab sealed, and so on.

In addition to the foregoing types of study, each truck and major unit of equipment was equipped with an automatic time recorder. This device contained a chart which was changed three times weekly and which showed the time of day when the equipment was in motion or when it was idle. By means of field inspections, supplemented by questioning of each driver or operator when the chart was changed, the nature of work performed, delay involved, or reason for idleness was catalogued and noted on the charts. Recognition

was given to the fact that trucks can be working when standing still by being used as a mobile tool house or when being loaded or unloaded. They can, on the other hand, be in a non-working category while moving as, for example, when used to take the crew to lunch during inclement weather or to run a personal errand. Methods of questioning were devised which brought out these facts and which overcame other early difficulties in accounting for equipment use. By such means, a very comprehensive day-to-day record of equipment time utilization was obtained.

Prior to undertaking the field studies, and several times following, discussions of the purposes of the study were held with the maintenance men in the area under study. From the very beginning, the cooperation and job relations were excellent. The importance of working at normal pace and not speeding up during a study was stressed to the maintenance personnel. Naturally, there was a certain amount of speed-up, particularly during the early studies. After the first few weeks, however, the men became used to the studies and the tendency to accelerate pace was reduced. Because of difficulty in estimating the extent of the speed-up no adjustments have been made to any of the study data presented in this report to compensate for its effect.

To accomplish the objectives of the one-year study, a study group composed of about 11 men was employed. Of this number, four were Bureau employees and seven were State personnel. The field studies were under the technical direction of a Bureau man assigned as full-time resident engineer throughout the study. A state man was likewise assigned full-time to the study. All other personnel were assigned temporarily, and during the course of the study, a total of 31 Bureau men and 26 State men were engaged at various times in making field studies of maintenance. Field headquarters were established at Warehouse Point, where office space, equipment, telephone service and other accommodations were provided by the State.

FOREMEN'S TIME CHARGES

Prior to starting the study an appraisal was made of the reliability of the foremen's semi-monthly reports as a source record for labor and equipment charge-outs to items of work and to sections of highway. This appraisal indicated that labor time records were sufficiently accurate for study purposes and that it would not be necessary to establish a separate labor time-keeping procedure. For equipment, however, the time-keeping procedure lacked the precision required for study purposes and a separate equipment time-keeping method was devised as mentioned in the preceding chapter.

After the study was underway, checks of the foremen's charge-out procedures were made to verify the earlier appraisal. Data compiled on studies during the first two months of study were compared with the foremen's reports and revealed that foremen's reports fell somewhat short of reflecting a precise record of labor and equipment charge-outs insofar as study requirements were concerned. Further confirmation of this finding was made during the latter stages of the study.

It was found, for example, that for individual pieces of equipment, the time charges reported by the foremen and the charges as carried on the study records did not agree on 49 percent of the equipment-hours. The situation in this respect is not as serious, however, as may appear at first glance. In cases where several trucks are employed on a single operation, the foreman may charge certain trucks to one control section and other trucks to other control sections for the entire day in order to avoid splitting up the time for each truck in accordance with actual time spent in each control section. Such practices may result in reasonably reliable costs chargeable to each control section, but do not reflect a sufficiently accurate picture of actual use of each unit of equipment. The separate equipment time-keeping procedure employed on the study overcame this deficiency.

For labor, the time charges reported by the foremen did not agree with the charges carried on the study records for 47 per-cent of the man-hours of individual laborers. As in the case of equipment, the difference may be due to the tendency on the part of the foreman to make charge-outs of part of his crew occasionally to one control section and the remainder to other control sections upon which work may have been performed on a particular day. There is also a tendency to make the charges to the one or two control sections upon which the greatest amount of time may have been spent, thereby omitting charges of small amounts of time spent on other control sections.

To simplify accounting, the foremen have been instructed that all charges should be to the nearest half hour and that it is not necessary to show charges of less than one hour on any control section. Another factor affecting precise record-keeping is the possible tendency to undercharge work orders (which are usually estimated low) and to "balance the books" by absorbing the excess on routine maintenance work which may be underway elsewhere in the vicinity. Further, the flexibility of the budget for snow and ice control results in certain charges being made against this

account, which under other circumstances might be handled differently. For example, cleaning and edging shoulders and brooming in preparation for surface treatments are occasionally charged against snow and ice control.

No separate labor time-keeping procedure was devised for study purposes; hence, foremen's reports are the only source of labor time data. There are, therefore, discrepancies that become apparent in some instances when an exact comparison between equipment-time charges (from study records) is made with labor-time charges (from foremen's reports). Further, the breakdown of the equipment-time charges is in considerably more detail than the breakdown of labor-time charges. For purposes of general comparisons, however, the agreement between the two sources is sufficiently close.

Because of the greater detail in the record of equipment-time utilization, the charts in the latter portion of this report which show the trend in the maintenance work load throughout the year (Figures 5 to 11) are based upon equipment data rather than labor data.

LABOR WORK-LOAD TREND

During the year, 173,656 man-hours of working time were expended on maintenance in the Warehouse Point area. Figure 2 shows the distribution of this working time plus non-working time in accordance with the foremen's semi-monthly reports. The chart does not include the time of foremen or crew leaders. All items shown represent time for which the men were paid with the exception of other non-working time. This is mainly absences in excess of annual leave and absence during recovery from job-incurred disability during which compensation was paid but also includes time attending safety meetings and while taking promotional examinations and military leave.

For about nine months during the year, an average of 3,000 man-hours per week was expended on maintenance. During the winter months, a sharp increase took place and reached a peak during the week of January 29 to February 4 when the men worked an average of 95 hours each. The effect of work orders in maintaining a balanced work-load during the spring and fall is evident by inspection of Figure 2. A decrease in working time is evident in weeks containing holidays except during the winter. Corresponding decreases in working time are evident on the equipment chart, Figure 3.

Vacation time was small during the winter but not entirely eliminated. The taking of vacations during the winter is discouraged because all the men are needed in order to operate all available trucks. Sick leave reached a peak during March which is a bad time for colds, "flu", and all respiratory diseases.

Work orders accounted for 30,589 man-hours or 18 percent of the working time. The main items were surface and shoulder betterments in the late summer and fall, new drainage construction in the spring, summer and fall, and roadside work in connection with new construction in the spring and fall. This roadside work consisted of landscaping, seeding and mulching, and planting of shrubs which must be done during the planting seasons. Other work performed under work orders included severe storm damage repairs, drainage replacements, guide rail replacements, new guide rail installations, guide rail repairs due to traffic accidents, maintenance of detours in connection with construction contracts, subgrade sampling, and other miscellaneous work.

Routine maintenance accounted for 143,067 man-hours of effort throughout the year. Among the routine work items is included repairs of the damage caused by storms, which involved repairs of washouts and some patching of eroded shoulders. Snow and ice control extended through the fall, winter and spring. Stockpiling of materials was extensive through the fall and winter. Most of the shoulder work occurred during the spring and summer. Most of the surface work was on patching during and following the period of thaw and in surface treatment work during the summer. The bulk of the routine roadside maintenance was in mowing during the summer and early fall although tree work was carried on throughout the year. Drainage maintenance was sporadic throughout the year, reaching peaks during and following heavy storms. Guide rail repairs and general maintenance were fairly uniform throughout the year.

The work identified on the chart as general maintenance includes maintenance of buildings and equipment including the drivers' time during 1500-mile vehicle checks, upkeep of small tools and barrier signs, operation of the state-owned sand pits, handling of miscellaneous materials, hauling of materials for bridge repairs, transportation of men and equipment not assignable to any particular maintenance operation and training of equipment operators.

EQUIPMENT WORK-LOAD TREND

Utilization of the vehicles and equipment was determined mainly from automatic time recorders mounted on each unit. This equipment fleet varied somewhat during the study but mainly consisted of 36 trucks of various sizes and 12 pieces of specialized equipment. The utilization of this equipment during the year is shown in Figure 3.

During the year the equipment was in use for 55,928 equipment-hours of working time or 51 percent of the total available time. 1/ Total available time is all hours of normally scheduled shift time, 45 hours per week less holidays, plus all overtime during which the equipment is in use. Working time is total available time less all major waits and delays of 30 minutes or more in duration. Waits and delays less than 30 minutes each in duration are classified as minor delays and are included as part of the working time.

During the year the equipment was standby in the garage or at stockyards for 36,382 hours or 33 percent of the total available time. This time includes several categories of non-working time. For instance, four wheel drive trucks during the winter season are insurance that the roads will be kept open in the event of a severe storm. They are in readiness to roll at any time although not in use between storms. During the other seasons there is no intention to use them except about one day a month which is to keep the engine and battery in operating condition. They are in effect stored until the next winter. The same is true in regard to other specialized equipment such as the distributor, roller, front end spreader, eductor, etc. They have extended periods of non-use during which they are in effect stored. All such non-use was lumped together with daily standby (temporary non-use) as "parked in garage".

The amount of equipment working time in any week throughout the year was very irregular depending in part on the degree of mechanization of the operations under way. Snow and ice control created the largest demand for equipment usage. While the average work-load was about 900 equipment-hours per week, the peak work-load of 2,550 hours was reached during the week of January 29 to February 4 almost entirely due to snow and ice control. A decrease in working time is evident in weeks containing holidays except during the winter. Labor Day, Columbus Day, Good Friday, Memorial Day, and Independence Day are very noticeable. Corresponding decreases in working time are evident on the labor chart, Figure 2.

1/ This usage of equipment on maintenance compares favorably with usage of equipment on construction work. On the latter it has been found that equipment is in use 55 percent of the total available time during the active highway construction season. See Road Research Release No. 1 of the Highway Research Board Committee on Economics of Highway Construction and Maintenance Methods, March 1949. When the year -around usage of construction equipment is considered, considerably less than 55 percent usage is achieved due to winter shutdowns, moves between contracts, layovers between contracts, and time lost in setting up.

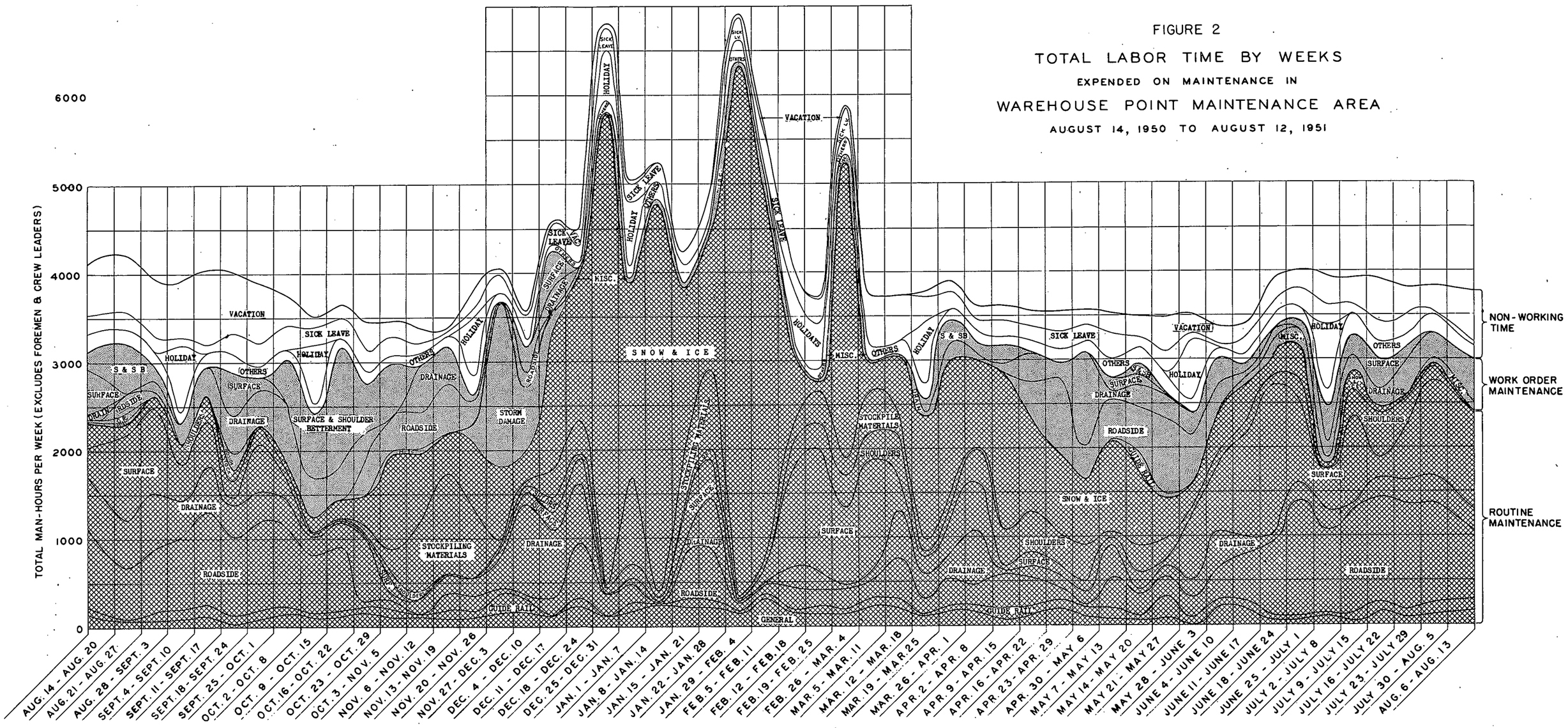
FIGURE 2

TOTAL LABOR TIME BY WEEKS

EXPENDED ON MAINTENANCE IN

WAREHOUSE POINT MAINTENANCE AREA

AUGUST 14, 1950 TO AUGUST 12, 1951



EQUIPMENT LIST

LOCATION	EQUIP. NO.	TYPE 1/	SIZE OF BODY	STRUCK CAPACITY IN CUBIC YARDS Without Side-Boards	STRUCK CAPACITY IN CUBIC YARDS With 0.5 Side-Boards	STATE DESIGNATED CAPACITY IN POUNDS Light Weight	Capacity	Gross Weight
WHSE.PT	2-125	STAKE TRUCK	0.8'x6.5'x10.0'	1.93	3.13	9,200	6,000	15,200
"	2-339	4 WHEEL DRIVE TRUCK	1.1'x7.0'x10.5'	2.99	4.36	18,525	13,000	31,525
"	2-353	TRUCK	1.1'x6.5'x10.0'	2.65	3.85	9,100	8,000	17,100
"	2-426	4-WHEEL DRIVE TRUCK	1.1'x7.0'x10.5'	2.99	4.36	15,400	16,000	31,400
"	2-552	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	15,450	13,000	28,450
"	2-558	TRUCK	0.8'x6.5'x10.0'	1.93	3.13	8,400	8,000	16,400
"	2-599	FENCE TRUCK	1.1'x6.0'x8.0'	1.96	2.84	6,600	8,000	14,600
"	2-600	(Transferred 11/3/50) TRUCK	1.1'x6.0'x8.0'	1.96	2.84	6,600	6,000	12,600
"	2-607	TRUCK	1.1'x6.0'x8.0'	1.96	2.84	6,600	6,000	12,600
"	2-609	TRUCK	1.1'x6.0'x8.0'	1.96	2.84	6,600	8,000	14,600
"	2-691	4-WHEEL DRIVE SAND SPREADER TRUCK	1.3'x7.2'x9.5'	3.29	5.83/2	17,800	13,000	30,800
"	2-701	TRUCK WITH POWER WINCH	1.3'x7.0'x10.8'	3.64	5.04	15,000	13,000	28,000
"	2-713	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	15,450	16,000	31,450
"	2-741	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	14,000	13,000	27,000
"	2-776	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	14,500	13,000	27,500
"	2-781	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	14,500	16,000	30,500
"	2-863	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	14,000	14,000	28,000
"	2-868	TRUCK WITH FRONT END SCOOP-LOADER	1.5'x7.0'x10.5'	4.08	5.44	14,000	14,000	28,000
"	2-880	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	15,450	13,000	28,450
"	3-604	DISTRIBUTOR	1300 US GALLONS					
"	4-015	EDUCTOR	3.0'x6.25'x9.0'=6.25 cy.=1200 gals.					
"	5-343	PATROL GRADER	10.7' BLADE					
"	7-146	ROLLER	5-6 TONS					
"	7-158	ROLLER	1.8 TONS					
"	9-074 3/	BITUMINOUS MIXER	½ C. Y. BATCH					
"	14-161 3/	BUCKET LOADER						
WHSE.PT	14-177 3/	BUCKET LOADER						
"	14-181 3/	BUCKET LOADER						
"	15-043 3/	SURFACE MATERIAL SPREADER (FRONT END SPREADER - CENTRIFUGAL TYPE)						
"	24-028	TRACTOR						
"	24-043	TRACTOR						
"	27-010	4-WHEEL DRIVE SNOW TRUCK - SAND SPREADER						
"	27-014	4-WHEEL DRIVE SNOW TRUCK - (TRANSFERRED 9/20/50)						
COL'VILLE	2-354	TRUCK	1.1'x6.5'x10.0'	2.65	3.85	9,100	6,000	15,100
"	2-355	TRUCK	1.1'x6.5'x10.0'	2.65	3.85	—	—	—4/
"	2-422	4-WHEEL DRIVE TRUCK	1.1'x7.0'x10.5'	2.99	4.36	15,400	16,000	31,400
"	2-480	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	15,450	16,000	31,450
"	2-503	TRUCK	1.1'x7.0'x10.5'	2.99	4.36	13,900	13,000	26,900
"	2-711	TRUCK WITH POWER WINCH	1.3'x7.0'x10.8'	3.64	5.04	16,500	13,000	29,500
"	2-855	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	15,450	13,000	28,450
"	2-869	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	14,000	14,000	28,000
"	6-002	½ C. Y. BACK-HOE						
HARTFORD	2-500	TRUCK	1.1'x7.0'x10.5'	2.99	4.36	13,900	13,000	26,900
"	2-588	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	14,000	14,000	28,000
"	2-755	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	15,450	16,000	31,450
SIMSBURY	2-464	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	15,450	16,000	31,450
"	2-619	TRUCK	1.2'x6.0'x8.0'	2.13	3.20 5/	6,600	8,000	14,600
"	2-746	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	14,000	14,000	28,000
TAR'VILLE	2-424	4-WHEEL DRIVE TRUCK	1.1'x7.0'x10.5'	2.99	4.36	16,000	14,000	30,000
"	2-745	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	14,000	14,000	28,000
GRANBY	2-737	TRUCK WITH FRONT END SCOOP-LOADER	1.5'x7.0'x10.5'	4.08	5.44	14,000	14,000	28,000
"	2-779	TRUCK	1.5'x7.0'x10.5'	4.08	5.44	14,500	16,000	30,500

1/ All trucks have standard dump bodies unless otherwise specified
2/ This unit has 1.0 foot sideboards
3/ Non-rental
4/ Data not available
5/ This unit has 0.6 foot sideboards

It is common practice when short of equipment or in need of a specialized piece to borrow it from the general foreman in the adjoining area. This loan is easily arranged with little additional accounting required and the equipment, when no longer needed, is returned to its home garage. This practice has become fairly extensive, with equipment from this area being on loan to other areas for about 7,000 hours during the year. This time is not included as part of the total available time of equipment in the study area. No record was kept of the use of borrowed equipment in the study area but it appears to have been approximately equal to the loans. The most extensive loans of equipment were in the spring and fall.

When the equipment was available and there was no need to utilize it on the day's work, it was classified as standby. Specialized equipment was standby for much of the year and was parked either in the garage or at a stockyard. Occasionally equipment became standby at the job site. There was always some standby equipment; even during the peak work loads in the winter such equipment as the distributor, rollers, and eductor were standby.

During the winter extra effort was put forth to keep the trucks operative, the mechanics frequently working overtime. The result was that less time was lost from work due to repairs than at other times of the year. More time was spent on equipment maintenance in the winter due to the fact the equipment was used more.

On operations using large amounts of equipment, surface treatments and shoulder and surface betterments for example, a piece of equipment frequently had to wait on other equipment operations before or during its own work. This may have been due to an interruption in plans or because one machine or operation was slower than another. Other major delays to equipment consisted mostly of delays peculiar to the operation being performed. Included are waits for materials, wait for the oil ferry on bituminous treatments, changing blades on the tractor mowers, waits for instructions, delays due to weather, delays at the site of highway accidents, and delays for which the cause could not be determined from questioning of the drivers.

Usage of equipment for general maintenance included use by the foremen or crew leaders for inspections or supervision, use by the garage, transportation of men and equipment, hauling of lumber and gravel for bridge repairs, cleanup of stockpiles and sandpits, use while burning brush at stockyards, construction of salt stockades, and miscellaneous usage.

The percentage distribution of the total hours of available time of equipment for the entire year, including both routine and work order maintenance is as follows:

Item	Percent of Total Available Time 1/
Major delays (0.5 hour or more in duration)	49
Storm damage	1
Snow and ice	15
Stockpiling materials	4
Shoulders	3
Surface	12
Drainage	5
Roadside	8
Safety and traffic control devices	2
General	1
Total	100

1/ Excludes time of equipment loaned to or borrowed from other areas.

A more detailed breakdown of the total equipment utilization for the year is shown in the following table.

Distribution of Equipment-Hours of Total
Available Time for All Equipment for 52-Week Period

Item	Hours
Major Delays	
Parked in garage	31,981
Standby idle at stockyard	4,401
Standby idle on job	3,205
Under repair	8,270
1500-mile check	1,700
Wait on other equipment operation	787
Start late and quit early	1,002
Other	1,368
sub-total	52,714
Storm Damage	
Clean up fallen limbs and trees	697
General cleanup	172
Repair washouts	326
Other	349
sub-total	1,544

Item	Hours
Snow and Ice	
Clearing snow off bridges by hand	380
Plowing snow off bridges and intersections - Case Tractor	102
Clearing snow and ice out of waterways by hand	1,650
Loading sand trucks at stockpile - Nelson Loader	400
Salting ice and snow	445
Sanding ice and snow	5,373
Plowing ice and snow	4,739
Snow fence removal	587
Erect snow fence	1,054
Clean up winter sand by hand	435
Clean up winter sand - Patrol Grader	189
Clean up winter sand - Pickup Broom	1,002
Other	423
sub-total	16,779
Stockpiling Materials	
Stockpiling salt	248
Mixing bituminous cold mix	609
Stockpiling winter sand	3,055
Other	36
sub-total	3,948
Shoulders	
Shoulder replacement	29
Cleaning and edging - Truk Loader, Tow Grader	1,478
Cleaning and edging - Patrol Grader	267
Bituminous surface treatment - RT 6	442
Patch with bituminous hot mix	244
Patch with bituminous cold mix	572
sub-total	3,032
Surface	
Construction service roads with state institutions	635
Seal joints and cracks with asphalt	349
Surface replacements	2,000
Bituminous surface treatment - RC 2 sand	764
Bituminous surface treatment - RC 2 pea stone	417
Bituminous surface treatment - RT 6	2,951
Armor coating	652
Patching with bituminous hot mix	203
Patching with bituminous cold mix	5,382
Other	64
sub-total	13,417

Item		Hours
Drainage		
Replace drainage structures		107
Construct catch basins		175
Lay pipe		543
Eductor - clean catch basin sumps		485
Clean and grub ditches		1,494
Clean catch basin grates and gutters		1,443
Other		812
	sub-total	5,059
Roadside		
Spraying elm trees		117
Spraying poison ivy		21
Planting trees and shrubs		346
Mulching		598
Seeding		230
Landscaping		981
Trimming trees and chopping brush picking up brush		501
Sight lining		248
General roadside cleanup		649
Picnic areas		358
Tree removal		1,057
Picking up hay		357
Power mowing		428
Tractor mowing		1,173
Hand mowing		1,307
Other		383
	sub-total	8,754
Safety Traffic Control Devices		
Install reflector buttons		49
Guide rail removal		14
Erect new guide rail		98
Guide rail repair		1,867
Other		9
	sub-total	2,037
General		
Construction of salt stockades		25
Burn brush in stockyard		41
Clean up of stockpiles and sandpits		74
Haul gravel for bridge maintenance		17
Haul lumber for bridge repair		65
Transportation of men and equipment		180
Use by foreman		438
Use by garage		305
Other		213
	sub-total	1,358
	Grand total	108,642 1/

1/ Excludes time of equipment loaned to or borrowed from other areas.

Figure 3 and the preceding table show the utilization that was made of all equipment during the study period. Some specialized equipment was used very rarely; one bucket loader was used only five percent of the time. Trucks were used to a much greater extent, one truck being used 93 percent of the time. The following table shows the extent of use of the equipment.

Extent of Equipment Use

Amount of time worked expressed as a percent of the total available time	Number of Major Units	
	Trucks	Other
0	-	-
1 - 10	-	6
11 - 20	4	3
21 - 30	1	4
31 - 40	3	1
41 - 50	2	-
51 - 60	5	-
61 - 70	12	-
71 - 80	6	-
81 - 90	3	-
91 - 100	1	-

The extent of equipment utilization is dependent in part on the versatility of the equipment. The bucket loaders can be used only for loading materials, one roller is equipped with rooter teeth for ripping up pavements to be replaced, one tractor mounts a plow in the winter and a mowing machine in the summer. Two of the trucks normally carry snow plow underframes all summer for use with the front mounted drags or hones. Two other trucks are rigged to be used with the front end scoop-loaders. Two trucks are equipped with winches. Another carries the snow plow head frame and hoist for heavy lifting. Another is a four wheel drive equipped with a material spreader in place of its tailgate. One truck worked on sixty different tasks during the year while the eductor only worked on one. The following two tables show the extent of the versatility of the equipment.

Number of Major Maintenance Activities Worked On	Number of Major Units	
	Trucks	Others
1	-	4
2	-	4
3	-	2
4	-	2
5	2	1
6	2	1
7	3	-
8	16	-
9	14	-

Number of Different Maintenance Tasks Worked On	Number of Major Units Trucks	Others
1	-	1
2	-	3
3	-	2
4	-	1
5	-	2
6 - 7	-	4
8 - 10	2	-
11 - 15	1	-
16 - 20	5	-
21 - 25	1	1
26 - 30	3	-
31 - 40	9	-
41 - 50	14	-
51 - 60	2	-

Comparisons of the utilization of several types of equipment during the seasons of the year and comparison of the seasonal variations in the use of each of the types of equipment are shown graphically in Figure 4. For purposes of comparison, trucks which rated at 6,000 or 8,000 pounds capacity are classified as 3-ton trucks. The larger trucks which are rated from 13,000 to 16,000 pounds capacity are classified as 7-ton trucks. Trucks of similar capacity but which are equipped with four-wheel drive are classified separately. Other equipment includes a 1300-gallon distributor, a 1200-gallon eductor, a patrol grader, a 5-6-ton three-wheel roller, a 1.8-ton tandem roller, a ½ cubic yard shovel with backhoe attachment mounted on rubber tires, a ½ cubic yard batch-type bituminous mixer, three bucket loaders mounted on rubber tires, a front end material spreader, two tractors equipped with cutter bars for mowing, and a truck equipped with a material spreader assigned to the study area during the summer only.

The seasons of the year as used here are four equal 13-week periods approximating the seasons of the year as normally used. Fall is from September 18th through December 17th, 1950; Winter is from December 18th, 1950 through March 18th, 1951; Spring is from March 19th through June 17th, 1951; and Summer is from June 18th through August 12th, 1951, and August 14th through September 17th, 1950.

An inspection of Figure 4 reveals certain information of considerable interest concerning the extent of equipment usage. The maximum truck use occurred during the winter when snow and ice control was the major maintenance activity. Other work done at this time included stockpiling of materials and surface maintenance. Other equipment usage was small at all times reaching a maximum of 25 percent utilization during the summer. The tractor mowers, distributor, front end spreader, motor grader, three-wheel roller, back hoe, and eductor were in use at this time of the year. Four-wheel drive trucks were seldom used except during the winter when they were in use over 45 percent of the time. It will be noted that these trucks were under repair a large percentage of the time, over 60 percent during one season. This was due to the difficulty in obtaining spare parts and often required three to six months.

Loans of equipment to other areas were most extensive during the spring and fall. Specialized equipment was most frequently loaned as the extent of their use precludes assignment of all types to each area. The backhoe and operator were on loan for much of the year. The operator travelled back and forth daily using a 3-ton truck which was also considered to be on loan as it was unavailable for use in this area. Large trucks were preferred on certain maintenance operations while small trucks were preferred on other operations.

The following tables show some other aspects of the seasonal variations in the utilization of both labor and equipment.

Seasonal Distribution of Working Time of Labor

Class of Maintenance	Percent of Total Annual Working Time				
	Summer	Fall	Winter	Spring	Year
Work order	21	47	2	30	100
Routine	23	18	39	20	100
All maintenance	23	23	32	22	100

Seasonal Distribution of Equipment Working Time

Class of Maintenance	Percent of Total Annual Working Time				
	Summer	Fall	Winter	Spring	Year
Work order	26	53	5	16	100
Routine	21	19	41	19	100
All maintenance	22	23	36	19	100

The peak work-load on routine maintenance occurred during the winter; therefore, little work order maintenance was performed in this season. It is also noted that the work order operations occurring in the spring of 1951 at the Warehouse Point area were largely manual with little equipment usage. This was principally seeding and mulching of slopes on new construction at Bradley Field airport.

Distribution of Working Time for
Each Class of Equipment by Seasons

Class of Equipment	Percent of Total Annual Working Time				
	Summer	Fall	Winter	Spring	Year
3-ton trucks	22	25	33	20	100
7-ton trucks	20	23	38	19	100
4-wheel drive trucks	16	8	69	7	100
Other equipment	41	18	23	18	100
All equipment	22	23	36	19	100

FIGURE 3

TOTAL AVAILABLE EQUIPMENT TIME BY WEEKS

EXPENDED ON MAINTENANCE IN

WAREHOUSE POINT MAINTENANCE AREA

AUGUST 14, 1950 TO AUGUST 12, 1951

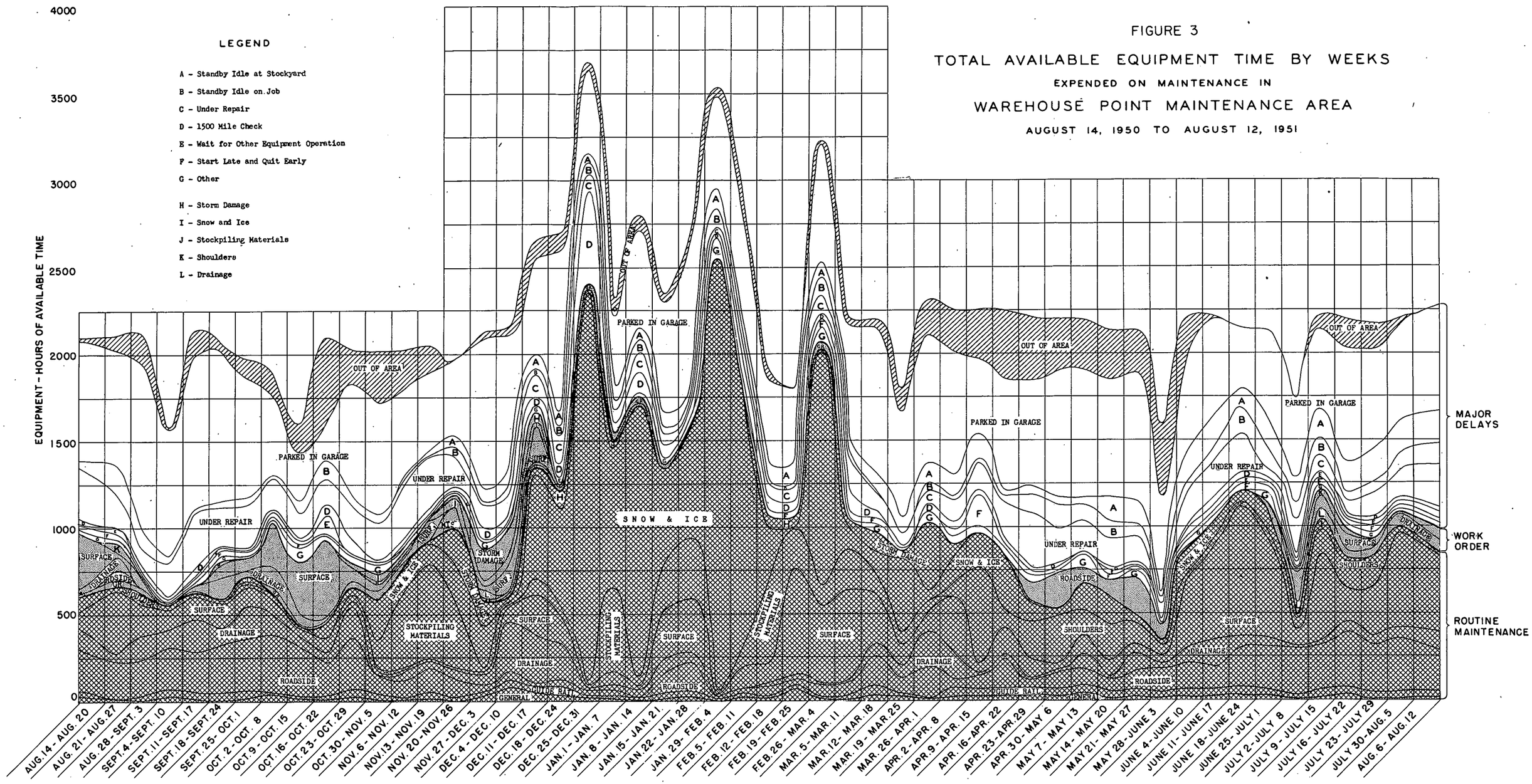
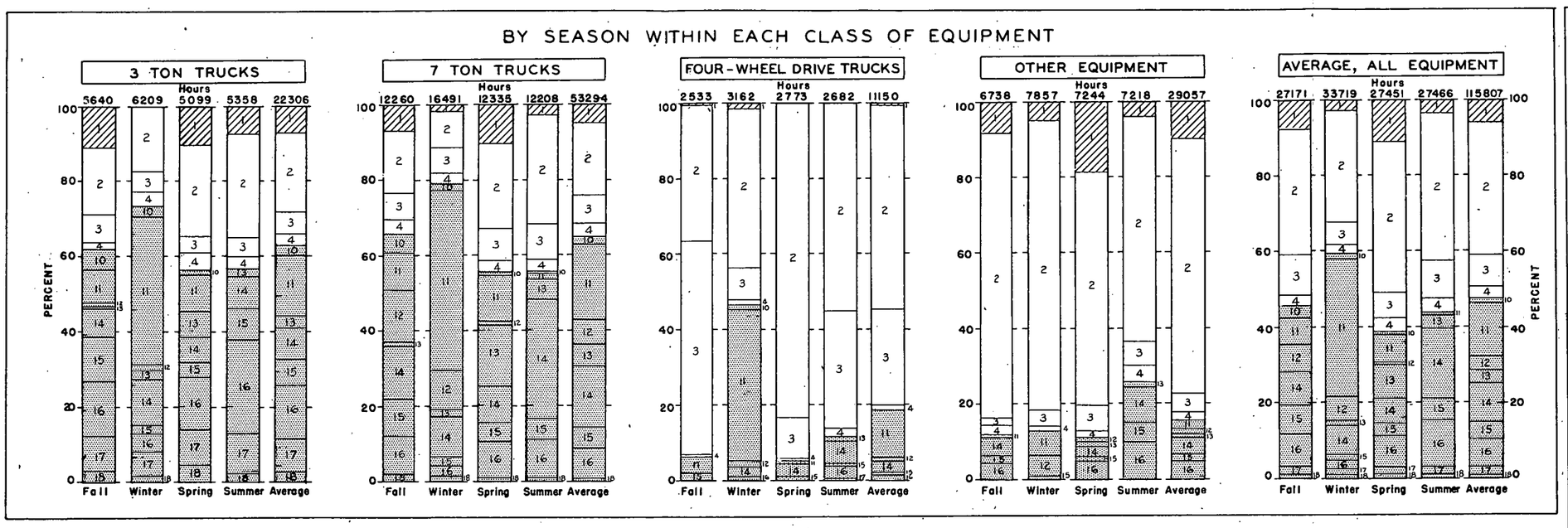
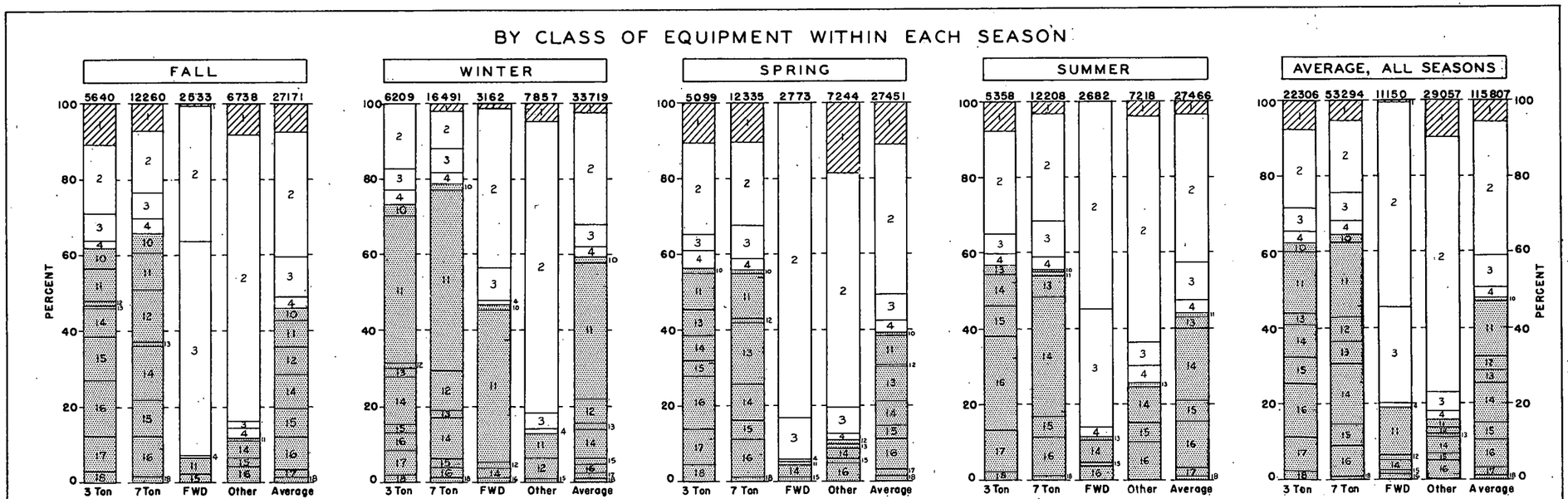


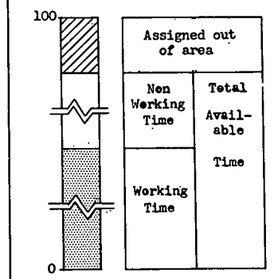
FIGURE 4

DISTRIBUTION OF TOTAL AVAILABLE TIME OF MAJOR EQUIPMENT





LEGEND



1. ASSIGNED TO WORK IN ANOTHER AREA

NON-WORKING TIME IN AREA

2. Standby: available for use but not being used. Parked in garage, at stockyard, or on job
3. Repair: under repair, awaiting repair, 1500 mile checkup
4. Other: start late, quit early, wait on other operations

WORKING TIME IN AREA

10. Storm damage: general cleanup, clean up fallen limbs, repair washouts
11. Snow and ice: plowing, sanding, and salting snow and ice; snow fence erection and removal; clean upwinter sand
12. Stockpiling materials: stockpiling winter sand, cold patch, and winter salt
13. Shoulders: patching and treating shoulders; cleaning and edging
14. Surface: Patching, armor coating, and surface treating; sealing cracks and joints
15. Drainage: cleaning catch basin grates and gutters; grub ditches; clean catch basin sumps
16. Roadside: mowing, tree removal, clean picnic areas, sight-lining, landscaping, trimming trees, seeding, mulching, planting, spraying
17. Safety and traffic control: guide rail work, install reflector buttons
18. General: clean up stockpiles and sand pits; use by foreman or mechanics; haul miscellaneous materials

All trucks were utilized to their greatest extent during the winter. The 3-ton trucks were utilized to a greater extent throughout the year so that the variation from the normal was not as pronounced as for the 7-ton trucks. Four-wheel drive trucks were rarely used during other seasons so that over two-thirds of their use was during the winter. Equipment of a specialized nature, such as bucket loaders, were employed during the winter, while others were utilized more during the summer.

The seasonal variations in labor and equipment utilization on various major maintenance activities are presented in the final sections of this report. The following table, however, is of interest in showing the distribution of the equipment work-load for the various activities by the four major seasons of the year.

Distribution of Equipment Working Time
for Each Maintenance Activity by Seasons

Maintenance Activity	Percent of Total Annual Working Time				
	Summer	Fall	Winter	Spring	Year
Storm damage	2	58	30	10	100
Snow and ice	-	1	98	1	100
Stockpiling materials	-	42	55	3	100
Shoulders	23	4	12	61	100
Surface	43	20	22	15	100
Drainage	30	41	11	18	100
Roadside	38	27	9	26	100
Guide rail	28	25	23	24	100
General	17	33	24	26	100
All maintenance	22	23	36	19	100

SUMMARY OF FIELD STUDIES

The detailed summary data relating to time utilization of labor and equipment are presented in the later pages of this report in accordance with the following table arrangements:

A. Table Form for Distribution of Man-Hours of Working Time

Distribution of Man-Hours of Working Time
on (Type of Operation)

Item	Percent
1.0 Operating cycle items on assigned task (Items listed as encountered, codes 1.1 to 1.9)	
2.0 Related items including travel and preparatory work	
2.1 Travel to and from garage	
2.2 Travel between stockpile and work site to obtain materials for day's work	
2.3 Travel to new work site (This is sometimes a cycle element)	
2.4 Maneuvers, minor moves ahead	
2.5 Put out and pick up signs	
2.5 Flagging traffic	
2.6 Load and unload men, tools, equipment, materials, etc.	
2.6 Load bituminous patch at stockyard	
2.7 (unassigned)	
2.8 (unassigned)	
2.9 Load truck with sand for possible emergency winter use	
2.9 Miscellaneous	
3.0 Waits and delays	
3.1 Those related to performing the assigned task, getting stuck, wait on other operations, etc.	
3.2 Those related to equipment repair and maintenance	
3.3 Instructions, inspection, supervision	
3.4 Start late, excess lunch, quit early	
3.5 Idle	
3.6 Personal	
3.7 Resting	
3.8 (unassigned)	
3.9 Other	

B. Table Form for Distribution of Equipment-Hours of Working Time

Distribution of Equipment-Hours of Working Time of (Name of Equipment) on (Type of Operation)

Item	Percent
5.0 Operating cycle items on assigned task 1/ (Items listed as encountered in normal cyclic operation, codes 5.1 to 5.9)	
6.0 Related items including travel and preparatory work	
6.1 Travel to and from garage	
6.2 Travel between stockpile and work site to obtain materials for day's work	
6.3 Travel to new work site	
6.4 Minor moves, turns, maneuvers; moves ahead (this is sometimes a cycle element)	
6.5 Put out and pick up signs	
6.6 Load and unload men, tools, materials, supplies and equipment	
6.7 (unassigned)	
6.8 (unassigned)	
6.9 Load truck with sand for possible emergency winter use	
6.9 Miscellaneous	
7.0 Waits and delays	
7.1 Parked while men work	
7.1 Those related to performing the assigned task, getting stuck, wait on other operations, etc.	
7.2 Those related to equipment maintenance and repair	
7.3 Instructions, inspection, supervision	
7.4 Start late, excess lunch, quit early	
7.5 Idle	
7.6 Personal	
7.7 (unassigned)	
7.8 (unassigned)	
7.9 Other	

Definitions of some of the terms used in this report are as follows:

Total Available Time is equal to normal daily shift time plus all overtime.

Working Time is equal to total available working time less all major waits and delays of 30 minutes or more in duration. Waits and delays less than 30 minutes each in duration are classified as minor delays and are included as part of the working time.

1/ In some cases a unit works in the capacity of a general purpose service truck and has no clearly defined operating cycle.

The foregoing tables provide for combining three general groupings of time elements.

Identifying Code		
Labor Studies	Equipment Studies	Time Element Grouping
1.0	5.0	Operating cycle items on the assigned task
2.0	6.0	Related items including travel and preparatory work
3.0	7.0	Waits and delays

On all tables summarizing the detailed studies on labor operations, the various items listed in the table are identified in the first digit by the number 1, 2, or 3. For all tables summarizing equipment-time study data, the various items carry code numbers having a 5, 6, or 7 as the first digit. These groupings and code numbers have been employed in order to standardize the manner of tabulation and to provide a ready means of making comparisons between the various tables.

Operating Cycle Items on the Assigned Task. Under this general grouping for any particular maintenance operation are included the constantly recurring items which are associated with and essential to the performance of the particular task. A power shovel, for example, has four cycle items: (1) load, (2) swing, (3) dump, and (4) return. However, most cycle items on maintenance work are not as clearcut as those for a power shovel. On labor operations, it is frequently difficult to decide whether a particular item such as a constantly recurring delay of a few seconds between each part of a series of cycle items is a bonafide cycle item or not. An inspection of the tables will show several such situations where a particular item might just as reasonably be classified in some other manner. In each instance the decision is based upon judgment. However, each particular item is identified separately in the table for purposes of making regroupings, if desired.

Within the general groupings of operating cycle items in each table, each individual item is given a code number ranging from 1.1 to 1.9 for labor cycle items and from 5.1 to 5.9 for equipment cycle items. The individual codes are peculiar to each table and have no relation to other items in other tables which may have a similar code number.

Related Items Including Travel and Preparatory Work. Under this general grouping for any particular maintenance operation are included those items which are essential to the performance of the day's work but which do not recur with regular cyclic frequency in accomplishing the particular assigned task. Obviously, there are some borderline cases where it is difficult to decide into which general group a particular item should be placed.

For purposes of this report, however, certain items have been selected within this general grouping and assigned code numbers as shown on the following page.

Identifying Item Code On Labor Studies	Identifying Item Code On Equipment Studies	Items included in the general group: "Related Items Including Travel and Preparatory Work"
2.1	6.1	Travel to and from garage
2.2	6.2	Travel between stockpile and worksite to obtain materials for day's work
2.3	6.3	Travel to new work site
2.4	6.4	Minor moves, turns, and maneuvers
2.5	6.5	Put out and pick up signs
2.6	6.6	Load and unload men, tools, and equipment
2.7	6.7	(this code number not used)
2.8	6.8	(this code number not used)
2.9	6.9	Miscellaneous

The foregoing items are largely self-explanatory and reference to the individual tables contained in the latter part of this report, and to the narrative description of each operation, will clarify the nature of these items.

Items included under miscellaneous are too small to show individually and are generally not recurrent. Included are burying dead animals encountered along the highway, picking up trash and debris from the traveled way, dumping a load of debris accumulated during the day, loading truck with sand for possible emergency winter use, dumping the emergency sand in the morning, truck use by a foreman, preparation of materials including heating tar and mixing paint, moving of belt loaders, starting up of belt loaders, preparation of a platform on which to stockpile salt, cover bulk salt with tarpaulin, check and sand roads in the morning, bituminous patching of one hole while a truck was used on sightlining the rest of the day, and dusting of surface treatments by the front end spreader and hauling units.

The same item code numbers are used throughout all tables to simplify interpretation and enable comparisons to be made readily. In cases where a particular item may be insignificant on the average but which may be large on one particular operation, it will be given the appropriate identifying code shown above but will be labeled as to exact nature in the table. Thus, some tables will show two or more entries opposite the same code number.

Waits and Delays. It is in this category of items that the greatest possibility of variable interpretation exists. The first impression is that a wait or delay is something that can be avoided; but a careful scrutiny of the nature of the wait and delay items in this group will reveal many that are without doubt unavoidable. They are catalogued as waits or delays simply because their effect is to reduce accomplishment on the assigned task. No attempt has been made in the studies to classify a wait or delay, or any other item, as avoidable or unavoidable.

At this point, definitions of "waits and delays" may be of help in considering the general nature of the items included in this category.

Waits and Delays - Non-productive time incurred when men or equipment are in readiness to work but are unable to work due to (1) lack of work to do; (2) interference with other operations; (3) waiting for tools, equipment, or supplies to perform their task; (4) taking care of personal matters; (5) resting, and so on.

Major Wait or Delay - An individual non-productive time interval of 30 minutes or more in duration.
(NOTE: In order to obtain a suitable basis for comparing one operation with another major waits and delays have been excluded from all detailed stop-watch time studies.)

Minor Wait or Delay - An individual non-productive time interval of less than 30 minutes in duration. The majority of minor waits and delays are of a few seconds each in duration.

On those tables showing distribution of man-hours, items under general group code 3.0 include all minor waits and delays. Actually labor very rarely experiences a major wait or delay inasmuch as there is always some item upon which they can work rather than just stand around. One exception is the practice of labor to rest occasionally for periods in excess of one half-hour when on long hours of continuous work on emergency snow removal operation.

On tables showing distribution of equipment-hours, items under general group code 7.0 include only minor waits and delays. Major waits and delays to equipment are a significant aspect of the equipment management problem and their nature and magnitude have been discussed separately in a previous section of this report.

Items which have been selected for inclusion in the general grouping of waits and delays are as follows:

Identifying Item Code On Labor Studies	On Equipment Studies	Items Included in the General Group: "Waits and Delays"
3.1	7.1	Those related to performing the assigned task
3.2	7.2	Those related to equipment maintenance and repairs
3.3	7.3	Instructions, inspection, supervision
3.4	7.4	Start late, excess lunch, quit early
3.5	7.5	Idle
3.6	7.6	Personal
3.7	7.7	Resting (labor only)
3.8	7.8	(this code number not used)
3.9	7.9	Other

Waits on other operations are in the first category. These may be cyclical on some operations. Many are entirely dependent on the particular operation being performed but some occur frequently on many different operations such as the first men to board a truck waiting for the rest of the crew to board before the truck starts, wait for

truck to move into position for hand loading or unloading, and waiting for a truck to be moved out of the way so work can continue. Many of the other items are self-explanatory. Idle in reference to labor means the man is killing time, two or more of the men may stop to talk, or a man may merely stand around. Typical personal delays are removing or donning clothing, obtaining a drink of water, eating, stopping to make a purchase, warming self near fire, or taking care of physical needs. When used in reference to equipment, it means the equipment is idle due to the actions of the driver or operator of that piece of equipment. Resting refers to labor only and differs from an idle or personal delay in that it represents a well deserved break during heavy manual labor. Other waits and delays are those small time elements which are insignificant if separated out individually. It includes donning special protective clothing, searching for mislaid tools, waiting for the truck to be driven from the garage in the morning, weather delays, travel to and from lunch in the winter, travel to garage for medical shots, travel to obtain drinking water, moving parked cars that interfere with the progress of the work, traffic delays, giving directional instructions to the public when requested, waiting to refuel the truck in the evening, and similar items.

The same item code numbers are used throughout all tables to simplify interpretation and enable comparisons to be made readily. In cases where a particular item may be insignificant on the average but which may be large on the particular operation, it is given the appropriate identifying code and labeled as to exact nature in the table. Thus some tables will show two or more entries opposite the same code number.

An analysis was made of the distribution of labor and equipment-time for all studies. The values presented here are a simple average of all maintenance items on which studies were taken. An analysis was made by weighting the average by number of studies taken and the results obtained are practically identical. No analysis was made weighting the average by the hours of working time expended on each item but it is reasonable to assume that such an analysis would give approximately the same results.

Average Distribution of Working Time
on All Maintenance Items

Item	Percent of Working Time Labor		Equipment	
Operating cycle items		48		40
Related items				
Travel to and from garage	10		9	
Travel between stockpile and work site	1		1	
Travel to new work site	5		4	
Minor moves, turns, maneuvers	2		3	
Put out and pick up signs	3		1	
Load and unload men, tools, etc.	4		3	
Miscellaneous	3	28	2	23
Waits and delays				
Those related to performing the task	7		24	
Equipment repairs and maintenance	2		4	
Instructions, inspection, supervision	3		2	

Start late, excess lunch, quit early	2		2	
Idle	3		1	
Personal	3		1	
Resting	1		-	
Other	3	24	3	37
Total	100			100

Under waits and delays, it will be noted that 24 percent of the equipment-working time was in the category of "Those related to performing the task." About one-third of the waits and delays in this particular group were incurred by trucks on crew labor operations wherein the truck was parked while the men were working; the remaining two-thirds were principally in connection with waiting on other operations.

The following portion of this report presents the detailed data concerning each maintenance operation upon which studies were made. The studies are combined into eight major groups. An approximate distribution of the total maintenance work load among the major items, including a group classified as "other," is as follows:

Major Group	Distribution of Total Annual Work Load - Percent	
	Labor	Equipment
Surface	17	24
Shoulders	6	5
Safety and traffic control	3	4
Drainage	13	9
Roadside	19	16
Storm Damage	2	3
Stockpiling materials	5	7
Snow and ice control	30	30
Other	5	2
Total	100	100

The foregoing percentages include both routine and work order maintenance, and for equipment represent the distribution of the 55,928 hours of working time for the year.

For each major group in the following portion of the report there is a brief discussion of the nature of the operation and an accompanying chart which shows the distribution of the work load by weeks during the year. There is also an inset on each chart showing the relationship of each major category of work to the total maintenance work load. In developing these charts, equipment usage data were employed rather than labor data. As mentioned previously in this report, the equipment usage data obtained from the automatic time recorder charts are in considerable detail and thus are preferable to labor data for this purpose.

SURFACE

That portion of the highway which is most noticed by the public is the surface and any neglect resulting in roughness, waviness, or

other irregularity brings immediate complaint. Hence, maintenance of the surface is continuous throughout the year. The approximate distribution of the work load throughout the year, based upon equipment usage, and the relation of surface to the total maintenance work load is shown in Figure 5.

Patching was the largest item comprising about 40 percent of the equipment work load on surfacing items throughout the year. Patching reached its peak in February and March, during and following the period of thaw. Surface treatments were made in the summer beginning with the sand-tar treatments in June and ending with the armor coats in August. Surface treatments amounted to about 35 percent of the work load and account for the fact that 43 percent of the surface work was done in the summer. Sealing of joints and cracks was done in the late summer or early fall as were most of the surface replacements.

Surface maintenance is fairly well mechanized—particularly surface treatments. Approximately 24 percent of all equipment usage and 17 percent of labor time was on surface maintenance.

The table on the following page shows accomplishment rates for the various items.

Accomplishment Rates on Surface Maintenance Items Observed During Study Periods

Item	Size of Crew	Amount of Equipment	Amount of Work Accomplished Per Day
Patching with bituminous cold mix	3	1	4.75 cu. yds. material in 78 patches covering 119 sq. yds.
Surface treatments	17 - 30	11 - 19	1.20 miles of armor coat or 2.38 miles of sand-tar surface or 6.98 miles of sand-tar shoulders or 2.49 miles of experimental treatments (all 2-lane highways)
Crack and joint sealing	6	1	3000 ft. of cracks and joints sealed on 1.25 miles of 2-lane pavement

Detailed discussions concerning each operation listed in the above table are included in the following pages.

PATCHING WITH BITUMINOUS COLD MIX

All holes and depressions in bituminous surface treated pavements and shoulders were patched with a bituminous cold patch material mixed by State forces and stockpiled throughout the district. (For further details concerning mixing operations, refer to the section of this report on stockpiling materials.) It is the general policy for each foreman to send a crew out patching every Friday and on the day before all legal holidays in order to prepare a smooth riding surface for the traveling public. An extensive patching program is conducted each year following the period of thaw and prior to commencing summer oiling operations.

1. Truck being loaded with bituminous cold patching material by bucket loader.

The first operation performed by the crew was to proceed to the stockyard to obtain a load of patch material. Ordinarily the loading was done by use of a belt loader; occasionally, by hand. In either instance, the patch was scooped from the pile by a shovel or a fork. After loading the truck, the crew traveled to the job site, put out "Men Working" signs and then commenced patching. The whole crew followed and worked behind the truck. Travel was always along the right edge of the road patching both surface and shoulder as one operation. A bass push broom was used to clean any loose material from holes. Holes were filled with patch either by shovel or by fork. On larger patched areas, a rake was used to level the patch. Sometimes, sand from along the roadside was spread lightly on the patchwork to prevent the bituminous patch material from sticking to the truck tires during rolling. For the final operation, the driver rolled back and forth with the rear wheels over the patch making at least 2 passes. Sometimes, a hand tamper was used.

As patch was used up, the truck body was raised to provide easier access to the material. When washboard effects were encountered in a blacktop traveled path, the high spots were reduced by means of a pick to a level below the surrounding surface and the resultant hole was filled with patch. The debris from the picking was cast off to the side of the road. Some of the better material was used as a filler in the deeper holes.

2. Patching raveled shoulders with bituminous cold mix, five-man crew including crew leader who is leveling patch with rake. The material was rolled with the truck wheels.

When too much tar accumulated on the patching tools, they were soaked in kerosene and placed over a fire. Then the patch was scraped off.

Equipment Used	Materials
1 - 7-ton dump truck	1 can kerosene cold patch
2 signs (Men Working)	

Tools Used	Crew
1 broom	1 driver (straw boss)
1 rake	2 men
3 shovels	
2 picks	
2 forks	
1 hand tamper	
1 bucket	

Detailed stop-watch studies were conducted on bituminous patching covering a total of 303.2 man-hours, excluding the foreman.

During these 303.2 man-hours, the distribution of time was as follows:

Distribution of Man-Hours of Working Time
on Patching with Bituminous Cold Mix

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Prepare hole for patching	2	
1.1 Sweeping	2	
1.2 Spreading	13	
1.3 Leveling	3	
1.4 Cover patch with sand or dust	1	
1.5 Rolling patch with truck	2	
1.6 Maneuvers and turns while patching	1	
1.7 Short moves ahead	9	33
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	10	
2.2 Travel between stockpile and work site to obtain load of patch for day's work	11	

2.3 Travel to new work site	6	
2.4 Maneuvers, minor moves ahead	1	
2.5 Put out and pick up signs	3	
2.5 Flagging traffic	1	
2.6 Load and unload men, tools and equipment	2	
2.6 Load bituminous patch material at stockyard	6	
2.9 Load truck with sand for possible emergency winter use	1	
2.9 Miscellaneous	1	42
3.0 Waits and delays		
3.1 Waits on other operations	5	
3.1 Wait while others spread patch	3	
3.2 Maintenance of truck	1	
3.2 Cleaning and care of tools	2	
3.3 Instructions	1	
3.4 Start late, excess lunch and quit early	2	
3.5 Idle	6	
3.6 Personal	2	
3.7 Resting	1	
3.9 Other	2	25
Total		100

During the 303.2 man-hours of study, it was estimated that 55 cubic yards, loose, of patch material were placed. The exact amount is not known inasmuch as the truck was not weighed, nor was the load struck for measurement. These 55 cubic yards were used to make 879 patches over an area of 12,076 square feet or 1342 square yards.

Thus, a 3-man crew, truck driver (straw boss) and 2 men working a 9-hour day, would place 4.75 cubic yards of bituminous patch material in 78 patches covering an area of 119 square yards, in accordance with rates of work accomplished during the periods of study.

During the 52-week period, 35 trucks out of the total of 37 were used at various times on bituminous cold patching for a total of 5198 hours. The distribution of this working time in accordance with detailed studies covering a period of 88.6 hours of work is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks Used on Patching with Bituminous Cold Mix

Item	Percent	
5.0 Operating cycle items on assigned task		
5.2 Men spreading patch	37	
5.5 Rolling patches	4	
5.6 Maneuvers and turns while patching	1	
5.7 Short moves ahead	12	54
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	10	
6.2 Travel between stockpile and work site to obtain load of patch for day's work	11	
6.3 Travel to new work site	6	

6.4 Minor moves, turns and maneuvers	1	
6.5 Put out and pick up signs	4	
6.6 Load and unload men, tools and equipment	2	
6.6 Load bituminous patch material at stockyard	4	
6.9 Load truck with sand for possible emergency winter use	1	39
7.0 Waits and delays		
7.1 Waits on other operations	2	
7.2 Maintenance of truck	1	
7.3 Instructions	1	
7.4 Start late, excess lunch and quit early	2	
7.6 Personal	1	7
Total		100

The average mileage driven by the truck on days during which studies were made was as follows:

Item	Average miles driven per day
To and from garage	21.3
To and from stockpile	21.7
To put out and pick up signs	4.3
To new work site	7.7
Short moves ahead while patching	5.0
Other minor moves	1.2
Total	61.2

During the course of the year's study, bituminous surface treatments were applied to the roads in the area using road tars, cutback asphalt and asphalt emulsions to seal the surface and reinforce the wearing course. The two most common types were (1) surface treatment with RT-4 or RT-6 tar with sand, and (2) stone surfacing with RC-5 or a fast breaking asphaltic emulsion with ½" crushed stone cover. Surface treatments were also made especially on shoulder work with MC-3 asphalt and sand. A limited amount of surface treatment was done using RC-2 asphalt with either sand, 3/8" pea gravel, or ½" crushed gravel for cover.

Maintenance personnel expect a good armor coat job to last 5 to 10 years, whereas the sand-tar treatment is expected to last only 1 to 3 years. Because of its non-skid qualities, armor coating is applied at known icy spots such as hills and bridge floors. It is the general practice, however, to armor coat only those sections where there is little or no likelihood of surface irregularities or other structural deterioration developing because of poor drainage or other conditions.

The temperatures at which the asphaltic materials were applied were observed to be as follows: RC-2 from 180 to 190 degrees F., RC-5 from 225 to 270 degrees F., and emulsion at 200 degrees Fahrenheit. These temperatures were slightly high in order to get good spread and uniform film thickness under application rates as low as 1/8-gallon per square yard. The higher temperatures, of course, accelerate the setting up of the rapid curing cutbacks by driving off the volatiles.

On stone surface treatments 500' sections of roadway were marked off on the pavement as a control on the application of the bitumen and the stone cover. The distributor applied bitumen to 500 or 1000' sections and then waited for the stone spreader to catch up before applying bitumen to the next section. This practice insured getting a stone application into the bitumen before the cut-back asphalt set or the asphalt emulsion broke. Immediately after the stone spreader, several men broomed and hand spotted any sparsely covered areas with additional stone and the surface was then rolled with a 5 to 7 ton gasoline roller as the final step in the treatment. This imbeds the particles more firmly in the asphalt. After the traffic had whipped all the loose stone to the shoulder of the roadway, maintenance forces picked up and salvaged the loose stone.

On the sand-tar treatment and the MC-3 and sand treatment, the bitumen and sand was mixed on the road with a metal blade steel hone mounted on the front of a truck. The blades of the hone carried a wave of mulched material in front of them and deposited the thoroughly mixed sand and bitumen in low areas, thereby reducing the irregularities in the pavement surface. Roads with poor base conditions are always given this type of treatment until such time as reconstruction can be undertaken. After the surface was thoroughly honed, the travel way was dusted with sand using a mechanical sand spreader so that traffic would not pick up and track the fresh surface.

On RC-2 surface treatment the bitumen was immediately covered with either sand or gravel aggregate. The distributor applied the bitumen to 1000 foot sections, using the fifth wheel odometer to measure the distance, and then waited for the aggregate spreader to catch up before applying bitumen to the next section. Any areas of the roadway not thoroughly

covered by the spreader were hand spotted and traffic was immediately allowed to travel over the new application. No honing was done on RC-2 surface treatments with sand cover. All work done with RC-2 and gravel cover was not rolled as it was felt that steel tired rollers would tend to break the stone particles of the gravel cover. The only rolling action applied was the pneumatic tire rolling caused by travel of State trucks on the job and the traffic using the roadway. After the traffic had whipped all the loose gravel to the shoulder of the roadway, maintenance forces picked up and salvaged the loose gravel.

The composition of the crew and equipment was the same for all treatments with the exceptions noted.

Equipment	Labor
1 - Power broom	1 - Foreman
1 - Distributor	2 - Crew leaders
1 - Front end spreader	1 - Power broom truck driver
7-16 Trucks hauling sand or stone	1 - Distributor driver
1 - Truck for hand spotting	1 - Distributor operator (rear end)
2 - Hone trucks (RT & MC only)	4 - Men operating front end spreader
1 - Sand spreader (RT & MC only)	7-16 Truck drivers
1 - Roller (crushed stone only)	1 - Hand spotting truck driver
1 - Water truck at quarry (crushed stone only)	4-10 Men brooming, spotting, flagging as needed
	2 - Hone truck drivers (RT & MC only)
	1 - Truck driver for spreading sand (RT & MC only)
	1 - Roller operator (crushed stone only)
	1 - Water truck driver (crushed stone only)
11-19 pieces equipment	17-30 men plus foreman and crew leaders

During the summer of 1951, two crews and two sets of equipment were used together on armor coat and pea gravel treatments. The crews worked in adjoining lanes of a 2-lane highway, but were staggered to facilitate the passage of traffic.

According to the foremen's reports, total accomplishment on surface treatment during the 1951 season was as shown in the following table.

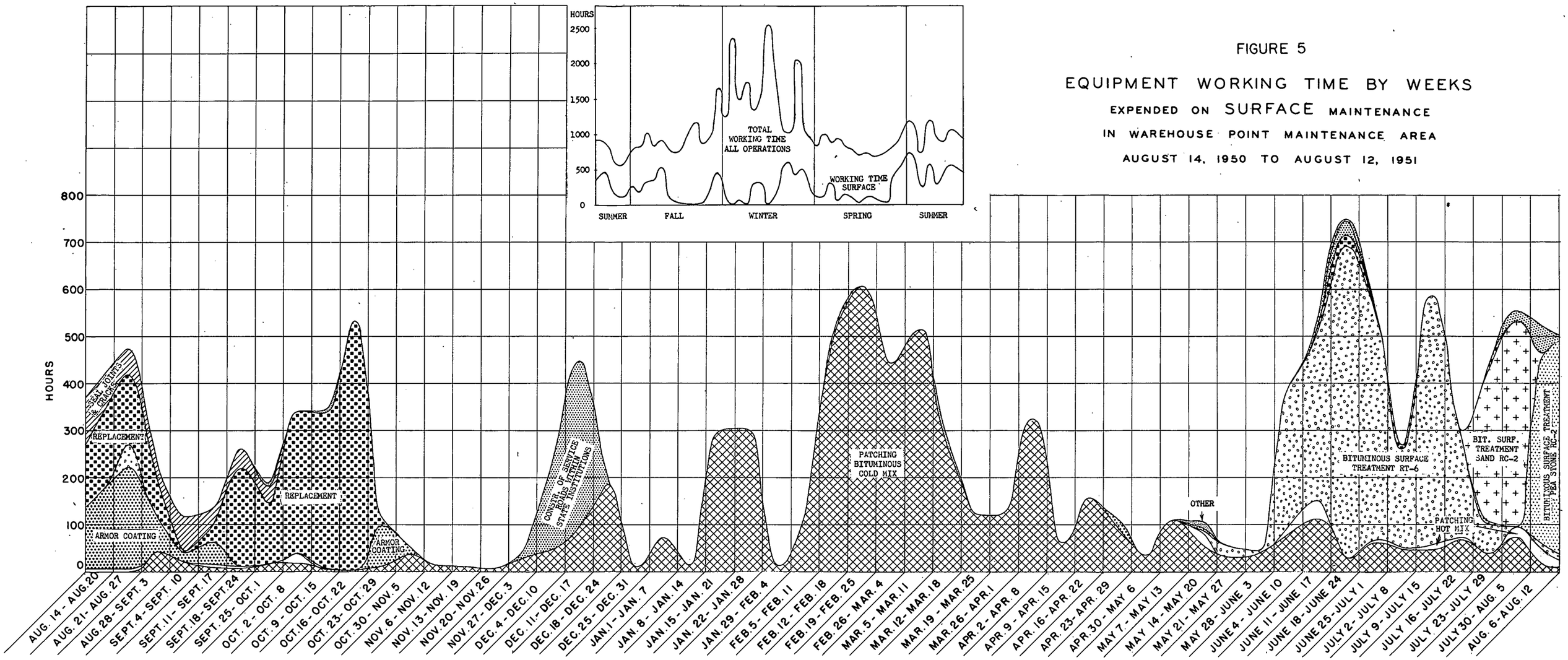
FIGURE 5

EQUIPMENT WORKING TIME BY WEEKS

EXPENDED ON SURFACE MAINTENANCE

IN WAREHOUSE POINT MAINTENANCE AREA

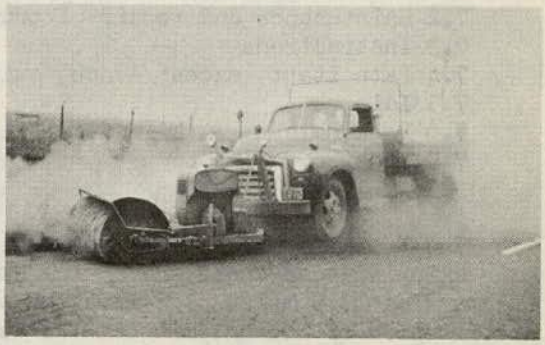
AUGUST 14, 1950 TO AUGUST 12, 1951



Item	Armor Coat	Sand-Tar Surface	Sand-Tar Shoulders	RC-2 Treatments
Miles of roadway treated	9.28	90.37	28.12	9.05
Square yards treated	131,499	1,432,014	179,075	67,974
Type of bituminous material	RS-2	RT-4,RT-6	RT-4,RT-6	RC-2
Gallons applied	35,432	211,003	35,745	12,267
Type of aggregate	½" crushed stone	screened sand	screened sand	sand and pea gravel
Tons applied	1848.75			40.55 (sand) 835.35 (gravel)
Cubic yards applied		6387	860	

A rotary power broom mounted on the front of a 3-ton dump truck was used to clean the surface to be treated. The broom was mounted on the hydraulic snow plow hoist so that it could be raised and lowered. A 4-cylinder air-cooled gasoline engine powered the broom by means of a direct chain drive. To operate the broom clutch or regulate the speed of the broom motor, it was necessary for the operator to dismount from the truck. The broom was 2.5' in diameter, by 5.4' long mounted at a fixed angle to give an effective sweeping width of 4.6'.

The broom was always parked at the garage for the night. When not mounted on the truck from the previous day's use, it had to be attached. This usually required less than ten minutes. In addition, the broom was usually greased and fueled at the garage before starting for the work site. Since the small fuel tank on the broom motor had an insufficient capacity to permit a full day's operation without refueling, it was necessary to take along an extra supply of fuel.



3. Power broom preparing surface for armor coating.

Before leaving the garage, the driver received his instructions on which routes to cover. He generally worked from one to three days ahead of the distributor; if dust collected again, the stretch was re-broomed prior to treatment.

The brooming procedure was as follows: The broom traveled ahead on the right-hand side of the road until an area requiring brooming was encountered; the broom was lowered and sweeping was continued as long as necessary. In most cases, the surface to be treated was sufficiently clean except next to the shoulder and usually only one pass was required on each side of the road. However, if a particularly dusty stretch was encountered more than one pass on a side was necessary. In that case the operator usually stopped and backed up to make another short pass, rather than make a second pass the entire length of the job.

The broom was greased and refueled usually at noon. The operator wore a dust mask and goggles while brooming.

During the 52-week period, the truck mounted power broom worked 225.7 hours on brooming the surface in preparation for surface treatments, 56.0 hours in preparation for armor coating, and 21.7 hours in preparation of shoulders for treatment. Detailed time studies covering a period of 53.7 hours gives the following time distribution.

Distribution of Equipment-Hours of Working Time of Power Broom

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Broom surface	39	
5.2 Travel between spots	8	
5.3 Back up for second pass	2	49
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	11	
6.3 Travel to new work site	12	
6.4 Minor moves, turns, and maneuvers	3	
6.5 Put out and pick up signs	1	27
7.0 Waits and delays		
7.1 Wait on other operations	2	
7.2 Maintenance of broom	3	
7.2 Broom repairs	3	
7.2 Maintenance and repair of truck	1	
7.3 Instructions	4	
7.4 Late start, excess lunch, quit early	5	
7.5 Idle	1	
7.6 Personal	2	
7.9 Other	3	24
Total		100

The truck-mounted power broom operated at a speed of 7.4 miles per hour skipping some spots and making extra passes on others for an accomplishment of 13.5 miles of 2-lane roadway per 9.0-hour day. The mileage distribution of the broom truck was as follows:

Item	Miles per day
To and from garage	20.7
To new work site	21.6
Minor moves, turns and maneuvers	0.4
Brooming	25.4
Deadheading	2.4
Other	0.1
Total	70.6 miles

A 1300-gallon distributor was used to apply the bituminous material. The distributor bar could be adjusted to spray any width up to 14'. This distributor was designed for a continual flow through the bar at constant pressure and had a valve at each nozzle. The valves were connected by bars attached at each nozzle with a pin. By disconnecting nozzles the width could be adjusted in increments of 8".

4. Distributor obtaining load of asphalt from ferry.

The outer 3 feet of the bar on each side was hinged for folding when traveling, thus reducing the vehicle width to the legal 8 feet.

One contract based on the low bid was let for all bitumen of each type used throughout the state and orders then placed against this contract as needed. The required bitumen was ordered from the vendor the afternoon preceding the day of intended use and a meeting place near the intended site specified. The vendor delivered the bitumen in semi-trailer combinations equipped with heating units, and having capacities from 3400 to 5400 gallons. Sometimes two of these units (termed "ferries") were emptied in a day. Hauling fees are paid on all bitumen not used so every effort was made to empty the ferry and frequently the distributor returned to the garage with a full load.

5. Distributor spraying 14-foot width.

One man with a squeegee frequently worked with the distributor spreading out the bitumen where it dripped from the spray bar at the end of a run.

During the 52-week period the distributor worked 26.4 hours on armor coating, 203.1 hours on surface treatment with tar, 32.4 hours on shoulder treatment, and 81.3 hours on experimental surface treatments using other bituminous materials.

Time studies covering a period of 126.5 hours give the time distribution shown on the following page.

Distribution of Equipment-Hours of Working Time of Distributor

Item	Armor Coat	Sand-Tar Surface	Sand-Tar Shoulders	RC-2 Sand	RC-2 Pea Gravel
5.0 Operating cycle items on assigned task					
5.1 Travel to load oil	3	1	2	-	-
5.1 Connect and disconnect hose	4	3	4	5	2
5.1 Load oil	11	14	15	11	5
5.2 Heat oil	7	-	-	-	7
5.3 Spray oil	6	16	26	14	7
5.4 Hand spray small areas	3	-	-	-	-
	34	34	47	30	21
6.0 Related items including travel and preparatory work					
6.1 Travel to and from garage	7	12	8	8	19
6.3 Travel to new work site	3	5	2	2	-
6.4 Minor moves, turns, and maneuvers	6	5	6	8	8
	16	22	16	18	27
7.0 Waits and delays					
7.1 Wait for ferry	-	1	-*	3	-
7.1 Wait for spreader	22	30	22	28	39
7.1 Wait on other operations	9	2	4	5	2
7.2 Adjust spraybar	4	2	3	5	2
7.2 Truck and distributor maintenance	7	1	1	1	1
7.3 Instructions	3	3	3	4	3
7.4 Late start, excess lunch, quit early	2	2	1	5	2
7.6 Personal	1	-*	-*	-	-
7.9 Other	2	3	3	1	3
	50	44	37	52	52
Total	100	100	100	100	100
Hours of study represented	26.0	46.7	24.8	19.0	10.0

*Less than 1/2 of 1%

The average daily mileage driven by the distributor on these assignments is shown in the following table.

Item	Armor Coat	Sand Tar Surface	Sand Tar Shoulders	RC-2 Sand	RC-2 Pea Gravel
To and from garage	11.5	28.3	17.7	15.3	45.0
To new work site	4.0	10.2	4.8	4.0	-
To load oil	2.0	0.8	0.2	-	-
Spreading oil	2.2	9.0	12.4	6.9	3.1
Minor moves, turns and maneuvers	1.6	0.8	2.2	2.7	2.6
Other	-	-	-	0.6	0.5
	21.3	49.1	37.3	29.5	51.2

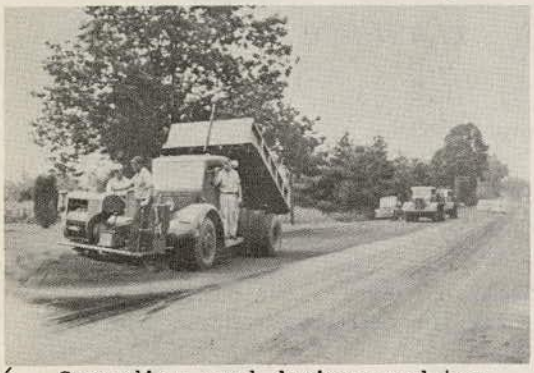
During the study period, the productive rates of the distributor were observed to vary with the application rate for the treatment. Observed application and production rates are shown.

Productive Rates of Distributor on Various Oil Treatments

	Hand Spraying Armor Coat	Armor Coat	Sand Tar Surface	Sand Tar Shoulders	RC-2 Sand	RC-2 Pea Gravel
Observed application rate (gal./sq. yd.)	0.61	0.30	0.13	0.20	0.15	0.20
Spraying rate (gal./hour)	261	8,392	7,435	4,502	6,178	6,468
(sq. yd./hour)	431	28,145	55,747	22,433	40,000	32,461
(lane miles/hour)		4.05	3.31	5.77	5.41	4.61
Accomplishment rate, 2-lane rd. (miles/day)		1.15	2.33	6.80	3.26	1.42

FRONT END SPREADER

The front end spreader consisted of a rotary centrifugal sand spreader mounted integrally at the discharge end of a self-powered belt conveyor unit. The unit was of such length and so constructed that it could be



6. Spreading sand during sand-tar surface treatment; train of sand trucks following. Sand is carried from truck body by under-body belt conveyor to the front end spreader.

7. Spreading sand during shoulder treatment, shoulder shield not being used.

suspended underneath a sand truck with the loading end of the conveyor at the back of the truck under the tailgate and with the centrifugal spreader extending in front of the truck. As the truck moves forward, the material to be spread was supplied from the rear of the truck onto the conveyor belt which ran under the truck to the centrifugal unit where it was spread in front of the front wheels of the truck. A four-cylinder air-cooled gasoline engine powered the rotor and conveyor belt.

8. Spreading crushed stone during armor coating; note gauge boards in use.

9. Rear view of spreader on armor coating showing size of spreader crew. In addition to the truck driver the crew consists of four men: the spreader operator and three men controlling flow of aggregate. A flagman, a man brooming to insure uniform cover and a foreman are also visible.

There were two attachments for the spreader; (1) a metal shield covering two-thirds of the circumference of the spinner for confining the spread while treating shoulders; (2) a set of gauge boards for confining the spread of gravel or crushed stone (material that bounces when it hits the road) during armor coating and similar treatments.

10. Front end spreader awaiting truck load of aggregate; distributor and Warehouse Point garage in background.

The following cycle of operations were involved in the use of this spreader. A truck drove onto the spreader, straddling the conveyor belt. At the front, chains from the two jacking arms at the front of the spreader frame were hooked into slots cut in the front bumper of the truck. A hand-operated hydraulic pump mounted near the operator's platform operated the jacks raising the spreader at the front of the truck. Simultaneously, at the rear of the truck, a wooden bar was placed under the spreader frame to raise the spreader while it was attached to the truck by means of a pair of tongs. Then a detachable funnel-shaped steel hopper was placed on the spreader frame under the tailgate. Two men with shovels climbed onto the truck to control the flow of aggregate. A third man at the rear signaled the driver to open the tailgate and raise the bed of the truck.

Two boards were fastened in each corner at the rear of the body to channel the flow of material into the hopper. When the hopper was full the operator was signaled to start the belt. The conveyor was operated until the aggregate was at the rotor. The driver started ahead and spreading was started at the edge of the fresh oil.

During spreading the operator on the platform in the front directed the driver as to lateral position and speed. The width of spread was controlled by the spinner speed and the depth or application rate by the conveyor belt speed and the truck speed after the width was established. As spreading proceeded the driver was signaled to raise the body higher from time to time until empty whereupon he was signaled to lower it. Spreading continued until all sand was off the belt. Then the truck stopped and backed up about 15 feet where the spreader was unhooked. The truck backed off, the next truck drove on and the cycle was repeated.

11. Loaded truck driving onto spreader.

The check valves and pistons on the hydraulic jacks used to raise the front end of the spreader sometimes leaked, particularly on bumpy roads, allowing the spreader to settle.

12. Operator jacking up front end during attaching of spreader to truck.

13. Attaching spreader at rear of truck.

If this was not noticed in time by the operator the spreader frame dragged causing a furrow in the freshly oiled surface. Poor spreads sometimes occurred on high crowns or on superelevated curves.

When there were several days' work in one area the spreader was parked at the roadside for the night. At other times it was returned to the garage mounted on the last truck to dump. In the morning at the parking site or garage the operator first refueled and greased the machine. On long moves, between work sites and to and from the garage, extra chains were used, both front and rear, to secure the spreader in case the jack leaked or the tongs slipped.

During the 52-week period the front end spreader was used for 27.1 hours on armor coating, 220.8 hours on sand-tar surface treatment, 24.3 hours on sand-tar shoulder treatment, and 73.9 hours on other treatments.

Time studies covering a period of 101.9 hours give the following distribution:

Distribution of Equipment-Hours of Working Time of Front End Spreader

Item	Armor Coat	Sand-Tar Surface	Sand-Tar Shoulders	RC-2 Sand	RC-2 Pea Gravel
5.0 Operating cycle items on assigned task					
5.1 Attach spreader	9	12	11	13	13
5.2 Spread	27	31	34	35	32
5.4 Detach spreader	4	3	4	5	2
5.5 Exchange trucks	5	6	5	7	8
	45	52	54	60	55

Item	Armor Coat	Sand-Tar Surface	Sand-Tar Shoulders	RC-2 Sand	RC-2 Pea Gravel
6.0 Related items including travel and preparatory work					
6.1 Travel to and from garage or overnight parking area	5	7	6	2	6
6.3 Travel to new work site	5	8	3	4	-
6.4 Minor moves, turns, and maneuvers	4	7	6	5	5
6.9 Dusting or spotting	4	-	-	1	2
	18	22	15	12	13
7.0 Waits and delays					
7.1 Hauling unit shortage	6	1	6	5	-
7.1 Wait on distributor	15	9	8	11	14
7.2 Secure for traveling	2	1	1	2	1
7.2 Spreader attachments	5	-*	-*	-	1
7.2 Repair and maintenance of spreader	3	5	8	2	3
7.3 Instructions	1	1	1	1	2
7.4 Start late, excess lunch, quit early	1	4	3	5	2
7.6 Personal	1	2	1	1	-*
7.9 Other	3	3	3	1	9
	37	26	31	28	32
Total	100	100	100	100	100
Hours of study represented	21.4	32.6	23.0	15.8	9.1

The observed application and production rates of the spreader are shown in the following table.

Item	Armor Coat	Sand-Tar Surface	Sand-Tar Shoulders	RC-2 Sand	RC-2 Pea Gravel
Observed application rate (lb./sq.yd.)	36.8	7.9	12.3	14.3	28.5
Spreading rate (sq. yd./hr.)	7,110	26,084	17,353	17,060	9,843
(lane miles/hr.)	1.01	1.73	4.65	1.19	1.40
Accomplishment rate, 2-lane road (miles/day)	1.25	2.44	7.16	1.89	2.00

* Less than 1/2 of 1%

14. Attaching hopper to spreader.

15. Side view of truck and spreader showing flow of material from dump body into hopper under truck via conveyor belt to spinner at front where material is spread on road.

HAULING UNITS

The trucks used for hauling aggregate were 7-ton dump trucks having a body capacity of 4.8 cubic yards when struck off level with the side boards, and after deducting the volume excluded by the corner boards. Safety rails, made of 3/4" pipe, were set on each side of the body near the back to prevent men from falling off while controlling the flow of sand into the spreader hopper. The snow plow underframe and front hoist unit were removed during the summer so that they would not be in the way when driving onto the spreader and for reconditioning. Two pieces of 2-inch angle iron were welded to the chassis adjacent to the front bumper, one on each side. A slot was cut in each wide enough to accomodate a link of the spreader jacking chain.

The trucks were parked in the garage overnight. If they were hauling for the spreader the day before some of them were usually loaded. The loaded trucks went directly to the job site. The empty trucks either took men to the job site and then traveled tothe loading site, or they went directly to the loading site.

At the job site the loaded trucks followed the spreader in a train. When the truck ahead was empty and backed off the spreader the next truck drove on and proceeded as described previously in the discussion of the spreader. After spreading, the trucks returned to the loading site where they awaited their turn to be loaded.

During the studies, the coarse sand was hauled from a State-owned pit. A rented shovel with 1/2 cubic yard capacity bucket was used to feed two 18-inch belt loaders, thus enabling two trucks to be loaded simultaneously, one by each belt loader. A 1-inch screen was placed under the discharge end of the loaders at an angle so that the oversize material was discarded on the ground at one side of the truck.

Upon arrival at the pit the driver maneuvered his truck into waiting position or maneuvered and backed under one of the belt loaders if there

were no trucks ahead. A short steep one-way road was used at both entrance and exit. Although the trucks had no trouble driving up out of the pit, there was room for only two or three trucks to wait in the pit ready to back under the loader. The trucks would first wait outside the pit and then back down into it and wait again when there was room. When a truck stalled or broke down while hauling up out of the pit a delay was caused to other hauling units. While waiting the driver usually removed the safety rails so that they would not hit the oversize screen when backing under the loader. During loading the driver usually moved the truck forward or back several times so that the load would be evenly distributed. Sometimes the driver climbed into the back of the truck with a shovel to distribute the load into the corners; and to prevent the screen from being clogged by clods, by small oversize gravel which stick in the mesh if not knocked loose, or by an overload of damp sand. After loading the driver would move up to where he had left the safety rails, replace them, and then start the haul.

The trucks were loaded with 5 cubic yards of sand in an average of 9.3 minutes by the belt loaders. The loaders usually ran empty part of the time because the shovel could not meet the capacity of both loaders.

Pea stone was loaded by front end loader in a commercial pit. This machine loaded an average of 5.2 cubic yards in an average of 2.5 minutes and no time was required for exchange. The waiting truck backed up to the pile beside the truck being loaded. When the loaded truck moved out the next truck was already in position to be loaded.

Crushed stone was loaded in a commercial quarry either directly from bins or from a stockpile by a power shovel.

During the study period, 16 trucks hauled aggregate for surface treatment operations a total of 3022 hours. The time distribution in accordance with detailed studies is shown in the table which follows.

Distribution of Equipment-Hours of Working Time of Hauling Units

Item	Armor Coat	Sand-Tar Surface	Sand-Tar Shoulders	RC-2 Sand	RC-2 Pea Gravel
5.0 Operating cycle items on assigned task					
5.1 Load	3	5	6	7	3
5.1 Weigh, maneuvers, etc. at pit	3	5	5	3	5
5.2 Haul to work site	22	17	17	26	9
5.3 Attach and detach spreader	1	2	2	2	3
5.3 Spread	2	4	5	3	3
5.4 Return to pit	18	18	13	23	9
	49	51	48	64	32

Item	Armor Coat	Sand-Tar Surface	Sand-Tar Shoulders	RC-2 Sand	RC-2 Pea Gravel
6.0 Related items including travel and preparatory work					
6.1 Travel to and from garage	13	12	15	11	4
6.3 Travel to new work site	-	2	1	1	-
6.4 Minor moves, turns, and maneuvers	3	4	2	1	3
6.6 Load and unload men and tools	1	2	1	-*	-
6.9 Spotting and miscellaneous work	5	1	-*	1	-
	22	21	19	14	7
7.0 Waits and delays					
7.1 Waits at pit	4	3	3	3	6
7.1 Wait on spreader, moving	3	6	6	4	11
7.1 Wait on spreader, stopped	4	6	11	6	36
7.1 Wait on other operations	6	2	3	1	3
7.2 Repair of front end spreader	-	-*	1	1	-
7.2 Repair and maintenance of truck	1	3	2	1	-
7.3 Instructions	2	1	1	1	1
7.4 Start late, excess lunch, quit early	2	2	3	2	-
7.6 Personal	3	2	1	2	-*
7.9 Other	4	3	2	1	4
	29	28	33	22	61
Total	100	100	100	100	100
Hours of study represented	60.7	93.2	97.4	55.1	7.1

The observed production rates of the trucks hauling aggregate and the accomplishment in 9.0 hours of working time is shown in the following table.

Kind of treatment	No. of loads hauled per day	Tons hauled per 9.0-hour day
Armor coat	3.1	21.7
Sand-tar on surface	5.5	36.6
Sand-tar on shoulders	4.0	21.8
RC-2 and sand	4.3	27.5
RC-2 and pea gravel	6.3	39.5

The average haul speed was observed to be 26.3 mph and the return speed 28.4 mph.

*Less than 1/2 of 1%

The average mileage driven per day by trucks on these assignments was as follows:

Daily Mileage Traveled by Hauling Units
on Various Surface Treatments

Item	Armor Coat	Sand-Tar Surface	Sand-Tar Shoulders	RC-2 Sand	RC-2 Pea Gravel
To and from garage	29.8	25.1	30.5	26.0	6.1
To new work site	-	4.5	1.5	1.1	-
Minor moves, turns and maneuvers	3.0	0.6	0.2	0.1	0.4
Maneuvers at pit	0.3	0.7	1.1	1.5	2.3
Haul to work site	52.2	35.4	39.1	66.1	13.0
Return to pit	45.2	40.3	33.9	63.0	16.8
Follow spreader, waiting turn	0.9	2.3	3.9	1.9	3.1
Spreading	0.3	1.8	1.9	0.6	0.5
Other	0.8	2.9	1.7	0.6	-
Total	132.5	113.6	113.8	160.9	42.2

SPOTTING BY HAND FOLLOWING SPREADER

(Used on Asphalt Treatments)

The spotting truck followed spreading operations on asphalt treatment work to provide additional aggregate for spots missed or where asphalt was bleeding up through the cover stone or sand. As no honing was done on this type of treatment, one of the trucks usually used with the hone was assigned to spotting. This 7-ton dump truck was equipped with a snow plow underframe for the hone which made it impossible to use with the front end spreader.

Upon arrival at the job site in the morning, the spotting truck with the driver and one laborer traveled the length of the section to be oiled placing "Men Working" and "Fresh Oil" signs at intersections, sharp curves, and at each end. Sometimes, but not always, the driver was given special instructions about particular danger points requiring signs.

On some occasions the truck had all or part of a load of aggregate from the previous day's operations, while at other times it arrived empty. When the truck was already loaded, it usually had to wait upon oiling, spreading, and hand brooming operations, which normally preceded the spotting. If the truck was empty, it proceeded to the sand pit or quarry immediately after returning the laborer to his regular crew, usually hand brooming.

At the pit the spotting truck was loaded in regular order following the trucks hauling for the spreader which had arrived ahead. The spotting truck used the same material that was being spread by the other trucks.

Upon return to the job site a laborer was again assigned to the truck. This assignment was considered easy and usually one of the older men was assigned to spotting. If oiling and spreading operations had already advanced some distance, the spotting truck started at the beginning of the job and followed the route of the distributor, spotting where required. If oiling and spreading operations were not underway, or had not proceeded far enough for the train of hauling units following the spreader to be out of the way, the spotting truck parked at the side of the road and waited.

The spotting truck usually followed the hand brooming crew. However, whenever an area was encountered with insufficient material to blot excess asphalt, the spotting truck moved ahead of the brooming crew and the laborer shoveled off the necessary material.

Areas requiring spotting were the result of insufficient aggregate caused by irregular distribution by the front end spreader, by excess oil, particularly where the distributor stopped to wait for the spreader and then started up again, by traffic at intersections, and by hauling units turning around on the fresh surface.

The spotting truck traveled in first gear on hills and where heavy spotting was required. At other times the truck traveled in second gear with the motor idling. The laborer watched ahead for places requiring spotting, and as the truck passed over the area, he cast a small shovelful with a wide sweeping motion to cover the area evenly with a thin layer of aggregate.

When no spotting was required, the truck soon caught up to spreading operations and after stopping and waiting for the hauling units to get several hundred feet ahead, again proceeded ahead spotting as required.

When changing trucks at the spreader, small piles of sand or gravel were sometimes spilled. When such piles were encountered, the driver stopped the spotting truck, dismounted with a shovel, and spread the pile covering any oily spots. When the spreader was not kept tightly jacked up to the truck, it sometimes dragged on the surface and left an oily streak where the gravel had been pushed aside. The driver stopped the spotting truck at these spots and swept sand or gravel over the streak with a hand broom.

On some surfacing operations, two distributors and two front end spreaders were used traveling in the same direction, one several hundred feet behind the other. When the entire width of roadway was covered using this proceedure, the spotting truck traveled along the center of the roadway spreading sand or gravel in either lane where required. On normal surfacing operations using only one distributor, the spotting truck followed the same route as the distributor and spotted one lane at a time. The spotting truck never had difficulty keeping pace with the operations ahead, even when two distributors and spreaders were in use. At the end of the day, the spotting truck was dispatched to pick up the signs. If any additional spotting was required, one of the trucks hauling sand to the spreader was used. Since the spotting truck could easily keep pace with the oiling and spreading operations, it was occasionally used for other purposes such as carrying messages from one part of the job to another, and for transporting the hand brooming crew to a new working site when necessary.

During the 52-week study period, 3 trucks were used for 39.5 hours on armor coating and 101.0 hours on surface treatment for spotting. The distribution of time in accordance with detailed studies is as follows:

Distribution of Equipment-Hours of Working Time
of Spotting Truck

Item	Armor Coat	RC-2 Sand	RC-2 Pea Gravel
5.0 Operating cycle items on assigned task			
5.1 Spot spreading, moving	18	25	21
5.1 Spot spreading, stopped	3	1	1
5.2 Travel between spots	1	7	4
	22	33	26
6.0 Related items including travel and preparatory work			
6.1 Travel to and from garage	14	9	14
6.2 Haul to work site	10	6	2
6.2 Return to pit	5	5	-
6.3 Travel to new work site	4	1	-
6.4 Minor moves, turns, and maneuvers	2	3	3
6.4 Maneuvers, weigh, etc., at pit	1	2	2
6.5 Put out and pick up signs	2	11	6

Item	Armor Coat	RC-2 Sand	RC-2 Pea Gravel
6.6 Load and unload men and tools	1	1	3
6.6 Load aggregate	1	1	-*
6.9 Miscellaneous work	1	-*	9
	41	39	39
7.0 Waits and delays			
7.1 Standby, parked on job	1	2	-
7.1 Wait on other operations	24	12	26
7.1 Waits at pit	-*	2	1
7.2 Adjust tailgate	1	-*	1
7.2 Maintenance and repair of truck	-*	1	1
7.3 Instructions	2	2	4
7.4 Start late, excess lunch, quit early	4	5	-
7.6 Personal	3	2	-
7.9 Other	2	2	2
	37	28	35
Total	100	100	100
Hours of study represented	13.5	21.1	4.9

The observed productive rates and accomplishment of the spotting truck on the various treatments were as follows:

Item	Productive Rate (lane miles/hour)	Accomplishment (miles of road/day)
Armor coat	0.88	1.60
RC-2 and sand	1.57	3.57
RC-2 and pea gravel	1.53	2.29

The distribution of the average daily mileage was as follows:

Distribution of Daily Mileage of Spotting Truck on Various Surface Treatments

Item	Armor Coat	RC-2 Sand	RC-2 Pea Gravel
To and from garage	23.5	19.4	41.6
To new work site	5.4	0.5	-
To put out and pick up signs	1.0	11.7	9.4
Minor moves, turns, and maneuvers	0.7	0.8	1.4
Maneuvers at pit or quarry	-	0.7	0.9
Haul to work site	17.5	12.1	4.7
Return to pit	10.0	9.9	-
Spot spreading	2.4	3.9	2.4
Deadheading between spots	0.4	2.8	2.6
Total	60.9	61.8	63.0

* Less than 1/2 of 1%

Two hones working as a team were used for mixing the sand-tar treatment. A hone was a multiple blade drag frame mounted on the snow plow underframe on the front of a 7-ton dump truck. The underframes were left on the two trucks so used all summer and enabled the multiple blade drag to be raised and lowered quite readily.

16. Hone (a front mounted multi-blade drag) in use on shoulder treatment work, first pass. This hone is attached to the regular snow plow head frame with the hydraulic hoist for raising or lowering the hone.

The hones were fabricated in the shops of the Connecticut Highway Department. They were 10 to 11 feet long and 6 feet wide with three 6.0 foot steel blades. The cutting edges were scrap pieces from snow plow and patrol grader blades cut to the required size. On the oldest of three hones available, the blades were fixed in position while on the others they were adjustable. On the second hone, the blades were pivoted at the center longitudinal frame member and adjustable 20 degrees either way by hand operated hydraulic jacks. On the newest hone, the blades were pivoted at the center longitudinal frame member and adjustable in increments up to 30 degrees in either direction. The ends of the blades were supported against pins set in sockets spaced along the longitudinal side members. All three hones had a circular arc at the point of attachment to the truck, similar to a reversible snow plow, at which point the angle of the entire unit could be adjusted. This was the only way in which the oldest hone could be adjusted.

Two hone trucks were used on surface treatment of shoulders and roadway working together as a team. At the job site they would wait until a stretch of road was completely oiled and sanded. When a mile or more of road was finished and all other equipment was out of the way, the hone trucks would start working the material. The pattern of operation was varied depending on the condition of the road. If there was a high crown and the pavement was raveling at the shoulders, the hones would work the material from the center toward the sides. If there were extensive patches and irregularities on the traveled roadway, the material was worked into these areas. The hones usually made eight passes each on a two-lane road.

On shoulder surfacing the two hones worked as a team, one making two passes, the other three on each shoulder. The first pass pushed material toward the center of the road and the last pass pushed it toward the shoulder.

The hones had to wait in the morning for other operations and were therefore used to put out signs. The cutting edges of the blades were generally changed at this time also.

During the 52-week study period, 2 trucks worked 361.4 hours on surface treatment and 53.6 hours on shoulder treatment. The distribution of this time in accordance with 78.3 hours of detailed study on surface and 25.0 hours while working on shoulders is as follows:

Distribution of Equipment-Hours of Working Time
of Hone Trucks

Item	Percent Surface	Percent Shoulders
5.0 Operating cycle items on assigned task		
5.1 Honing	27	29
5.2 Raise and lower hones	1	1
5.2 Deadheading	2	3
5.2 Maneuvers and turns	9	8
5.3 Adjust angle of blades	5	2
	44	43
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	18	9
6.3 Travel to new work site	5	7
6.5 Travel to put out and pick up signs	3	6
6.5 Put out and pick up signs	2	3
6.6 Load and unload men and tools	1	-*
	29	25
7.0 Waits and delays		
7.1 Standby, parked on job	1	1
7.1 Wait on other operations	13	21
7.2 Attach and detach hone	2	1
7.2 Maintenance and repair of truck & hone	1	1
7.3 Instructions	3	4
7.4 Late start, excess lunch, quit early	1	2
7.6 Personal	1	-*
7.9 Other	5	2
	27	32
Total	100	100

The hones operated at a speed of 12.4 mph on the surface; on shoulders the speed was somewhat slower, 8.9 miles per hour, largely due to increased hazard of driving closer to roadside obstacles. The hones, working together, made between 6 and 16 passes with an average of 14.9 passes on a section of roadway. The observed honing rates were 0.51 miles of 26 ft. roadway surface per hour and 1.35 lane miles of shoulder (one side) per hour. The accomplishment in 9.0 working hours was 2.05 miles of roadway surface per day or 2.61 miles of roadway shoulders (both sides) per day.

The average daily mileage driven by a truck used as a hone was as shown on the following table.

* Less than 1/2 of 1%

Distribution of Daily Mileage of Trucks
Used on Honing Operations

Item	Percent Surface	Percent Shoulders
To and from garage	40.6	18.9
To new work site	8.2	10.2
To put out and pick up signs	3.3	9.1
Minor moves, turns and maneuvers	3.1	3.0
Honing	29.6	21.0
Deadheading	1.6	4.1
Other	0.4	-
Total	86.3	66.3

Dusting Following Hone Using Sand Spreaders

Following honing operations the road was lightly dusted with sand to prevent the freshly oiled surface from picking up on the tires of vehicles. Two trucks were used for dusting: one was a four-wheel drive having a struck capacity of 5.8 cubic yards and equipped with a paddle-type spreader; the other was a four-wheel drive truck having a struck capacity of 6.8 cubic yards and equipped with a centrifugal-type spreader. Aside from dusting of oiled surfaces, these trucks were used only for snow and ice control.

The paddle-type spreader was mounted at the rear of the body after the tailgate had been removed. It was powered by a hydraulic motor connected to the truck hydraulic system. A horizontal shaft extended the width of the truck at the back. To this shaft paddle-like blades were attached. A hydraulically operated gate controlled the flow of sand onto these rotating paddles when the body was raised. When the sand struck these blades, it was scattered evenly over the road behind the truck. By adjusting the gate opening and varying the forward speed of the truck, the amount of sand spread per square yard was controlled.

The centrifugal-type spreader was powered by a two-cylinder air cooled gasoline engine. The body had a hopper-type bottom with a steel conveyor belt to carry the material to the rotor at the rear. An adjustable gate at the rear of the body controlled the rate of feed. The thickness of material spread on the road was controlled by adjusting the gate, varying the speed of the two-cylinder motor and by varying the forward speed of the truck.

Following the honing operation, one of the sand spreaders would travel over the road spreading a thin layer of sand. The paddle-type spreader did most of the shoulder dusting because the width dusted could be more easily controlled with this machine.

During the 52-week study period, the centrifugal-type spreader worked 125.0 hours dusting surfaces and the paddle-type spreader worked 132.4 hours dusting surfaces and 9.1 hours dusting shoulders. The distribution of this time in accordance with detailed studies is shown in the following table.

Distribution of Equipment-Hours of Working Time
of Mechanical Spreaders While Dusting
Surface Treated Roads

Item	Centrifugal-type on surface	Paddle-type on Surface	Paddle-type on Shoulders
5.0 Operating cycle items on assigned work			
5.1 Load	8	4	3
5.1 Maneuvers at pit	5	5	7
5.2 Haul to work site	20	20	25
5.3 Spread	8	5	8
5.3 Deadhead	2	-*	6
5.4 Return to pit	14	13	16
	57	47	65
6.0 Related items including travel and preparatory work			
6.1 Travel to and from garage	11	15	15
6.3 Travel to new work site	6	5	-
6.4 Minor moves, turns, and maneuvers	2	4	3
6.9 Miscellaneous work	-	2	-
	19	26	18
7.0 Waits and delays			
7.1 Wait on other operations	13	14	2
7.1 Waits at pit	4	4	7
7.2 Maintenance of truck	1	1	2
7.3 Instructions	1	2	2
7.4 Start late, excess lunch, quit early	2	3	-*
7.6 Personal	2	2	3
7.9 Other	1	1	1
	24	27	17
Total	100	100	100
Hours of study represented	23.1	42.0	10.3

The centrifugal-type spreader operated at a speed of 10.2 mph while dusting a 20-foot width at 1.0 lb. per square yard. The spreading rate was observed to be 1.38 miles per hour and the accomplishment 7.32 miles per 9.0 hours of working time.

The paddle-type spreader operated at a speed of 16.9 mph while dusting a 20-foot width at 1.3 lb. per square yard. The observed spreading rate was 1.74 miles per hour and the accomplishment 8.11 miles per 9.0 hours of working time. While dusting shoulders of various widths at 1.6 lb. per square yard, the paddle-type spreader operated at a speed of 19.7 mph. The productive rate was observed to be 2.28 shoulder miles per hour and the accomplishment 7.04 miles of roadway per day.

*Less than 1/2 of 1%

The average daily mileage of these vehicles while engaged in this work is shown in the following table.

Mileage Distribution of Mechanical Spreader While Dusting

Item	Centrifugal-type on surface	Paddle-type on Surface	Paddle-type on Shoulders
To and from garage	22.6	34.3	27.4
To new work site	8.3	6.0	-
Minor moves, turns, and maneuvers	-	0.3	0.2
Maneuvers at pit	1.3	0.9	0.6
Haul to work site	37.9	36.7	29.6
Return to pit	27.4	29.1	23.4
Spread - dusting	6.3	7.6	8.1
Deadhead	2.7	-	4.9
Other	-	0.2	-
Total	106.5	115.1	94.3

ROLLER (Used on Armor Coating Only)

The roller was used on armor coating operations to compact and press the crushed stone into the asphalt. It was a 5-6 ton three-wheel roller powered by a six-cylinder gasoline engine.

17. Hand brooming crew on armor coating operations.

18. Roller in use on armor coating operations.

A low bed semi-trailer was used to transport the roller on long moves between job sites. Short moves were made by running the roller along the road. The roller was parked overnight at locations where operations were to be continued the next day.

In the morning the roller waited for preceding operations to get under way. During this time, the operator refueled, checked the oil, warmed up the engine, and performed any necessary minor maintenance. If crushed stone had not yet been spread when the roller was warmed, it was maneuvered to a position near the beginning of the job and parked there while continuing to wait. When stone had been spread the roller maneuvered onto the pavement of the road and started rolling.

In normal operations, one distributor and one spreader were used and one lane of the road was treated at a time. During the summer of 1951, however, two distributors and two spreaders were used and the entire pavement width was surfaced with a single pass. The effective rolling width of the roller was 5.65 feet so that in rolling a 14-foot single lane, a minimum of three passes was required to cover the entire area; while five passes were required to cover the 28-foot wide double lane. In either case the operator waited until spreading had proceeded approximately 200 feet and then started rolling forward following the spreader. When the roller started on a new section, it made its first pass on the outside edge; then it was maneuvered to overlap the first pass, reversed, and moved back to the starting point. This procedure was continued until the entire width was covered. The last pass was continued forward into a new section and the entire operation was repeated.

During the 52-week study period, the roller worked 21.1 hours on this operation. The distribution of this time in accordance with 21.1 hours of detailed study is shown in the following table.

Distribution of Equipment-Hours of Working Time of Roller

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Rolling, forward	24	
5.1 Rolling, reverse	18	
5.2 Re-rolling, forward	5	
5.2 Re-rolling, reverse	5	52
6.0 Related items including travel and preparatory work		
6.1 Travel to and from overnight parking area	2	
6.3 Travel to new work site	3	
6.4 Minor moves, turns, and maneuvers	2	
6.6 Loading and unloading roller on transport	1	8
7.0 Waits and delays		
7.1 Awaiting travel of operator to and from garage	4	
7.1 Wait for operations to start, A.M.	4	
7.1 Wait on other operations ahead	22	
7.1 Wait for spot spreading	2	
7.2 Maintenance of roller	3	
7.3 Instructions	2	
7.6 Personal	1	
7.9 Other	2	40
Total		100

The roller was operated in high gear with the throttle wide open giving a maximum speed of 4.2 mph. The observed operating speeds were 3.9 mph forward and 3.7 mph in reverse. The observed accomplishment was 2.52 miles per day in 1951.

Traffic was allowed to use the lane not being worked on. When one side of the road was complete, it was immediately opened to traffic which was cautioned by signs not to travel faster than 20 mph over the loose stone.

After public traffic had traveled over the surface for a week or 10 days, a crew of three men was sent out with a truck to sweep and pick up all loose stone which had gradually worked to the side of the road. If the accumulation of loose stone was heavy, a truck with a front end scoop-loader was used to salvage this material.

SEALING CRACKS AND JOINTS WITH ASPHALT

The crew first traveled to the stockyard for the kettle and asphalt. There the 55-gallon drums of poured expansion joint filler (asphalt cement) were split open with an axe. The solidified asphalt cement was cut up into chunks and placed into the asphalt kettle. The kettle burner was fueled up with kerosene oil and the heater was lit. A fire extinguisher was always kept handy while the kettle was being heated. While the temperature was being raised to 350 degrees, some of the crew continued breaking and loading asphalt. Others loaded sand and crushed stone onto the truck. Extra asphalt was also loaded onto the truck. Then the pouring cones were cleaned by building a fire and melting the clinging asphalt.

After the asphalt came close to 350 degrees, the heater flame was extinguished. The kettle was then towed behind the truck to the work site. There the kettle again was ordinarily reheated to the proper pouring temperature, namely 350 degrees F. and then the flame was either extinguished or lowered considerably. Thereupon the crew began its work.

Two conemen filled their cones from the kettle and started pouring the asphalt cement into cracks and joints. Two men followed them with buckets and covered the fresh asphalt with sand to protect the joint filler against being picked up by traffic. When a hole was deep, the crushed stone usually was sprinkled into the hole by either the sandman or the coneman.

19. Maintainer sealing pavement joint with asphaltic material; note rubber gloves, goggles, and pouring cone.

During the joint filling operation, the kettle was tended by an additional man or by one of the conemen. He checked the temperature and adjusted the flame. Sometimes a bucket was carried in back of the kettle and a fire was built therein to heat up the cones for cleaning purposes.

20. Crack and joint sealing crew, two conemen, one sander, and flagman, kettle in foreground being pulled by truck; truck driver and crew leader not visible in this view.

Besides the conemen, sandmen and kettle tender, the crew also had a truck driver, a flagman and a crew leader. Normally the crew followed behind the truck and worked one side of the road at a time in the direction of traffic. When road conditions warranted an additional flagman, the crew leader acted in that capacity.

Detailed stop-watch studies have been conducted on crack and joint sealing operations covering a total of 164.3 man-hours, during which the working crew consisted of a truck driver, 2 conemen, and 1 to 2 sandmen. A crew leader supervised the operations, but the following data do not include the crew leader's time nor the flagman's.

Distribution of Man-Hours of Working Time on Sealing Cracks and Joints

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Cleaning, heating, loading cones	2	
1.2 Sealing, pouring asphalt	6	
1.2 Sealing, spreading sand	5	
1.3 Walking ahead to next crack or joint	12	
1.4 Maneuvering, checking and keeping kettle in operation	4	
1.5 Move kettle ahead while sealing	4	33
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	7	
2.3 Travel to new work site	10	
2.4 Minor moves, turns, and maneuvers	3	
2.5 Put out and pick up signs	3	
2.6 Load and unload men, materials, and equipment	3	26
3.0 Waits and delays		
3.1 Wait for arrival of truck	2	
3.1 Waits for kettle to heat	25	
3.1 Wait while others work	4	
3.1 Wait on other operations	2	
3.2 Maintenance and repair of tools and equipment	1	
3.3 Awaiting and receiving instructions	1	
3.4 Excess lunch and quit early	1	
3.6 Personal	2	
3.9 Other	3	41
Total		100

During the 164.3 man-hours of study a total of 361 gallons of asphalt was used to seal cracks on 6.43 miles of 2-lane (12 ft. lanes or total width of 24 ft.) concrete pavement. The asphalt was applied at the rate of 36.6 gallons per man-hour of actual pouring time. During this study 535 cracks with an average length of 4.5 feet were sealed per mile of two-lane 24-foot, concrete pavement. The rate of application of asphalt in this instance was 3.3 gallons per 100 feet of crack.

Under the observed conditions, a five-man crew (excluding the crew leader and flagmen) working a 9-hour day would apply 99 gallons of asphalt in the sealing of approximately 3,000 lineal feet of cracks and joints.

During the 52-week period 7 of the trucks were employed at various times for a total of 349 hours on crack and joint sealing. Detailed studies covering a period of 36.4 hours give the following time distribution.

Distribution of Equipment-Hours of Working Time
of Trucks on Sealing Cracks and Joints

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel ahead slowly as men pour asphalt	27	
5.1 Stopped as men pour asphalt	6	33
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	13	
6.2 Travel to and from stockpile	2	
6.3 Travel to new work site	2	
6.4 Minor moves, turns, and maneuvers	1	
6.5 Travel to put out and pick up signs	5	
6.5 Put out and pick up signs	1	
6.6 Load and unload men, tools, and equipment	3	
6.6 Load and unload materials	1	
6.9 Travel to and inspect bridges	2	
6.9 Travel on errands	2	32
7.0 Waits and delays		
7.1 Parked as men work filling asphalt kettle	5	
7.1 Wait as kettle heats	22	
7.2 Adjustment of burners on kettle	1	
7.2 Maintenance of truck	1	
7.3 Instructions	2	
7.4 Excess lunch and quit early	1	
7.5 Idle	1	
7.6 Personal	1	
7.9 Other	1	35
Total		100

The average mileage driven by the truck on days during which studies were made is shown in the table on the following page.

Item	Average miles driven per day
Travel to and from garage	24.4
To new work site	2.3
To and from stockpile	3.8
To put out and pick up signs	4.9
Travel ahead as men pour asphalt	3.3
Travel to inspect bridge	3.0
Travel on errands	1.5
	43.2

SHOULDERS

The usual practice in Connecticut is to treat the shoulders of most state highways with a bituminous treatment. The maintenance of shoulders was approximately 6 percent of the total maintenance work load for the year.

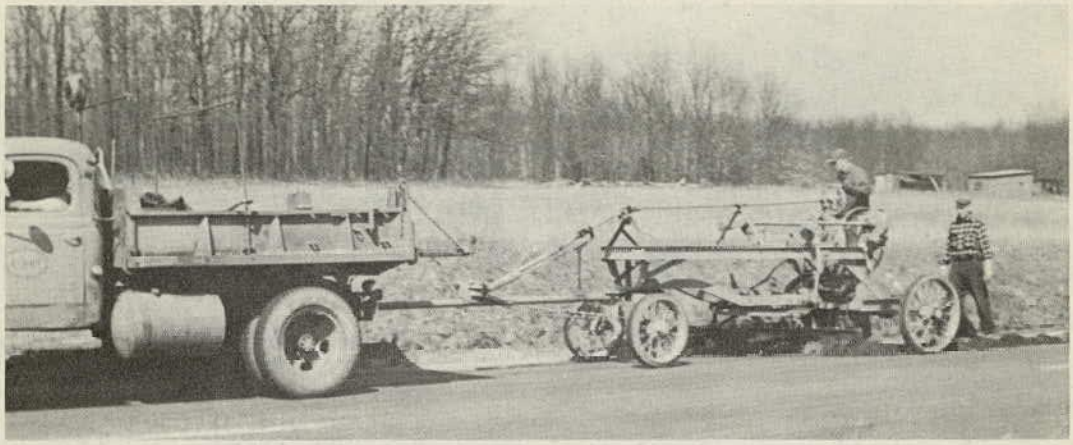
For equipment, the distribution of the work load and the relation to the total maintenance work load is shown in Figure 6. This distribution is based upon detailed records of equipment usage.

Cleaning and edging of shoulders occurring during April and May was the largest item comprising almost 60 percent of the shoulder work load. Patching with both hot and cold bituminous mixes occurred throughout the year except during the winter and comprised about one-quarter of the work load. It is a common practice to check and patch all roads prior to bituminous retreatments. Bituminous retreatments were given the shoulders during May, June, and July and comprised about 15 percent of the work load. Small amounts of shoulder replacements were made during the summer.

The following table shows accomplishment rates for the various items. Detailed discussions concerning each operation are included in the following pages.

Accomplishment Rates on Shoulder Maintenance Items Observed During Study Periods

Item	Size of Crew	Amount of Equipment	Amount of Work Accomplished Per Day
Cleaning and edging with tow grader and truck with front end scoop-loader	8	5	7.5 shoulder miles cleaned
Cleaning and edging with patrol grader with loader attachment	10	5	8.5 shoulder miles cleaned



21. Tow type blade grader edging and shaping shoulders, two operators and crew leader.

CLEANING AND EDGING SHOULDERS WITH TOW GRADER AND SCOOP-LOADER

GENERAL

The operation of cleaning and edging shoulders consists of trimming sod from the edges of surfaced shoulders, blading the accumulation of winter sand and debris on the shoulder into a windrow, and loading and disposing of the sod, sand and debris. This work is performed every three to five years usually in the spring. The cost thereof may be charged against snow and ice control, depending upon the foreman's estimate of whether cleanup of winter sand is the principal work being accomplished.

The operation was performed by either of two methods: a tow grader and truck with front end scoop-loader, or a motor patrol grader with conveyor loader attachment.

When a tow grader and scoop-loader were used, the first phase of the operation consisted of trimming the built-up turf and sod back from the outside edge of the shoulder and windrowing this material along the shoulder with other debris and accumulations of winter sand. The average width of the sod removed from the outside edge was about eight inches. This was done by a tow-type grader with a seven-foot blade, leaning wheels, and mechanical controls which was towed by a 3-ton truck. A crew of two men were required, one to operate the grader and one to drive the truck. The tow grader was usually parked overnight at a point near the work site.

The second phase of the operation was loading and disposing of the sand and debris. The loader employed was a 7-ton dump truck with a front end scoop attachment which could be raised or lowered by moving the dump body. With the scoop down on the pavement, the truck moved forward picking up the loose material. When the scoop was loaded it was raised approximately eight feet above the roadway, whereupon a dump truck backed under the scoop and the scoop was dumped. The truck then moved forward, perhaps 100 feet, so

22. Truck mounted scoop loader picking up windrow of debris.

23. Scoop-loader dumping load of debris into dump truck; operator, helper, and flagman in addition to hauling unit operator.

the loader could scoop up more material. The dumping operation was then repeated. Besides an operator for the scoop-loader, two other men were used —one to direct the loader operator and shovel up whatever loose material spilled, and the other to direct traffic.

From 2 to 3 trucks were ordinarily used to haul to the disposal area.

TRUCK AND TOW GRADER

During the 52-week period, the tow grader and a truck were used to clean and edge shoulders for a total of 216.5 hours. The distribution of this time in accordance with 30.2 hours of detailed study is as follows:

Distribution of Equipment-Hours of Working Time
of Truck Pulling the Tow Grader

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Blading	46	
5.2 Minor moves ahead	2	48
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage and parking area	13	
6.3 Travel to new work site	3	
6.4 Minor moves, turns and maneuvers	3	
6.9 Attach and detach tow grader to truck	1	20
7.0 Waits and delays		
7.1 Wait while scoop-loader catches up	15	
7.1 Wait for other crews and truck to arrive	1	
7.2 Maintenance of tow grader	1	
7.3 Instructions	3	
7.4 Excess lunch and quit early	3	
7.5 Idle	2	
7.6 Personal	1	
7.9 Transport men to garage for medical shots	4	
7.9 Other	2	32
Total		100

During the study periods blading of the shoulders was observed to proceed at a rate of 7.53 miles of shoulder per 9.0-hour day.

TRUK-LOADER

During the 52-week period the two trucks equipped with front end scoop-loaders were used on different days to load sand and debris from the shoulders for a total of 360.9 hours. The distribution of this time in accordance with 25.5 hours of study is as follows:

Distribution of Equipment-Hours of Working Time
of Scoop-Loader Loading Trucks with Windrowed Shoulder Debris

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Move ahead, loading scoop with debris	15	
5.2 Load scoop by hand	1	
5.3 Raise scoop	14	
5.4 Back truck into position under scoop	6	
5.5 Move ahead and dump scoop	9	
5.6 Back up and lower scoop	15	
5.7 Level load on truck with scoop	1	
5.8 Minor moves ahead	2	63
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	6	
6.3 Travel to new work site	2	
6.4 Minor moves, turns and maneuvers	2	
6.5 Put out and pick up signs	1	11
7.0 Waits and delays		
7.1 Wait for trucks to arrive at loading site	5	
7.2 Repair and maintenance of truk-loader	6	
7.2 Repair and maintenance of truck	3	
7.3 Instructions	2	
7.4 Excess lunch and quit early	3	
7.6 Personal	3	
7.9 Other	4	26
Total		100

During the study periods, loading of debris was observed to proceed at a rate of 25 truckloads per 9.0-hour day. The average truck load was estimated to contain 3.0 cubic yards of material. The average distance traveled to load the scoop was observed to be 87 feet and the average amount of material picked up per scoop was estimated to be less than 0.2 cubic yard. The total accomplishment was approximately 7.5 miles of shoulder per day on the sections studied.

TRUCKS HAULING SAND AND DEBRIS

The trucks followed the scoop-loader as a supply train. Each truck followed more or less the following cycle: (1) travel ahead of the loader receiving each scoop of material as it was picked up, (2) haul to the disposal area, (3) return to the work site where (4) it joined the train following the loader. During the 52-week period, 10 trucks were employed for a

total of 924.8 hours on hauling debris from the truk-loader. The distribution of this time in accordance with detailed studies covering a period of 60.0 truck-hours is shown in the following table.

Distribution of Equipment-Hours of Working Time
of Trucks Hauling Sand and Debris from the Scoop-Loader

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Back under scoop	3	
5.2 Receive debris from scoop-loader	4	
5.3 Move ahead between scoop loads	7	
5.4 Wait while scoop-loader fills scoop	11	
5.5 Haul to disposal site	11	
5.6 Maneuver and dump at disposal site	5	
5.7 Return to work site	10	51
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	10	
6.3 Travel to new work site	2	
6.4 Minor moves, turns and maneuvers	2	
6.5 Put out and pick up signs	3	
6.6 Load and unload men, tools and equipment	2	
6.9 Miscellaneous	3	22
7.0 Waits and delays		
7.1 Follow scoop-loader and await turn to be loaded	18	
7.2 Maintenance of truck	1	
7.2 Maintenance of scoop-loader	1	
7.3 Instructions	1	
7.4 Excess lunch and quit early	3	
7.9 Other	3	27
Total		100

During the 60.0 truck-hours of study, the trucks hauled 68 loads, estimated at 3.0 cubic yards each. Travel speeds observed for the trucks during the study were 16.7 miles per hour on the haul and 19.0 miles per hour on the return. An average of 66 miles per day was driven by each truck during the studies, as follows:

Item	Average miles driven per day
Travel to and from the garage	21
Haul and return	32
Travel ahead while being loaded	3
Follow loader while awaiting turn to load	2
Other	8
Total	66

CLEANING AND EDGING SHOULDERS WITH MOTOR PATROL GRADER EQUIPPED WITH CONVEYOR LOADER ATTACHMENT

GENERAL

The operation consisted of trimming sod from the edges of treated shoulders and disposing of accumulated debris and winter sand on the shoulder.

The patrol grader, with blade lowered and extended to the right, moved forward along the right shoulder windrowing sod, debris, and sand directly under the grader. As the grader moved forward, the windrow of material was picked up by the belt loader mounted on the rear of the grader and was discharged at the rear into trucks which followed behind. These trucks were backed as they followed the grader.

An operator for the grader and another for the belt loader were required to operate the grader-loader unit. Other men used for this operation included two directing traffic, one to assist the grader-loader operators, and one to direct dumping at the disposal site.

Four to five hauling units were usually used for this type of operation, depending to a large extent upon the length of haul involved in disposing of the material.

After returning to the loading site, the trucks generally traveled in a forward direction until such time as the truck operator thought he might soon move to a loading position. At this point, he usually turned around and followed, traveling backwards, eventually backing under the loader when the preceding unit commenced the haul trip.

NOTE: For additional discussion of the nature of this work, refer to preceding section which concerns similar operations performed with a tow-grader and scoop-loader.

MOTOR PATROL EQUIPPED WITH CONVEYOR LOADER ATTACHMENT

During the 52-week period, the motor patrol was used for this type of work for 6 days, or a total of 45.7 hours. The distribution of this time on the basis of 9.0 hours of study is as follows:

Distribution of Equipment-Hours of Working Time of Motor Patrol Grader Equipped with Conveyor Loader Attachment

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Move ahead loading	49	
5.2 Minor moves ahead, not loading	8	
5.3 Exchange trucks	11	68
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	3	
6.4 Minor moves, turns and maneuvers	2	5

Item	Percent	
7.0 Waits and delays		
7.2 Clean out spiral feeder on conveyor	10	
7.2 Repair and adjust conveyor drive chain	8	
7.2 Replace and adjust shoes on loader	2	
7.4 Excess lunch and quit early	4	
7.9 Other	3	27
Total		100

During the study periods, loading of debris was observed to proceed at a rate of 51 truckloads per 9.0-hour day. At 3.0 yards per truckload, this is equivalent to 153 cubic yards. On the sections studied, the accomplishment was approximately 8.5 miles of shoulder per 9.0-hour day.

TRUCKS HAULING SAND AND DEBRIS

The trucks used in conjunction with the operation of edging and cleaning shoulders loaded while traveling backward. After each load was obtained, the loader stopped and the truck pulled away under direction of a flagman and commenced the haul to the dumping site. Immediately after the loaded unit pulled away, the next truck in line backed into a loading position and the loading cycle was resumed.

Each truck followed more or less the following cycle: (1) load at the motor patrol, (2) haul to the disposal site, (3) maneuver and dump the load, (4) return to the job site where (5) it joined the train waiting to load.

During the 52-week period, 7 trucks were employed for a total of 212.1 hours on hauling from the loader while edging and cleaning shoulders. The distribution of this time, in accordance with detailed studies covering a period of 34.2 hours, is as follows:

Distribution of Equipment-Hours of Working Time of Trucks Hauling Sand and Debris from the Motor Patrol Grader Equipped with Conveyor Loader Attachment

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Receive load of debris from loader	15	
5.2 Haul to disposal site	9	
5.3 Maneuver and dump at disposal site	4	
5.4 Return to work site	8	
5.5 Exchange	1	37
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	2	
6.4 Minor moves, turns and maneuvers	1	
6.5 Put out and pick up signs	3	
6.6 Load and unload men, tools and equipment	1	
6.9 Miscellaneous	2	9

FIGURE 6

EQUIPMENT WORKING TIME BY WEEKS

EXPENDED ON SHOULDER MAINTENANCE

IN WAREHOUSE POINT MAINTENANCE AREA

AUGUST 14, 1950 TO AUGUST 12, 1951

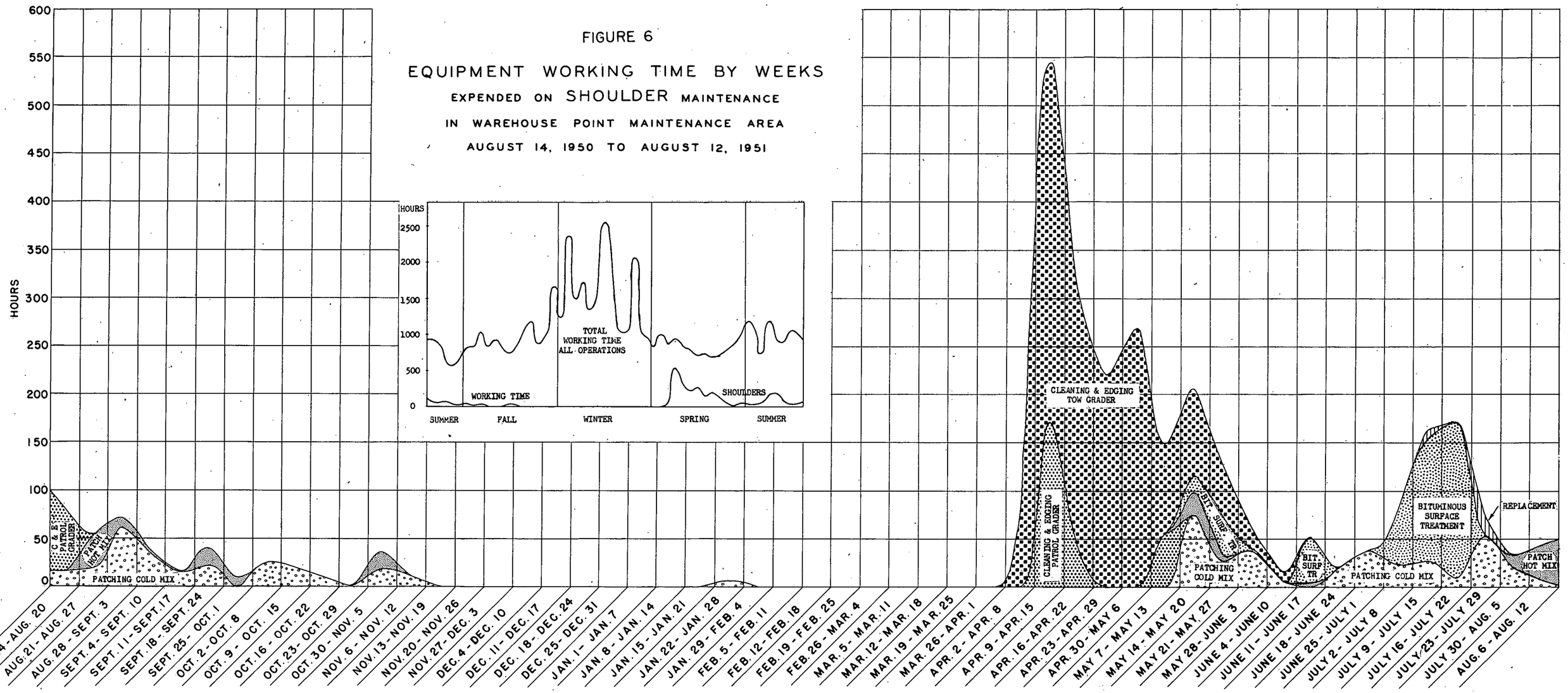
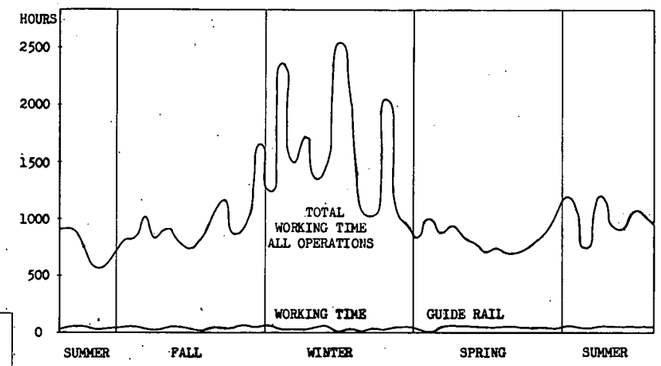
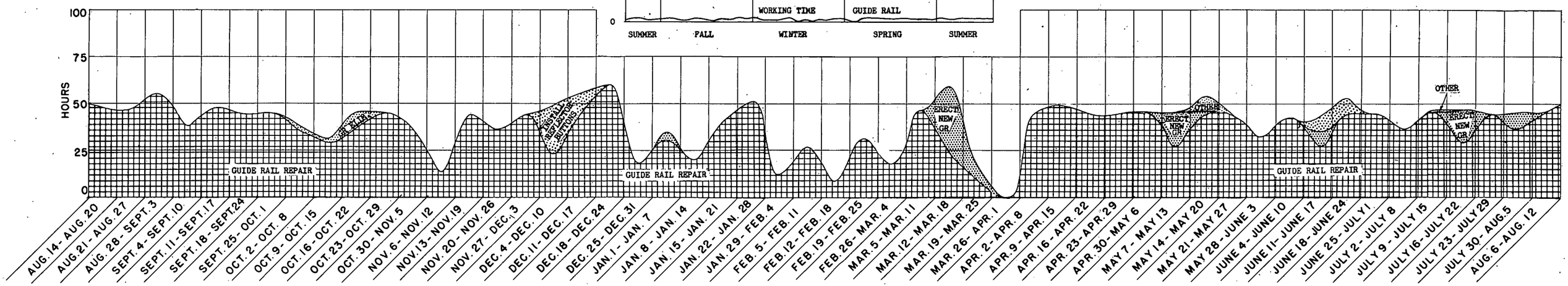


FIGURE 7

EQUIPMENT WORKING TIME BY WEEKS
EXPENDED ON GUIDE RAIL MAINTENANCE
IN WAREHOUSE POINT MAINTENANCE AREA
AUGUST 14, 1950 TO AUGUST 12, 1951





Item	Percent	
7.0 Waits and delays		
7.1 Wait to be loaded	38	
7.1 Wait on other operations	1	
7.2 Maintenance and repair of conveyor	5	
7.2 Maintenance of truck	1	
7.3 Instructions	1	
7.4 Start late and quit early	4	
7.9 Other	4	54
Total		100

During the 34.2 truck-hours of study, the trucks hauled 51 loads, estimated at 3.0 cubic yards each.

Travel speeds observed for the trucks during the study were 17.2 miles per hour on the haul and 15.8 miles per hour on the return. An average of 36 miles per day was driven by each truck during the study as follows:

Item	Average miles driven per day
Travel to and from the garage	2
Haul and return	24
Follow grader while waiting for load	5
Other	5
Total	36

SAFETY AND TRAFFIC CONTROL

Center line stripes are machine-painted throughout the State by 2 specialized crews. Stop bars, cross walks, rotaries, short stretches of center lines, bridge stripes, parking stalls and pavement lettering are hand-painted by a man in each district. Each district also has a sign crew which erects and maintains its regulatory, warning and informational signs. During the winter the painters are usually switched over to help on sign work in one of the districts.

Traffic control signals, highway lighting and bridge lighting are maintained either by the towns and cities or by the Highway Department on a state-wide basis.

Guide rail repair comprised over 90 percent of the work on safety and traffic control. The remainder consisted of erection of new guide rail, removal of guide rail where no longer required and installation of reflector buttons. Guide rail maintenance was approximately 4 percent of the total maintenance work load for the year. Inasmuch as one crew of three men and a crew leader did most of the guide rail maintenance in the Warehouse Point area, the work load was fairly uniformly spread out through the study year.

For equipment, Figure 7 shows the distribution of the work load through the year and the relation of guide rail to the total maintenance work load. This chart is based upon detailed records of equipment usage.

The following table shows accomplishment rates for the various items.

Accomplishment Rates on Safety and Traffic Control Items Observed During Study Periods

Item	Size of Crew	Amount of Equipment	Amount of Work Accomplished Per Day
Painting centerline stripes	7	3	striped 38.7 miles of 2-lane highway
Guide rail repair	3	1	380 ft. of guide rail repaired
Guide rail elimination	2	1	190 ft. of guide rail eliminated
Installing reflector buttons	3	1	installed 1370 reflector buttons

Detailed discussions concerning each operation listed in the above table are included in the following pages.

CENTER LINE STRIPING OPERATIONS

Center line stripes are painted on the pavement for the purpose of controlling and regulating traffic in passing and non-passing zones. In Connecticut a non-passing zone on vertical and horizontal curves is considered to be any section of highway where there is a sight distance of less than 800 feet. As a general rule, center stripes in Connecticut are one of the three following types: a single dashed line indicating passing in either direction, a double solid line indicating no passing in either direction, or a combination of a solid and a dashed line allowing passing on the side having the dashed line. All center line stripes are painted with white paint and glass beads for an average width of 4 inches. The dashed line consists of alternating dashes (15 feet long) and spaces 25 feet long. On double lines, the space between the lines is 4 inches also.

Center line stripes were painted with a striping machine manufactured by the Connecticut State Highway Department and consisting of the following basic components:

375-gallon tank
2 - Air Compressors--60 cu. ft. of 100 lbs. pressure
Power unit - (runs pump to agitator)
2-cylinder gasoline engine
Pump
4 pressure gauges (having regulators to vary pressure)
- curtain pressure 40#
- Atomizers 60#
- Tank 50#
- Compressor 50#

2 Nozzles

The above equipment was mounted on a 1949 chassis.

24. Reloading painting machine at noon; note paint cans and bags of beads.

In centerline striping operations, a 7-man crew and foreman plus 3 trucks and a passenger car were used. A driver and 2 men rode the specially designed paint truck and a driver and 1 man rode in each of the other two trucks. One of these 2 trucks closely followed the paint truck and put out signs and red flags to mark the wet paint, while the other followed 30 or 40 minutes behind (depending on the weather and hence on how fast the paint dried) and picked up the signs and red flags. In the morning the 2 flag trucks each loaded up at the garage with about 30 5-gallon cans of paint and an equal number of 25-pound bags of glass beads. Since the paint truck was usually parked overnight off to the side of the road near where the previous day's work ended, it was loaded on the job site. The paint and beads from one truck were loaded into the paint truck the first thing in the morning, and the paint and beads off of the other truck were loaded into the paint truck at noon. The paint was transferred by means of a suction pump on the paint truck. When all the paint was loaded, solvent was run through the hose to clean it out. The beads were then loaded into the top of the tank by means of a funnel. One bag of beads was loaded for each can of paint.

The paint was agitated for at least ten minutes per can on a vibratory shaking machine. This was done on the day before it was to be used.

While the paint truck was in operation painting stripes, the driver rode in the middle of the front seat and centered the truck on the road by means of the junction of the windshields as a rear sight and a front sight consisting of a large ring with crossed wires in the center. This front sight was mounted on the hood of the truck. One of the men in the rear was concerned with aligning the new stripes with the old stripes, if any, and watching for markers along the road which indicated changes in type of stripe. The placement of these markers is checked each year in advance of the painting operation. By means of a small wheel he was able to move the nozzles slightly from side to side to align them with the old stripe. By adjusting a cam, he was able to position the dashed lines and superimpose them over the old dashed lines. The other man in the rear of the paint truck controlled the type

25. Specially built painting machine in operation; foreman does not generally ride in this position. Note excess aggregate from recent armor coat.

26. Truck putting out flags usually follows painting machine much closer. Study observer not part of the crew.

of stripe which was being painted. By throwing certain levers or switches on the control board in front of him, he could produce any line or combination of lines required. These switches electrically activated air valves, and the air in turn activated the nozzles. The dashed lines were spaced by a timer in the form of a cam which was driven by an extra wheel.

Two detailed stop-watch studies were made on the center stripe painting machine covering a period of 18.00 equipment-hours or two working days.

The distribution of working time of the center line painting machine based upon the above studies is as follows:

Distribution of Equipment-Hours of Working Time of Paint Machine

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Painting dashed lines	11	
5.1 Painting combination lines	11	
5.1 Painting double solid lines	13	
5.2 Travel ahead between lines, intersections, etc.	1	36
6.0 Related items including travel and preparatory work		
6.1 Travel to and from overnight parking area	1	
6.3 Travel to new route	7	
6.4 Travel to turn around	2	
6.4 Minor moves, turns, and maneuvers	2	
6.6 Unload and open paint cans and bead bags	3	
6.6 Load paint and beads into tank	5	20
7.0 Waits and delays		
7.1 Await arrival of crew in morning	15	
7.1 Quit early, men travel back to garage in Hartford	11	
7.1 Wait on other operations	2	
7.2 Morning preparations and nightly cleanup	7	
7.2 Maintenance and adjustments	2	
7.3 Instructions	4	
7.4 Excess lunch	1	
7.6 Personal	1	
7.9 Other	1	44
Total		100

Detailed studies were made on the paint truck for 18.0 hours. During actual painting time, 35% of the total time, the truck painted at the rate

of 12.1 miles per hour. The speed of the painting machine was independent of the type of stripe being painted. The equivalent length of single solid line that was painted was 98.54 miles.

For the average 9-hour day under observed conditions, the paint truck striped 38.7 miles of 2-lane road.

The average mileage driven by the painting machine on days during which studies were conducted was as follows:

Item	Average miles driven per day
To and from overnight parking area	1.9
To new route	15.0
To turn	0.6
Painting	
Dashed line	11.5
Combination dashed and solid lines	12.3
Double solid lines	14.1
Travel ahead between lines	0.8
Total	56.2

The lead flag truck followed about two or three hundred feet behind the paint truck and put out signs and small red flags to keep automobiles off of the wet paint. "Keep off" signs were placed at either end of a road that had been striped and red flags were spaced down the center depending on how much traffic the road carried. In towns, where there were a lot of breaks in the lines and much traffic, the flags were positioned very close. The spacing between flags on country roads was much greater.

Both flag trucks were equipped with a platform behind the truck about two feet off the ground. On the left hand side a seat was mounted. The flags were stacked in piles on the bed of the truck. The man in the rear either stood or sat (depending on his preference) as he set the flags on the white line. Since the trucks were only moving at a speed of 12 miles per hour, it was possible to set the flags down without their falling over.

The flags themselves were about 6" square and were attached to a rod which was attached to a small piece of channel iron which acted as a base.

The rear flag truck drove along in the right-hand lane near the white line. The man in the rear sat on the left side of the platform so that he could see the flags ahead. As the truck passed them, he grabbed them by the small rubber knob on top and stacked them on the bed of the truck.

At noon time, it was regular procedure for the crew putting out flags to exchange trucks with the crew picking up flags. The men continued performing the same jobs, but now the truck that had been putting out flags was picking them up and vice-versa.

The distribution of working time for the truck putting out flags on painting center line stripes based upon 17.6 hours of detailed stop-watch

studies is as follows:

Distribution of Equipment-Hours of Working Time
of Truck Putting Out Flags

Items	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel putting out flags	37	37
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	19	
6.3 Travel to new route	7	
6.4 Minor moves, turns, and maneuvers	3	
6.6 Load and unload paint cans and bead bags	2	
6.6 Transfer and arrange flags and signs	4	35
7.0 Waits and delays		
7.1 Wait on paint loading operations	4	
7.1 Wait on other operations	4	
7.2 Wait for paint truck to start	9	
7.2 Wait for evening cleanup of paint truck	4	
7.2 Maintenance of truck	2	
7.3 Instructions	1	
7.4 Start late, excess lunch, quit early	2	
7.6 Personal	1	
7.9 Other	1	28
Total		100

Detailed studies were made on the truck putting out flags for a total time of 17.6 hours. While they were actually putting out flags (37% of the total time), the trucks traveled at a rate of 11.5 miles per hour. An average of 34.9 flags were placed every mile giving a spacing of 151 feet between flags.

The average mileage driven by the trucks putting out flags on days the studies were conducted was as follows:

Item	Average miles driven per day
To and from garage	51.3
To new route	15.7
Putting out flags	37.2
Total	104.2

The distribution of working time of the truck picking up flags based upon 18.5 hours of detailed stop-watch studies is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks Picking up Flags

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel picking up flags	26	26

Item	Percent	
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	19	
6.2 Travel to dispose of empty paint cans	4	
6.3 Travel to new route	8	
6.4 Minor moves, turns, and maneuvers	2	
6.6 Load and unload paint cans and bead bags	5	
6.6 Transfer and arrange flags and signs	6	
6.9 Miscellaneous work	2	46
7.0 Waits and delays		
7.1 Wait on paint loading operations	5	
7.1 Wait on other operations	1	
7.1 Wait for paint to dry	14	
7.2 Maintenance of truck	1	
7.3 Instructions	2	
7.4 Start late, excess lunch, quit early	1	
7.6 Personal	3	
7.9 Other	1	28
Total		100

While the pickup trucks were actually picking up the flags (26% of the total time), they traveled at a rate of 15.2 miles per hour.

The average mileage driven by the truck picking up flags on days during which studies were conducted was as follows:

Item	Average miles driven per day
To and from garage	51.7
To new route	21.0
To dispose of empty paint cans	5.7
Picking up flags	36.8
Total	115.2

GUIDE RAIL

At all locations where the roadway is dangerously elevated above the abutting ground, State law requires that the State "shall erect and maintain a sufficient railing or fence." Generally 4 to 1 or flatter filled slope is considered safe without guide rail protection. At all steeper slopes guide railing is required. The State Highway Department is responsible for the reasonable maintenance of all guide rail installed on all State maintained highways. Occasionally short stretches of new guide rail were erected or eliminated but the majority of the work performed by the maintenance crews was on repair operations.

The State law specifies that a railing or fence shall be deemed sufficient if it is constructed equal to, or better than, and reasonably maintained under, the following specifications: The railing or fence shall consist of wooden posts not less than 6" in diameter, 6'-6" in length and set 3'-6" in the ground, spaced not more than 10' apart on centers to which shall be attached by means of hook bolts 5/8" in diameter, two horizontal lines of

3/4" galvanized steel rope or cable. The minimum tensile strength of the rope shall be not less than 15,000 pounds. At the ends of the railing and for continuous sections of 500' or more in length, at intervals not to exceed 500', cable shall be anchored by "dead men" set not less than 3', in the ground with four square feet area at right angles to the pull of the cables. The present standard of the Highway Department requires pressure-treated creosoted posts. The lower cable is placed at a height of 15" from the ground. The top cable 12" above it. One compensating spring type anchor must be used on each 250' of fence or less. At the ends of the railing, adjacent to the anchor, a single guard post is erected.

The following table shows the amounts of materials used on guide rail work during the 52-week period, August 14, 1950 - August 12, 1951.

Total number new creosoted posts used on erection of new fence	169
Total number creosoted posts used on guide rail replacements	115
Total number creosoted posts used to repair traffic damage claims	66
Total number creosoted posts used on routine repairs	1167
Total number of new creosoted posts used	1517
Total length of 3/4" cable used from salvage (no new cable used)	5300 ft.
Total number white untreated posts used from salvage (estimated)	600
Total length of guide rail eliminated	820 ft.
Total number of reflector buttons installed in steel posts	2576
Total number of reflector buttons installed in wooden posts	661

1" x 6" reflectorized plates were placed on posts 4" from peak facing traffic for the purpose of illuminating posts at night. On tangents, one reflector plate was placed on every other post while on curves every post was reflectorized.

On all new guide rail erected or major replacements, reflector buttons were used. These buttons were placed on the post at the same spot and with the same spacing among posts as the reflectorized plates with the added specification that they must be visible 500 feet back from a spot in the center of the road.

GUIDE RAIL REPAIR

The crew normally consisted of 4 men: crew leader, driver and 2 helpers. However, occasionally the crew consisted of only 3 men due to vacations, sickness or the assignment of a member of the crew to other operations. One of the men worked regularly as the rear operator on the distributor during the oiling season.

The equipment of the crew consisted of items as shown on the following page.

1 3-ton dump truck equipped with a snow plow hoist
5 shovels (2 with extended handles)
3 bull bars
6 wrenches
3 pipe wrenches
1 post twister (peavy or cant-hook)
1 cable cutter
4 wire cutters
3 claw hammers
1 draw knife
2 two-man saws
1 tamper
6 chains
3 braces and bits

27. Pulling old post from ground by hoisting truck dump body, usual method when a line of posts was to be removed.

The crew loaded up the truck with new creosoted posts or salvaged posts in good condition. When loaded, the truck was driven to the job site, where the speed was slackened for visual inspection of the guide rail. The crew looked for rotten or misaligned posts and for posts lacking bolts or reflectors. When a section of guide rail needing repair was found, the crew stopped. New hook bolts and reflectors were attached to posts where necessary.

When a post had deteriorated beyond usefulness, its bolts were removed and it was extracted by hand and taken to the truck. A new post was carried

28. Reboring replacement post to attach cable hardware. Posts are purchased with holes already drilled to meet present specifications, which do not always line up with old type guide rail.

29. Attaching hardware, note reflectorized strip already attached. Also note proximity of "Men Working" sign.

to the same hole, which was enlarged and deepened if it needed it. Thereupon, the new post was inserted and juggled around to be properly aligned with the others. Then the earth was filled back and tamped. Two bolts were inserted into the pre-drilled holes in the post and the cable was attached. Then the bolts were tightened. If quite a few posts in a row were to be replaced, the truck might be used to extract them. In this case the post was chained to the front of the truck body and was pulled out of the ground by raising the body.

When posts had been knocked out of alignment, the crew dug around each post, realigned the post by hand or by the use of a crow bar or sledge. Then the earth was replaced and tamped. Alignment may be checked by eye or by the use of a string line. If the post replaced was among a group of white posts then the new post was painted white on top and tarred on the bottom to match the others. In the handling of creosoted posts, the men have been instructed to wear issued rubber gloves to prevent burns from the creosote.

In addition to directing the realignment of posts, the crew leader also gave a detailed inspection to the remainder of the guide rail. After completing the repair of the guide rail, the old posts were loaded on the truck and the reconnaissance was continued.

Detailed stop-watch studies have been conducted on guide rail repair covering a total of 101.8 man-hours observed on 6 separate days. On 3 of the days studied, the crew consisted of 3 men: 1 truck driver, and 2 laborers while on the other days studies were conducted on a crew of 2 men including just 1 laborer, both of the above mentioned crews being supervised by 1 crew leader. Since the crew leader acted in a supervisory capacity for the most part, his time was not included in the distribution which follows:

Distribution of Man-Hours of Working Time on
Guide Rail Repair Work
(Does not include crew leader's time)

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Remove old posts	5	
1.2 Place new posts	16	
1.3 Straighten old posts	6	
1.4 Mounting cable, hardware and reflectors	4	
1.5 Repair cable anchor and restretch cable	2	
1.6 Walk between truck and work area	1	34
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	15	
2.3 Travel to new work site	15 1/	
2.4 Minor moves, turns, and maneuvers	1	
2.4 Walk ahead to next site	4	
2.5 Putting out and picking up signs	3	
2.6 Load and unload men, tools, and equipment	4	
2.6 Move or fetch tools	1	
2.6 Loading and unloading posts	2	
2.9 Inspect and check guide rail	2	
2.9 Miscellaneous work	2	49

Item	Percent	
3.0 Waits and delays		
3.1 Wait on other operations	2	
3.1 Wait while others work	3	
3.3 Instructions	2	
3.4 Start late and quit early	2	
3.5 Idle	1	
3.6 Personal	2	
3.7 Resting	1	
3.9 Weather	2	
3.9 Other	2	17
Total		100

1/ Visual inspection was accomplished during these moves

On the basis of the rates of accomplishment observed during the studies, a typical crew of 3 men (1 truck driver, and 2 laborers) plus a crew leader working a 9-hour day would accomplish the following work each day:

Item (including installation of cable, hardware, reflectors)	Total number of posts handled each day by a 3-man crew
Remove old posts	4.7
Place new posts	8.2 1/
Straighten old posts	30.1

In rough terms, this is equivalent to reconditioning about 380 lineal feet of guide rail per day.

During working time, detailed studies were conducted on the truck used by the guide rail crew on three separate occasions for a total study time of 46.2 hours. The following tabulation shows the distribution of the 1867 hours of working time in accordance with these studies.

Distribution of Equipment-Hours of Working Time
of Trucks Used On Guide Rail Repair Operations

Item	Percent
5.0 Operating cycle items on assigned task (Note: This unit works in the capacity of a general purpose service truck and has no clearly defined operating cycle.)	
6.0 Related items including travel and preparatory work	
6.1 Travel to and from garage	14
6.3 Travel to new work site (including inspection enroute)	17
6.4 Minor moves, turns and maneuvers	3
6.5 Put out and pick up signs	4
6.6 Load and unload men, tools, and equipment	5

Item	Percent	
6.6 Load and unload posts	3	
6.6 Load and unload materials	1	
6.9 Travel to inspect guide rail	6	
6.9 Load truck with sand for possible emergency winter use	1	54
7.0 Waits and delays		
7.1 Parked while men work	37	
7.3 Instructions	2	
7.4 Start late, excess lunch and quit early	2	
7.6 Personal	2	
7.9 Weather	2	
7.9 Other	1	46
Total		100

1/ 4.7 of these posts used to replace the 4.7 old posts removed

The average mileage driven by the truck on the days during which studies were made was as follows:

Item	Average miles driven per day
Major travel	
To and from garage	28.1
To new work site	27.8
To inspect guide rail	10.0
To put out and pick up signs	0.4
Other minor travel	1.7
Total	68.0

On guide rail that has been damaged by traffic, one of the crew leader's tasks is to seek out evidence concerning the individual who may have caused the damage in order that the State may recover damages. During the 52-week period, there were 60 major fence breaks necessitating damage claims by the State of which 18 involved the placement of 66 new creosoted posts. On 5 claims, a total of 29 salvage white posts were used. On the remaining 37 claims, no additional material was used except for 1 cable splicer, the work consisting mainly of realignment and tightening.

GUIDE RAIL REMOVAL

Lengths of guide rail may be removed in cases where requests are made by adjacent property owners, where side slopes have been flattened below the minimum highway standards, or when adjacent land has been filled in enough to make guide rail unnecessary.

The case studied was one where a property owner had requested the removal of the guide rail after he had filled in his land.

The crew first wedged both cables in the hook bolts of the first post in the section of guide rail that was to be left standing so as to keep the

cable taut when the anchor plate was to be removed. One man dug out around the anchor plate as another man dug the new hole for the anchor. In a case where a complete section of guide rail is to be removed, it is unnecessary to wedge the cables or dig new anchor holes.

The bolt holding the anchor plate to the anchor rod was removed as the cable was detached from the other end of the anchor rod. The anchor rod was then pulled out by attaching to the truck and backing up. The anchor plate was lifted out of the hole by a winch or snow plow lift on the front end of the truck, moved to the new hole and deposited therein.

The anchor rod was then bolted to the anchor plate in the new hole and after they were adjusted to the correct position in the holes, they were covered with earth and tamped. The cable was then cut with large cutters to the proper length and then attached to the anchor rod. A turnbuckle allowed the cable to be drawn taut, after which the wedges in the cables were removed.

The remaining work consisted of detaching the hardware from the posts, removing the cables and rolling them up. The posts were removed by attaching one end of a chain to the post at the ground line and attaching the other end to either corner of the front of the dump body on the truck which was positioned as close to the post as possible.

One man at the side of the truck attached the chain to the post, guided the truck driver while the body was being hoisted to remove the post, occasionally hit the post with a sledge hammer to loosen it, and detached the chain from the post when the dump body was lowered after having dragged the post out of the hole. This team moved right down the length of the guide rail, removing a post, moving on to the next one, and so on.

The crew then loaded the removed posts onto the truck along with the cables and hardware. The last stop was to fill in all the holes left by the posts and the anchor.

Detailed stop-watch studies were conducted on guide rail elimination operations over a period of 18.0 man-hours, during which the crew consisted of a crew leader, driver and one other man. The studies covered only the working time of the latter two men. The distribution of time in accordance with those studies is shown in the following table.

Distribution of Man-Hours of Working Time
On Guide Rail Elimination Operations

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Detach cable from posts	4	
1.2 Remove and roll up cable	5	
1.3 Remove posts and fill holes	6	
1.4 Remove cable anchors	13	
1.5 Install cable anchors at new location	21	
1.6 Place new guide posts	3	
1.7 Attach cable to posts and anchors	1	
1.8 Walk around work site	3	56

Item	Percent	
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	13	
2.4 Minor moves, turns, and maneuvers	3	
2.5 Put out and pick up signs	1	
2.6 Load and unload men, tools, and equipment	5	
2.6 Load and unload posts and materials	3	25
3.0 Waits and delays		
3.1 Wait on other operations	5	
3.3 Instructions	4	
3.4 Excess lunch and quit early	4	
3.6 Personal	4	
3.7 Rest	1	
3.9 Other	1	19
Total		100

For the crew of one crew leader and 2 men, the observed daily rate involved removal of 190 feet of guide rail, removal of 19 old posts, removal and replacement of 2 cable anchors and re-setting of 2 guide posts, one at each anchor.

During working time, one detailed study was conducted on the truck used by the guide rail crew for a total study time of 9.0 hours. The following tabulation shows the distribution of the working time in accordance with this study.

Distribution of Equipment-Hours of Working Time
Of Trucks Used On Guide Rail Elimination Operations

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Maneuver to pull posts	4	
5.2 Pull posts with truck body	2	
5.3 Pull cable and anchor blocks	1	7
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	12	
6.4 Minor moves, turns and maneuvers	2	
6.5 Put out and pick up signs	1	
6.6 Load and unload men, tools and equipment	1	
6.6 Load and unload materials	3	19
7.0 Waits and delays		
7.1 Parked as men work	63	
7.3 Instructions	4	
7.4 Excess lunch and quit early	3	
7.6 Personals	3	
7.9 Other	1	74
Total		100

On the one day during which studies were conducted, the truck was driven a total of 26.2 miles. This included only the travel to and from the garage, since the crew worked at only one location during the day.

INSTALLATION OF REFLECTOR BUTTONS IN STEEL GUIDE RAIL POSTS

Two thousand four hundred and seventy-six glass 7/8-inch reflector buttons were installed in the steel guide rail posts on the North Meadows Expressway during a period of 3 days, December 5, 6 and 7, 1950. Approximately 100 missing and broken buttons were replaced at a later date.

The reflector buttons were mounted one per post by means of a hand tool which consisted of a short 6" section of pipe approximately 7/8" in diameter for holding and tightening the locking ring.

The reflector buttons came mounted, the shank of which was inserted into a previously drilled hole in the web of the steel guide rail post from the near side. A locking ring was inserted into the special hand tool and then slipped over the shank of the reflector button sticking out of the far side of the post. A half twist locked the ring onto the shank and the button was secure. The workman then walked ten feet ahead to the next post where the process was repeated. The men were equipped with a roofer's apron for carrying the reflector buttons and locking rings during installation operations.

Occasionally as the need arose, the men returned to the truck for additional supplies of buttons and locking rings.

The time distribution of man-hours of working time installing reflector buttons in steel guide rail posts based upon 13.1 hours of detailed stopwatch studies is as follows:

1/ Distribution of Man-Hours of Working Time on Installing Reflector Buttons in Steel Guide Rail Posts

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Insert locking ring in tool	6	
1.1 Install button in post	38	
1.2 Walk ahead to next post	10	54
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	10	
2.3 Travel to new work site	12	
2.4 Minor moves, turns, and maneuvers	2	
2.4 Walk around area and to new site	2	
2.6 Load and unload men, tools, and equipment	4	
2.6 Load and unload materials	4	
2.9 Load truck with sand for possible emergency winter use	1	35

1/ Based upon one-half day study and not necessarily typical of a full day's operations.

Item	Percent	
3.0 Waits and delays		
3.2 Put chains on truck	2	
3.2 Maintenance of truck and hand tools	1	
3.4 Excess lunch and quit early	3	
3.5 Idle	2	
3.9 Other	3	11
Total		100

Based upon rates as observed during the studies, a typical 3-man crew working a 9.0-hour day would install 1370 buttons.

During the 52-week period, one truck was employed at various times for a total of 40.5 equipment-hours on installation of reflector buttons. Following is the time distribution of the one truck based upon a limited study of 4.4 hours. Since only a half-day study was made, the distribution is not necessarily typical of a full day's operations.

Distribution of Equipment-Hours of Working Time
of Truck Used on Installing Reflector Buttons

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This truck works in the capacity of a general purpose service truck and has no clearly defined operating cycle.		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	10	
6.3 Travel to new work site	12	
6.4 Minor moves, turns, and maneuvers	5	
6.6 Load and unload men, tools, and equipment	4	
6.6 Load and unload materials	4	
6.9 Used by crew leader to call garage	30	
6.9 Load truck with sand for possible emergency winter use	1	66
7.0 Waits and delays		
7.1 Parked while men work	24	
7.2 Mount chains on truck	3	
7.2 Maintenance of truck	2	
7.4 Excess lunch	2	
7.9 Other	3	34
Total		100

The actual mileage driven by the truck during the one-half day study was as follows:

Item	Miles
To and from garage	10.8
To new work site	15.9
Travel by crew leader to check into headquarters	5.3
Other minor travel	1.4
Total	33.4

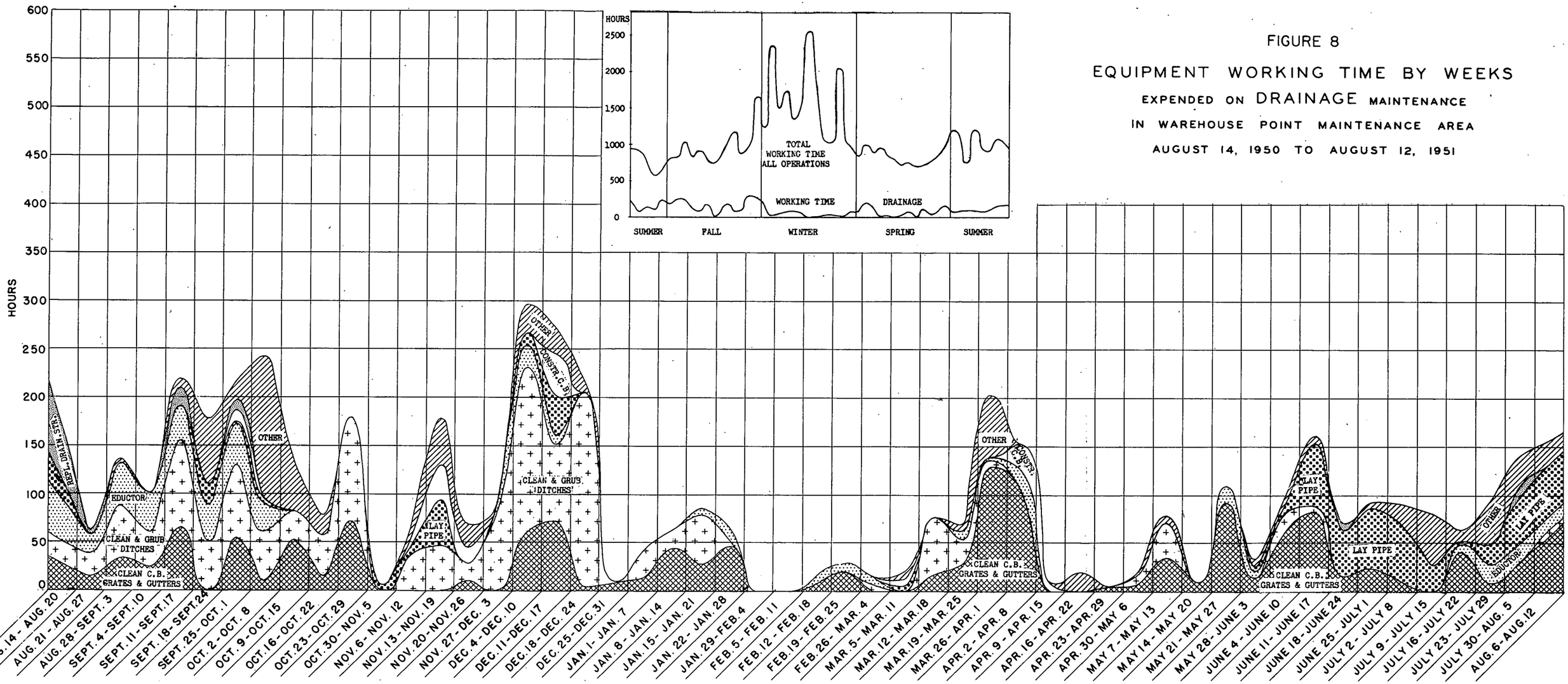
FIGURE 8

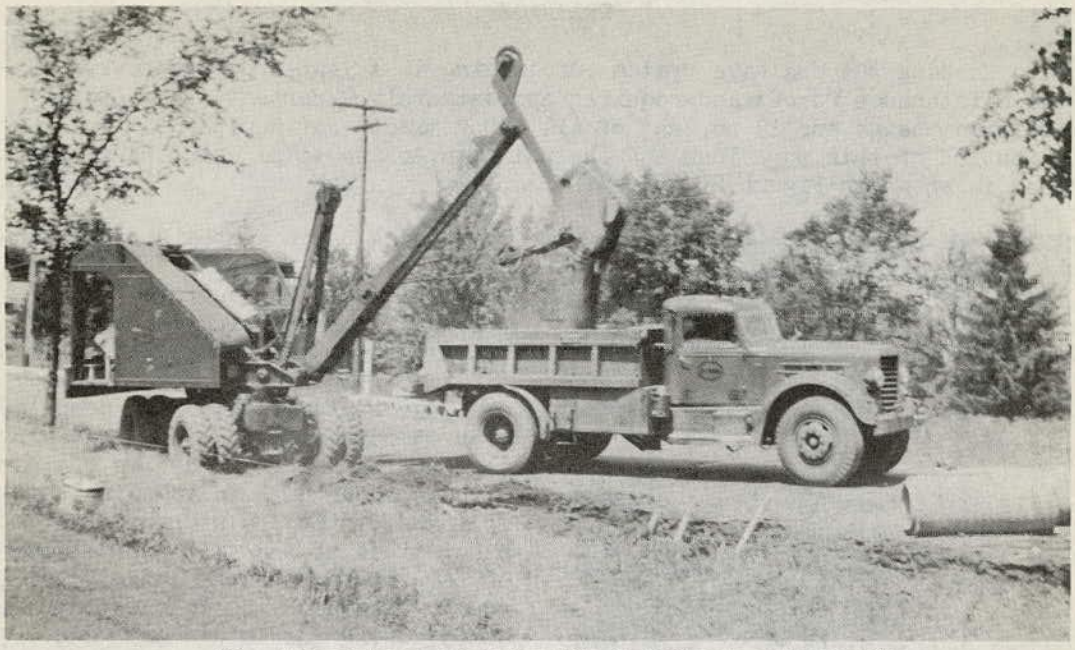
EQUIPMENT WORKING TIME BY WEEKS

EXPENDED ON DRAINAGE MAINTENANCE

IN WAREHOUSE POINT MAINTENANCE AREA

AUGUST 14, 1950 TO AUGUST 12, 1951





30. Excavating trench with back-hoe; string line for grade visible in foreground.

31. Placing reinforced concrete pipe in trench using back-hoe.

DRAINAGE

Keeping the drainage system functioning is a year-around activity of the maintenance forces and required approximately 9 percent of the total equipment usage and 13 percent of all labor time. For equipment, the distribution of this work load and the relation to the total maintenance work load is shown in Figure 8.

32. View inside trench showing placing of pipe.

Catch basin grates and gutters were cleaned during and following heavy rains throughout the year reaching a peak during the spring rains due to the accumulation of winter sand which was washed into the drainage system. This item comprised over 25 percent of the drainage work load. Cleaning and grubbing of ditches occurred mainly during the fall and winter and sporadically at other times of the year and totaled 30 percent of the work load. The eductor was used to clean catch basin sumps during the late summer and fall and occasionally at other times of the year and accounted for 10 percent of the work load.

Parts of the area are becoming suburban in character and there was extensive home building activity. This necessitated additions to the drainage system to such an extent that one crew was assigned to this work exclusively for the greater part of the year. New construction and replacement of existing structures comprised over 15 percent of the work load occurring mainly during the summer and fall. Other work included paving ditches with bituminous materials and constructing berms.

The following table shows accomplishment rates for the various items.

Accomplishment Rates on Drainage Maintenance Items Observed During Study Periods

Item	Size of Crew	Amount of Equipment	Amount of Work Accomplished Per Day
Cleanup of drainage ditches	3	1	clean and grub 1230 ft. of 3-ft. ditch
Clean catch basin grates and gutters	3	1	clean 78 catch basin grates and 200 ft. of gutter
Eductor cleaning catch basin sumps	2	1	clean 16.3 catch basin sumps

Detailed discussions concerning each operation listed in the table on the preceding page are included in the following pages.

CLEANUP OF DRAINAGE DITCHES

When drainage ditches become grown over with vegetation, the flow of water therein is impeded. Mowing and grubbing were the usual operations involved in re-conditioning the ditches. A typical crew which consisted of a truck driver and 2 to 3 men had the following equipment.

1 dump truck
4 mattocks
4 hand shovels
2 spade forks
1 scythe
1 whet stone
2 "Men Working" signs

Sod, hay and slough were then cast to the side, or were shoveled into the truck in those instances where the surrounding area was developed or where it would otherwise have been objectionable if dirt were cast aside. The loaded dirt was usually dumped at locations where it could be used to advantage to flatten out the slopes.

33. Two men cleaning ditch with shovels; pick mattocks and scythes are also used.

Detailed stop-watch studies have been conducted on drainage ditch cleanup work covering a total of 190.5 man-hours.

Distribution of Man-Hours of Working Time
on Drainage Ditch Cleanup Operations

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Mowing	2	
1.1 Grubbing and cleaning	25	
1.2 Casting slough	7	
1.2 Loading slough onto truck	15	
1.3 Walk ahead	4	53
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	6	
2.2 Travel to dump load of slough	3	
2.3 Travel to new work site	2	
2.4 Minor moves, turns, and maneuvers	1	
2.5 Put out and pick up signs	2	
2.6 Load and unload men, tools, and equipment	3	
2.9 Miscellaneous work	1	18

Item	Percent	
3.0 Waits and delays		
3.1 Wait on other operations	4	
3.2 Maintenance of truck	1	
3.3 Instructions and inspections	2	
3.4 Excess lunch, quit early	3	
3.5 Idle	10	
3.6 Personal	3	
3.7 Resting	5	
3.9 Other	1	29
Total		100

The average width of ditch grubbed was approximately 3 feet. With a 3-man crew working 9 hours per day, 1,228 lineal feet, (0.23 miles), of ditch would be cleaned under the conditions prevailing during the study periods.

During the 52-week period, 28 trucks were used at various times on cleaning drainage ditches for a total of 1494 hours. The distribution of this working time in accordance with detailed studies covering a period of 77.0 hours of work is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks on Cleanup of Drainage Ditches

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This truck works in the capacity of a general purpose service truck and has no clearly defined operating cycle		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	7	
6.2 Travel to and from dump site	3	
6.3 Travel to new work site	10	
6.4 Minor moves, turns, and maneuvers	4	
6.5 Put out and pick up signs	2	
6.6 Load and unload men, tools, equipment and materials	5	
6.6 Load slough onto truck	21	
6.6 Dump load of slough	1	
6.9 In use by crew leader	1	54
7.0 Waits and delays		
7.1 Parked as men work	39	
7.2 Maintenance of truck	1	
7.3 Instructions	2	
7.4 Quit early	1	
7.9 Other	3	46
Total		100

The average mileage driven by the truck on days during which studies were made was as shown on the following page.

Item	Average miles driven per day
To and from garage	11
To new work site	7
To dump slough and return	6
Total	24

CLEANING CATCH BASIN GRATES AND GUTTERS

This operation usually followed a rain storm or was performed on rainy days. It consisted of removing debris from grates of catch basins and dirt from gutters. The debris from the catch basin grates was usually picked up with forks or shovels and sometimes by hand, ordinarily thrown into the truck. The debris accumulated was hauled away and deposited along the roadside to build up embankments where needed.

The cleaning of catch basin grates and gutters was accomplished by use of a truck with a crew consisting of a driver, and 2 or 3 men. Normal equipment used by the above crew were 3 shovels and 3 spade forks.

Detailed stop-watch studies were conducted on cleaning catch basin grates and gutters covering a total of 70.2 man-hours. During these studies the crew consisted of a driver and 2 or 3 men, the driver acting as straw boss.

The following table shows the percentage distribution of total man-hours spent cleaning catch basin grates and gutters as obtained from 70.2 man-hours of study.

34. Ditch after cleaning, showing common type of roadway cross section and showing leakoff or scupper between paved shoulder and ditch.

Distribution of Man-Hours of Working Time on Cleaning Catch Basin Grates and Gutters

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Clean catch basin grates	3	
1.2 Fork and shovel debris onto truck	6	
1.2 Throw debris onto truck by hand	1	
1.3 Clean gutters by side casting debris	1	
1.4 Travel between catch basins	20	
1.4 Walking ahead inspecting	2	33

Item	Percent	
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	5	
2.2 Travel to dump load	1	
2.3 Travel to new work site	23	
2.5 Put out and pick up signs	6	
2.6 Load and unload men and tools	3	
2.9 Load truck with sand for possible emergency winter use	2	
2.9 Miscellaneous work	1	41
3.0 Waits and delays		
3.1 Wait in truck while others work	8	
3.2 Sweep floor and clean truck during rainstorm	3	
3.3 Instructions	2	
3.4 Quit early	3	
3.5 Idle	3	
3.6 Personal	2	
3.9 Weather	2	
3.9 Other	3	26
Total		100

During 3 studies covering a total of 58.2 man-hours, 167 catch basin grates and 427 lineal feet of gutter were cleaned.

For a crew consisting of 2 men and 1 truck driver working a 9-hour day, the daily accomplishment would be the cleaning of 78 catch basins and 200 lineal feet of gutter under conditions prevailing during the periods of study.

During the 52-week period 32 trucks were used at various times on cleaning catch basin grates and gutters for a total of 1443 hours. The distribution of this working time in accordance with detailed studies covering a period of 22.8 hours is as follows:

Distribution of Equipment-Hours of Working Time
of Truck on Cleaning Catch Basin Grates and Gutters

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This truck works in the capacity of a general purpose service truck and has no clearly defined operating cycle.		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	5	
6.2 Travel to dump site and return	1	
6.3 Travel to new work site	24	
6.4 Travel ahead to next catch basin	19	
6.5 Put out and pick up signs	8	
6.6 Load and unload men and tools	2	
6.6 Load debris onto truck	13	
6.9 Load truck with sand for possible emergency winter use	2	74

Item	Percent	
7.0 Waits and delays		
7.1 Standby as men sweep garage	3	
7.1 Parked as men work	11	
7.2 Maintenance of truck	1	
7.3 Instructions	3	
7.4 Quit early	3	
7.6 Personal	2	
7.9 Weather, rain	1	
7.9 Other	2	26
Total		100

An average of 1 truckload of debris was picked up and hauled away each 9.0-hour working day.

The average mileage driven by each truck on days during which studies were conducted was as follows:

Item	Average miles driven per day
Travel to and from garage	10.7
Travel to put out and pick up signs	10.7
Travel to new work site	27.4
Travel to dump load and return	2.8
Travel ahead to next catch basin	19.0
Other travel	0.3
Total	70.9

CLEANING CATCH BASIN SUMPS

To accomplish the cleaning of catch basin sumps, an eductor mounted on a truck chassis was employed. In addition to the regular truck motor, the eductor was equipped with 2 auxiliary engines. The smaller of these two engines ran a pump for filling the sediment tank with water. The larger one was used either to raise the body for dumping its load or to run a second pump that forces water through the suction hose and the jet pipe.

The normal crew consisted of a driver and a helper. They first traveled to a water source, usually a stream or pond, where the sediment tank was filled. Then they proceeded to the job site where the truck was maneuvered close to the catch basin. The grate was removed and any sticks or stones were removed by hand or by a potato hook. The suction tube was lowered into the basin and with the pump engine idling the catch basin was filled with water. The jet pipe was used periodically to stir and break up the sediment and get it into suspension in the water.

The engine throttle was opened increasing pump speed and power and starting the suction action. The suction was induced by a reduction nozzle in the water line which caused an updraft or suction in the flexible pipe suction line. As the sludge was drawn up, the suction tube was lowered into the catch basin. Periodically the engine had to be idled to replenish the pool of water in the basin. This was again stirred up with the jet pipe and

35. Side view of eductor in use cleaning a catch basin sump. Tank contains water and sludge from previously cleaned sumps, canvas hose is water line, flexible tubing is suction line, and operator is stirring the sludge with a jet pipe. Note pump engine and controls readily accessible to operator.

suction was resumed. The water which was drawn up into the tank by this suction process was then screened before being circulated again into the sump. By this process the solids in the sludge were left in the tank. Occasionally the screen plugged up with debris, whereupon, the blocking action was cleared by turning down the power to the pump to reduce the suction. The helper also shoveled the solids to the other side of the tank. After cleaning several catch basins and the sludge started to accumulate in the tank, the excess water displaced by the solids was discarded by back flushing it into the catch basin prior to moving to the next location.

After the catch basin sump had been cleaned, the grate was replaced and the crew moved on to the next basin. When the sediment had built up so high as to lower the efficiency of the suction action (normally 6 to 9 basins), the truck was driven to a dump area. There the rear end of the tank was unlocked and the body was raised to discharge the contents. Thereupon a fresh supply of water was obtained and the process repeated.

During the 52-week period from August 14, 1950, to August 12, 1951, a general distribution of time for the eductor is as shown on the following page.

Distribution of Total Available Eductor Time

Item	Hours	Percent
Non-working time (all time of 0.50 hour or more in duration when the eductor was not working)		
Not in use, parked in garage	1000.0	49
Under repair	114.4	6
1500-mile check-up	9.5	-
Start late, quit early	16.8	1
Awaiting repair	405.0	20
Working time	484.8	24

During working time, detailed studies were conducted on 4 separate occasions for a total study time of 32.6 hours. The following tabulation shows the time distribution in accordance with these detailed studies.

Distribution of Equipment-Hours of Working Time of the Eductor

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Load water	8	
5.2 Travel from water site to work site	5	
5.3 Maneuver to catch basin	2	
5.3 Remove and replace grate and start pump	1	
5.3 Lower and raise suction tube	3	
5.3 Pump sludge, including backflushing	24	
5.3 Drain off excess from tank	1	
5.3 Travel ahead to next catch basin	2	
5.4 Travel from work site to dump site	5	
5.5 Dump sludge	4	
5.6 Travel from dump site to water site	6	61
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	13	
6.4 Minor moves, turns, and maneuvers	1	
6.5 Put out and pick up signs	3	
6.6 Load and unload men and tools	3	
6.9 Miscellaneous work	1	21
7.0 Waits and delays		
7.2 Maintenance and repair of eductor	2	
7.2 Maintenance of truck	1	
7.3 Instructions	1	
7.4 Start late, excess lunch, quit early	5	
7.5 Idle	2	
7.6 Personal	4	
7.9 Other	3	18
Total		100

During the period of study, 59 catch basins were cleaned. This is equivalent to a rate of 16.3 catch basins cleaned each 9-hour working day under the observed working conditions.

Mileage driven by the eductor on days upon which studies were made was as follows:

Item	Average miles driven per day
To and from garage	22.8
To put out and pick up signs	1.8
To next catch basin	0.8
Travel to dump sludge	7.7
Travel to obtain water	8.7
Travel from water site to work site	6.6
Other minor travel	2.5
Total	50.9

The catch basins were fairly well loaded with debris, thus causing the apparent slow rate of accomplishment per day with this specialized equipment.

ROADSIDE

The public demands well maintained roadsides in Connecticut. Roadside maintenance is a year-around activity although relatively little was done between storms during the winter months. The work load built up during the spring to a relatively high level during the summer and declined gradually during the fall. Of the total maintenance work load for the year, approximately 16 percent of all equipment usage and 19 percent of all labor time was expended on roadside maintenance. For equipment, the distribution of the work load and the relation of roadside to the total maintenance equipment work load is shown in Figure 9.

Mowing which accounted for a third of the work load was started in the spring and continued until early fall. The first mowing was done with the

36. Breaking ground with garden type tractor with cultivator attachment.

37. Raking stones and debris from area to be seeded.

power mowers and tractor mowers. During the summer temporary employees were used for hand mowing in conjunction with the tractor mowers. The mown hay was progressively raked, picked up and stored for future use in mulching on slope stabilization operations. Unsuitable material was burned at designated locations.

Tree removal was performed all during the year and amounted to 12 percent of the work load. Some of this work was done by contract. Trimming of trees, chopping of brush from the roadsides and sightline clearance were carried on throughout the year and amounted to 9 percent of the work load. General cleanup of the roadsides was performed all year and was heaviest in the spring and fall. General cleanup accounted for 7 percent of the roadside work load. Cleaning of roadside picnic areas was performed from May to September with the most work coming at the beginning and end of the season when tables were put out and picked up. Spraying of elms was done in June to be most effective in insect control.

38. Seeding with hand seeder, centrifugal type.

39. Raking in seed with wooden tine rakes.

Landscape work which included the spreading of loam or top soil, harrowing and preparation of the ground, seeding, mulching, and planting of trees and shrubs was performed in the spring and in the fall. Landscape work was done for erosion control, traffic control, or safety and amounted to 25 percent of the work load.

Other roadside maintenance included picking up fallen limbs, picking up stones and repairing washouts, and transportation of men and equipment, and other miscellaneous work of short duration.

The following table shows accomplishment rates for the various items. Detailed discussions concerning each operation are included in the following pages.

Accomplishment Rates on Roadside Maintenance Items Observed During Study Periods

Item	Size of Crew	Amount of Equipment	Amount of Work Accomplished Per Day
Hand seeding	14	3	44,000 sq. ft. seeded
Hand mulching	5	1	8,600 sq. ft. mulched, includes picking up hay mulch from roadsides
Machine seeding	3	1	310,000 sq. ft. seeded
Machine mulching	18 - 20	4	156,000 sq. ft. mulched
Harrowing mulched areas	1	1	209,100 sq. ft. harrowed
Topdressing turf shoulders	3	1	441,400 sq. ft. topdressed along 4.3 miles of shoulders
Planting shrubs	12	3	240 blueberry shrubs or 450 gray dogwoods, shadblows or yews or 85 hawthornes
Planting trees	7	2	plant 75 trees
Cleaning picnic areas	2	1	11 picnic areas cleaned
Spraying elm trees	4	1	342 elms sprayed
Spraying poison ivy	2	1	4940 sq. ft. and 14 trees sprayed for poison ivy control
Clearing sight lines	5	1	17,200 sq. ft. sightlines cleared, 2.0 loads of brush
Tree removal	6	2	2.1 trees removed
Power mowing	2	1	3.5 acres mowed
Tractor mowing	2	2	12.2 acres on parkways or 8.6 acres roadside on 8.7 miles of highway
Hand mowing	6	1	0.82 acres mowed on 3.2 miles of highway
Picking up hay	5	1	1.4 acres of mown hay picked up

HAND SEEDING

Hand seeding was done on small irregular areas and where there was not sufficient work to justify the use of the seeding machine. Observations were made on one hand seeding operation. A 14-man crew seeded the equivalent of 0.82 miles of variable width parkway center strip on the North Meadows Expressway during one working day. One member of this crew acted in capacity of straw boss, and worked while supervising operations. The composition of the crew was approximately as follows:

Spreading fertilizer	1 man and truck
Breaking ground with 2-wheel garden tractor	2 men
Raking stones from strip	6 men
Picking up stones for disposal	3 men and truck
Seeding, raking and rolling	2 men

Two men worked together for a half-day spreading fertilizer. Each man carried a bucket from which he broadcast the fertilizer at the rate of 14.4 lbs. per thousand square feet. Occasionally, one of the men would drop back and drive the truck forward so that their fertilizer source was always close at hand.

40. Rolling area to embed seed.

At first the men broke the hard, baked crust with rakes in preparing the ground for seed. This was slow hard work and the bottle-neck of the operation so a 2-wheel garden tractor with cultivator attachment was brought out. This tractor was powered by a one-cylinder air-cooled gasoline engine and had two forward speeds and reverse. The tractor had two wheels on a single axle and handled similar to a wheelbarrow. Two operators took turns on the tractor and the other one picked up debris from the tractor's path so as not to clog the cultivator.

A large crew, averaging about six men, raked the stones from the area to the gutter. The rakers left the ground in condition to be seeded. A crew of three men with a 7-ton dump truck came along next. Two men shoveled the stones into the truck while the third man drove the truck along the gutter. When a load was obtained the driver drove the truck to the dump area nearby.

After the ground was prepared, one man, helped at times by two others, did all the seeding. Seed was spread by a hand seeder at the rate of 1.69 lbs. per thousand square feet. After spreading, the seed was covered by lightly raking the ground with wooden toothed rakes. Then the ground was rolled with a hand roller weighing about 250 pounds. Two of the men helped with the raking and rolling while one man did all the seeding.

41. Picking up stones and debris from gutter for disposal.

The distribution of 126.0 man-hours on hand seeding operations is shown in the following table.

Distribution of Man-Hours of Working Time on Hand Seeding

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Breaking ground	6	
1.2 Raking stones	30	
1.3 Loading and disposing of stones	15	
1.4 Spreading fertilizer	2	
1.5 Spreading seed	2	
1.6 Raking and rolling	5	60
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	9	
2.5 Load and haul fertilizer	1	
2.5 Load and unload tools and equipment	3	
2.9 Miscellaneous	2	15
3.0 Waits and delays		
3.1 Wait on other operations	2	
3.3 Supervision	5	
3.4 Quit early, excess lunch	3	
3.5 Idle	6	
3.6 Personal	2	
3.7 Resting	4	
3.9 Other	3	25
Total		100

Based upon observed conditions and rates of accomplishment for the individual operating cycle items comprising hand seeding operations, a 14-man crew will hand seed approximately 1.01 acres or 44,000 square feet per 9.0-hour day. The observed productive rates for the individual operating cycle

items comprising hand seeding operations are as follows:

Item	Square yards per man-hour
1.1 Break ground with rakes	175
1.1 Break ground with tractor	1290
1.2 Rake stones	125
1.3 Load and dispose of stones	250
1.4 Spread fertilizer	1890
1.5 Spread seed	2360
1.6 Rake in seed	1570
1.6 Roll	1370

Total hand seeding operation 65 sq.yd. per man-hour
or 0.0134 acre per man-hour

During the 52-week period, 3 trucks worked 60.0 hours on hand seeding operations. The distribution of 25.3 hours of detailed study of trucks is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks on Hand Seeding Operations

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Parked as mobile materials storehouse	8	
5.2 Load stones and debris	16	
5.3 Haul stones and debris to dump site	2	
5.4 Return to work site	2	28
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	11	
6.3 Travel to new work site	3	
6.4 Minor moves, turns and maneuvers	4	
6.5 Put out and pick up signs	1	
6.6 Load and unload men, tools and equipment	4	
6.6 Unload materials	1	
6.9 Miscellaneous work	1	25
7.0 Waits and delays		
7.1 Parked while men work	35	
7.2 Maintenance of Gravely garden tractor	2	
7.4 Start late, excess lunch, quit early	7	
7.6 Personal	1	
7.9 Other	2	47
Total		100

The distribution of the mileage driven by the average truck on the day studied was as shown on the following page.

Item	Average miles driven per day
To and from garage	24.6
To new work site	3.2
To put out and pick up signs	1.5
Haul stones and debris	1.5
Return to work site	2.9
Other	4.7
Total	38.4 miles

HAND MULCHING

Observations were made on one small hand mulching operation. The operation entailed gathering hay previously cut in roadside mowing operations, hauling it by truck to the seeded areas, and spreading it as a protective cover. The crew on the gathering operation consisted of the driver and 3 men. One additional man, obtained from another crew, was used in the spreading operation. This crew was supervised by a non-working crew leader. The time of the crew leader was not included in the study.

The operations involved were as follows: the driver and 3-man crew traveled from the garage to the area where mowing operations had left a supply of suitable hay; two men walked along the roadside, with pitch forks, throwing the hay onto the truck; another man, on the truck, stacked the hay to make a stable load; the driver drove the truck slowly ahead as the two men loaded; the men on the ground walked ahead through short areas barren of hay, or rode the truck if the barren areas were long; and when the truck was loaded, the men climbed aboard and rode to the area where the hay was to be spread as mulch.

In the operation studied, the area mulched was the fill slope of a newly constructed highway adjacent to a bridge abutment. One man threw hay from the truck to the seeded area. The driver and 3 men (including the extra man obtained by the crew leader from another crew) spread the hay with forks and rakes. The truck was moved ahead as the adjacent areas were covered. When the load was placed, the crew went back for more hay.

It should be noted that this short study is not a typical hand mulching operation because it involved picking up hay from a distant source and mulching a single highway slope not very extensive in area.

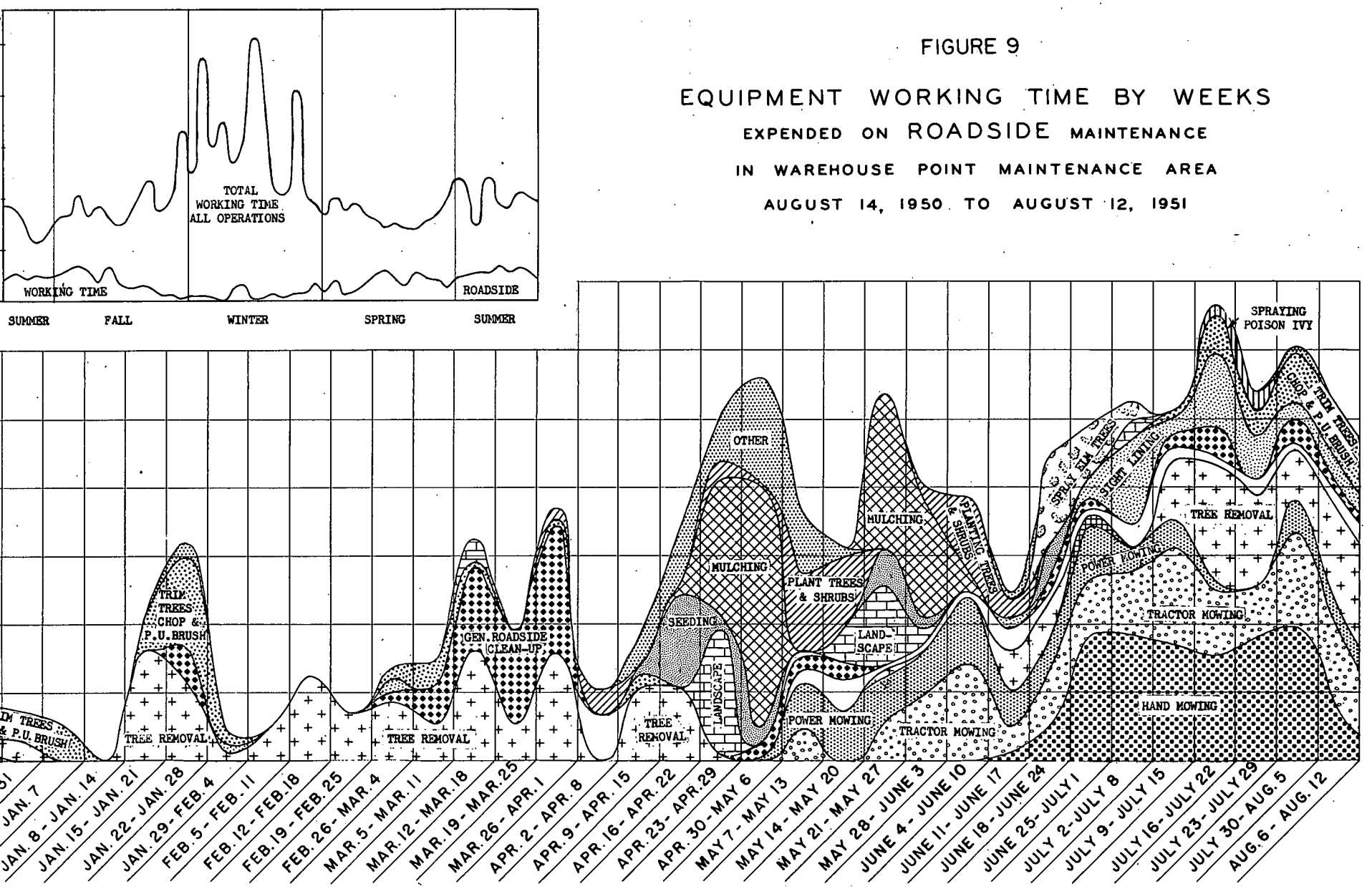
Detailed stop-watch studies were conducted on mulching operations covering a period of 16.7 man-hours. During these 16.7 man-hours the distribution of time is as follows:

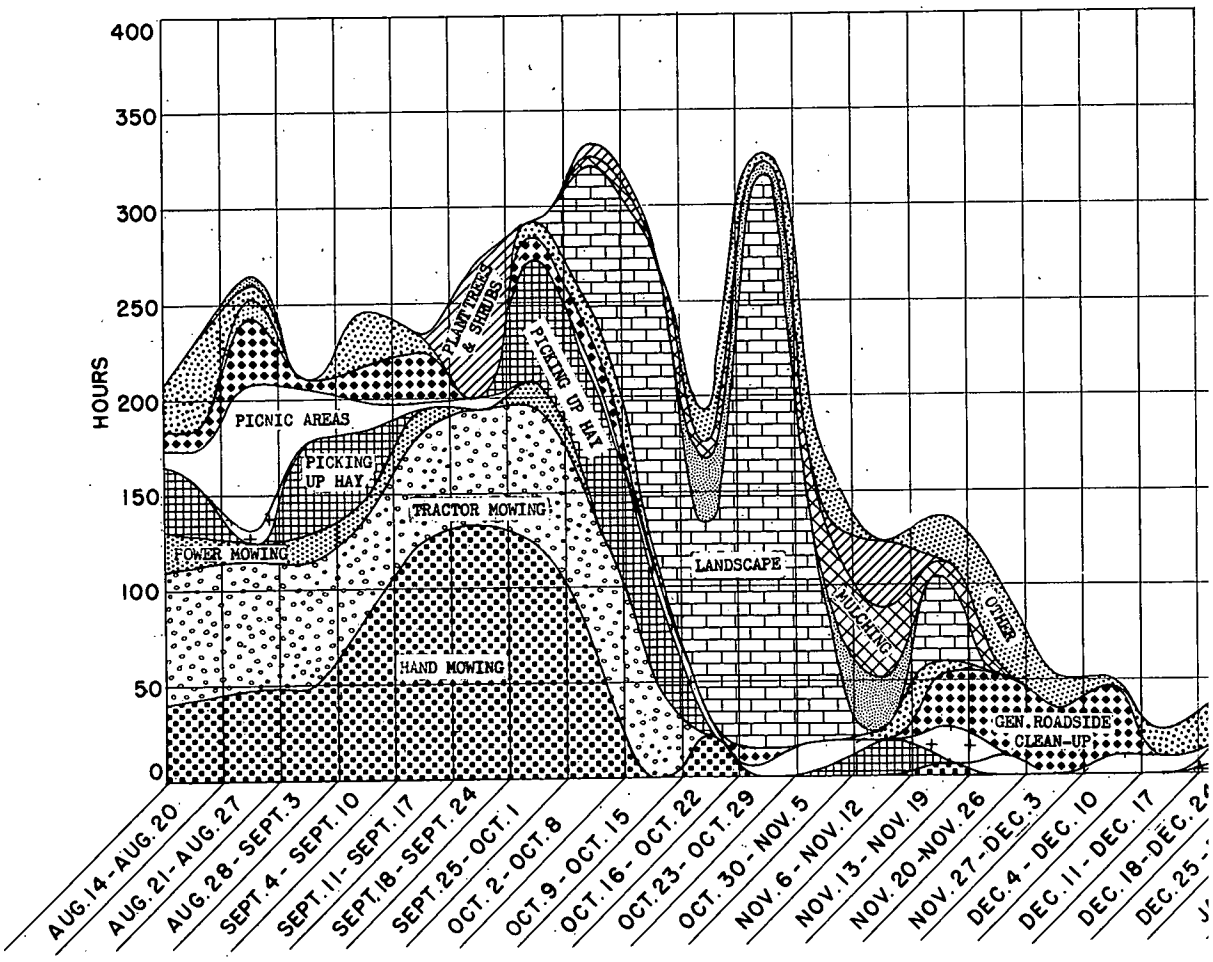
Distribution of Man-Hours of Working Time
on Hand Mulching Operations

Item	Percent
1.0 Operating cycle items on assigned task	
1.1 Loading hay	23
1.2 Haul and return for new load	13

FIGURE 9

EQUIPMENT WORKING TIME BY WEEKS
EXPENDED ON ROADSIDE MAINTENANCE
IN WAREHOUSE POINT MAINTENANCE AREA
AUGUST 14, 1950 TO AUGUST 12, 1951




HOURS
400
350
300
250
200
150
100
50
0
PICNIC AREAS
PICKING UP HAY
POWER MOWING
TRACTOR MOWING
HAND MOWING
PLANT TREES & SHRUBS
PICKING UP HAY
LANDSCAPE
MULCHING
OTHER
GEN. ROADSIDE CLEAN-UP
AUG. 14 - AUG. 20
AUG. 21 - AUG. 27
AUG. 28 - SEPT. 3
SEPT. 4 - SEPT. 10
SEPT. 11 - SEPT. 17
SEPT. 18 - SEPT. 24
SEPT. 25 - OCT. 1
OCT. 2 - OCT. 8
OCT. 9 - OCT. 15
OCT. 16 - OCT. 22
OCT. 23 - OCT. 29
OCT. 30 - NOV. 5
NOV. 6 - NOV. 12
NOV. 13 - NOV. 19
NOV. 20 - NOV. 26
NOV. 27 - DEC. 3
DEC. 4 - DEC. 10
DEC. 11 - DEC. 17
DEC. 18 - DEC. 24

Item	Percent	
1.3 Spread hay as mulch	10	46
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	5	
2.3 Travel to new work site	3	
2.4 Maneuvers, minor moves ahead	6	
2.5 Put out and pick up signs	4	
2.6 Loading and unloading tools and men	5	
2.9 Miscellaneous	1	24
3.0 Waits and delays		
3.1 Wait on other operations	2	
3.3 Instructions	8	
3.5 Idle	8	
3.6 Personal	9	
3.7 Rest	2	
3.9 Other	1	30
Total		100

During the study a 3:1 slope was mulched. Under the observed conditions and rates of accomplishment a 5-man crew can mulch 8622 square feet or 0.2 acres per 9.0-hour day.

For the 52-week period, hand mulching operations were performed a total of 13.3 hours. The following time distribution of truck-hours is based on one 3.0-hour study.

Distribution of Equipment-Hours of Working Time
of Truck Used on Hand Mulching Operations

Item	Percent	
5.0 Operating cycle on assigned task		
5.1 Load hay	26	
5.2 Haul and return for new load	13	
5.3 Unload and spread hay	11	50
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	5	
6.3 Travel to new work site	3	
6.4 Minor moves, turns and maneuvers	1	
6.5 Put out and pick up signs	4	
6.6 Load and unload men and tools	6	19
7.0 Waits and delays		
7.1 Wait on other operations	4	
7.3 Instructions	8	
7.5 Idle	9	
7.6 Personal	9	
7.9 Other	1	31
Total		100

The mileage driven by the truck while under observation was as shown on the following page.

Nature of Travel	Miles
To and from garage	6
To new site	2
To obtain hay	11
While loading hay	4
To put out and pick up signs	2
Total	25

MACHINE SEEDING

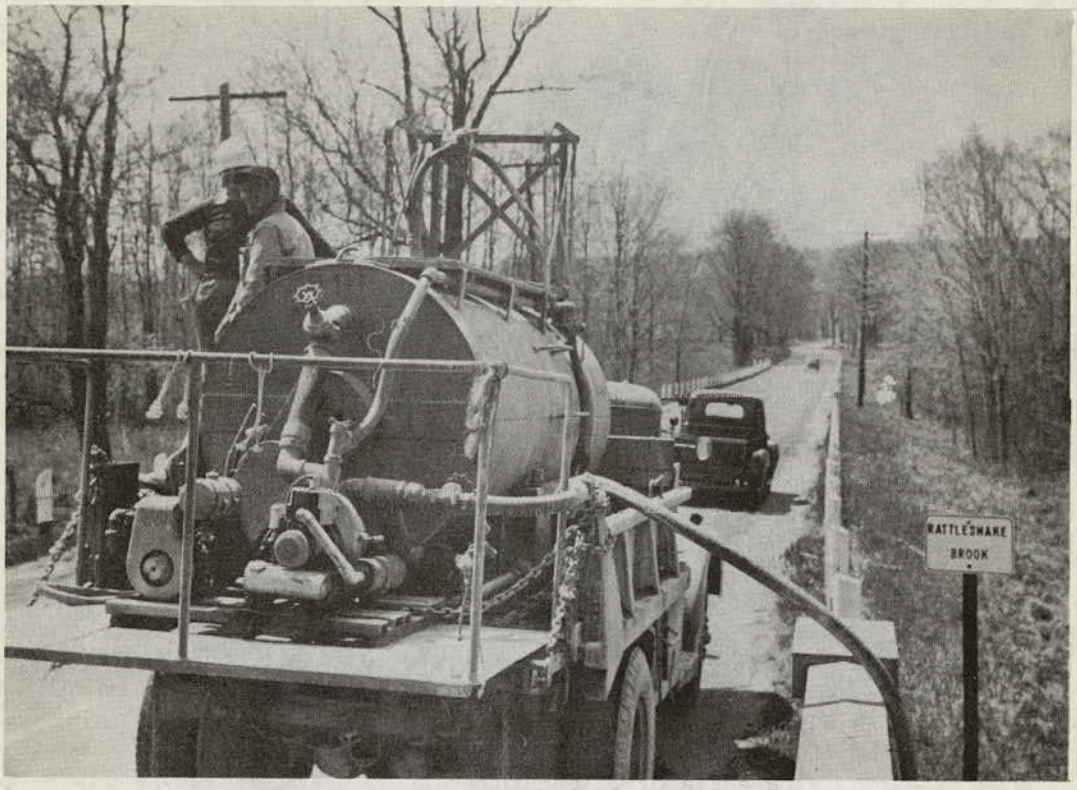
Studies of machine seeding were made during spring planting of grass seed on cut and fill slopes, and other locations which varied in size from narrow shoulder strips to large flat areas. The machine employed was constructed by the State.

The seeding was done by spraying a mixture of grass seed, water, and fertilizer through a 2½-inch hose, with a special fan-shaped spraying nozzle. The spray mixture was carried in a 1,000-gallon steel tank with built-in agitators turned by a 2-horsepower air-cooled gasoline engine. Pressure for spraying was provided by a 3-inch centrifugal pump assembly driven by another Wisconsin 22-horsepower air-cooled engine. The entire seeding assembly was mounted as a unit on steel I-beam skids, and during the studies was carried on a 7-ton dump truck.

The seeding crew normally consisted of 3 men, a truck driver, a sprayman, and a mechanic to operate the 2 auxiliary engines. The first operation was to drive the truck out of the garage and put up the detachable safety railing about the sprayman's platform atop the tank. Following this, the seeder truck was driven to a water source where the suction hose was lowered into the water by the sprayman. The mechanic started the pump engine, and as the tank filled, the sprayman usually stood on his platform and observed the rising water through the 18-inch manhole located in the top center of the tank directly aft of the platform. When the tank was full the mechanic turned off the pump engine and the suction hose was pulled back onto the truck. Generally the driver assisted the sprayman in handling this hose.

Next the truck was driven to a loading area where 22 80-pound bags of fertilizer and 60 pounds of grass seed were poured by hand through the manhole into the 1,000-gallon tank. The crew of three was generally assisted at this point by one or two additional laborers. The loading was done from a truck parked alongside the seeder truck. Two men swung the fertilizer bags up onto the tank, and another man ripped the bags open at the manhole. It was necessary that the agitator be set in motion before these materials were poured into the tank, for if the fertilizer were allowed to settle to the bottom of the tank, the agitator blades would not be able to pass through the resulting mass. It would then be necessary to drain the tank and shovel the collected fertilizer out of the tank.

As soon as the spray materials were loaded into the tank, the seeder maneuvered into position at the area to be seeded. The pump engine was started and as the machine moved ahead slowly, the sprayman directed the spray onto the area on the leeward side. The spray extended out about 40 feet



42. Filling seeding and fertilizing machine tank with water.

under normal working conditions with a light breeze blowing. If the area to be sprayed was on the windward side and the wind was high, this area was left for spraying later when wind conditions were more favorable. The spray-man attempted to cover 65,000 square feet ($1\frac{1}{2}$ acres) with each load, which is the area for which the mixture was designed.

When the areas to be seeded extended away from the road more than about 50 feet, the seeder could not travel along the pavement, but had to move onto the area. Under these conditions, about a 5 to 10 percent overlap was obtained in order to avoid bare spots. During the studies, several large areas adjacent to airport runways were seeded. These, obviously, are not representative of normal highway seeding operations where it is possible to seed most cut and fill slopes by driving the seeder along the shoulder of the road. Unfortunately, the soil was very sandy, with little or no binder and the seeder became stuck repeatedly. This caused delays and waits while a bulldozer or motor patrol arrived to pull the seeder free. Once freed, it was usually necessary to keep the bulldozer or grader hooked on for an additional 5 or 10 minutes, pulling the seeder until it completed spraying the soft area.

When these large areas were being sprayed, the seeder would turn upon completing a run into the area, and move toward the wind a distance approximately equal to the distance which the spray was being blown. The seeder

43. Filling seeding and fertilizing machine with fertilizer; seed is already in and the agitator is running.

would then make another run through the area, and spray while moving ahead.

When the mixture tank became empty, the pump auxiliary motors were turned off and the seeder was driven to the water source again.

44. Seeding and fertilizing roadside cut by machine.

At the end of the day, the truck was driven into the garage after the safety railing about the operator's platform had been taken down.

The seeding machine was used on limited occasions and no over-all time record was kept of its use. During the period that seeding operations were in progress in the area, 19.5 hours of study observations were made. The distribution of this working time in accordance with the detailed studies is shown in the tabulation on the following page.

Distribution of Equipment-Hours of Working Time
of Seeding Machine

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel to and from work site to load tank	11	
5.2 Fill tank with water	13	
5.3 Charge tank with seed and fertilizer	14	
5.4 Spraying (seeding)	15	
5.5 Minor moves, turns, and maneuvers	5	
5.6 Other	2	60
6.0 Related items, including travel and preparatory work		
6.1 Travel to and from garage	3	
6.3 Travel to new work site	1	
6.4 Minor moves, turns, and maneuvers	1	
6.6 Load and unload men, tools and equipment	1	6
7.0 Waits and delays		
7.1 Wait for operators to arrive from Wethersfield	19	
7.1 Stuck in soft grade - Wait for bulldozer	4	
7.2 Clean up seeding machine and truck at night	2	
7.2 Maintenance of truck	1	
7.2 Maintenance of auxiliary motors	2	
7.3 Instructions	4	
7.9 Other	2	34
Total		100

Approximately 310,000 square feet were seeded during a 9.0-hour day. The application rate during the study period was observed to be approximately 1.0 pound of seed, 28.5 pounds of fertilizer, and 15.5 gallons of water per 1,000 square feet.

During the 15 percent of the time that actual spraying was underway, the truck hauling the seeding machine traveled at an average speed of approximately 1.7 miles per hour.

The average mileage driven by the truck hauling the seeding machine on days during which studies were made was as follows:

Item	Average miles driven per day
To and from garage	4.2
To new work site	0.3
To water source	3.0
To fertilizer site	2.8
From fertilizer site to work site	0.7
Travel ahead spraying	1.0
Other	0.2
Total	12.2

MACHINE MULCHING

Mulch was spread on an area as soon as possible after it had been seeded and fertilized—before the area could dry and allow the sprayed materials

45. Three men loosening windrow of hay in preparation for use by mulching machine in windrow method.

46. Mulching by machine using windrow method. Machine and crew of four men with two extra men spotting bare spots and distributing excess windrow.

47. Crew of four loosening hay and crew of four including driver loading truck in truck feeding method.

48. Mulching by machine using truck feeding method, usual method used on roadsides, crew of six including two drivers.

to blow away. The mulch spreader consisted of a large blower driven by a 6-cylinder gasoline engine. The blower had a rated displacement capacity of 11,392 cubic feet of free air, or 11,420 pounds per hour of hay mulch. The entire unit was mounted on an I-beam frame which permitted easy loading and unloading and was transported by the same 3-ton dump truck during the time the studies were being conducted on it. A 10-foot length of 18-inch diameter spiratube flexible tubing was attached to the blower inlet and a 3-foot length of 18-inch spiratube with a special nozzle attached was clamped over the discharge opening of the blower. This arrangement permitted the operator to

49. Tractor pulling disc harrow over area to hold down mulch.

control the distribution of the mulch. The unit was capable of throwing the mulch about 50 feet depending to some extent upon the wind velocity. The blower spread only to the right side, and mulching runs were made with the right side on the leeward side. Roadside areas which lay on the windward side had to be mulched when the wind was low. When mulching the large seeded areas, the spreader would turn at the end of a run, and return to the other end of the area to make another mulching run alongside the preceding one.

The entire crew for mulching consisted of from 18 to 20 men, excluding foremen and crew leaders. The mulch spreader itself required a driver, an operator who tended the blower motor and directed the outlet nozzle, and two laborers who fed the mulch to the suction hose by means of forks.

Two procedures were followed in supplying mulch to these two men at the suction hose. In one method bales of mulch were distributed in a windrow and were broken open, the mulch then being shaken out with pitchforks. One truck was used to haul the bales, 4 to 6 laborers loading it at a stockpile of bales. As the loaded truck moved slowly along the proposed windrow line, 1 or 2 of these men would roll the bales off, and the other men, including the 2 who fed the spreader suction hose, would break up the compacted mulch. When a windrow had thus been prepared, the spreader would move along it and the mulch would be blown on the desired area. This procedure left the mulch spreader idle after each windrow had been spread, for it had to wait then while another windrow was distributed.

In the second method, this wait was eliminated. Instead of carrying tied bales from the stockpile, three distributing trucks carried mulch that had already been broken down from the bale form by a crew of from 8 to 10 laborers at the stockpile. As one of these trucks would move ahead beside the spreader truck, a single laborer on it would fork the mulch down on the ground between the two vehicles. The two men at the suction hose would then pull it over under the hose inlet in such a manner as to keep a steady stream of mulch passing through the blower. With three trucks supplying the mulch

in this way, there were no waits for mulch once the first load had arrived at the spreader.

It should be noted that this was not a representative highway project but an airport job. Ordinarily baled hay would not be used for highway projects but rather hay picked up from roadside mowing. This would eliminate the time spent on opening up the bales and then shaking the hay loose.

One truck was used to haul the mulching machine. During the 52-week study period this truck was assigned to mulching operation a total of 100.8 hours. The distribution of this working time in accordance with 31.2 hours of study is as follows:

Distribution of Equipment-Hours of Working Time
of Mulching Machine

Item	Percent Windrowed		Percent Truck-feed	
5.0 Operating cycle items on assigned task				
5.1 Maneuver mulching machine into position	9		9	
5.2 Blowing mulch	28		38	
5.3 Travel ahead not mulching	3	40	1	48
6.0 Related items including travel and preparatory work				
6.1 Travel to and from garage	9		7	
6.2 Travel to new work site	1		2	
6.5 Load and unload men, tools and equipment	1	11	-	9
7.0 Waits and delays				
7.1 Wait for hay truck	-		20	
7.1 Wait for hay to be distributed in windrow	6		-	
7.1 Wait while windrow is moved	15		-	
7.1 Wait while mulched area is harrowed	2		-	
7.1 Mulching truck stuck in soft grade	4		5	
7.2 Maintenance of truck	6		1	
7.2 Maintenance of mulching machine	-		6	
7.2 Clear and adjust suction hose	1		1	
7.3 Instructions and inspections	10		4	
7.4 Quit early	2		2	
7.9 Wait for arrival of men to feed hay to mulcher	1		-	
7.9 Travel to obtain drinking water	-		1	
7.9 Other	2	49	3	43
Total		100		100

The rate of applying mulch during actual blowing time (Item 5.2) was observed to be 33,240 and 45,780 square feet per hour for the windrow and truck feeding methods, respectively. This difference in rate was due largely to the faster travel speed of the machine when mulch was supplied directly from the hay trucks.

During a 9-hour day, mulching was accomplished on areas of 83,765 and 156,568 square feet respectively, for the windrow and truck feeding methods.

During the study periods it was observed that mulching on cut slopes was performed at a much slower rate than on either fill slopes or flat areas, due principally to excessive wind.

The application rate observed during the study period was approximately 110 pounds of hay mulch per 1,000 square feet.

The mulching machine traveled forward at an average speed of 0.36 miles per hour while actually blowing and spreading mulch by the truck feeding method. This rate includes time when the machine was blowing mulch even though standing still temporarily.

The average mileage traveled by the truck transporting the mulching machine on the days studies were conducted was as follows:

Item	Average mileage driven per day: Windrow Method	Average mileage driven per day: Truck Feeding Method
To and from garage	11.7	11.7
To new work site	0.5	0.9
Travel ahead while mulching	1.0	1.1
Other	1.0	1.3
Total	14.2	15.0

HARROWING MULCHED AREAS

A disc harrow was pulled over newly mulched flat areas to work the mulch into the soil to anchor it in place. Branches of trees and snow fence were spread over the cut and fill slopes to hold the mulch in place.

During the 52-week period tractors were assigned to pulling the disc harrow for a total of 73.5 hours. The distribution of working time for a tractor while pulling a disc harrow as observed during an 8.3-hour period of study is as follows:

Distribution of Equipment-Hours of Working Time
of Tractor Pulling Disc Harrow Over Flat Mulched Areas

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Pull disc harrow over mulched areas	58	
5.2 Minor moves, turns and maneuvers	1	59
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage (parked overnight at job site)	-	
6.9 Tow mulching machine over soft area	4	4
7.0 Waits and delays		
7.1 Wait for additional areas to be mulched	25	
7.2 Maintenance of tractor	4	
7.5 Idle	6	
7.9 Other	2	37
Total		100

During the study period, the tractor and disc combination was observed to harrow at the rate of 4.8 acres per 9.0-hour day.

TOPDRESSING TURF SHOULDERS WITH THE SEEDING MACHINE

These studies were made during the spring months when fertilizing operations commonly are performed.

All seeded areas are topdressed as necessary to maintain satisfactory turf. Areas topdressed include: turfed shoulders, cut slopes, fill slopes, and any areas where it is essential to maintain an established turf.

Topdressing was accomplished by spraying an admixture of water and fertilizer through a 2½-inch hose fitted with a special fan-shaped spraying nozzle. The mixture was carried in a 1,000-gallon steel tank containing built-in agitators turned by a small 2-horsepower air-cooled gasoline engine. Pressure for spraying was provided by a 3-inch centrifugal pump assembly driven by a 22-horsepower air-cooled engine. The entire assembly was mounted as a unit on steel I-beam skids and, during the studies, was carried on a 7-ton truck.

The topdressing crew normally consisted of 3 men, a truck driver, a sprayman, and a mechanic to operate the 2 auxiliary engines. This particular operation was essentially the same as that described for machine seeding, the difference being the absence of seed.

During the 52-week period the seeding machine was used for topdressing turf shoulders, a total of 9.0 working hours. The distribution of this working time in accordance with detailed studies covering a period of 9.0 hours of work is shown in the table which follows.

Distribution of Equipment-Hours of Working Time of Seeding Machine

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel to and from water source	14	
5.2 Load seeding machine with water	17	
5.3 Load fertilizer into tank	5	
5.4 Mix fertilizer and water	1	
5.5 Maneuvers and turns while topdressing	3	
5.6 Spraying turf shoulders	14	
5.7 Short moves ahead	1	55
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	18	
6.3 Travel to new work site	3	
6.6 Load and unload men, tools and equipment	1	
6.9 Miscellaneous	2	24
7.0 Waits and delays		
7.1 Wait for operators to arrive from Wethersfield Garage	8	
7.2 Maintenance of auxiliary equipment	2	
7.2 Maintenance of truck	1	
7.4 Start late, excess lunch and quit early	6	

Item	Percent	
7.5 Idle	1	
7.6 Personal delays	3	21
Total		100

Under the observed conditions and rates of accomplishment the seeding machine will cover 441,400 square feet on 4.3 miles of turf shoulders in a 9.0-hour day. The width of shoulder sprayed or topdressed varied from 5 feet to 40 feet with an average width of 16 feet.

The application rate during the study period was observed to be approximately 1 pound of fertilizer and 1 gallon of water for each 95 square feet sprayed.

The truck hauling the seeding machine traveled at an average speed of 3 to 4 miles per hour during actual spraying operations.

The average mileage driven by the truck hauling the seeding machine on days during which studies were made was as follows:

Item	Average miles driven per day
To and from garage	40
To and from water source	18
To new work site	6
Other	7
Total	71

PLANTING SHRUBS

Shrubs are planted either in the spring or fall, the spring being preferred. Studies were conducted on spring planting of blueberry, evergreen and gray dogwood shrubs along with hawthorne and maple trees.

The hawthornes were planted between the outside lanes of a divided highway and paralleling service roads. Planted in a single row outside the present guide rail, it was intended that the shrubs will grow so as to one day replace the guide rail, and serve as barriers to cross traffic. The blueberry shrubs were planted on the median strip of the divided highway to prevent headlight glare from opposing traffic.

The typical hawthorne planting crew consisted of the following:

Equipment:
- 3 Trucks
- 10 Long-handled shovels
- 3 Short-handled shovels
- 4 Picks
- 1 Grubbing hoe
- 6 Pairs of gloves
- Several 20-25-foot lengths of 1/2 - 3/4-inch rope
- Several pocket knives
- 1 Hole-locating stick

Labor: 1 Foreman
3 Drivers
5 Diggers
4 Shrub handlers and planters

The holes for the hawthornes were spotted at 25-foot intervals. The distance from guide rail to the holes was kept uniform by measuring out from the guide rail cable with a stick which was as long as the desired offset. The radius of the hole was marked off on this stick, and this was used to establish the size of a roughly outlined 2-foot circle which was scratched in the dirt with the stick end. After the circle was thus located, the soil was broken with a pick and thrown into a pile at one side of the hole with a hand shovel. In a few instances the topsoil was loose, and was taken up without the employment of the pick. The pick was used later as compacted earth was encountered. The size of the shrub roots dictated the depth to which the holes were dug; for the hawthornes, holes about 18-inches deep allowed for the planting of the shrubs with several inches of soil cover over the uppermost roots. Each hole was dug by one man. One of the truck drivers dug holes along with the 5 diggers when he was not driving. His truck was used to transport the diggers to and from the work site and to fetch drinking water for the crew.

The shrubs were obtained from a nearby State nursery, 2 trucks being employed to transport them. They were supplied with a ball of earth encasing the roots which was wrapped with burlap. Four to six laborers were required for loading the hawthornes onto the trucks. The average weight of the shrubs was about 125 pounds, and the thorns of these shrubs made handling

50. Planting evergreen shrubs at entrance to Bradley Field airport.

51. Planting hawthorne trees as barrier between expressway and service roads.

them rather difficult. Because of the thorns, the men handling them had to wear leather gloves. The lighter shrubs were lifted onto the trucks by two men on the ground; the heavier ones had to be lifted aboard with the assistance of two men standing on the truck tailgate, who lifted them by means of a rope which was passed under the burlap-wrapped roots by the two men on the ground. As they were lifted, another man steadied the shrubs by holding the branches. One or two men, who normally are full-time workers at the nursery, assisted in the loading at odd times through the day.

When the load of shrubs arrived at the work site, one or two laborers would roll the shrubs off of the truck, while two or three others on the ground rolled them into the holes. The hawthornes were thus distributed, one at each hole, as the truck moved along the line of holes. Since the same men worked at both shrub loading and planting, the number of men planting at any one time varied from 2 to 4. The 2 truck drivers also acted as handlers and planters when not driving.

The planting consisted of the following major operations:

1. Align shrub in hole
2. Enlarge hole with shovel if necessary
3. Cut burlap loose from about roots and spread burlap on bottom of hole
4. Backfill on roots with shovel from excavated soil pile
5. Tamp backfill
6. Form water cup with shovel
7. Cut string from about shrub and spread branches

Evergreen shrubs were planted at the entrance to the airport at Bradley Field for their esthetic value; gray dogwood shrubs were planted in the median strip of the Enfield cut-off to cut down headlight glare; whereas the maple trees were replacements.

Detailed stop-watch studies were conducted on the planting of shrubs over a period of 199.0 man-hours, excluding foremen. The following table shows the distribution of working time in accordance with these studies.

Distribution of Man-Hours of Working Time
on Planting Shrubs

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Locate holes	2	
1.2 Dig holes	26	
1.3 Distribute shrubs at planting site	8	
1.4 Plant shrubs	10	
1.5 Cut strings and shake out branches	2	
1.6 Prune and trim shrubs	1	
1.7 Clean up area	5	54
2.0 Related items, including travel and preparatory work		
2.1 Travel to and from garage	10	
2.2 Travel between stockpile and work site to obtain load of shrubs	6	
2.3 Travel to new work site	2	
2.6 Load and unload men, tools, and equipment	4	
2.6 Load shrubs at nursery	7	
2.9 Travel to and from dump site with debris	1	30
3.0 Waits and delays		
3.1 Wait on other operations	1	
3.3 Instructions	3	
3.4 Start late, excess lunch and quit early	3	
3.5 Idle	2	
3.6 Personal	3	
3.7 Resting	2	
3.9 Other	2	16
Total		100

Under the observed conditions and rates of accomplishment, a 12-man crew, working a 9-hour day, will plant approximately

240 Blueberry bushes, or
450 Gray Dogwoods, Shadblows, and Yew shrubs, or
85 Hawthornes

During the 52-week period from August 14, 1950, through August 12, 1951, 4 trucks were used on planting shrubs for a total of 145.5 equipment-hours of working time. The distribution of this working time, in accordance with detailed stop-watch studies covering a total of 41.1 equipment-hours, is as shown on the following page.

Distribution of Equipment-Hours of Working Time
of Trucks Used on Planting Shrubs

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This unit works in the capacity of a general purpose service truck and has no clearly defined operating cycle.		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	13	
6.2 Travel between nursery and work site to obtain shrubs	13	
6.3 Travel to new work site	1	
6.4 Minor moves, turns and maneuvers	11	
6.6 Load and unload men, tools and equipment	5	
6.6 Load shrubs at nursery	11	
6.6 Distribute shrubs at planting site	7	
6.9 Miscellaneous	2	63
7.0 Waits and delays		
7.1 Parked as men work	20	
7.1 Waits on other operations	4	
7.2 Maintenance of truck	1	
7.3 Instructions	3	
7.4 Start late, excess lunch and quit early	2	
7.5 Idle	2	
7.6 Personal	2	
7.9 Other waits and delays	3	37
Total		100

The average mileage driven by each truck on the day during which studies were conducted was as follows:

Item	Average miles driven per day
Travel to and from garage	24
Travel between nursery and work site	19
Travel to new work site	1
Travel to and from dump site	2
Minor travel including maneuvers	5
Total	51

An average truck load consisted of:

50 Hawthornes, or
50 Gray Dogwoods, Shadblows, and Yew shrubs, or
178 Blueberry bushes

PLANTING TREES

Trees which are removed for safety purposes from residential or developed areas and State-maintained parks and picnic areas, are replaced with deciduous shade trees. Trees are also planted to control erosion along slopes

and for their esthetic value in landscaping areas such as intersection medians and dividing islands, when they can be located so as not to interfere with sight distance.

These trees were normally planted with a crew of two or three men using a 3-ton dump truck. The extent of this work was limited and no overall control was maintained of the total accomplishment. One detailed study of this operation was made on a day when a 7-man crew was involved. On this day, the trees planted were 1 to 1½-inches in diameter and from 12 to 15 feet in height. The distribution of the working time for the crew is as follows:

Distribution of Man-Hours of Working Time
on Planting Trees 1/

Item	Percent	
1.0 Operating cycle operations on assigned task		
1.1 Walk between truck and tree site	1	
1.2 Dig holes	14	
1.3 Unload and carry tree to planting site	2	
1.4 Prepare tree for planting	1	
1.5 Plant tree	12	
1.6 Walk to next tree site	7	37
2.0 Related items including travel & preparatory work		
2.1 Travel to and from garage	42	
2.4 Minor moves, turns and maneuvers	1	
2.6 Load and unload men, tools and equipment	1	
2.9 Miscellaneous	2	46
3.0 Waits and delays		
3.1 Wait for hole to be dug	4	
3.1 Wait while dirt is shoveled around tree	6	
3.3 Instructions	3	
3.5 Idle	2	
3.6 Personal delays	1	
3.9 Other	1	17
Total		100

Under the observed conditions and rates of accomplishment, the 7-man crew will plant 75 trees in a 9.0-hour working day.

During the 52-week study period, 5 trucks were employed at various times for a total of 135.1 hours on tree planting operations.

Two trucks were used on the day the detailed stop-watch study was made. Distribution of the truck working time based upon that study is as shown on the following page.

1/ Based upon a limited study and not necessarily typical of a normal day's work.

Distribution of Equipment-Hours of Working Time
of Trucks Used on Planting Trees 1/

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This unit works in the capacity of a general purpose service truck and has no clearly defined operating cycle		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	45	
6.4 Minor moves, turns and maneuvers	3	
6.6 Load and unload men, tools and equipment	1	
6.6 Unload trees	3	52
7.0 Waits and delays		
7.1 Parked as men work	47	
7.9 Other	1	48
Total		100

The average mileage driven by each truck on the day of study was 32 miles.

CLEANING PICNIC AREAS

This operation involved maintaining the roadside picnic areas of the district in good condition. The crew consisted of two men, a driver and another man. Firewood was usually distributed to the fireplaces at the picnic areas but not necessarily each time the areas were cleaned.

52. Planting tree for landscape purposes on North Meadows Expressway, Hartford, Connecticut; dead or unsuitable trees that have been removed are replaced with young trees in similar fashion.

The equipment consisted of a canvas tarpaulin spread in the body of the truck upon which the rubbish from each picnic area was placed. The rubbish was then covered with the remainder of the tarpaulin to prevent spillage in transit. A bushel basket for distributing the firewood and a shovel to clean out the fireplaces were also part of the equipment.

The truck was first loaded with specially cut firewood at the stockpile. The crew then traveled to the first picnic area to be cleaned. Usually one man would distribute sufficient firewood to each fireplace in the area with the bushel basket while the other man cleaned out the fireplaces, if necessary, picked up loose paper and trash from the area, and rolled the rubbish barrels to be

1/ Based upon a limited study and not necessarily typical of a full working day's operations.

emptied to the truck. Both men then spread the tarpaulin in the body of the truck, emptied the rubbish barrels onto it, and covered the rubbish with the outer edges of the tarpaulin. An especially dirty barrel was disinfected, after which the barrels were returned to their respective positions in the picnic area. There was no special order in which the preceding work was performed, but generally the pattern described was followed.

After the picnic area was cleaned and firewood distributed, the crew traveled to the next area on their list and the cycle was repeated.

When the truck was loaded with rubbish, after cleaning from 3 to 6 (average was 5) picnic areas, the material was hauled to a disposal site. At the dump, either both men pushed the rubbish to the tailgate and then pulled the tarpaulin out from under it, thereby dumping it off the truck, or the little firewood left was unloaded with the tools and the rubbish was dumped by raising the body, after which the firewood and tools were again loaded on the truck.

The crew then traveled to the next picnic area to be cleaned and the cycle was repeated.

At the end of the day, after the travel to the stockpile, the remaining firewood on the truck was dumped off and the truck was then refueled and parked for the night.

On the days upon which studies were taken, the crew worked only a portion of the day on cleaning picnic areas and the remainder of each day on some other operation. Thus, the distribution of time under these conditions was somewhat different than had the crew worked continuously each entire day upon cleaning picnic areas. However, the study data which are present reflect the actual conditions encountered during the studies.

Detailed stop-watch studies were conducted on cleaning picnic areas covering a total of 27.1 man-hours, during which time the crew consisted of two men, a truck driver and one helper. The distribution of time in accordance with these studies is as follows:

Distribution of Man-Hours of Working Time
on Cleaning Picnic Areas

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Pickup and load trash onto truck	8	
1.2 Distribute firewood to fireplaces	3	
1.3 Repair of picnic tables, picking up ashes and other work	2	
1.4 Travel ahead to the next area to be cleaned	24	37
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	24	
2.2 Travel to and from stockyard to pickup new picnic tables	7	
2.4 Minor moves, turns and maneuvers	2	
2.6 Load and unload men, tools and equipment	3	

Item	Percent	
2.6 At stockyard loading firewood and picnic tables	2	
2.9 Travel to and from dump site	9	
2.9 Dump load at dump site	1	48
3.0 Waits and delays		
3.1 Wait on other operations	1	
3.2 Maintenance of truck	1	
3.3 Instructions	8	
3.4 Excess lunch and quit early	3	
3.5 Idle	1	
3.6 Personal delays	1	15
Total		100

The average work done in each area consisted of emptying 1.6 barrels of rubbish and ashes and distributing 1 bushel basket of firewood.

Under the observed conditions and rate of accomplishment, a 2-man crew will clean 11 picnic areas in a 9.0-hour working day.

During the 52-week period, 10 trucks were used at various times on cleaning picnic areas for a total of 213.6 hours. The distribution of working time in accordance with 3 detailed stop-watch studies covering a period of 13.6 hours of work is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks Used Cleaning Picnic Areas

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Load trash onto truck	6	
5.2 Unload firewood and picnic tables	2	
5.3 Travel ahead to next area to be cleaned	27	35
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	27	
6.2 Travel to and from stockyard for picnic tables	4	
6.4 Minor moves, turns and maneuvers	2	
6.6 Load and unload men, tools and equipment	2	
6.6 Load firewood and picnic tables at stockyard	1	
6.9 Travel to and from dump site	10	
6.9 Dump load at dump site	-*	46
7.0 Waits and delays		
7.1 Parked as men work	5	
7.2 Maintenance of truck	1	
7.3 Instructions	6	
7.4 Excess lunch and quit early	3	
7.5 Idle	1	
7.6 Personal delays	2	
7.9 Other	1	19
Total		100

* Less than 0.5% of time.

The mileage driven by the truck on the days during which studies were made and which embraces a total of 13.6 hours of crew time was as shown in the following table:

Item	Miles driven
To and from garage	25.7
To new work site	25.6
To dump rubbish	9.2
To and from stockyard for picnic tables	8.4
Other	0.2
Total	69.1

The large percent time indicated for travel to and from the garage in the foregoing tables is explained by the fact that the picnic areas were cleaned in half a day on Fridays during the spring, summer and fall.

SPRAYING ELM TREES (Foliage Spray)

All elm trees standing alongside or adjacent to state highways are sprayed once a year for the control of canker worm and the elm leaf beetle. This spraying usually takes place during the latter part of May or the first of June. Control of the elm leaf beetle is best accomplished when the spraying is done during a 10-day larva period. Accordingly, a longer workday was needed to complete this highly seasonal work within the 10-day period. As a result, the normal working hours were increased to 14.5 hours, 5:00 A.M. - 9:00 P.M., with three half-hour eating periods. In urban areas, spraying was done during early morning and late evening hours when the air was calm and there were fewer cars on the street. During the middle of the day, the rural areas were covered where windblown spray did not create a public hazard.

53. Spraying elm tree for control of cankerworm and elm leaf beetle.

The equipment used in spraying elm trees consisted of a hydraulic sprayer with nozzle capacity of 55 gallons per minute at maximum pressure of 800 psi carried on a 7-ton truck. The pump itself was a three-cylinder, piston-type pump, driven by an engine through a belt drive. The spray mixture was carried in a 400-gallon tank which was filled by an injector pump using the pressure of the tree sprayer. The tank was never completely emptied; usually

about twenty-five gallons of mixture were left in the tank to operate the injection unit in refilling the tank. Maximum lift of the injection unit was about 18 feet.

One tankful of spray mixture ordinarily covered at least twenty trees of 60' height and 50' crown.

The operation required a crew of four men. Upon arrival at a spray site, the foreman first posted the tree, then walked to a forward position to direct traffic. Meanwhile the rear flagman had opened the throttle of the sprayer's engine, setting the operating pressure at 600 psi. (For exceptionally high trees - over 65' - the operating pressure was momentarily boosted to 800 psi.) While the truck moved forward at its slowest speed, the sprayman (standing on a platform mounted on top of the truck) sprayed first the forward side of the tree, up inside, and then the back side as the truck moved out from underneath. Rarely was spraying done at a standstill. The spray stream depended upon the height of tree or nearness of boughs and could be varied from a fog to a solid 3/16" jet for greatest distance.

During the 52-week study period, the sprayer was used in spraying elm trees for a total of 116.8 equipment hours. The distribution of the working time in accordance with 29.4 hours of detailed stop-watch studies is shown in the following table.

Distribution of Equipment-Hours of Working Time of Hydraulic Sprayer Mounted on 7-Ton Dump Truck Spraying Elm Trees

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel to and from water source	11	
5.2 Load tank with water at water site	16	
5.3 Post tree with tag indicating it had been sprayed	2	
5.4 Travel ahead spraying elm trees	17	
5.5 Travel ahead to next tree	26	72
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	2	
6.4 Minor moves, turns and maneuvers	1	
6.6 Load and unload materials	3	6
7.0 Waits and delays		
7.2 Maintenance of sprayer	5	
7.2 Clean out spray nozzle and hose	1	
7.2 Maintenance of truck	2	
7.3 Instructions	1	
7.4 Excess lunch	2	
7.6 Personal	5	
7.9 Travel to and from restaurant for lunch	4	
7.9 Operator dons special clothing for spraying	1	
7.9 Other	1	22
Total		100

Under the observed conditions and rates of accomplishment, this equipment will spray approximately 342 elm trees in a 9.0-hour day.

An average of 11.6 gallons of mixture was used to spray one tree.

The size of the trees sprayed varied as follows:

Butt diameter	Range: 3" to 36" Average 15"
Height	Range: 15' to 65' Average 41.5'
Crown	Range: 10' to 65' Average 29'

The average mileage traveled by the spray truck on days during which studies were conducted was as follows:

Item	Average daily mileage
To and from garage	7.9
To and from water source	26.1
To and from restaurant for lunch	17.8
Travel ahead to next tree	40.4
Other	5.2
Total	97.4

SPRAYING POISON IVY

For spraying poison ivy, a crew of two men, a truck, and the spray equipment was employed. Two 50-gallon drums were filled with mixture in the morning and under normal operation were enough for a day's operation. The spray was exceedingly fine and a heavy concentration of it was not needed. Over a period of a week or two, this mixture caused the ivy first to turn yellow and then to die.

The spray equipment consisted of a pump, driven by a one-cylinder gasoline engine, two fifty-gallon drums and the spraying bar. The pump and engine were bolted to the bed of the truck near the tailgate and the drums were lashed to the sideboards behind the pump. Two hoses ran between the pump and the barrels, one to draw the mixture and the other to return the overflow from the pump. The spray bar had two nozzles, one set at either end of a 1-foot long pipe. The shut-off valve was at the hose end of the 10-foot length of pipe. Once the engine was started, it was left running even when traveling between sites. This was done because of the difficulty in starting the engine.

Since the crew only worked once a year on spraying ivy and then only for a short length of time, generally during the month of July, all complaints were taken care of first. Then the crew traveled over most of the state highway system in the district looking for patches of poison ivy growing near the roadway or near sidewalks. When a patch was located, one man operated the spray bar while the other maneuvered the truck ahead. The 10-foot length of the spray bar permitted spraying to a height of about 15' on trees and, along with the long hose, to a distance of 20 feet or more back from the highway (depending on the wind velocity and direction).

54. Clearing roadsides. Truck is being loaded with brush; note condition of roadsides in background almost obscuring car parked on right shoulder.

More satisfactory results were obtained when the spraying was accomplished on a hot sunny day, which allowed the spray mixture to dry thoroughly on the leaves over a period of 2 to 3 hours.

During the 52-week study period, one 3-ton truck with the poison ivy spraying equipment attached was used for a total of 20.7 working hours on the eradication of poison ivy. The distribution of that working time based upon 17.1 hours of detailed stop-watch studies is as follows:

Distribution of Equipment-Hours of Working Time of Spraying Equipment on Spraying Poison Ivy

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Starting up and adjusting pump	3	
5.2 Spray poison ivy	15	
5.3 Locating patches of poison ivy at working site	2	20
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	7	
6.3 Travel to new work site looking for poison ivy	50	
6.6 Load and unload men, tools and equipment	5	
6.6 Load spray mixture onto truck	2	
6.9 Miscellaneous	3	67

Item	Percent	
7.0 Waits and delays		
7.1 Waits on other operations	1	
7.2 Maintenance of spraying equipment	4	
7.3 Instructions	2	
7.4 Start late, excess lunch and quit early	3	
7.5 Idle	1	
7.6 Personal delays	1	
7.9 Other	1	13
Total		100

Under the observed conditions and rates of accomplishment, this equipment will spray 38 gallons of mixture over 4940 square feet and 14 trees in a 9.0-hour day. Trees were sprayed to an average radius of 2 feet around the base on the ground and to an average height of 7.5 feet up the trunk.

The average distance traveled on the days studies were conducted was as follows:

Item	Average miles driven per day
To and from garage	14.9
Travel to new work site looking for poison ivy	71.2
Total	86.1

55. Topping out tree to be removed.

CLEARING SIGHT LINES

During the months of June and July, all locations of restricted sight distances such as at intersections and on curves and hills are cleared of brush, grass and weeds to improve sight distance. Overhanging boughs are also cut on the straight-away. Usually these are the areas which would normally not be reached by the regular hand mowing crew until later in the season. As indicated above, the clearing sight line operation consisted of any one or combination of the following three basic operations, cutting brush, hand mowing, or trimming trees.

56. Lines are used to lower limbs in congested areas.

A typical crew consisted of a crew leader or foreman and 5 men, 1 truck driver and 4 laborers.

A 7-ton dump truck was used to transport the men to and from work as well as to haul the cut brush debris to a suitable dumping area.

Scythes, axes, brush hooks, polesaws, pruning clippers, pitch forks and brooms were carried aboard the truck, unloaded at the job site, and used as needed.

The section of road requiring clearing was selected and the crew assigned to the job by higher supervisory personnel. At the job site the crew leader determined what clearing was necessary and directed the operations.

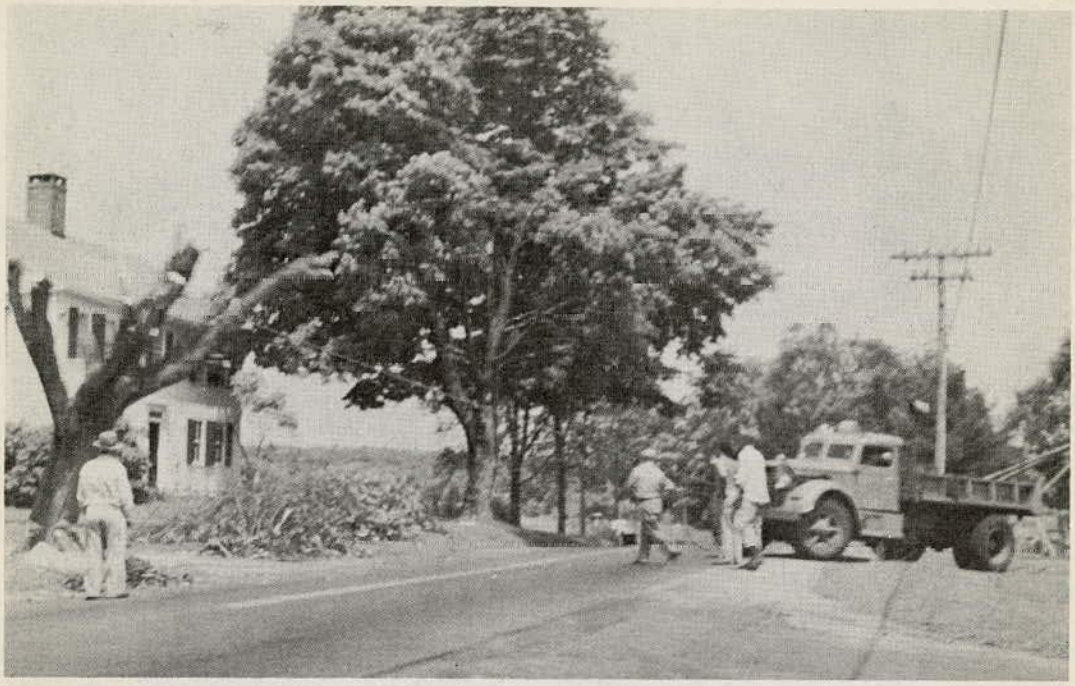
After putting out the necessary "Men Working" signs the crew was split up and men assigned to different sections of the roadside. When branches or trees were to be cut, two men worked together, one cutting the branches with a polesaw or axe, the other hauling them to the roadside for subsequent loading on the truck. When only light brush or grass was cut the men worked individually with axes, brush hooks, pruning clippers, and scythes.

If the section of roadway to be cleared was extensive and several loads of brush were expected the entire crew worked on cutting until more than a truckload was down. Then two men in addition to the driver were assigned to loading brush on the truck at the roadside. One man gathered the brush and passed it up to the second laborer who stacked it on the truck. If necessary, the entire crew worked loading brush. If not, the remainder of the crew continued cutting. When the truck was loaded the entire crew usually rested and then returned to cutting while the truck hauled to the dump and

57. Cutting up limbs with power chain saw.

58. Loading logs on truck using winch and tripod, cutting up logs in foreground.

returned. Upon return of the truck, loading was resumed unless the crew leader estimated that insufficient brush was down to provide a load without interruption. When only a small amount of brush was involved, two men were



59. Removing trunk of tree.

assigned to loading when cutting was about half complete.

Upon completion of the job, whether large or small, the tools and equipment were loaded, the crew rode to the dump site and unloaded and reloaded tools for dumping, and then proceeded directly to the next job site.

Detailed stop watch studies were conducted on clearing sight line operations covering a total of 93.2 man-hours. During the study period the operation consisted of cutting brush and trimming trees with the time distribution being as shown in the following table.

Distribution of Man-Hours of Working Time
Clearing Sight Lines

Item	Percent
1.0 Operating cycle items on assigned task	
1.1 Cut brush	10
1.2 Trim branches off tree	8
1.3 Cut trees down	3
1.4 Mow grass with scythe	2
1.5 Pick up and stack brush	4
1.60 Disposal of brush and debris	
1.61 Load brush onto truck by hand	10
1.62 Load brush and hay with pitchfork	2
1.63 Distribute load on truck	6
1.64 Move ahead while loading	2
1.65 Driver waiting in truck while men load	6

Item	Percent	
1.66 Travel to and from dump site	2	
1.67 Dump load	1	56
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	6	
2.3 Travel to new work site	2	
2.4 Minor moves, turns and maneuvers	1	
2.4 Walk to next work site	2	
2.5 Put out and pick up signs	1	
2.6 Load and unload men, tools and equipment	3	
2.9 Miscellaneous	2	17
3.0 Waits and delays		
3.1 Wait on other operations	2	
3.2 Repair and maintenance of tools	2	
3.3 Instructions	3	
3.4 Excess lunch	3	
3.5 Idle	8	
3.6 Personal delays	4	
3.7 Resting	2	
3.9 Other	3	27
Total		100

During 93.2 man-hours of observed operations an area of approximately 35,665 square feet at 11 different locations were cleared which included the cutting of 97 trees, from 1 to 4 inches in diameter, 10 to 20' high.

A typical crew of 5 men and 1 crew leader working a 9.0-hour day would clear 17,200 square feet of sight lines.

During the 52-week study period 16 trucks were employed for a total of 242.6 hours on clearing sight lines. The distribution of this working time in accordance with 24.9 hours of detailed stop-watch studies is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks Used on Clearing Sight Lines

Item	Percent	
5.0 Operating cycle items on assigned task		
5.2 Load brush and debris onto truck	5	
5.3 Move ahead loading brush	14	
5.4 Travel to and from dump site	3	
5.5 Dump load at dump site	1	23
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	7	
6.3 Travel to new work site	3	
6.4 Minor moves, turns and maneuvers	3	
6.5 Put out and pick up signs	1	
6.6 Load and unload men, tools and equipment	2	
6.9 Patch hole with bituminous cold mix	3	
6.9 Miscellaneous	3	22
7.0 Waits and delays		
7.1 Parked while men work	44	

Item	Percent	
7.2 Maintenance of truck	1	
7.3 Instructions	1	
7.4 Quit early	1	
7.6 Personal	1	
7.6 Travel to obtain drinking water, personal errands, to eat lunch	3	
7.9 Weather	2	
7.9 Other	2	55
Total		100

During the 24.9 hours of detailed study, a total of 6 loads of brush and debris were loaded and hauled away. The average size of the loads being 8' x 10' x 8' or 640 cubic feet.

On the days that studies were made, 23% of the trucks' available working time was spent in loading up and hauling brush and debris to the dump site. Based upon rates as observed during the study one truck working a 9.0-hour day should haul away 2.0 truckloads of brush per day.

The average mileage traveled on days when studies were conducted was as follows:

Item	Average miles driven per day
To and from garage	14.5
To new work site	4.7
To and from dump site	4.0
To obtain drinking water and personal errands	6.2
Minor moves, turns and maneuvers	1.8
Travel ahead loading brush and debris	0.2
Other	2.8
Total	34.2

TREE REMOVAL

Tree removal operations were usually performed by a crew of 5 to 6 men, including 1 truck driver, 1 winch truck driver, 1 or 2 tree climbers and 2 laborers. Two trucks, one with tripod and winch, and the other a 3-ton dump truck, plus the following tools and equipment were used:

1 Power chain saw (5 foot cutting blade)
1 24-foot extension ladder
2 2-man cross-cut saws
3 Hand bull saws used mainly by climbers
4 to 6 axes
2 Pole saws
1 Pruning saw
2 Safety harnesses
1/2-inch climbing and hoisting lines
3/4- and 1-inch lines used to hold and lower limbs

The climbers ascended the tree by means of an extension ladder and climbing ropes and then commenced removing the crown of the tree, limb by limb, using hand saws. While the climbers worked in the tree, the men on the ground handled lines, hoisted tools to the climbers, cut up the fallen limbs, stacked the logs and branches, and hauled them away to the State dumping area or, in some cases, put the wood in a convenient place for use by the adjacent landowners.

Limbs cut from the tree were allowed to fall, providing no damage would result to electrical wires or adjacent property; otherwise they were lowered to the ground using lines attached to a truck.

The fallen limbs were trimmed of branches with axes by the ground crew and cut up into convenient lengths with the chain saw. Branches were piled aside for subsequent disposal. Logs cut from large limbs were offered to the adjacent landowner for his use and were delivered to him. If the landowner declined, the logs were loaded onto the truck by means of the winch truck and hauled away to a disposal area.

Up to this point, the operation may be called "topping out the tree". The trunk or stub, which was the part left after all the limbs had been removed, might then be left standing for removal at a later date. If it was desired to remove the tree completely, the remaining trunk was then felled with the chain saw, cut at or slightly below the ground level. The roots or base that remained in the ground were then covered over with topsoil. The felled trunk was cut into easily handled lengths and disposed of in the same manner as large limbs. After all branches and logs had been removed from the site, the area was raked and cleaned.

The distribution of the labor time expended on tree removal in accordance with detailed studies covering a period of 148 hours is as follows:

Distribution of Man-Hours of Working Time
on Tree Removal

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Climbing and rigging lines, in tree	2	
1.1 Cutting limbs on branches, in tree	1	
1.2 Rigging lines, on ground	5	
1.2 Handling tools and equipment, on ground	2	
1.2 Lowering limbs and branches, on ground	1	
1.2 Cutting up limbs, on ground	4	
1.2 Stack limbs and brush	2	
1.3 Removal of trunk and stump	2	
1.4 Load logs and brush on truck	7	
1.4 Travel to and from disposal area	5	
1.5 Clean up area and miscellaneous work	4	35
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	15	
2.3 Travel to new work site	2	
2.4 Minor travel and maneuvers	2	
2.5 Put out and pick up signs	1	

Item	Percent	
2.6 Load and unload men, tools and equipment	6	
2.9 Load truck with sand for possible emergency use	1	27
3.0 Waits and delays		
3.1 Wait on other operations, in tree	1	
3.1 Standby as climber works in tree	9	
3.1 Wait on other operations, on ground	6	
3.1 Wait on other operations, at garage	1	
3.2 Maintenance and repair of tools and equipment	2	
3.3 Instructions and inspections	5	
3.4 Start late, excess lunch, quit early	7	
3.5 Idle	2	
3.6 Personal	3	
3.7 Resting	1	
3.9 Other	1	38
Total		100

During 385 man-hours of study, the crew removed 15 trees ranging in size from 4 to 40 inches in diameter and averaging 19 inches. Heights ranged from 20 to 90 feet, and averaged 55 feet. The trees removed included elm, oak, maple, birch, pine and wild cherry. Fourteen loads of branches and 12 loads of logs were trucked to the disposal area. A typical 6-man crew will remove 2.1 trees in a 9.0-hour day.

During the 52-week period, 9 trucks were employed at various times for a total of 1057 hours on tree removal operations. The distribution of this time, in accordance with detailed studies covering a period of 103.4 hours, is as follows: (Note: Labor and equipment studies were not concurrent.)

Distribution of Equipment-Hours of Working Time
of Trucks on Tree Removal Operations

Item	Percent	
5.0 Operating cycle operations on assigned task		
5.1 Loading and unloading logs and brush	9	
5.2 To and from disposal area	6	15
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	12	
6.3 Travel to new work site	1	
6.4 Minor moves and maneuvers	4	
6.6 Load and unload men, tools and equipment	7	
6.9 Load truck with sand for possible emergency use	1	25
7.0 Waits and delays		
7.1 Parked as men work	49	
7.1 Wait on other operations	1	
7.2 Maintenance and repair of truck	1	
7.3 Instructions	2	
7.4 Late start, excess lunch, quit early	4	
7.6 Personal	2	
7.9 Other	1	60
Total		100

The distribution of the average daily mileage of a truck on this assignment was as follows:

Item	Miles per day
Travel between work site and disposal area	9.2
Travel to and from garage	25.8
Travel to new work site	1.8
Minor moves and maneuvers	0.6
Load and unload tools and equipment	0.2
Travel between garage and emergency sand stockpile	0.3
Total	37.9

POWER MOWING

There were two types of power mowers assigned to the Warehouse Point area. One was a rotary disc-type powered by a one-cylinder gasoline engine and equipped with a 5-foot cutting width while the other type of which there were 2 mowers was a rotary blade-type power mower having a 30" cutting width.

Power mowers were used on developed areas, traffic islands, median strips, parks and picnic areas. Ordinarily, when grass reached a height of 4 to 5 inches, it was mowed back to a height of 1 to 2 inches. During the dry season, it was cut to about 3 inches high. Depending on weather conditions, power mowing operations were generally started the first of May. During the months of May and June, all developed areas were mowed approximately once a week. Through the months of July, August and September,

60. Mowing traffic islands with rotary disc-type power mower.

mowing twice a month was generally sufficient to keep the grass trimmed properly. All areas were mowed and trimmed up into shape for standing over the winter sometime during the first part of October. The mowers normally worked in pairs and were hauled out to the job by truck. The operator either walked behind the power mower or rode on an attachable sulky. The crew consisted of two men, one of whom also drove the truck.

During the 52-week study period, a total of 109.6 hours of detailed stop-watch studies were taken covering power mowing operations. The following table shows the distribution of that working time.

Distribution of Man-Hours of Working Time
on Power Mowing Operations

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Walk with or ride mower to uncut area	4	
1.2 Mow	29	
1.3 Trim with scythe	8	41
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	15	
2.3 Travel to new work site	4	
2.4 Minor moves, turns and maneuvers	1	
2.5 Put out and pick up signs	1	
2.6 Load and unload men, tools and equipment	5	
2.6 Load and unload power mowers	3	
2.9 Miscellaneous work	2	31
3.0 Waits and delays		
3.1 Waits on other operations	2	
3.2 Maintenance, repair and adjustment of power mowers	6	
3.2 Sharpen tools	1	
3.3 Instructions	2	
3.4 Start late, excess lunch, quit early	1	
3.5 Idle	3	
3.6 Personal delays	3	
3.7 Resting	2	
3.9 Weather	6	
3.9 Other	2	28
Total		100

On several of the days studied, part of the day was spent in cleaning picnic areas.

During the 109.6 man-hours of detailed study on power mowing operations, 846,711 square feet or 19.4 acres of grass were mowed, 15,100 square feet were trimmed with the power mowers, 12,172 square feet were trimmed with a scythe and 140 feet of hedge were clipped.

The majority of power mowing was done using a combination of the rotary disc machine (5.0 feet cutting edge) and one of the rotary blade-type mowers (30" cutting edge).

The combined average mowing rate of the above 2 power mowers was 490 square feet per minute or 0.67 acres per hour of actual mowing time. The average mowing rate of the rotary disc mower when used alone was 763 square feet per minute or 1.05 acres per hour, while that of the rotary blade-type was 253 square feet per minute or 0.35 acre per hour.

A 2-man crew working a 9.0-hour day will mow 153,468 square feet or 3.5 acres under the observed conditions and rates of accomplishment.

61. Trimming edge of expressway median strip using rotary blade-type power mower; operator is riding sulky.

During the 52-week period 4 trucks were used for 428 hours to transport the power mowers to and from work. The distribution of that working time in accordance with 44.9 hours of detailed stop-watch studies is as follows:

Distribution of Equipment-Hours of Working Time of Trucks Used on Power Mowing Operations

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This unit works in the capacity of a general purpose service truck and has no clearly defined operating cycle.		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	17	
6.3 Travel to new work site	5	
6.4 Minor moves, turns and maneuvers	2	
6.6 Load and unload men, tools and equipment	7	31
7.0 Waits and delays		
7.1 Parked while crew works	60	
7.2 Wait for maintenance and repair of power mowers	2	
7.4 Start late, excess lunch and quit early	1	
7.6 Personal delays	2	
7.9 Weather	3	
7.9 Other	1	69
Total		100

The average mileage traveled by the trucks on the days during which studies were conducted was as shown in the table on the following page.

Item		Average miles per day
To and from garage		36.1
To new site		9.4
To put up and pick up signs		2.0
Other		1.0
	Total	48.5

TRACTOR MOWING

Two small tractors equipped with cutting bars were employed on tractor-mowing operations. All roadsides are normally mowed once a year, to a height of 4" by the tractor mowers, standard practice requiring the mowing of all roadsides back for a minimum distance of 10 feet. Parkways, turf shoulders and developed areas are mowed by tractor 5 to 6 times per year, with mowing operations being conducted as soon as the grass reaches a height of 8" or more.

Although tractor-mowers occasionally operated singly, ordinarily 2 tractors worked together with one following the other in the direction of traffic. The second tractor extended the swathe along the roadside. When broad areas or intersections were encountered, the mowers made additional passes and traveled in any direction when off the traveled path. Obstructed areas were by-passed such as steep slopes, guide rail, and dense brush, and mowed at a later date by the hand mowing crew. In by-passing an obstruction, the operator raised his cutting bar and then lowered it when ready to resume mowing. The cutting bars were 5 feet in length and required lubrication several times a day. At the end of a day the tractors, if too far from a state

62. Second tractor of team widening swath mowed by first tractor which can be seen in background.

garage, were parked at a farmyard and the operators were transported back to their headquarters by the hand mowing truck.

During the 52-week period, August 14, 1950, to August 12, 1951, a general distribution of the time for the tractor mowers on days they were assigned to tractor mowing operations is as follows:

Distribution of Total Available Time for Two Tractor Mowers on Days Assigned to Mowing Operations

Item	Hours	Percent
Non-working time (all time of 0.50 hour or more)		
Start late and quit early 1/	172.0	12
General care and maintenance	55.5	4
Under repair	47.4	3
Weather	18.0	1
Standby at job site	16.3	1
Instructions	1.0	-*
Working time on mowing	1176.1	79
	1486.3	100

During working time, detailed studies were conducted on 9 separate days for a total study time of 83.2 equipment-hours. The following tabulation shows the distribution of the working time in accordance with these detailed studies.

Distribution of Equipment-Hours of Working Time of Tractor Mowers

Item	Percent			
	Roadside		Parkway Median Strip	
5.0 Operating cycle items on assigned task				
5.1 Mowing	39		45	
5.2 Maneuvers and turns while mowing	7		2	
5.3 Pass around obstacles	4		1	
5.4 Travel ahead not mowing	17	67	4	52
6.0 Related items including travel and preparatory work				
6.1 Travel to and from garage or parking area	6		20	
6.3 Travel to new work site	1		-	
6.4 Minor moves, turns and maneuvers	1		1	
6.5 Put out and pick up signs	1		1	
6.9 Hook up cutter bar for traveling	-	9	1	23

1/ Operators in transit
* Less than 1/2 of 1%

Item	Percent Roadside		Percent Parkway Median Strip	
7.0 Waits and delays				
7.1 Waits on other operations	1		1	
7.2 Maintenance of tractor and mower (Includes greasing cutter bar)	8		9	
7.2 Change and sharpen knife blades	1		2	
7.2 Repairs to tractor	1		-	
7.3 Instructions	2		4	
7.4 Start late, excess lunch and quit early	2		3	
7.5 Idle	1		-	
7.6 Personal delays	3		4	
7.9 Clear grass from clogged cutter bar	3		1	
7.9 Other	2	24	1	25
Total		100		100

Based upon rates as observed during the study periods, a total of 4.3 acres on roadside mowing or 6.1 acres on parkway mowing should be mowed per mower per day. During the studies 26.6 acres of roadside were mowed on a total roadway distance of 26.9 miles. This is equivalent to an average of 1.0 acre per mile of roadway mowed by tractors.

HAND MOWING

Hand mowing operations were performed in areas where tractor mowing operations were not feasible. There were many sections upon which both tractor mowing and hand mowing was required and in such instances the hand mowing crew was sent out as a followup operation after the tractor mowing was completed. Roadsides were mowed at least once a year.

The hand mowing crew in the study area normally consisted of from 4 to 8 temporary summer employees plus a truck driver who was in charge of the work. If the necessary hand mowing was not completed by autumn, regular maintenance crews were assigned to complete the job. A 3-ton truck was used to transport the men and equipment to and from the work area. The equipment carried on the truck for a 6-man crew included 8 snathes, 18 scythe blades, 6 whet stones, 1 bush hook, 2 axes, 2 pitchforks, 2 rakes, 2 hand files, and 2 wrenches.

In hand mowing operations work is done on both sides of the roadway behind guide rails and in other areas where there are steep slopes and rough terrain that cannot be reached by the tractor mowers. The grass was cut to a height of about 4 inches. Besides regular hand mowing this involved clipping grass around obstacles and cutting brush. Small bushes or brush were cut with a bush hook, axe or bush scythe. Occasionally, weeds or shrubs were pulled out or grubbed by hand when impossible to cut by scythe.

The truck was left parked by the roadside as the men worked. Periodically the driver walked back and drove it ahead normally keeping it within

sight distance. Besides being used to transport men, tools, and water, it also was used as a tool house.

Detailed stop watch studies have been conducted on hand mowing operations covering a total of 243 man-hours, during which the crew varied in size from 4 to 8 men, including the driver who acted as straw boss. The distribution of time in accordance with these studies is shown in the following table.

Distribution of Man-Hours of Working Time
on Hand Mowing Operations

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Mowing	18	
1.2 Clipping	4	
1.3 Cutting brush and miscellaneous work	2	
1.3 Raking	2	
1.4 Walk ahead	12	38
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	16	
2.3 Travel to new work site	2	
2.4 Minor moves, turns and maneuvers	1	
2.5 Put out and pick up signs	2	
2.6 Load and unload men, tools and equipment	1	22
3.0 Waits and delays		
3.1 Waits on other operations	2	
3.2 Care and maintenance of tools and equipment	4	
3.3 Instructions	2	
3.4 Excess lunch and quit early	3	
3.5 Idle	13	
3.6 Personal	6	
3.7 Resting	2	
3.9 Travel to fetch drinking water	2	
3.9 Rain	4	
3.9 Other	2	40
Total		100

During the periods of study, a typical crew of 6 men working a 9-hour day would complete 0.32 acres of mowing per day. In addition the crew would accomplish the related trimming and incidental clean-up work. The area hand mowed averaged 0.26 acres per mile of roadway during the periods of study.

During the 52-week period 20 trucks out of the total 37 trucks assigned to the Warehouse Point area were employed at various times for a total of 1307 hours on hand mowing operations. The distribution of this working time in accordance with detailed studies covering a period of 42.1 hours of work is as shown on the following page.

Distribution of Equipment-Hours of Working Time
of Trucks Used on Hand Mowing Operations

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This unit works in the capacity of a general purpose service truck and has no clearly defined operating cycle.		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	16	
6.3 Travel to new work site	3	
6.4 Minor moves, turns and maneuvers	3	
6.5 Put out and pick up signs	7	
6.6 Load and unload men, tools and equipment	2	31
7.0 Waits and delays		
7.1 Parked while men work	48	
7.2 Maintenance of tools and equipment	1	
7.3 Instructions	1	
7.4 Excess lunch and quit early	3	
7.6 Personal delays	3	
7.9 Travel to fetch drinking water	9	
7.9 Rain	3	
7.9 Other	1	69
Total		100

The average mileage driven by the truck on days during which studies were made was as follows:

Item	Average miles driven per day
To and from garage	38
To put out and take up signs	9
To new site	7
To obtain drinking water	17
Short moves ahead while mowing	2
Total	73

PICKING UP HAY

After completion of hand mowing operations, the grass and bushes were allowed to dry for a period of a week to ten days before being picked up. A typical crew consisted of five men, and a dump truck. Two of the men walked ahead of the truck stacking the hay into piles or windrow. The other three worked directly with the truck; one man driving the truck, one man pitching hay onto the truck, and one man distributing the load on the truck. The equipment normally used consisted of four pitch forks and two hand rakes. Loaded hay was hauled to the nearest State-owned stockpile or sand pit where it was dumped in a pile to be used at a later date. If there were any new construction jobs nearby having recently seeded slopes, all hay suitable for mulching was separated and hauled directly to the construction area and spread as mulch over the seeded areas. The remaining brush and bushes were

63. Picking up hay and brush, man in foreground is gathering hay into stacks.

picked up and hauled to a sand pit to be burned.

Detailed stop-watch studies were conducted on picking up hay operations covering a total of 45.1 man-hours, or one day's work of a five-man crew supervised by one crew leader.

The distribution of time in accordance with these studies is shown in the following table.

Distribution of Man-Hours of Working Time
on Picking up Hay

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Stack hay	19	
1.2 Fork hay onto truck	5	
1.3 Distribute load on truck	5	
1.4 Walk ahead	12	
1.5 Ride truck ahead	9	
1.6 Travel to and from dump site	6	
1.7 Dump load	-*	56
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	4	

* Less than 0.5% of time

Item	Percent	
2.3 Travel to new work site	3	
2.4 Minor moves, turns and maneuvers	-*	
2.5 Put out and pick up signs	5	
2.6 Load and unload men, tools and equipment	1	13
3.0 Waits and delays		
3.1 Wait on other operations	4	
3.1 Wait for hay to be stacked	3	
3.1 Wait for hay to be loaded	6	
3.1 Wait for truck to move ahead	4	
3.1 Wait for signs to be put out and picked up	4	
3.2 Maintenance of truck	1	
3.3 Instructions	1	
3.5 Idle	1	
3.6 Personal	2	
3.7 Resting	1	
3.9 Other	4	31
Total		100

Based upon conditions prevailing during the period of study, a five-man crew will dispose of 1.4 acres of hay per day.

Observations also revealed that, for the area of roadside studied, the hay loaded on the trucks occupied space equal to 360 cubic feet per acre of raked hay. The area from which hay was picked up averaged 0.35 acre per mile of roadway.

During the 52-week period 9 trucks out of the total 37 trucks assigned to the Warehouse Point maintenance area were employed at various times for a total of 357 hours on picking up hay operations. The distribution of this working time in accordance with detailed studies covering a period of 9.0 hours of work is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks Picking Up Hay

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Loading hay	32	
5.2 Short moves ahead while loading	18	
5.3 Travel to and from dump site	15	
5.4 Dump load	-*	65
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	5	
6.3 Travel to new work site	2	
6.4 Minor moves, turns and maneuvers	1	
6.5 Put out and pick up signs	9	
6.6 Load and unload men, tools and equipment	3	20
7.0 Waits and delays		
7.1 Parked as men work	10	

* Less than 0.5% of time

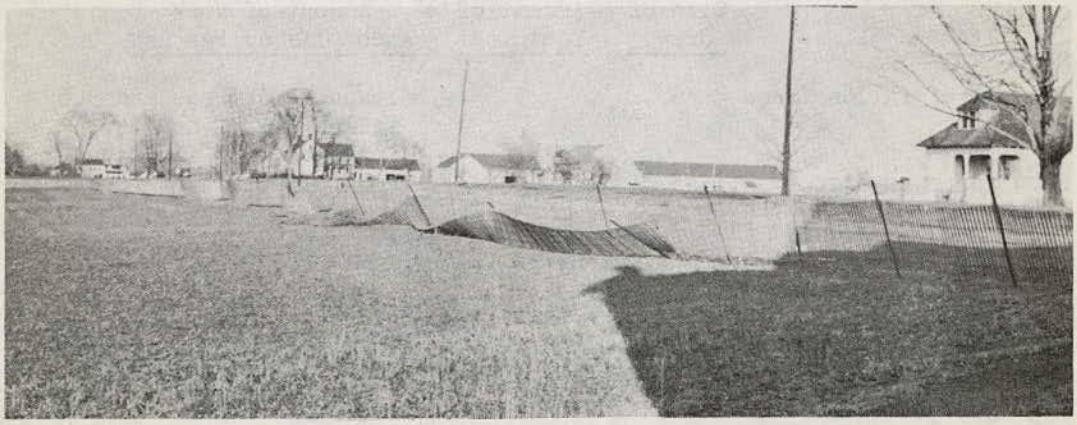
Item	Percent	
7.2 Maintenance of truck	2	
7.6 Personal delays	1	
7.9 Other	2	15
Total		100

The average mileage driven by the truck on days during which studies were made was as follows:

Item	Average miles driven per day
To and from garage	11
To put out and pick up signs	9
To new work site	3
Short moves ahead while loading	6
Travel to unload hay	29
Total	58

STORM DAMAGE

Only a small amount, about 3 percent, of the total maintenance effort during the year's study was chargeable to storm damage. It will be noted on Figure 2 that labor charges to storm damage appear only in the period around the latter part of November and the first part of December. These data were obtained from foremen's reports. On Figure 3, however, equipment charges are also shown during March and April to storm damage, as obtained by the study crew. These differences became apparent only at the end of the study period and are representative of minor discrepancies that will be found if a precise reconciliation of data from two separate sources is attempted. In total, however, such differences have little effect upon the general findings. In this particular instance, it is likely that the foremen charged the labor to snow and ice control rather than to storm damage, and no doubt involves simply a matter of opinion as to the proper account for assigning



64. Damage to snow fence caused by windstorm of November 25, 1950.

65. Repairing washouts of fill slope using small hand-operated scoop type scraper.

the charges.

Because of the small magnitude of this item, no separate chart has been prepared to show the distribution of the work load throughout the year.

The following table shows accomplishment rates for the various items. Detailed discussions concerning each operation are included in the following pages.

Accomplishment Rates on Storm Damage Repair Items Observed During Study Periods

Item	Size of Crew	Amount of Equipment	Amount of Work Accomplished Per Day
Cleanup of fallen trees	6	3	cleanup 2.4 trees and 3.6 fallen limbs, haul 5.3 loads of logs and brush
Snow fence repair	5	1	repair 3000 ft. of fence

CLEANUP OF FALLEN TREES

During the 1950 November windstorm, trees and limbs were blown down throughout the study area, causing the roadside crew to spend several weeks in cleaning up the debris. The size of the crew varied from 3-6 men depending upon the work to be done. For instance, if several large trees and limbs were down at one location, necessitating the use of the winch truck, the whole crew of 6 men would work at that location sawing and cutting up the fallen trees, loading the logs and brush onto trucks and hauling the debris

to a suitable dumping area, usually a State-owned sandpit or stockyard where it could be burned. However, if the scheduled work was located at several small sites fairly well scattered throughout the district, the men would be split into 2 crews of 3 men each. Using a 3-ton dump truck for transportation, each 3-man crew would then work at different locations cutting and cleaning up the debris. The normal tools and equipment used by the 6-man crew on these cleanup operations consisted of:

1 Winch truck	1 25' piece 3/8" rope
2 3-ton dump trucks	1 Iron wedge
1 Power chain saw	1 Shovel
1 Peavy	1 1-gallon can fuel (power saw)
4 Axes	1 Log chain 12'
2 6-foot cross cut saws	1 Pole saw
1 8-lb. sledge	1 Long handled grading rake

The winch truck was used principally for loading logs onto the dump trucks and on several instances was used to place large limbs in a better position for sawing with the chain saw.

Stop-watch studies were conducted on 3 occasions covering a total of 91.1 man-hours of working time on cleanup of fallen trees.

The distribution of working time is as shown in the following table.

Distribution of Man-Hours of Working Time
Cleaning Up Fallen Trees

Item	Percent
1.0 Operating cycle items on assigned task	
1.1 Cutting limbs with axe	3
1.2 Rigging lines	2
1.3 Prepare and position log for sawing	2
1.4 Cutting limbs with chain saw	4
1.5 Walk ahead	1
1.6 Stacking brush	3
1.6 Stacking logs	3
1.7 Load brush onto truck	4
1.8 Travel to and from dump site	5
1.9 Dump load brush	- 1/
	27
2.0 Related items including travel and preparatory work	
2.1 Travel to and from garage	14
2.3 Travel to new work site	6
2.4 Minor moves, turns and maneuvers	3
2.5 Put out and pick up signs	4
2.6 Load and unload men, tools and equipment	5
2.6 Handling tools and equipment	2
2.9 Travel to inspect trees for damage	6
2.9 Inspect trees for damage	1
2.9 Load truck with sand for possible emergency winter use	1

1/ Less than 0.5% of time

Item	Percent	
2.9 Miscellaneous	3	45
3.0 Waits and delays		
3.1 Wait while others work	4	
3.2 Maintenance of truck	1	
3.2 Maintenance of power chain saw	2	
3.2 Repair of equipment	3	
3.3 Instructions	5	
3.4 Excess lunch and quit early	6	
3.5 Idle	1	
3.6 Personal	3	
3.7 Resting	1	
3.9 Other	2	28
Total		100

During the 91.1 man-hours of observed working time, a total of 4 fallen trees and 6 fallen limbs were cleaned up from 8 different sites. The fallen trees and limbs varied in size from 10" to 42" diameter at butt with a length of 30' to 80'. The cleanup operations also involved the picking up and hauling to dump site of 9 truck loads of logs and brush.

A typical crew of 6 men working a 9.0-hour day should clean up 2.4 fallen trees and 3.6 fallen limbs, involving the picking up and hauling away of 5.3 truck loads of logs and brush.

During the 52-week period, 11 trucks were employed at various times for a total of 697 equipment-hours on cleanup of fallen trees, resulting from storm damage.

The distribution of this working time based upon 32.5 hours of detailed stop-watch study is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks Used on Cleanup of Fallen Trees

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Move trees with truck	- 1/	
5.2 Load logs with winch truck	9	
5.3 Load logs onto truck	-	
5.4 Load brush onto truck	2	
5.5 Haul to dump site and return	4	
5.6 Dump load at dump site	- 1/	15
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	9	
6.3 Travel to new work site	4	
6.4 Minor moves, turns, and maneuvers	4	
6.5 Put out and pick up signs	3	
6.6 Load and unload men, tools, and equipment	4	

1/ Less than 0.5% of time

Item	Percent	
6.9 Travel to inspect trees for damage	3	
6.9 Load truck with sand for possible emergency winter use	3	30
7.0 Waits and delays		
7.1 Parked while men work	24	
7.1 Wait on other operations while being loaded	3	
7.2 Maintenance of truck	2	
7.2 Repairs to auxiliary equipment	2	
7.3 Instructions	1	
7.4 Excess lunch and quit early	6	
7.5 Idle	12	
7.6 Personal	2	
7.9 Other	3	55
Total		100

The average daily mileage traveled by the trucks on days during which studies were conducted was as follows:

Item	Average daily mileage traveled
To and from garage	17.3
To new work site	3.8
To inspect trees for damage	5.9
To put out and pick up signs	3.6
Haul to dump site and return	6.9
Other minor travel	0.6
Total	38.1

SNOW FENCE REPAIR

Following the November 25th storm, it was the responsibility of each foreman to check and repair all snow fence in his district damaged by the wind. This work consisted principally of straightening up the blown down snow fence, placing new posts and guy wire stakes where necessary. Several broken sections of fence had to be wired together prior to being re-erected. Repairing operations were accomplished with a crew of 4-6 men supervised by a crew leader. Normal working procedure was to load up a 7-ton dump truck with several bundles of posts and guy wire stakes at the stockyard, travel to a designated starting location, make the necessary repairs and then travel ahead to the next section continuing the same pattern of operation throughout the day, returning to the garage at night.

Accomplishment studies were taken on 3 separate occasions covering a total of 78.1 man-hours of working time on repairing snow fence operations. The distribution of that working time is as shown in the table on the following page.

Distribution of Man-Hours of Working Time
On Snow Fence Repair (Based on Accomplishment Studies)

Item	Approximate Percent	1/
1.0 Operating cycle items on assigned task		
1.1 Straighten up snow fence	37	
1.2 Drive new posts	1	
1.3 Re-attach fence to posts	10	
1.4 Drive guy stakes	9	
1.4 Attach guy wires to fence	1	
1.5 Repair fence break	2	
1.6 Check and inspect fence	3	63
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	9	
2.3 Travel to new work site	6	
2.4 Minor moves, turns, and maneuvers	1	
2.6 Load and unload men, tools, and equipment	6	
2.6 Load and unload posts and stakes	3	
2.9 Saw and split out stakes	5	
2.9 Load truck with sand for possible emergency winter use	2	32
3.0 Waits and delays		
3.2 Maintenance of truck	1	
3.3 Instructions	1	
3.4 Excess lunch and quit early	2	
3.9 Other	1	5
Total		100

During the 78.1 man-hours of observed study, a total of 5,185 feet of snow fence was straightened up and repaired and involved the following items:

23 new posts driven
6 new bracing posts driven
192 old posts straightened and re-driven
145 new guy wire stakes driven
53 old guy wire stakes re-driven
14 posts fence re-attached

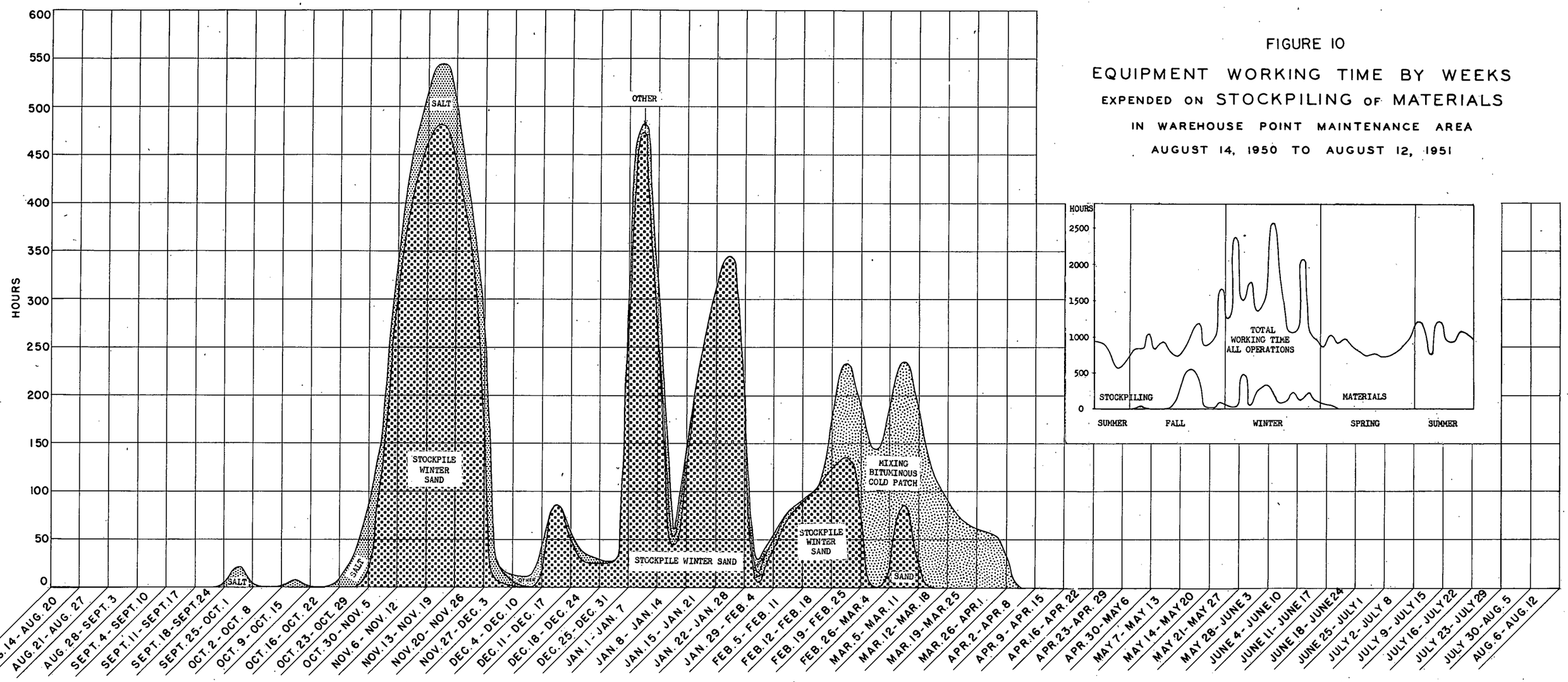
During a 9.0-hour day, a typical crew of 5 men would repair approximately 3000 feet of snow fence.

During the 52-week period, 12 trucks were employed on various occasions for a total of 134 equipment hours on snow fence repair operations. The distribution of that working time based upon 18.4 hours of detailed stop-watch study is as shown in the table on the following page.

1/ In accomplishment studies, various work items may include small waits and delays that could not be readily separated or classified by a single observer when studying several workmen at one time.

FIGURE 10

EQUIPMENT WORKING TIME BY WEEKS
EXPENDED ON STOCKPILING OF MATERIALS
IN WAREHOUSE POINT MAINTENANCE AREA
AUGUST 14, 1950 TO AUGUST 12, 1951



Distribution of Equipment-Hours of Working Time
of Trucks Used On Snow Fence Repair Operations

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This unit works in the capacity of a general purpose truck and has no clearly defined operating cycle		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	9	
6.3 Travel to new work site	6	
6.4 Minor moves, turns, and maneuvers	2	
6.6 Load and unload men, tools and equipment	5	
6.6 Load and unload posts and guy stakes	1	
6.9 Load truck with sand for possible emergency winter use	4	27
7.0 Waits and delays		
7.1 Parked as men straighten up and repair snow fence	67	
7.2 Maintenance of truck	1	
7.3 Instructions	1	
7.4 Excess lunch and quit early	2	
7.9 Other	2	73
Total		100

The average daily mileage traveled by the truck on days during which studies were conducted was as follows:

Item	Average daily mileage driven
Travel to and from garage	18.6
Travel to new work site	8.5
Other minor travel	0.8
Total	27.9

STOCKPILING OF MATERIALS

The costs of handling materials are charged against the materials themselves. The costs of the materials then, including handling charges, can later be assigned as the materials are used.

The effectiveness of snow and ice control depends to a large extent on adequate preparation. Sand and salt are stockpiled at convenient locations in the fall in preparation for instant use during the winter.

The first material to be stockpiled in the fall was rocksalt both in bags and in bulk. Salt was stockpiled at several convenient locations where it could be protected from the elements. Sand was next stockpiled at eight convenient locations throughout the area. As the stockpiles became depleted during the winter, they were replenished during lulls between storms. Additional salt also became necessary as stockpiles ran low. Stockpiling of

66. Loading trucks at State-owned sand pit using ½-yard shovel and two belt loaders.

sand was 77 percent of the materials handling work load and stockpiling salt comprised 6 percent of the work load.

During late winter and early spring bituminous cold patch material was mixed and stockpiled at one central location in the area. This comprised 16 percent of the work load. Throughout the year miscellaneous supplies such as asphaltic crack filler, concrete blocks, reinforced concrete pipe, and creosoted guide rail posts occasionally required handling. Stockpiling of materials was approximately 6 percent of the total maintenance work load for the year. For equipment, the distribution of the work load and the relation to the total maintenance equipment work load is shown in Figure 10.

The following table shows accomplishment rates for various items.

Accomplishment Rates of Stockpiling Materials Items Observed During Study Periods

Item	Size of Crew	Amount of Equipment	Amount of Work Accomplished Per Day
Cleanup of sand pit	4	1	32.5 cu. yds. of oversize stone hauled to dump
Stockpiling winter sand	19	13	378 cu. yds. stockpiled
Stockpiling bag salt	8	2	96.5 tons bag salt stockpiled
Stockpiling bulk salt	10	3	125 tons bulk salt stockpiled
Mixing bituminous cold patch	8	5	150 half cu. yd. batches mixed

Detailed discussions concerning each operation listed in the table on the preceding page are included in the following pages.

CLEANUP OF SANDPITS

Several days prior to hauling sand for summer oiling operations or to winter sand stock piles, a crew of men was assigned to clean up the sandpit. The work mainly consisted of cleaning up, loading on to trucks and hauling away all oversize material (mostly stones) which had been screened out from previous operations in the pit. Rather than clean up the pit following completion of any operation, it was the practice to wait and clean up prior to starting a new operation.

Detailed stop-watch studies were conducted on one day's operations covering 27.9 man-hours of working time on the cleanup of a State-owned sandpit in Simsbury by a crew of 4 men, including 1 driver, using 1 belt loader and a 7-ton dump truck.

On the day studies were conducted all debris and oversized stone were hauled to a dump site in another section of the same sandpit.

The distribution of labor working time based upon the above one day study is as shown in the table on the following page.

67. Replenishing sand stockpile with belt loader.

Distribution of Man-Hours of Working Time
on Cleanup of Sand Pits

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Shovel stone onto belt loader	53	
1.2 Haul to dump site and return	2	
1.3 Dump load	1	56
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	2	
2.3 Travel to new work site	2	
2.4 Minor moves, turns, and maneuvers	2	
2.6 Load and unload men, tools, and equipment	2	
2.9 Move belt loader to new position by hand	3	
2.9 Move belt loader to new position by truck	2	
2.9 Miscellaneous cleanup work	1	14
3.0 Waits and delays		
3.1 Wait for truck to dump load and return	7	
3.2 Maintenance of belt loader	3	
3.3 Instructions	4	
3.4 Excess lunch and quit early	8	
3.5 Idle	1	
3.6 Personnel	3	
3.7 Resting	2	
3.9 Other	2	30
Total		100

During 9.0 hours of working time, a typical crew of 4 men would load approximately 32.5 cubic yards of oversize stone, while working at the same rates as observed during the study period.

Throughout the 52-week period, 8 trucks were employed at various times for a total of 84.7 equipment hours on cleanup of sandpit operations. One detailed stop-watch study covering a period of 8.0 equipment-hours gave the following time distribution.

Distribution of Equipment-Hours of Working Time
of Trucks Used on Cleanup of Sand Pits

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Maneuver under belt loader	2	
5.2 Load truck	62	
5.3 Haul to dump site	2	
5.4 Dump load	2	
5.5 Return to belt loader	2	70
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	2	
6.3 Travel to new work site	2	
6.4 Minor moves, turns, and maneuvers	2	
6.6 Load and unload men, tools, and equipment	1	
6.9 Move belt loader with truck	1	8

Item	Percent	
7.0 Waits and delays		
7.1 Standby waiting as belt loader is moved by hand	3	
7.2 Maintenance of belt loader	7	
7.3 Instructions	4	
7.4 Excess lunch and quit early	5	
7.6 Personal	2	
7.9 Other	1	22
Total		100

During the study period, 7 truckloads of screened oversize stone averaging 3.5 cubic yards per load were hauled to the dump site.

The mileage traveled by the truck on the day studies were conducted was as follows:

Item	Miles driven
Travel to and from garage	2.6
Travel to new work site	2.8
Haul to dump site	0.6
Return to work site	0.6
Other minor travel and maneuvers	0.9
Total	7.5

STOCKPILING SAND FOR SNOW AND ICE CONTROL

Sand for control of snow and ice on roadway surfaces was stockpiled at eight readily accessible points throughout the Warehouse Point area for use during winter emergency conditions.

During the winter season, 1950-51, several trucks and belt conveyors were in use at various times while stockpiling approximately 10,368 cubic yards of sand. The total equipment time devoted to stockpiling this yardage amounted to 3055 equipment-hours, excluding belt conveyor time and shovel time for a rented unit.

Normal operations at the sand pit involved the use of a 1/2-cubic yard shovel or a rented 3/8-cubic yard shovel and two belt loaders, including operators for each loader and the shovel. At the stockpile, operations ordinarily involved two belt conveyors, two operators, and two to three men who leveled the top of the stock pile. The number of trucks assigned to hauling varied with the length of haul.

The following sections deal with the various operations involved in stockpiling sand.

1/2-CUBIC YARD SHOVEL SUPPLYING BELT LOADERS IN SAND PIT

Detailed stop-watch studies covering 17.3 equipment-hours of the operations of the 1/2-cubic yard rubber-tired shovel supplying sand in the pit

to the belt loaders for screening and loading into trucks show that the shovel obtained approximately 90 percent of its rated capacity per dipper load while producing at the rate of approximately 113 cubic yards of sand per hour. The shovel was utilized 35 percent of the study period in productive work, moving a total of 687 cubic yards.

On the basis of these studies, the distribution of time for the 1/2-cubic yard shovel is as follows:

Distribution of Equipment-Hours of Working Time
of 1/2-Cubic Yard Power Shovel Working in Sand Pit

Item		Percent	
5.0 Operating cycle items on assigned task			
5.1 Load	0.07 minute per cycle	10	
5.2 Swing	0.06 minute per cycle	9	
5.3 Dump	0.04 minute per cycle	6	
5.4 Return	0.07 minute per cycle	10	35
Total	0.24 minute per cycle		
6.0 Related items including travel and preparatory work			
6.1 Transport shovel between Farmington and Simsbury sand pit		17	
6.4 Shovel moves		3	
6.6 Loading and unloading shovel onto low-bed trailer		3	23
7.0 Waits and delays			
7.1 Bulldozing and non-productive casting		14	
7.1 Lack of hauling units at belt loader		10	
7.1 Hauling unit exchanges		3	
7.1 Belt loader delays		6	
7.1 Wait for arrival of crew in morning		1	
7.2 Maintenance of shovel		5	
7.3 Instructions		1	
7.5 Idle		1	
7.9 Other		1	42
	Total		100

The shovel loaded sand onto two belt loaders whose bottoms were together at the point of a V. At the top, each belt fed one hauling unit.

The swing of the shovel averaged about 75 degrees. It was necessary for the shovel to dump very slowly so as not to clog the belts. Thus the dump time was quite long. Occasionally, the belt loader got clogged and stopped, thus delaying the shovel.

Under the observed conditions and rates of production, the 1/2-cubic yard rubber-tired shovel will produce 356 cubic yards in a 9.0-hour day.

During 67.6 hours of study, the belt loaders fed by the shovel loaded 40 cubic yards of sand per belt per hour of actual loading time. Thus, during a 9-hour working day, each loader would be loading 55 percent of the time, or 5.0 hours, and accordingly would load (5.0 x 40) 200 cubic yards of sand. For the two loaders, this was equivalent to a production of 400 cubic

yards per 9.0-hour day. This rate is in excess of the 9.0-hour rate for the shovel, but the difference is due to the fact that the studies were taken at different times under different conditions.

Distribution of Equipment-Hours of Working Time
of Belt Loaders in Sand Pit Loading Trucks

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Loading sand into trucks	55	
5.2 Truck exchange and maneuver	5	60
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	2	
6.4 Move loader in pit	1	3
7.0 Waits and delays		
7.1 Waiting due to lack of hauling units	16	
7.1 Belt running empty	2	
7.1 Wait for loader operator	2	
7.1 Wait on other operations	1	
7.2 Maintenance of loader	6	
7.2 Starting up or engine stalled	2	
7.4 Excess lunch and quit early	1	
7.5 Idle - Shovel loading trucks directly	3	
7.5 Idle - Shovel not producing or sand being fed to other loader	2	
7.9 Other	2	37
Total		100

During the 52-week study period, trucks were in use at various times for a total of 2969 hours hauling sand to stockpiles for winter use on snow and ice control. The trucks averaged between 6 and 7 loads each per day with an average haul distance of 6.3 miles. In addition the trucks drove an average of 18.3 miles per day between the garage and the work site. The average driving speed during sand hauling operations was 27.2 miles per hour for hauling and 28.8 miles per hour on the return trip. The distribution of truck time based upon 220.4 truck-hours of study is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks Hauling Sand to Stockpiles

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Load at pit	11	
5.2 Haul to stockpile	18	
5.3 Dump	7	
5.4 Return to sand pit	17	
5.5 Exchange and maneuvers	3	56
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	9	
6.9 Move belt loaders	3	
6.9 Load truck with sand for possible emergency winter use	1	13

Item	Percent	
7.0 Waits and delays		
7.1 Waits on other operations (Sand pit and stockpile)	15	
7.1 Belt loader delays	6	
7.2 Maintenance of truck	2	
7.3 Instructions	1	
7.4 Start late, excess lunch and quit early	3	
7.6 Personal	1	
7.9 Other	3	31
Total		100

For the purpose of computing quantities of sand stockpiled, the State used an average figure of 4.5 cubic yards per truck load. In reality, the trucks carried an average load of 5.0 cubic yards, based upon weighed truck loads. For the average load, the loading time at the pit was 8.1 minutes and dumping time at the stockpile was 5.3 minutes.

During 86.8 hours of study, the belt loaders used in sand stockpiling operations averaged 42 cubic yards of sand per belt per hour of actual time the conveyor was in operation. Thus, during a 9-hour working day each conveyor would be stockpiling 33 percent of the time, or 3.0 hours, and accordingly would stockpile (3.0 x 42) 126 cubic yards of sand. Calcium chloride was, at times, added to the sand as it moved up the belt by a man pouring from an open bag.

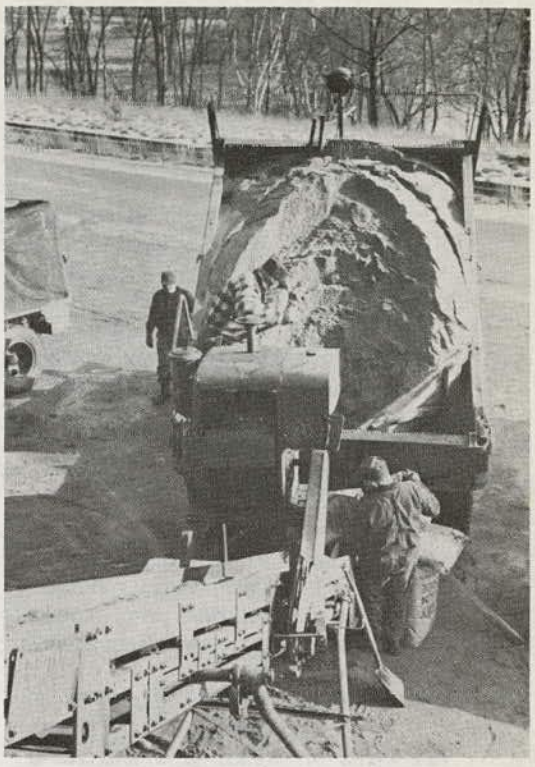
Distribution of Equipment-Hours of Working Time
of Belt Loaders Used at the Stockpile

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Stockpiling sand	33	
5.2 Truck exchanges and maneuvers	4	37
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	6	
6.4 Move loader	4	10
7.0 Waits and delays		
7.1 Lack of sand to stockpile - waiting for trucks	33	
7.1 Truck delays	1	
7.2 Maintenance of loader	4	
7.2 Starting up or stalled engine	1	
7.4 Start late, excess lunch, or quit early	6	
7.5 Loader idle at garage	7	
7.6 Personal	1	53
Total		100

STOCKPILING BAG SALT FOR WINTER USE

During the 1950-51 winter season, a total of 600,000 pounds of rock salt in bags was stockpiled and stored for snow and ice control. Salt was received in box cars of 80,000 lbs. per carload at a railroad siding, 0.2 mile north of the Warehouse Point Garage on Route 20, Enfield.

The box cars were usually loaded with 800 - 100-lb. bags, stacked in 4 rows, 7 bags high. Salt bags were loaded onto trucks, hauled to the Warehouse Point Garage and stockpiled in the warehouse. A crew of 6 men, plus 1 crew leader, together with 2 or 3 trucks with drivers, were usually assigned to perform this work. Three men worked at the railroad siding, helping the drivers to load their trucks, carrying the bags from the freight car onto the truck with a pushcart. Bags were piled on the truck in 4 rows, 5 bags high, each truck carrying approximately 90 bags.



68. Calcium chloride is sometimes added to prevent freezing of the pile.

At the warehouse, 3 men and the drivers unloaded the trucks with the help of a belt loader. One man and the driver fed the bags to the loader and the other men took the bags off of the loader and stacked them.

Studies were taken covering 59.7 man-hours of unloading and stockpiling of 1600 bags of salt. The distribution of working time of all labor, including the truck drivers and the 3 helpers at the railroad siding (but excluding the crew leader), is as follows:

Distribution of Man-Hours of Working Time
Spent Stockpiling Bag Salt for Winter Use

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Load bag salt onto trucks	22	
1.2 Haul to warehouse	1	
1.3 Unload and stack bag salt	12	
1.4 Return to railroad siding	1	36
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	1	
2.6 Load and unload men, tools, and equipment	1	
2.9 Miscellaneous work at railroad siding	4	
2.9 Miscellaneous work at warehouse (stockpile)	5	11
3.0 Waits and delays		
3.1 Wait for arrival of freight car	14	
3.1 Wait on other operations at railroad siding	19	
3.1 Wait on other operations at warehouse (stockpile)	4	
3.1 Wait for arrival of hauling units at railroad siding	12	
3.9 Other	4	53
Total		100

Under the observed conditions and production rates, a typical crew of 6 men with 2 trucks and 2 drivers, and a crew leader, will unload and stockpile 96.5 tons of bag salt in a 9.0-hour day.

Detailed studies covering a period of 14.5 truck-hours yield the following time distribution:

Distribution of Equipment-Hours of Trucks
on Stockpiling Bag Salt Operations

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Maneuver to obtain load	3	
5.2 Load salt	34	
5.3 Haul to warehouse (stockpile)	4	
5.4 Maneuver to unload at warehouse	2	
5.5 Unload salt	16	
5.6 Return to railroad siding	4	63
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	3	
6.6 Load and unload men, tools, and equipment	4	
6.9 Miscellaneous work preparing platform for storing salt	2	9
7.0 Waits and delays		
7.1 Wait for arrival of freight car	7	
7.1 Wait on other operations at railroad siding	11	
7.1 Wait on other operations at warehouse (stockpile)	5	
7.2 Maintenance of truck	3	
7.9 Other	2	28
Total		100

The average mileage driven by each truck on days during which studies were made was as follows:

Item	Average miles driven per day
To and from garage	1.2
Haul to warehouse	1.4
Return to railroad siding	1.1
Minor moves, turns, and maneuvers	0.1
Total	3.8

STOCKPILING BULK ROCK SALT FOR WINTER USE

A total of 520,500 pounds of bulk rock salt was stockpiled and stored for winter use during the 1950-51 winter season.

Bulk rock salt for snow and ice control was shipped in by railroad box car and hauled by truck to a specially constructed stockade. Two trucks were used to haul the forty tons received in each carload. A slip-scoop, pulled by a third truck was used to move the salt to the side door of the

car where it poured by gravity or was shoveled into a hopper mounted on a belt loader which loaded it into the hauling trucks. The scoop was 2 feet wide by 2.4 feet long by 1 foot deep with a heaped capacity of approximately 0.2 cubic yard. A rope was attached to the pivoted yoke anchored at each side near the middle of the scoop. Thus when the two handles extending from the rear of the scoop were raised the front dug down and as the forward pull was continued, the scoop flipped over and dumped. Two men worked in the car operating the scoop and hand shoveling into the hopper when necessary. Two more men worked outside the car leveling the load on the truck with hand shovels, guiding the tow-rope attached to the scoop and operating the belt loader.

The trucks hauled to the stockade 1.5 miles from the railroad siding. The stockade was 16 feet wide by 32 feet long by 6 feet high and was constructed of hewn timber guide rails salvaged from the Merritt Parkway. A canvas tarpaulin was used to cover the open top after the bin was filled. The trucks dumped directly into the stockade until the bottom was covered. Then they dumped into the hopper of a belt loader which was used to fill the remainder of the stockade.

At the stockade three men shoveled the salt into the corners, operated and moved the belt loader, and directed the dumping of the trucks. Three additional men, who were performing other work in the stockyard, helped, when necessary, hand shoveling, moving the loader, and covering the stockade with the tarpaulin.

There were four laborers at the railroad car; three laborers at the stockade, with three additional laborers when help was necessary. Two trucks were used for hauling, and one for pulling scoop. A crew leader supervised the work.

The distribution of working time based upon 28.7 man-hours of detailed stop-watch study is as follows:

Distribution of Man-Hours of Working Time
on Stockpiling Bulk Salt

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Shovel salt by hand in railroad car	12	
1.2 Operate scoop in railroad car	16	
1.3 Driving truck pulling scoop	5	
1.4 Spread load on truck by hand (truck driver)	8	
1.5 Haul to stockade (stockpile)	5	
1.6 Dump salt directly in bin (stockade)	3	
1.6 Dump salt onto belt loader	2	
1.7 Shoveling salt by hand in bin	11	
1.8 Return to railroad siding from stockade	3	65
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	2	
2.4 Minor moves, turns, and maneuvers	3	
2.9 Move belt loaders	4	
2.9 Cover salt with tarpaulin and secure	3	12

Item	Percent	
3.0 Waits and delays		
3.1 Wait for hauling units (shortage)	5	
3.1 Waits on other operations	1	
3.1 Wait to obtain load	2	
3.2 Maintenance of belt loaders	6	
3.2 Maintenance of truck	1	
3.2 Maintenance of other equipment	2	
3.3 Instructions	2	
3.9 Other	4	23
Total		100

Under the observed conditions and production rates, a 10-man crew working a 9-hour day will stockpile 250,900 pounds or 125 tons of bulk rock salt. A typical crew of 10 men (excluding the foreman) includes

3 drivers
3 - at stockpile - hand shoveling and operating belt loader
2 - at railroad siding - hand shoveling and operating belt loader
2 - at railroad siding - operating scoop

Detailed studies covering 10.3 truck-hours give the following time distribution.

Distribution of Equipment-Hours of Working Time of Trucks Used in Stockpiling Bulk Rock Salt

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Maneuver into loading position	1	
5.2 Loading truck	38	
5.3 Truck pulling scoop	15	
5.4 Haul to stockade	10	
5.5 Maneuver into position to dump	1	
5.6 Dump directly into bin	3	
5.6 Dump onto belt loader	3	
5.7 Return to railroad siding	6	77
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	3	
6.9 Attach, detach and adjust corner boards and safety rails	1	
6.9 Dumping sand loaded for possible emergency winter use	2	6
7.0 Waits and delays		
7.1 Waits by truck pulling scoop due to shortage of hauling units	9	
7.2 Maintenance of truck	1	
7.3 Instructions	3	
7.9 Travel by foreman on errand	2	
7.9 Other	2	17
Total		100

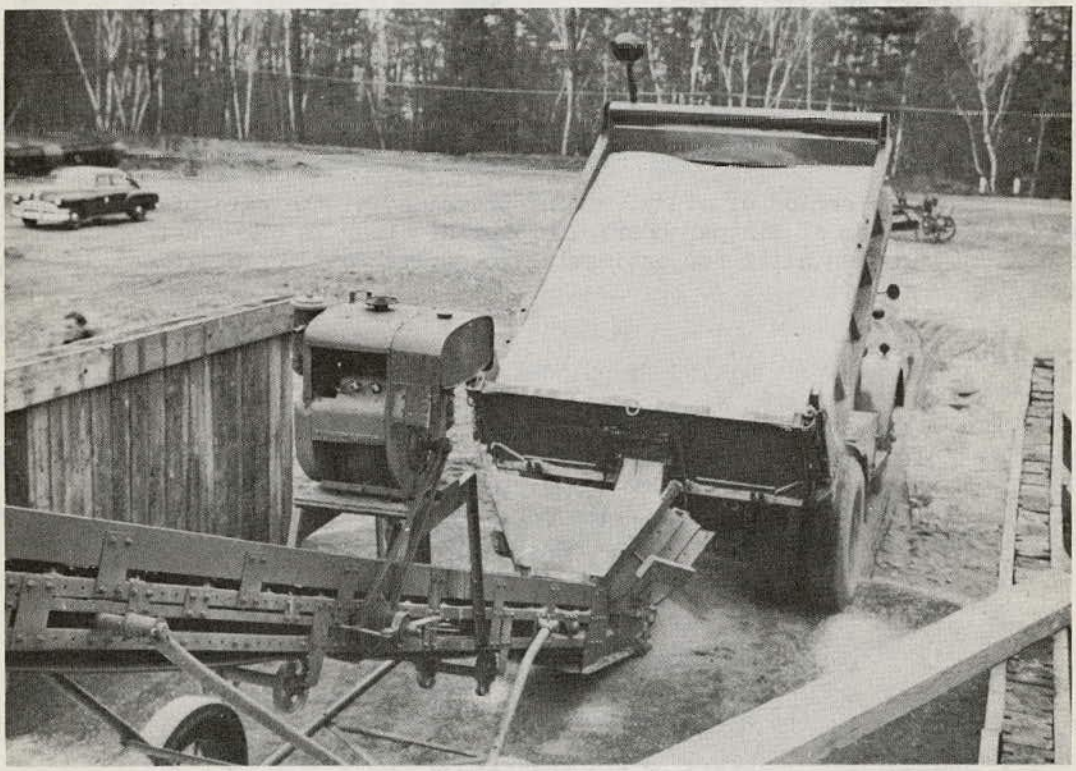
The average truck load was 10,000 lbs. or 5 tons.

The average mileage driven during a 3.5-hour study period (while unloading 1 carload of bulk salt) by a typical truck hauling bulk salt to stockpile was as follows:

Item	Average miles
To and from garage	3.3
Haul to stockpile	10.0
Return to railroad siding	8.5
Total	21.8

MIXING SAND AND CALCIUM CHLORIDE WITH THE BUCKET LOADER

A six-man crew plus a 7-ton truck and a bucket loader were used to mix sand and calcium chloride. One man operated the loader, one man the truck, two men shoveled the sand and calcium chloride into the worm of the loader, one man directed the truck dumping the mix and the sixth man carried the bags of calcium chloride to the mixing site.



69. Stockpiling bulk rock salt in a stockade constructed for this purpose. The pile is then covered with canvas or weatherproof paper tarpaulins.

Four 100-lb. bags of calcium chloride were used with each truck load of sand. The calcium chloride was spread over the sand directly in front of the loader by the two men shoveling into the loader who were responsible for proportioning the sand and calcium chloride. The loader loaded this mixture onto the truck which carried it to a far corner of the stockyard for stockpiling.

During the 52-week study period, two of the loaders were employed for a total of 40.4 hours, mixing Ca Cl_2 and sand. The distribution of this working time in accordance with 2.0 hours of detailed stop-watch studies is as follows:

Distribution of Equipment-Hours of Working Time
of Bucket Loader Mixing Calcium Chloride and Sand

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Maneuver loader into position	5	
5.2 Mix and load sand and Ca Cl_2 into truck	51	56
6.0 Related items including travel and preparatory work		
6.9 Start and stop engine	1	
6.9 Change cutting depth of loader	1	2
7.0 Waits and delays		
7.1 Wait for truck to dump load	38	
7.5 Idle	4	42
Total		100

During the period of study, mixing proceeded at the rate of approximately 41 cubic yards of mix per hour. This brief study is not considered sufficiently representative for estimating accomplishment for a typical 9.0-hour day.

MIXING BITUMINOUS COLD PATCH

During the 52-week study period, approximately 1460 cubic yards of bituminous cold patch material were mixed over a period of 26 working days. Seventeen thousand gallons of RT-6 and 7,650 gallons of RT-8 or a total of 24,650 gallons were mixed with 1,460 cubic yards of sand. The average amount of tar used per ½-cubic yard batch was 8.4 gallons.

Average daily quantities of materials used and mixed were as follows:

948 gallons of tar
57 cubic yards or 15 truckloads of sand
112 ½-yard batches mixed per day

A typical crew consists of the following:

Equipment: 1 Bituminous mixer
1 Distributor
2 18-inch belt conveyors
1 ½ cubic yard power shovel (used on 50% of days)

Equipment: 2 Trucks
1 Screen (remove oversize rock at sand pit)
Labor: 2 Crew leaders
1 Mixer operator
1 Power shovel operator (used only on days shovel worked)
2 Belt loader operators
1 Distributor operator
1 Laborer at mixer
2 Sand truck drivers
3 Laborers feeding belt loaders (used only on days shovel did not work)
10-12 total, including crew leaders

Materials employed consisted of ungraded sand screened for trash and oversize material and mixed with RT-6 or RT-8 tar in ½ cubic yard batches. Tar was supplied by the distributor and bulk measured at the mixer.

Mixing took place at the Simsbury stockyard and sand was supplied from a nearby State-owned pit. The mixer drum was jacketed and heated.

The operations were somewhat erratic and daily production varied considerably. The differences in the daily production rates of the equipment employed are due to the fact that (1) studies on the various units were taken on different days and (2) no major delays are included in the tables. If these latter delays were taken into account, the daily production rates would tend to equalize.

70. Loading truck with sand at State-owned pit.

1/2 Cubic Yard Power Shovel Supplying Belt Conveyors in Sand Pit

The 1/2 cubic yard power shovel worked supplying sand in the pit to the belt conveyors for screening and loading onto trucks on 13 out of the 26 days on which bituminous cold patch was mixed.

During the 52-week study period, the power shovel worked a total of 81.0 equipment-hours on mixing bituminous cold patch operations. Detailed studies covering a total of 13.0 hours give the following time distribution.

Distribution of Equipment-Hours of Working Time
of 1/2 Cubic Yard Power Shovel Loading Sand Trucks
in Pit

Item		Percent	
5.0 Operating cycle items on assigned task			
5.1 Load	0.07 minute per cycle	2	
5.2 Swing	0.07 minute per cycle	2	
5.3 Dump	0.10 minute per cycle	3	
5.4 Return	0.07 minute per cycle	2	9
Total	0.31 minute per cycle		
6.0 Related items including travel and preparatory work			
6.1 Moving shovel between (to and from) sand pit and Farmington		25	
6.4 Shovel moves		4	
6.6 Loading and unloading shovel from transport		5	
6.9 Cleanup of oversize material from screens		5	
6.9 Bulldozing and non-productive casting		4	
6.9 Miscellaneous work		3	46
7.0 Waits and delays			
7.1 Lack of hauling units at belt loader		33	
7.1 Belt loader delays		5	
7.1 Hauling unit exchanges		1	
7.2 Maintenance of shovel		2	
7.9 Other		4	45
	Total		100

During the period of study, the shovel loaded at the rate of 75 cubic yards (sufficient for 150 batches) per 9.0-hour day.

18-inch Belt Conveyor - Sand Pit

An 18-inch belt conveyor fitted with metal cleats spaced on 2-foot centers was employed at the sand pit to load ungraded sand into trucks for transportation to the mixer. This sand was screened for oversize material as it was discharged into the trucks. Fifty percent of the time sand was fed to the belt by hand. The remainder of the time it was fed by the State-owned 1/2-yard power shovel.

No overall time control was kept for this conveyor inasmuch as this unit is considered auxiliary rather than a major unit of equipment. However, since the performance and production rate of this unit was an integral part

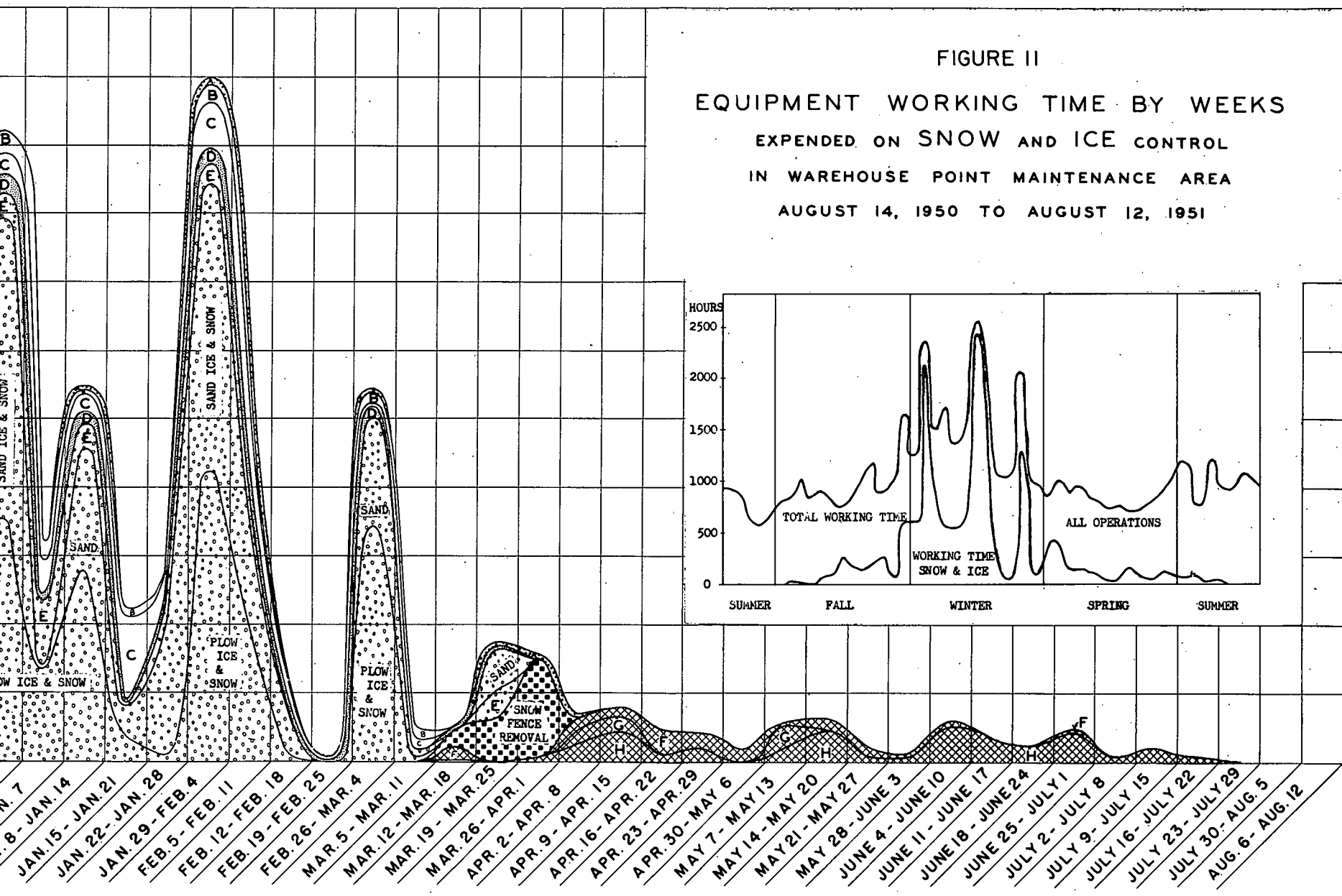
FIGURE II

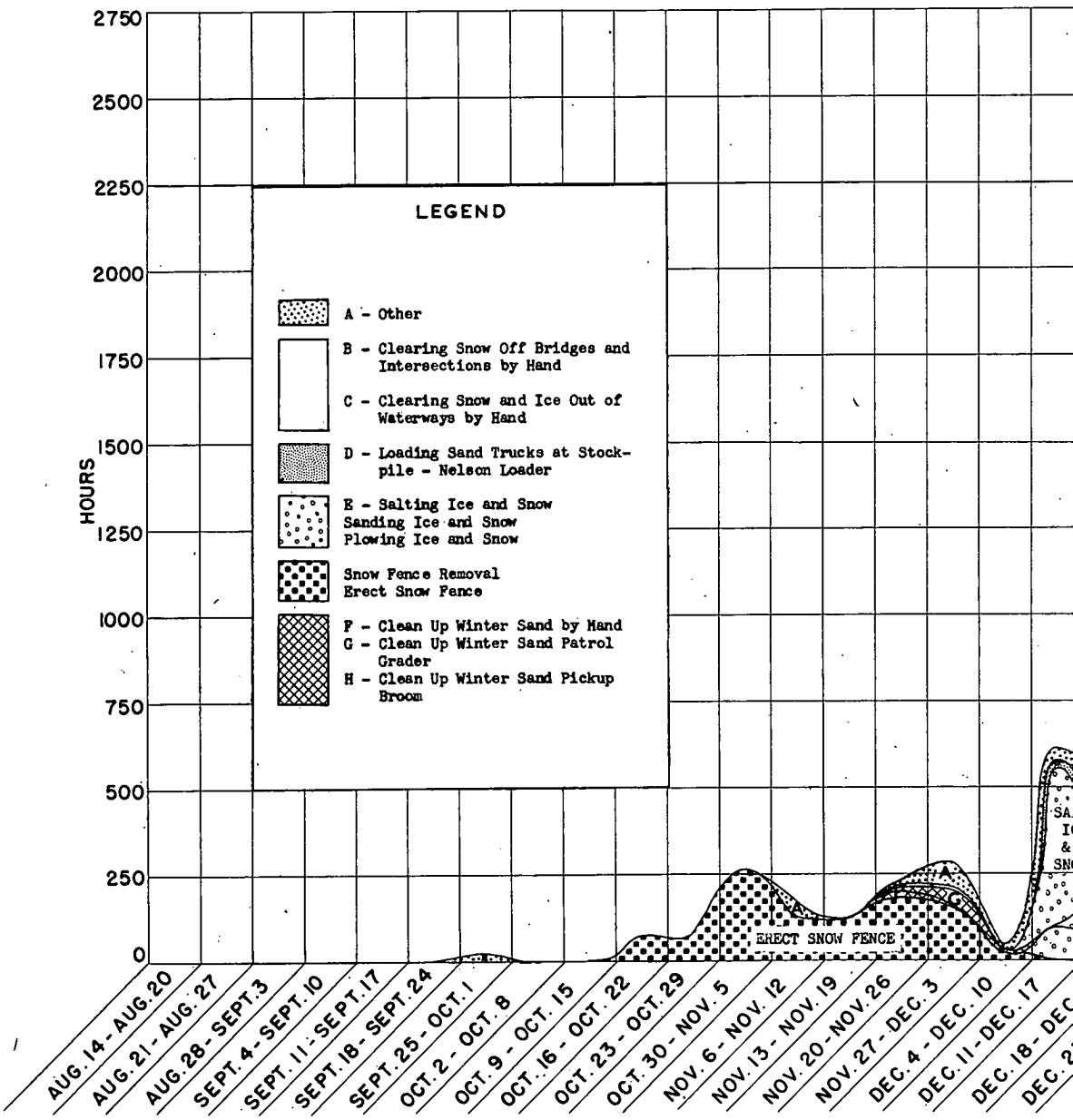
EQUIPMENT WORKING TIME BY WEEKS

EXPENDED ON SNOW AND ICE CONTROL

IN WAREHOUSE POINT MAINTENANCE AREA

AUGUST 14, 1950 TO AUGUST 12, 1951




LEGEND
A - Other
B - Clearing Snow Off Bridges and Intersections by Hand
C - Clearing Snow and Ice Out of Waterways by Hand
D - Loading Sand Trucks at Stockpile - Nelson Loader
E - Salting Ice and Snow
Sanding Ice and Snow
Plowing Ice and Snow
Snow Fence Removal
Erect Snow Fence
F - Clean Up Winter Sand by Hand
G - Clean Up Winter Sand Patrol Grader
H - Clean Up Winter Sand Pickup Broom
HOURS
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
ERECT SNOW FENCE
AUG. 14 - AUG. 20
AUG. 21 - AUG. 27
AUG. 28 - SEPT. 3
SEPT. 4 - SEPT. 10
SEPT. 11 - SEPT. 17
SEPT. 18 - SEPT. 24
SEPT. 25 - OCT. 1
OCT. 2 - OCT. 8
OCT. 9 - OCT. 15
OCT. 16 - OCT. 22
OCT. 23 - OCT. 29
OCT. 30 - NOV. 5
NOV. 6 - NOV. 12
NOV. 13 - NOV. 19
NOV. 20 - NOV. 26
NOV. 27 - DEC. 3
DEC. 4 - DEC. 10
DEC. 11 - DEC. 17
DEC. 18 - DEC

71. Mixing and stockpiling bituminous cold patch using RT-6 or RT-8 and sand, 1/2-yard batch type mixer in center is supplied with tar by distributor visible behind truck supplying sand.

of the total operation, a limited number of time studies were conducted on this unit.

Time studies of the belt conveyor loading sand trucks covering a period of 13.2 hours give the following time distribution.

Distribution of Equipment-Hours of Working Time of the Belt Conveyor Loading Sand Trucks in Pit

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Load sand	36	36
6.0 Related items including travel and preparatory work		
6.4 Move loader	6	
6.9 Adjust screen	2	8
7.0 Waits and delays		
7.1 Wait for sand trucks	38	
7.1 Wait on other operations	3	
7.2 Loader maintenance	3	
7.2 Starting and re-starting stalled motor	5	
7.3 Instructions	1	
7.9 Weather	4	
7.9 Other	2	56
Total		100

During the period of study the conveyor loaded at the rate of 93 cubic yards of sand per 9.0-hour day. This was equivalent to 186 one-half cubic yard batches of cold mix or 23 truckloads of 4 cubic yards each.

SAND TRUCKS

Seven-ton dump trucks were used to haul the screened pit sand from the belt conveyor to the mixer. Each truck hauled from 4 to 4-1/2 cubic yards per load which was sufficient to produce from 8 to 9 batches of cold mix. To control the dumping of approximately 1/2 cubic yard per batch each truck was fitted with "angle boards" placed diagonally across the rear corners of the dump body to funnel sand through a rear trap door into the mixer skip.

Each sand truck followed more or less the following cycle: (1) travel to pit to obtain sand, (2) maneuver and loading at pit, (3) haul to mixer where (4) it discharged into the mixer skip. At the mixer the truck completed another series of moves as follows: (1) back to skip, (2) raise body, (3) dump sand, (4) lower body and, (5) move forward from skip.

During the 52-week study period, three trucks assigned to the Warehouse Point maintenance sub-district were employed for a total of 412.8 hours working on mixing cold patch operations. Time studies on the trucks covering a period of 63.3 hours give the following time distribution:

Distribution of Equipment-Hours of Working Time
of Trucks Used to Haul Sand from the Pit to the Mixer

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Maneuver into loading position	2	
5.2 Load	10	
5.3 Haul to mixer	5	
5.4 Maneuver to dump	4	
5.5 Dump	8	
5.6 Clean out dump body and close tail gate	2	
5.7 Return to pit	4	35
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	5	
6.4 Minor moves, turns, and maneuvers	1	
6.6 Load and unload men, tools, and equipment	2	
6.9 Moving belt loaders	2	
6.9 Move mixer	2	
6.9 Load truck with sand for possible emergency winter use	2	
6.9 Miscellaneous	1	15
7.0 Waits and delays		
7.1 Wait for trucks ahead to be loaded in pit	5	
7.1 Wait for trucks ahead to dump load	7	
7.1 Waits to dump between batches	9	
7.1 Wait for distributor to reload with tar	2	
7.1 Wait for blasting off overhanging top of sand pit	1	
7.2 Maintenance and repair of other equipment	10	
7.2 Maintenance and repair of truck	2	
7.3 Instructions	4	
7.4 Start late, excess lunch and quit early	5	
7.6 Personals	2	
7.9 Other	3	50
Total		100

The average truck cycle, exclusive of waiting on trucks ahead, and including waits during mixing, was observed to be 30 minutes.

Truck speeds were as follows:

Haul	9.3 miles per hour
Return	8.9 miles per hour

During the period of study, each truck hauled an average of 8 loads, or 72 one-half cubic yard batches per 9.0-hour day.

The average mileage driven by a truck each day according to the studies was as follows:

Item	Average miles driven per day
Travel to and from garage	7.0
Haul to mixer	2.8
Return to pit	2.0
Other	1.8
Total	13.6

During the 52-week period, the distributor was used on cold patch mixing operations for a total of 25 days.

The distribution of time for the distributor during this period was:

Distribution of Total Available Distributor Time

Item	Hours	Percent
Non-working time (all time of 0.50 hour or more when the distributor was not working)		
Maintenance and repairs	10.4	4
Start late and quit early	4.3	2
Not in use, parked in garage	60.1	27
Working time		
Mixing cold patch	150.2	67

During working time, detailed studies were conducted on four separate occasions on cold patch mixing for a total study time of 28.9 hours. The tabulation on the following page shows the time distribution in accordance with these studies.

Distribution of Equipment-Hours of Working Time
of Distributor on Mixing Bituminous Cold Patch Operations

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Pump tar to fill mixer measuring trough	10	10
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	16	
6.6 Connect & disconnect hose to ferry & reserve tank	3	
6.6 Load from ferry and reserve tank	4	
6.6 Unloading into reserve tank	2	
6.6 Connect and disconnect hose to mixer	1	
6.9 Prepare to heat tar and commence mixing operations	4	
6.9 Heat tar	6	
6.9 Miscellaneous	2	38
7.0 Waits and delays		
7.1 Wait between batches during mixing	32	
7.1 Wait for sand trucks to arrive at mixer	4	
7.1 Wait for exchanging of conveyor loaders	2	
7.1 Wait for mixer to start	1	
7.2 Maintenance of distributor	4	
7.2 Maintenance and repairs to mixer and conveyor loader	2	
7.4 Excess lunch and quit early	3	
7.6 Personal	3	
7.9 Other	1	52
Total		100

Actual pumping was at the rate of 1055 gallons per hour. However, during the period of study, the total amount pumped in a 9.0-hour day was 950 gallons. At 8.4 gallons per 1/2 cubic yard batch, this was equivalent to 113 batches per day.

The average mileage driven by the distributor on days during which studies were made was 26.1 miles round trip to and from the garage.

During the 52-week period, the batch type mixer, having a capacity of 1/2 cubic yard, was used solely on mixing bituminous cold patch.

The distribution of time for the mixer during this period was:

Distribution of Total Available Mixer Time

Item	Hours	Percent
Non-working time (all time of 0.5 hour or more when the mixer was not working)		
1 Not in use, parked at garage	691.5	32
2 Not in use, parked at stockpile	1242.9	59
3 Under repair	10.8	1
4 Other	39.9	2
Working time on cold patch mixing	130.0	6
Total	2115.1	100

Detailed studies conducted on 4 separate days for a total study time of 23.6 hours show the following time distribution.

Distribution of Equipment-Hours of Working Time
of Mixer on Mixing Bituminous Cold Patch Operations

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Raise skip	3	
5.2 Charge	4	
5.3 Mix (1/2 cubic yard batch)	22	
5.4 Discharge	18	47
6.0 Related items including travel and preparatory work		
6.4 Move mixer	4	
6.9 Prepare mixer for mixing	6	
6.9 Heat mixer and warm up motor	6	
6.9 Shutting down - clean drum, disconnect distributor, etc.	6	22
7.0 Waits and delays		
7.1 Delays during mixing cycle	4	
7.1 Wait for tar (RT-6)	5	
7.1 Wait for sand	4	
7.1 Move and exchange belt conveyors	4	
7.2 Maintenance and repair of mixer	6	
7.2 Maintenance of belt conveyor	5	
7.3 Instructions	1	
7.4 Excess lunch	1	
7.9 Other	1	31
Total		100

Batch mixing operations were observed to proceed at the rate of 37-1/2 cubic yard batches per hour of actual mixing time, mixing operations taking place 47 percent of the working time. During the period of study, mixing was at the rate of 157 batches per 9.0-hour day.

18-inch Belt Conveyor - Stockpile

The 18-inch belt conveyor was located adjacent to the mixer to stockpile mixed cold patch. The mixer discharged directly onto the belt. As in the case of the belt conveyor at the sand pit, no overall time control was kept of this unit. However, it was considered that time studies on the operation of this unit were desirable. The belt was 18-inches wide and fitted with metal cleats spaced on 2-foot centers.

Distribution of time of the belt conveyor on stockpiling cold patch as obtained from 20.1 hours of detailed study is shown in the table on the following page.

Distribution of Equipment-Hours of Working Time
of Belt Conveyor Stockpiling Bituminous Cold Patch

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Convey mixed batches to stockpile	22	22
6.0 Related items including travel and preparatory work		
6.4 Move conveyor	4	
6.9 Starting up and shutting down	2	
6.9 Cleanup of conveyor at night	2	8
7.0 Waits and delays		
7.1 Wait between batches	41	
7.1 Mixer waiting for sand trucks to arrive	5	
7.1 Wait while bitumen is heated	3	
7.1 Wait on other operations	1	
7.1 Wait for mixer to be moved	3	
7.1 Cleanup around mixer	3	
7.2 Maintenance of conveyor	5	
7.2 Repairs to conveyor	2	
7.4 Excess lunch and quit early	5	
7.9 Other	2	70
Total		100

During the period of study the conveyor stockpiled at the rate of 93 cubic yards or 186 batches of cold patch per 9.0-hour day.

SNOW AND ICE CONTROL

Snow and ice control is the largest activity that the maintenance forces are called upon to perform. Storms are unpredictable and it takes planning and preparation to meet emergencies. Of the total maintenance work load for the year approximately 30 percent of equipment usage and 30 percent of labor-time was expended on snow and ice control. For equipment, Figure 11 shows the distribution of the work load in the Warehouse Point area during the winter of 1950-51 and the relation of snow and ice control to the total maintenance work load during the study period.

Erection of snow fence was the first item of preparation and amounted to 6 percent of the equipment work load on snow and ice control. Snow fence was erected in the fall between October 15 and December 15 at about the same time as sand stockpiles were built up. Snow fence was removed during the last three weeks in March and amounted to 4 percent of the work load. Bucket loaders were used all winter, from November 15 to April 1, to load trucks with sand at the end of the day so that they would be ready for emergencies. They were further used for loading of sand during storms and their use through the winter amounted to 2 percent of the work load.

Use of equipment during storms accounted for 63 percent of the work load. Of this amount, plowing accounted for 28 percent of the work load although no plowing was done during 4 of the 18 storms. Sanding accounted for 32 percent of the work load and was done on all 18 storms. Salting accounted for the remaining 3 percent and was heaviest during the early storms particularly the

sleet storm of December 15 and 16 and the snow storm of January 7 and 8. The major portion of the available salt was used during these early storms so that there was none available during the latter part of the winter when several sleet storms and freezing rains occurred.

The accident frequency rate declined during the winter, being highest during the early storms when motorists apparently were less careful. The average for the winter was one accident on the 262 miles of highway in the area during each 9 hours of storm.

72. Erecting snow fence, one man spotting posts and opening hole with crowbar, two men driving posts. Others are hauling and distributing fence rolls.

Immediately following storms, snow and ice were removed from bridges, waterways, and drainage structures. This work amounted to an additional 12 percent of the work load.

In the spring from March 15 and extending into July, winter sand was cleaned up from the shoulders of the highways. This cleanup amounted to 10 percent of the snow and ice control work load.

The table on the following page shows accomplishment rates for the various items.

Accomplishment Rates of Snow and Ice Control Items
Observed During Study Periods

Item	Size of Crew	Amount of Equipment	Amount of Work Accomplished Per Day
Erect snow fence	6	2	1750 ft. snow fence erected
Install snow plow frames on trucks	2	-	3 frames and hoists mounted
Painting arrows to locate drainage inlets	2	1	230 arrows painted on 9.7 miles of highway
Bucket loader at sand stockpile	1	1	18.2 cu. yds. per evening in a half hour
Change cutting edges on plow blades	2	-	change 4.8 cutting edges
Snow and ice removal	all	all	keep roads open
Flink spreader sanding	2	1	25 miles sanded in half a day
Check and spot sand in morning	2	1	13.3 miles checked in 2½ hours
Clearing snow and ice from drainage inlets by hand	3	1	146 catch basins cleared on 4.9 miles of highway
Clearing snow and ice from bridges by hand	4	1	1870 cu. ft. removed from 2050 ft. of bridge gutter
Clearing bridges and intersections with Case tractor	4 - 7	2	18,900 sq. ft. cleared average depth 2½ inches
Snow fence removal	7	2	3760 ft. snow fence removed
Pick up and store sand boxes	4	1	36 sand boxes picked up and stored
Clean up winter sand from parkways	24	7	8400 ft. of centerstrip broomed 84 cu. yds. of sand removed from 15.7 miles of gutter
Cleanup of winter sand with pickup broom	7	4	12 cu. yds. of sand removed from 8.4 miles of shoulder

Detailed discussions concerning each operation listed in the above table are included in the following pages.

ERECTING SNOW FENCE

Snow fence was erected in the fall, prior to the freezing of the ground. It is generally placed at all locations where experience has shown it to be effective in reducing drifting on the pavement. All private property owners are contacted prior to placement of snow fence on their property. In this connection it is usually stipulated that all snow fence will be completely removed in time for spring plowing.

73. Stretching and tying snow fence. Fence has still to be guyed.

During the 1950-51 winter season, a total of 90,225 feet of snow fence was erected at 280 different sites throughout the Warehouse Point area. This was an average of 322 feet per stretch of fence.

A line of snow fence was usually erected at a distance of 50 to 60 feet from the shoulder of the road. A measuring stick about 10 feet long was used to get this distance for the beginning of the fence. There a post was driven, to which a string was attached and strung out for the fence line. The other end of the string was attached to a post at the other end of the proposed fence.

A man using a crow bar made post holes along the string line, spacing them by means of the measuring stick. In the meantime, as the truck was driven along the string line, fence rolls, posts, and stakes were distributed. Next the posts were inserted into the holes and driven with a sledge hammer. The man pounding the posts stood on the truck or used a sawhorse.

The snow fence was then unrolled, stood up, and attached to the posts with wire ties. To accomplish this, one man held the fence, another used a spring leaf to stretch the fence taut, and a third man attached the wire ties.

The final operation was to guy the fence, approximately every 40 feet, against the direction of the prevailing wind. In addition, longitudinal guys were used to secure the ends of the fence. For guying, wood stakes were used, tied with wire to the posts.

Ordinarily snow fence was handled in 50-foot and 100-foot rolls. Most of it was 4 feet high, with 3 slats per foot.

A list of the tools used in the erection of snow fence is as shown on the following page.

1 ball of string
1 10-foot measuring stick
2 sledge hammers, 16 lb.
1 pair of pliers
1 claw hammer
2 spring leaves
1 crow bar
1 or 2 shovels and picks

A typical crew consisted of 6 men (2 drivers and 4 men) supervised by a foreman. A six-man crew normally operated using 2 dump trucks. One truck was used as a platform from which to drive posts, and the other transported additional snow fence and posts from the stockpile.

Detailed stop-watch studies were conducted on the erection of snow fence covering a total of 265.5 man-hours, excluding foremen. The time distribution is as shown in the following table.

Distribution of Man-Hours of Working Time on Erection of Snow Fence

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Travel to and from stockpile	4	
1.2 Load and unload snow fence	2	
1.2 Load and unload posts	2	
1.2 Load and unload guy stakes and other materials	1	
1.3 Preparations for erection of snow fence	12	
1.4 Walk to and from truck	3	
1.5 Place and drive post	9	
1.6 Ride truck ahead	2	
1.7 Erect and attach fence	15	
1.8 Place guy wire	3	
1.9 Walk along fence	5	58
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	5	
2.3 Travel to new work site	3	
2.4 Walk to new work site	2	
2.4 Maneuver truck	1	
2.6 Load and unload men, tools and equipment	3	
2.9 Miscellaneous	3	17
3.0 Waits and delays		
3.1 Wait on other operations	10	
3.3 Instructions and inspections	4	
3.4 Excess lunch and quit early	2	
3.5 Idle	3	
3.6 Personal	3	
3.7 Resting	1	
3.9 Other	2	25
Total		100

Based upon conditions existing during the studies, a typical crew of 6 men (excluding foremen) working a 9-hour day would erect 1,752 lineal feet of snow fence.

1 post used per 10 feet of fence
1 guy wire used per 25.8 feet of fence

During the 52-week period, 23 trucks out of a total of 37 trucks available were employed at various times for a total of 1054 hours on erecting snow fence. Detailed studies covering a period of 97.0 equipment-hours of work gives the following time distribution.

Distribution of Equipment-Hours of Working Time
of Trucks Used on Erection of Snow Fence

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel to and from stockpile	7	
5.2 Load and unload snow fence, posts, stakes and other materials	9	
5.3 Driving posts from truck body	2	18
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	7	
6.3 Travel to new work site	3	
6.4 Minor moves, turns and maneuvers	5	
6.6 Load and unload men, tools and equipment	2	17
7.0 Waits and delays		
7.1 Parked as men work	53	
7.1 Wait on other operations	1	
7.2 Maintenance of truck	1	
7.3 Instructions	4	
7.4 Start late, excess lunch and quit early	2	
7.6 Personal	2	
7.9 Other	2	65
Total		100

The average mileage driven by each truck on days during which studies were conducted was as follows:

Item	Average miles driven per day
To and from garage	12.7
To and from stockpile	12.3
To new site	3.5
Other	1.3
Total	29.8

INSTALLATION OF SNOW PLOW UNDERFRAMES

In order to attach snow plows to truck bodies certain braces and frameworks have to be mounted on the truck chassis. These attachments known as snow plow underframes are required to be installed on all equipment on or before November 1 of each year. A crew of 2 men, usually 1 mechanic and the truck driver, normally installed these parts in the following order.

1 Head frame
2 Side braces on head frame

3 Rear pusher frame
4 Front axle plate
5 Undercarriage frame
6 Pressure hose - Connect hydraulic hoist system

The work involved consisted of cleaning bolts, lifting the part into position and then inserting and tightening the necessary bolts. The tools needed to complete the work consisted of 1 bench vise, 1 chain hoist, and 1 set of mechanic's tools.

Detailed time studies were conducted on the mounting of undercarriages on 4 large and 2 small trucks. Each installation required approximately 6 man-hours but little difference was noted in the average time required for either the large or the small trucks.

Time studies covering a period of 36.3 man-hours give the following time distribution.

Distribution of Man-Hours of Working Time
Mounting Snow Plow Underframes

Item	Percent Large Trucks		Percent Small Trucks	
1.0 Operating cycle items on assigned task				
1.1 Install head frame	10		18	
1.2 Install side braces on head frame	10		13	
1.3 Install rear pusher plate	14		7	
1.4 Install front axle plate	10		4	
1.5 Install undercarriage	6		7	
1.6 Install pressure hose	4		6	
1.7 Install side sand spreader	1		-	
1.8 Attach rear light bracket	2	57	-	55
2.0 Related items including travel and preparatory work				
2.2 Travel between garage and stockyard	4		2	
2.4 Maneuver truck	2		3	
2.9 Police area and pick up tools	2		1	
2.9 Miscellaneous related work	3	11	6	12
3.0 Waits and delays				
3.1 Wait on other operations	10		10	
3.3 Instructions	4		6	
3.3 Inspection	3		5	
3.4 Excess lunch	2		1	
3.5 Idle	7		5	
3.6 Personal	3		5	
3.7 Resting	-		1	
3.9 Other	3	32	-	33
Total		100		100

Under conditions which prevailed during the period of study, a 2-man crew would mount 3 snow plow underframes during a 9.0-hour working day.

74. Painting arrows to aid in locating drainage structures to be kept open during winter.

PAINTING ARROWS FOR LOCATING DRAINAGE INLETS

All important drainage inlets which possibly could have been hidden under snow and ice were marked by painting a small white tear-drop shaped arrow near the center line of the highway opposite each drainage inlet. The purpose of the operation was to expedite the location of catch basin grates, leakoffs and other drainage structures following winter storms. The work was performed by two men, a driver and a helper, using a 3-ton dump truck for transportation. The materials used were a template, a small brush and a can of regular white traffic paint.

A typical cycle was as follows: The truck was stopped and "Men Working" signs were placed at the beginning and end of the section, following which work was started. When a drainage inlet was sighted, the truck was stopped and the men dismounted. The driver took the template to the center of the road and placed it with the head of the arrow pointing toward the structure approximately 1 foot to the right of center line and then directed traffic around the work area. The helper brought the paint and brush, and painted the arrow where the driver placed the template. After the arrow had been painted, the driver picked up the template and the equipment was reloaded onto the truck. They then proceeded to the next inlet. If there was more than one inlet close together within walking distance (± 500 feet), several arrows were painted before moving the truck ahead.

The distribution of working time painting arrows for locating drainage inlets based upon 17.9 man-hours of detailed stop-watch studies is as shown on the following page.

Distribution of Man-Hours of Working Time
Painting Arrows for Locating Drainage Inlets

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Paint arrows	7	
1.2 Walk ahead to next arrow	9	
1.2 Short moves ahead to next arrow	11	27
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	6	
2.4 Minor travel and maneuvers	1	
2.5 Travel to put out and pick up signs	26	
2.5 Put out and pick up signs	3	
2.5 Direct traffic, flagman	12	
2.6 Mount and dismount truck	4	
2.6 Load and unload tools and equipment	5	
2.9 Mix paint	4	
2.9 Miscellaneous work	2	63
3.0 Waits and delays		
3.3 Instructions	1	
3.4 Quit early	2	
3.5 Idle	3	
3.6 Personal	2	
3.9 Other	2	10
Total		100

Under conditions prevailing during the study, a typical 2-man crew working a 9.0-hour day would paint 230 arrows over approximately 9.69 miles of roadway.

During the 52-week period 3 trucks were employed at various times for a total of 54.0 equipment-hours on painting arrows to locate drainage inlets. A 9.0-hour detailed time study gives the following time distribution.

Distribution of Equipment-Hours of Working Time
of Trucks Used for Painting Arrows for Locating Drainage Inlets

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This truck works in the capacity of a general purpose service truck and has no clearly defined operating cycle.		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	6	
6.4 Short moves ahead to next arrow	11	
6.4 Minor moves, turns and maneuvers	2	
6.5 Travel to put out and pick up signs	25	
6.5 Put out and pick up signs	4	
6.6 Load and unload men, tools and equipment	5	53
7.0 Waits and delays		
7.1 Parked as men work	39	
7.4 Quit early	2	

Item	Percent	
7.5 Idle	1	
7.6 Personal	3	
7.9 Other	2	47
Total		100

The average mileage driven by the truck on the day that studies were conducted was as follows:

Item	Average miles driven per day
To and from garage	11.3
To put out and pick up signs	34.5
Travel ahead	9.1
Other	1.3
Total	56.2

BUCKET LOADER - LOADING TRUCKS AT THE EMERGENCY SAND STOCKPILE

Three self-propelled bucket loaders were assigned to the Warehouse Point area. During the 1950-1951 winter season, one was kept at the Simsbury emergency sand stockpile, another was placed at the emergency sand stockpile at Warehouse Point, while the third loader was kept at Warehouse Point as a replacement after being assigned to the area on February 27, 1951. The bucket loaders were mainly used for loading trucks with sand at the close of work in the afternoon and during winter storms. During the period from November 15 to April 1, sand trucks were loaded every night between 4:00 - 4:30 P.M. with a bucket loader at the Warehouse Point emergency stockpile. Detailed stop-watch studies were taken of these loading operations on 10 different days covering a total of 5.1 equipment hours. The distribution of that time is as follows:

Distribution of Equipment-Hours of Working Time on Bucket Loaders - Loading Sand Trucks at the Emergency Sand Stockpile

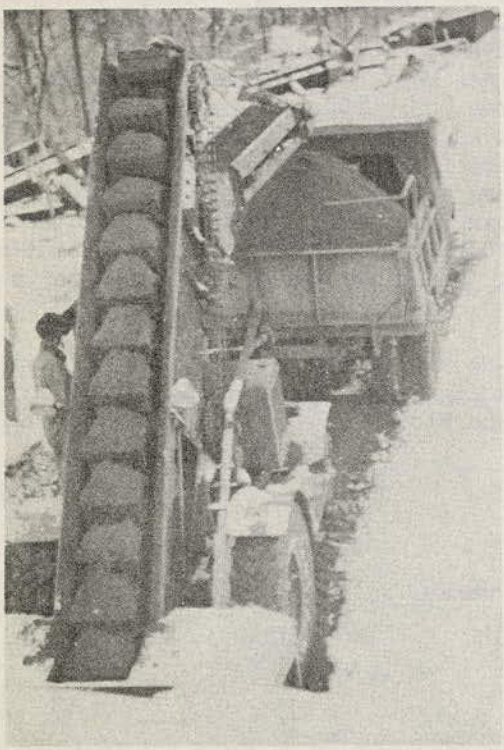
Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Loading sand onto trucks	35	
5.1 Maneuver loader into sand bank while loading	7	
5.1 Swing chute while loading	1	
5.2 Maneuver loader to new position	14	
5.3 Hauling unit exchange	10	
5.4 Adjust cutting depth of loader	1	68
6.0 Related items including travel and preparatory work		
6.4 Maneuver to park loader	1	1
7.0 Waits and delays		
7.1 Wait for arrival of next truck	10	

Item	Percent	
7.1 Wait on operations of trucks	2	
7.1 Wait for arrival of operator	2	
7.1 Loader stuck in soft sand	1	
7.1 Stalled and starting engine delays	3	
7.1 Frozen chunks of sand stuck in loader	2	
7.2 Maintenance of loader	2	
7.3 Instructions	2	
7.4 Quit early	3	
7.9 Other	4	31
Total		100

During the periods of study, sand was loaded at the rate of approximately 104 cubic yards of sand per hour of actual loading time; this is equivalent to 36.4 cubic yards per hour while the loaders are in operation from 4:00 to 4:30 each night.

CHANGING THE CUTTING BLADE ON SNOW PLOWS

Each snow plow was equipped with a cutting blade or edge 10 feet long for 3-ton trucks or 11 feet long for 7-ton trucks, 7" wide and 5/8" thick, attached with 14 5/8" bolts, 2" long.



75. Bucket loader loading truck with sand at Warehouse Point stockpile.

These cutting blades on the snow plows are changed from time to time as needed, usually during a slack period between winter storms. Maximum use is obtained from the blades. There are two sets of bolt holes on each blade, one at the top and one at the bottom. When the original blade is worn about half-way through, the worn blade is taken off, a new blade installed, with the worn blade bolted to the bottom of the new blade. The combined blades are then worn through the lower blade and through the bolts to a point where the new or upper blade is worn half through. The process is then repeated.

The normal procedure was to drive a truck with the snow plow attached into an open space in the garage, place the plow onto blocks in order to raise it off the floor to facilitate attaching and detaching from the truck as well as to ease the work of changing the blade. The truck was then detached and parked out of the way. A crew of two men, usually the driver and his helper, then get wrenches,

76. Three-ton truck with reversible plow making initial pass during storm.

hammers, and bars and proceed to change the blade. The operation of changing the blade consisted of four basic steps: (1) Preparation - placing plow on blocks and fetching tools; (2) Removal of old blade - removal of nuts and bolts followed by the removal of the blade; (3) Installation of new blade and remaining half of old blade - placing of blade, aligning of holes, placing of bolts and starting nuts, and tightening of nuts; (4) Clean up - reattaching plow to truck, return of tools and cleaning up area.

Detailed stop-watch studies were conducted on changing snow plow blades on two separate occasions covering 7.5 man-hours of working time. The distribution of working time based upon the above studies is shown in the following table.

Distribution of Man-Hours of Working Time
Changing Snow Plow Cutting Blades

Item	Percent	
Preparation		
Raise plow	2	
Place plow on blocks	3	
Fetch tools	2	
Sweep off blade with broom	2	
Other preparations	1	10
Removal of old blade		
Remove nuts and bolts	10	
Remove blade from plow	1	
Gather up bolts and washers	1	

Item	Percent	
Exchange or fetch new tools	1	
Other operations	1	14
Install new blade		
Place blade onto plow	1	
Align holes	2	
Place bolts and start nuts	9	
Tighten nuts onto bolts	20	
Adjust blocks	3	
Other operations	1	36
Clean up		
Attach plow to truck	2	
Raise plow to remove blocks	3	
Return blocks	1	
Pick up, assemble and return tools	3	
Clean up area	1	10
Waits and delays		
Wait for space in garage	15	
Wait while others work	5	
Idle	6	
Rest	4	30
Total		100

During a 9.0-hour working day, a typical crew of 2 men would change 4.8 blades when working at the same rates as observed during the studies.

SNOW AND ICE CONTROL

Snow and ice removal operations over the 262 miles of road in the Warehouse Point sub-district were performed by a fleet of 36 trucks, consisting of 27 7-ton trucks and 9 3-ton trucks. Each truck or group of trucks were assigned certain roads to keep open for traffic. All small trucks were equipped with reversible type plows, whereas the large trucks had both reversible and one-way plows available for attachment and use. All four-wheel drive trucks had an additional V-type plow with a wing. Each truck had a sand spreader, either side or rear type. The truck crew normally consisted of a driver and helper.

77. Seven-ton truck with reversible blade on light work.

In order to obtain a comparison between large and small trucks and also to get a comparison between light and heavy snowfall in rural and urban areas, it was decided to concentrate storm duration studies on the following four trucks.

No. 2-552 (7-Ton): Maintained Route 5A from Windsor center south to

Hartford city limits, and Road 905 west of Windsor center. This truck was chosen to represent typical performance of a large truck in a congested urban area. This truck patrolled 5.8 miles of roadway, 19.0 lane miles.

No. 2-745 (7-Ton): Maintained Route 187 from East Granby north to the state line, Route 190 from Route 187 in West Suffield west to the State line, and Road 485 from Route 190 north to the State line. This truck patrolled 13.6 miles of roadway, 27.2 lane miles, and represented a large truck in a rural area with fairly heavy snowfall.

No. 2-609 (3-Ton): Maintained Route 5 from East Windsor town line south to its intersection with Route 44 in East Hartford, Route 30 from an intersection with Route 5 east to its intersection with Route 83, and Route 194 from Route 5 southeast to its intersection with Route 30. 2-609 was a small truck patrolling 17.4 miles, 49.0 lane miles of a combined urban and rural area having light snowfall.

No. 2-713 (7-Ton): Maintained the same routes as truck 2-609, and was chosen to represent a large truck patrolling an urban and rural area having fairly light snowfall. The two trucks sometimes plow in echelon on Route 5.

The four trucks patrolled 95.2 lane miles of state highway keeping them open to traffic at all times.

The plowing of intersections, cross-overs on parkways, and bridge walks was accomplished in part by a small tractor.

Each afternoon during the winter months the trucks were loaded with sand prior to the driver quitting work. They were then parked ready for instant snow use. The gas tank was full, and chains, tools and salt were aboard.

At the start of a storm, all trucks, which were customarily already loaded with sand, were called out. Thereupon, they were driven to their respective assigned sections of road. The first operation consisted of checking the road and sanding any slippery spots. Points where sudden braking may be required, such as at intersections, traffic lights, stop signs, etc., were sanded first followed by hills and curves. Sand was sometimes mixed with calcium chloride at the rate of 50-75 pounds of the latter to 1 cubic yard of sand. Patrolling the road continued until enough snow had accumulated to make plowing feasible.

Plowing was then carried on until the storm ended, sometimes keeping the crews on duty up to 48 hours or more in succession. The plowing operation was combined with sanding where icy sections of roads were encountered. Plowing in echelon formation was usually done on heavily traveled roads during heavy, wet snow storms where traffic would both nullify the work of a single truck and also tend to pack the fallen snow.

Rock salt was often used at the beginning of the storm when the temperature was above 20 degrees Fahrenheit and when the snow was apt to stick to the roads and freeze and thus create an icy condition. The rock salt was distributed in a small windrow along the centerline of the road by means of a 3-inch tube projecting from the bottom of a barrel which was hung over the left side of the truck. Three 100-pound bags were usually specified per mile of road.

78. Seven-ton truck with reversible blade plowing back windrow of snow from expressway shoulder.

If a snow storm changed to sleet during freezing conditions, it was the practice to leave a blanket of snow underneath and thus allow the precipitation to remain in a mushy state rather than allow it to freeze. During this interim only sanding was carried on and no plowing was done until the sleet had stopped or the mush became too deep.

During the 52-week period trucks were assigned to snow and ice control work for a total of 15,712 equipment hours which amounted to 31 percent of the total truck working time for the year.

During the 1950-51 winter season, a total of 18 storms occurred and storm conditions were considered to exist for 300 hours. Individually, they ranged from 4 to 35.5 hours in length with a maximum of 5 inches snowfall during one storm.

Detailed storm duration studies were conducted on the four trucks on 18 occasions during the storm periods and extended over 184 truck-hours of operation.

The distribution of 10,240 hours of truck time charged to snow and ice control during winter storms, in accordance with the detailed studies, is shown on the following page.

Distribution of Equipment-Hours of Working Time
of Trucks on Winter Storm Operations

Item	Truck 2-552	Truck 2-745	Truck 2-609	Truck 2-713	Four Trucks
5.0 Operating cycle items on assigned task					
5.1 Check roads	-*	-*	7	2	2
5.2 Sand icy spots, w/spreader	5	6	8	5	6
5.2 Sand icy spots, by hand	1	-	2	-*	1
5.2 Travel between spots	3	5	3	16	6
5.2 Turns and maneuvers, while sanding	-*	-*	1	1	1
5.2 Travel to and from stockpile	10	3	19	11	11
5.2 Load sand	1	3	2	1	2
5.3 Salt icy spots	3	-*	-*	2	1
5.3 Maneuvers and travel between spots, while salting	2	-	-	1	1
5.3 Travel to and from stockpile	-*	-	-*	4	1
5.3 Load salt	-*	-	-*	2	1
5.4 Plow surface	32	43	26	12	28
5.4 Plow shoulders	9	12	2	4	7
5.4 Miscellaneous plowing, intersections stockpile, etc.	-*	-*	2	-*	1
5.4 Travel ahead not plowing	3	2	4	2	3
5.4 Turns and maneuvers, while plowing	5	3	-*	1	2
	74	77	76	64	74
6.0 Related items including travel and preparatory work					
6.1 Travel to and from garage	-*	1	-*	-*	1
6.6 Attach and adjust plow	1	3	3	4	2
6.6 Attach and adjust spreader	1	1	1	2	1
6.9 Miscellaneous	2	1	1	1	1
	4	6	5	7	5
7.0 Waits and delays					
7.1 Wait on other operations	2	1	2	-*	2
7.2 Repair and maintenance of truck	7	4	3	1	4
7.2 Repair and maintenance of plow and spreader	-*	-*	-*	-*	-*
7.3 Instructions	3	5	4	7	4
7.4 Excess lunch	2	1	2	2	2
7.4 Travel to eat lunch	-	1	2	3	1
7.5 Idle	1	-	1	-	-*
7.6 Personal	2	2	1	1	2
7.7 Driver resting	3	2	1	2	2
7.9 Wait for change in weather	-	-	-	10	2
7.9 Wait for traffic	1	-*	1	1	1
7.9 Other	1	1	2	2	1
	22	17	19	29	21
Total	100	100	100	100	100
Hours of study represented	54.1	38.2	47.4	44.6	184.3
Lane miles kept open	19.0	27.2	24.5	24.5	95.2

* Less than 1/2 of 1%

The mileage driven by each of the four trucks is shown in the following table.

Average mileage driven per storm

Item	Truck 2-552	Truck 2-745	Truck 2-609	Truck 2-713	Average
5.1 Check roads	-	-	17.0	6.1	7.7
5.2 Sand w/spreader	10.4	16.1	9.4	8.6	10.4
5.2 Sand by hand	1.2	-	2.4	-	1.1
5.2 Maneuvers and travel between spots, while sanding	17.1	26.3	7.7	44.7	24.1
5.2 Travel to and from stockpile	71.1	20.0	56.9	48.1	52.4
5.3 Salt ice	10.5	1.4	-	6.3	4.4
5.3 Maneuvers and travel between spots, while salting	6.9	-	-	1.7	2.0
5.4 Plow surface	114.0	216.0	59.1	40.2	87.2
5.4 Plow shoulders	22.0	57.9	3.8	12.0	17.9
5.4 Travel ahead not plowing	10.0	8.9	8.0	7.6	8.5
5.4 Turns and maneuvers, while plowing	8.1	2.0	0.2	1.0	2.4
6.1 Travel to and from garage	0.8	3.8	0.2	0.4	0.9
6.6 Travel to attach plow	-	9.3	3.3	4.8	3.9
7.2 Repair and maintenance of truck	-	-	3.0	-	1.0
7.4 Travel to eat lunch	-	4.8	7.9	9.9	6.5
7.9 Other	-	0.7	-	0.1	0.1
Total	272.1	367.2	178.9	191.5	230.5
Average duration of storm (hours)	27.0	28.6	14.6	14.9	19.4
Lane miles kept open	19.0	27.2	24.5	24.5	23.8

Sand was spread at the rate of 0.85 cubic yard per roadway mile when spread with a rotary spreader and at the rate of 1.4 cubic yards per mile when cast by hand. During sanding the trucks travelled at an average speed of 18.8 m.p.h. During the studies 206 slippery spots were sanded for an average length of 0.49 mile. Thirty slippery spots were salted for an average length of 1.4 miles each.

The observed plowing speeds of the four trucks under then existing conditions are shown in the following table.

Observed Plowing Speeds

Truck	
2-552 Roadway surface	13.0 mph
2-552 Shoulders	9.5 mph
2-745 Roadway surface	17.6 mph
2-745 Shoulders	16.8 mph
2-609 and 2-713 in echelon	14.6 mph
2-609 Roadway surface	16.7 mph
2-609 Shoulders	13.0 mph
2-713 Roadway surface	23.6 mph
2-713 Shoulders	18.9 mph

79. 4 wheel-drive truck with paddle-type spreader tailgate assembly sanding curve on main highway.

PADDLE-TYPE SPREADER SANDING ICE & SNOW

The paddle-type spreader is a hydraulically-powered rear end self-feeding material spreader which was mounted in place of the tailgate on a 7-ton 4-wheel drive dump truck. (This unit is more fully described in a previous section of this report—Surface Treatments, Dusting.)

During the winter months, the truck was assigned to winter maintenance on a section of route 5A from Windsor Locks north to the Massachusetts State Line. This is the main State route north of Hartford on the west side of the Connecticut River. Like most of the other trucks in the district it was assigned specifically to one section of highway for winter maintenance, including plowing and sanding ice and snow. Sand was obtained from the winter sand stockpile located 0.1 mile south of the Warehouse Point garage thus eliminating any major travel from garage to stockpile.

Detailed stop-watch studies were conducted on the paddle spreader on three different occasions for the purpose of determining rates of application and extent of the time that the unit was productively engaged in spreading sand. These studies totaled 13.6 hours and the distribution of this working time is as shown in the table on the following page.

Distribution of Equipment-Hours of Working Time
of Paddle-type Spreader Sanding Ice & Snow

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Sanding with plain sand	21	
5.1 Sanding with Ca Cl_2 and sand	4	
5.2 Travel ahead between sanded spots	11	
5.3 Maneuvers and turns at work site	1	
5.4 Travel to and from stockpile and work site	24	
5.5 Load plain sand	6	
5.5 Load Ca Cl_2 and sand	1	
5.6 Maneuvers and turns at stockpile	1	69
6.0 Related items including travel and preparatory work		
6.3 Travel to new work site (new route)	7	7
7.0 Waits and delays		
7.1 Wait for other operations	1	
7.1 Loader at stockpile stalled	2	
7.2 Maintenance of truck	1	
7.2 Clean obstructions out of spreader	4	
7.3 Instructions	2	
7.4 Excess lunch	6	
7.6 Personal	3	
7.9 Travel to eat lunch	3	
7.9 Other	2	24
Total		100

Actual sand spreading during the study periods was observed to proceed at the rate of 1 load of approximately 5.5 cubic yards every 20.4 minutes. Thus during a 9.0-hour day of straight sanding operations the spreader would actually be spreading 25 percent of the time or 135 minutes and accordingly would spread 6.6 loads or 36.3 cubic yards of sand. Application during a single trip over the road was observed to be at the average rate of 0.73 cubic yard per mile, thus the 36.3 cubic yards would cover approximately 50 miles of road. An average load covered approximately 7.5 miles of roadway. Spreading proceeded at a speed of 22.2 miles per hour.

During a normal 9.0-hour day's work, the spreader would spend approximately 50% of the time on sanding operations.

The average mileage driven during that one-half day while sanding ice and snow according to the studies was as follows:

Item	Average miles driven per day
Sanding	25.0
Travel ahead not sanding	8.0
To and from stockpile	25.5
Travel to new work site (new route)	5.0
Other	2.7
Total	66.2

CHECKING AND SPOT SANDING ROADS IN MORNING

Following winter snow storms and for a period of several days thereafter, it was the practice to send a crew of 2 men with a truckload of sand out checking and spot sanding all roads in the area at the start of each day's operations. This operation took about 2.5 hours. Even though the main traveled way was bare of ice, the object was to spot sand all scattered locations where ice had formed as a result of frost action or normal freezing and thawing. Over a period of years, each foreman assigned to a specific section of roadway got to know his "trouble spots" and could make his daily routine check quite readily.

Occasionally a similar check was made of all roads just prior to quitting time. Detailed stop-watch studies were taken of 4 of these morning checks, covering 23.2 man-hours of working time. The distribution of these man-hours is as follows:

Distribution of Man-Hours of Working Time
Checking and Spot Sanding Roads in Morning

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Load sand at stockpile	1	
1.2 Travel to and from sand stockpile	18	
1.3 Drive ahead checking roads	18	
1.4 Sanding ice with mechanical spreader	18	
1.4 Sand ice by hand shovel from back of truck	2	57
2.0 Related operations including travel and preparatory work		
2.1 Travel to and from garage	11	
2.3 Travel to new work site	10	
2.4 Minor moves, turns and maneuvers	2	
2.6 Load and unload men, tools and equipment	5	
2.9 Attach and detach sand spreader	2	30
3.0 Waits and delays		
3.1 Wait on other operations	1	
3.1 Wait while others work	1	
3.3 Awaiting instructions	4	
3.3 Receiving instructions	5	
3.6 Personal	1	
3.9 Other	1	13
Total		100

For the four studies, a total of 11.0 cubic yards of sand was spot sanded over 53.3 miles of roadway. Of this mileage checked, sand was spread over 21.0 miles. On the basis of these studies, a typical two-man crew will check and spot sand 13.3 miles of road in a 2.5-hour morning check period.

The distribution of truck-time based upon the four detailed stop-watch studies covering a total of 10.2 truck-hours of working time is as shown in the table on the following page.

Distribution of Equipment-Hours of Working Time
of Trucks Checking and Spot Sanding Roads in Morning

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Load sand at stockpile	1	
5.2 Travel to and from sand stockpile	16	
5.3 Drive ahead checking roads	18	
5.4 Sanding ice with mechanical spreader	18	
5.4 Sanding ice by hand shovel from back of truck	3	56
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	9	
6.3 Travel to new work site	11	
6.4 Minor moves, turns and maneuvers	3	
6.6 Load and unload men, tools and equipment	5	
6.9 Attach and detach sand spreader	3	31
7.0 Waits and delays		
7.3 Awaiting instructions	4	
7.3 Receiving instructions	6	
7.6 Personal	1	
7.9 Other	2	13
Total		100

The average mileage traveled by a truck on the days studies were conducted was as follows:

Item	Average mileage driven per day
Travel to and from garage	6.3
Travel to new work site	6.8
Travel to and from sand stockpile	10.3
Travel ahead checking roads	8.1
Travel ahead sanding roads	5.3
Total	36.8

CLEARING SNOW AND ICE OUT OF DRAINAGE INLETS BY HAND

Following every snow storm, it was essential that all drainage inlets be opened where necessary to insure adequate run-off during thaws. The work consisted mainly of removing snow and ice from catch basin grates and clearing a path for the water to flow from the snowbank (accumulated by plowing) to the catch basin.

This work was generally accomplished with a crew of 3 to 5 men which included 1 driver plus a dump truck. The usual tools employed included 2 pick-mattocks, 3 to 5 hand shovels, and 1 bar for cleaning weep-holes.

As in other operations on the traveled way, the first operation was to place "Men Working" signs facing the on-coming traffic at either end of the section of road to be worked upon. Following the placing of signs, the men started at one end of the section clearing snow and ice out of all drainage inlets. On 2-lane highways, the drainage inlets on both sides of the roadway

were cleared in one pass; but on 4-lane divided highways, just drainage inlets in the direction of travel were cleared in the initial pass, the other side was cleared on the way back. The driver kept the truck abreast of the work, occasionally dropping back and driving it ahead.

Observations were made on 2 separate occasions covering a total of 50.8 man-hours of working time clearing snow and ice out of drainage inlets. The time distribution for a 5-man crew obtained from the studies is shown in the following table.

Distribution of Man-Hours of Working Time on Clearing Snow & Ice Out of Drainage Inlets by Hand

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Chop ice with pick	1	
1.2 Clean snow & ice off catch basin grates	19	
1.3 Walk ahead to next catch basin	30	
1.4 Ride truck ahead to next catch basin	7	57
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	4	
2.3 Travel to new work site	5	
2.4 Minor moves, turns & maneuvers	1	
2.5 Put out and pick up signs	3	
2.6 Load and unload men, tools & equipment	2	
2.6 Detach snow plow	1	
2.9 Travel to check roads in morning	3	
2.9 Sanding road A.M.	1	
2.9 Travel ahead between sanded spots	1	21
3.0 Waits and delays		
3.1 Wait while others work	5	
3.1 Wait for truck as transportation	2	
3.3 Instructions	4	
3.4 Excess lunch	1	
3.5 Idle	2	
3.6 Personal	4	
3.7 Resting	1	
3.9 Travel to move personal car	2	
3.9 Other	1	22
Total		100

During the 50.8 man-hours of study, a total of 277 catch basin grates were cleared of ice and snow on 9.30 miles of roadway.

A typical crew of 3 working a 9.0-hour day will clear 146 catch basins on approximately 4.9 miles of roadway working at the same rates as observed during the study periods.

During the 52-week period, 35 trucks were employed at various times for a total of 1650 working hours on clearing snow and ice out of drainage inlets. Time studies covering a period of 14.0 hours give the time distribution as shown in the table on the following page.

Distribution of Equipment-Hours of Working Time
of Trucks Assigned to Clearing Snow & Ice Out
of Drainage Inlets by Hand

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This unit works in the capacity of a general purpose service truck and has no clearly defined operating cycle.		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	2	
6.3 Travel to new work site	12	
6.4 Minor moves, turns and maneuvers	10	
6.5 Put out and pick up signs	3	
6.6 Load and unload men, tools and equipment	5	
6.6 Detach snow plow	-*	
6.9 Travel to check roads in morning	7	
6.9 Sanding road A.M.	1	
6.9 Travel ahead between sanded spots	1	41
7.0 Waits and delays		
7.1 Parked as men work	33	
7.1 Wait on other operations	6	
7.3 Instructions	4	
7.4 Excess lunch, quit early	4	
7.5 Idle	3	
7.6 Personal	3	
7.9 Travel to eat lunch	2	
7.9 Travel to move personal car	2	
7.9 Other	2	59
Total		100

The average mileage traveled by the truck on days during which studies were conducted was as follows:

Item	Average mileage driven per day
To and from garage	4.8
To new work site	27.7
Travel to put out and pick up signs	4.5
Travel to check roads in morning	8.5
Travel sanding roads A.M.	2.5
Travel between sanded spots	2.5
Travel ahead to next catch basin	4.1
Other minor travel	4.6
Total	59.2

* Less than 1/2 of 1%

80. Tractor equipped with plow clearing an opening in an expressway median strip.

CLEARING SNOW AND ICE OFF BRIDGES AND APPROACHES BY HAND

After each snow storm was over and the traveled way had been cleared, it was the practice to clear all accumulated snow and ice from the gutters, drainage outlets and sidewalks on all bridges. This included all snow and ice which created a traveling hazard or was apt to damage the bridges.

Normally, one driver and four laborers performed the above operation. The driver put out caution signs and drove the truck as necessary. Two men went along one side of the bridge gutter, each with a pick-mattock chopping and breaking up the ice; the other two men followed up with shovels, shoveling the ice or snow into the truck or casting it over the bridge rail. When one side was completed, they started back on the other side performing the same operation until the bridge was entirely clean. All weep-holes and leak-offs pertaining to the structure were also cleaned in the same manner. Snow and ice loaded onto the truck was hauled to the nearest permissible dumping area.

After one bridge and its approaches were satisfactorily cleaned, the crew loaded their tools, mounted the truck and travelled to another location where the same operations were repeated. Tools used consisted of 2 pick-mattocks, 4 shovels (2 short-handled, 2 long-handled), and 1 bar (for cleaning weep-holes).

One detailed stop-watch study covering a total of 34.0 man-hours of working time was taken on clearing snow and ice off bridges by hand, giving

a time distribution as follows:

Distribution of Man-Hours of Working Time
on Clearing Snow & Ice Off Bridges by Hand

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Breaking up ice on bridge with pick & shovel	10	
1.2 Shoveling snow & ice off bridge	17	
1.3 Breaking up ice in gutter with pick & shovel	23	
1.4 Shoveling snow & ice out of gutter	17	
1.5 Walking ahead	5	
1.6 Walking between truck and working area	1	73
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	4	
2.3 Travel to new work site	10	
2.4 Minor moves, turns and maneuvers	1	
2.5 Put out and pick up signs	1	
2.6 Load and unload men, tools and equipment	2	18
3.0 Waits and delays		
3.2 Maintenance of truck	1	
3.3 Instructions	2	
3.4 Quit early	1	
3.6 Personal delays	2	
3.7 Resting	2	
3.9 Other	1	9
Total		100

During the one 9.0-hour day study on a crew of 4 men, approximately 1870 cubic feet of ice and snow was removed from 2055 lineal feet of roadway involving bridge and gutter sections.

During the 52-week period, 17 different trucks were employed at various times for a total of 380 equipment-hours, on clearing snow and ice off bridges by hand operations. Time studies covering one period of 7.4 hours give the following time distribution.

Distribution of Equipment-Hours of Working Time
of Trucks Used on Clearing Snow and Ice Off
Bridges by Hand

Item	Percent	
5.0 Operating cycle items on assigned task		
Note: This unit works in the capacity of a general purpose service truck and has no clearly defined operating cycle		
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	4	
6.3 Travel to new work site	11	
6.4 Minor moves, turns and maneuvers	3	
6.5 Put out and pick up signs	1	
6.6 Load and unload men, tools and equipment	4	23

Item	Percent	
7.0 Waits and delays		
7.1 Parked as men work	70	
7.2 Maintenance of truck	4	
7.3 Instructions	1	
7.4 Quit early	1	
7.9 Other	1	77
Total		100

The mileage traveled by the truck on the day of study was distributed as follows:

Item	Mileage Driven
To and from garage	6.1
Travel to new work site	17.1
Travel to put out and pick up signs	2.4
Travel to change tire (major delay)	2.8
Total	28.4

TRACTOR PLOW - CLEARING SNOW AND ICE FROM BRIDGES AND INTERSECTIONS

During the winter months a closed metal cab with glass windows was mounted on one of the small rubber tired tractors. This tractor, equipped with a reversible type snow plow, 7 feet long and 1.5 feet high, was used in removing snow from intersections, openings in the median strip on parkways, bridges, and medial dividers on bridges. The tractor was stored in the Warehouse Point garage and was driven to and from the work sites at a road speed of from 10 to 15 miles per hour. The clearing of an opening in the median strip involved a series of short passes from the center of the opening to the ends. From 6 to 8 passes were usually needed to clear the average opening.

In the clearing of bridges the tractor plow was used in conjunction with a working force of 3 to 6 men who shovelled snow from the sidewalk areas to the adjacent roadway. By a series of passes along the curb, the tractor pushed this material to the shoulder area just off the bridge.

The medial divider on the bridge was cleared by the tractor by a series of longitudinal passes. The plowed material was pushed to the shoulder area off the bridge.

During the past 52-week period, the tractor plow was employed for a total of 102 working hours on clearing intersections, bridges, and medial dividers.

81. Untying snow fence during removal.

82. Removing posts with lever and rolling fence rolls to truck.

Time studies covering a period of 12.9 hours give the time distribution shown in the following table.

Distribution of Equipment-Hours of Working Time of Tractor Plow Removing Snow from Bridges and Intersections

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Plow intersections	9	
5.2 Short moves ahead	9	
5.3 Maneuvers and turns while plowing	20	
5.4 Plow snow off bridges	11	49
6.0 Related items including travel		
6.1 To and from garage	20	
6.3 To new work site	7	
6.4 Minor moves, turns and maneuvers	2	
6.9 Travel to attach and detach plow	1	
6.9 Attach and detach plow	3	
6.9 Miscellaneous	1	34
7.0 Waits and delays		
7.1 Waits on other operations	1	
7.2 Maintenance of tractor	4	
7.2 Maintenance and repair of plow	3	
7.3 Instructions	3	
7.4 Excess lunch	2	
7.6 Personal	2	
7.9 Wait for traffic	1	
7.9 Other	1	17
Total		100

During the period of study, the tractor plow removed snow at the rate of 18,900 square feet per 9.0-hour day. The average depth of the snow was 2-1/2 inches.

The average mileage driven by the tractor on days during which studies were made was as shown on the following page.

Item	Average miles driven per day
To and from garage	16.8
To new work site	4.3
Short moves ahead	3.5
Other	0.7
Total	25.3

SNOW FENCE REMOVAL

Starting on or about March 15 all snow fence was dismantled and hauled to storage at various stockpiles throughout the area. The bulk of this work was accomplished this year during the 2-week period from March 15-30.

The snow fence was dismantled, rolled and loaded into trucks and hauled to the stockyard where it was stacked into separate piles of fence, posts and guy stakes. One truck was generally used to haul the posts, guy stakes, and other materials while the remaining trucks hauled snow fence. Approximately 1,000 feet of snow fence was hauled per load.

The following pattern of operations was followed in dismantling snow fence. First, one man walked along the fence removing guy wires, pulling guy stakes, then wrapping the wire around the stake which was tossed aside as he walked to the next stake. Next a man walked along the fence detaching the fence from the posts and unwiring the ends of the rolls that had been wired together. Most of the posts were pulled by a team of 2 men using a hand post puller; some were pulled with a truck using a chain hooked to the snow plow hoist; while others were loose enough to be pulled directly by hand. Simultaneously with the pulling of posts the snow fence was rolled up and tied by another team of 2 men. One man rolled up the fence while the other helped by stretching and straightening it and later holding it as the first man wired the roll together.

The remaining men gathered the dismantled fence, posts, and stakes, and loaded them onto the trucks. When it was possible to drive the truck along the fence site everyone worked dismantling and the fence was picked up the last thing as the trucks drove along the fence site while the whole crew loaded.

The following tools were normally used in snow fence removal operations:

1 Hand post puller
1 Snow plow hoist
2 Pliers
1 Claw hammer

83. Stacking fence rolls on truck, posts, guy wires and stakes, and wire ties are on other truck in background.

1 Crow bar
1 Sledge hammer (16 pounds)
2 Shovels

A typical crew consisted of 7 men, 2 drivers and 5 men, supervised by a foreman or crew leader. A seven-man crew normally operated using 2 dump trucks, one to haul fence and the other for posts, stakes and tools.

Detailed and topside studies were conducted on 306.1 man-hours of snow fence removal operations excluding the time of foremen. The time distribution is as follows:

Distribution of Man-Hours of Working Time
on Snow Fence Removal Operations

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Detach guy wires and stakes	5	
1.2 Remove snow fence from posts	8	
1.3 Remove posts - (hand puller)	2	
1.3 Remove posts - (pull with truck)	2	
1.3 Remove posts by hand	1	
1.4 Roll up and tie snow fence	9	
1.5 Carry or roll fence to truck	3	
1.5 Carry posts and stakes to truck	3	
1.5 Walk to and from truck	6	
1.6 Load snow fence	3	
1.6 Load posts and stakes	2	
1.7 Travel to and from stockyard (stockpile)	12	
1.8 Unload and stack snow fence	4	
1.8 Unload and stack posts and guy stakes	2	62
2.0 Related items including travel and preparatory work		
2.1 Travel to and from garage	3	
2.3 Travel to new work site	6	
2.4 Minor moves, turns and maneuvers	2	
2.5 Put out and pick up signs	1	
2.6 Load and unload men, tools and equipment	2	
2.9 Load truck with sand for possible emergency use	1	
2.9 Miscellaneous work	1	16
3.0 Waits and delays		
3.1 Waits on other operations	3	
3.3 Instructions	4	
3.4 Excess lunch and quit early	3	
3.5 Idle	5	
3.6 Personal	3	
3.9 Rain	2	
3.9 Other	2	22
Total		100

Based upon conditions encountered during the period of study, a typical crew of 7 men working a 9-hour day would remove 3,757 lineal feet of snow fence per day.

During the 52-week period 23 trucks were employed at various times for a total of 587 hours on snow fence removal. Time studies covering a period of 102.2 equipment-hours give the following time distribution.

Distribution of Equipment-Hours of Working Time
of Trucks Used on Snow Fence Removal Operations

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Pull posts	1	
5.2 Loading snow fence	5	
5.3 Loading posts and guy stakes	3	
5.4 Travel to and from stock yard (stockpile)	11	
5.5 Unloading & stacking snow fence, posts & guy stakes	8	28
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	4	
6.3 Travel to new work site	7	
6.4 Minor moves, turns and maneuvers	2	
6.5 Put out and pick up signs	1	
6.6 Load and unload men, tools and equipment	2	
6.9 Load truck with sand for possible emergency winter use	1	
6.9 Miscellaneous	1	18
7.0 Waits and delays		
7.1 Parked as men work	38	
7.1 Wait on other operations	1	
7.1 Wait as another truck is repaired	3	
7.2 Maintenance of truck	1	
7.3 Instructions	3	
7.4 Excess lunch and quit early	2	
7.5 Idle	1	
7.6 Personal	2	
7.9 Rain	2	
7.9 Other	1	54
Total		100

The average mileage driven by each truck on days during which studies were conducted was as follows:

Item	Average miles driven per day
To and from garage	6
To and from stockpile	21
To new work site	6
Other minor travel	2
Total	35

PICKING UP AND STORING WINTER SAND BOXES

Covered sand boxes 1.5 ft. by 4.0 ft. with a height of 1.6 ft. in the front and 2.5 ft. in the rear having a capacity of approximately ½ cubic yard of sand are distributed throughout the area on or before November 15 each year. Boxes are placed at dangerous spots where ice is known to accumulate and create hazardous conditions such as on steep hills, sharp curves, etc. All boxes were marked with a reflectorized sign on the front identifying them as emergency winter sand. They were distributed and filled with sand from the nearest emergency winter sand stockpile and covered with a liberal amount of salt to prevent freezing by a crew of 3 men using a 3-ton dump truck. An old hand shovel was placed in each box for the convenience of the public.

At the earliest opportunity after March 1 of each year, boxes were picked up and stored at the Warehouse Point Garage by a crew of 4 men using a 3-ton dump truck.

Detailed stop-watch studies covering a total of 6.8 man-hours were conducted on a 4-man crew picking up and storing winter sand boxes. The time distribution obtained is as follows:

Distribution of Man-Hours of Working Time on Picking Up and Storing Winter Sand Boxes 1/

Item	Percent	
1.0 Operating cycle items on assigned task		
1.1 Travel to new sand box site	48	
1.2 Load sand boxes and clean up sand with shovel	23	
1.3 Travel to stockyard (Warehouse Point Garage)	4	
1.4 Unloading and stacking sand boxes	8	83
2.0 Related items including travel and preparatory work		
2.4 Minor moves, turns and maneuvers	1	
2.6 Load and unload men, tools and equipment	1	2
3.0 Waits and delays		
3.4 Excess lunch	12	
3.5 Idle	2	
3.9 Other	1	15
Total		100

Based upon observed conditions, a typical 4-man crew working a 9.0-hour day would pick up and store 36 winter sand boxes.

During the 52-week study period, 3 trucks worked for a total of 19.9 hours picking up and storing winter sand boxes.

The distribution of truck working time obtained from one limited study of 1.7 hours is as follows:

1/ - Based upon one short 1.7 hour study of 4 men and not necessarily typical of a full day's operations.

Distribution of Equipment-Hours of Working Time of Trucks Used on Picking Up and Storing Winter Sand Boxes

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel to new sand box site	48	
5.2 Loading sand boxes on truck	24	
5.3 Travel to stockyard (Warehouse Point Garage)	5	
5.4 Unloading sand boxes	9	86
6.0 Related items including travel and preparatory work		
6.4 Minor moves, turns and maneuvers	1	
6.6 Load and unload men, tools and equipment	1	2
7.0 Waits and delays		
7.4 Excess lunch	12	12
Total		100

The average mileage driven by the truck during the study period was as follows:

Item	Average mileage driven
Travel to new sand box site	19.1
Travel to stockpile	1.3
Total	20.4

CLEAN UP WINTER SAND

The sand which had been spread for ice control during the winter was cleaned up in the spring for purposes of reducing objectionable dust and of preventing the clogging of ditches, gutters, catch-basins and pipes.

The sand was cleaned up by hand in built up areas; a rotary broom was used on parkway center strips; and a patrol grader with belt loader attachment was employed in curb and gutter sections. Elsewhere the patrol grader with belt loader attachment or the front end scoop-loader was used. Only roads with the heaviest accumulations of sand were cleaned by the foregoing methods. A pickup broom, self-propelled, was later rented and all roads, including those previously cleaned by other methods, were cleaned with this piece of equipment and a front end scoop-loader. Brooming of the surface and shoulders in the summer in preparation for oil treatment or armor coating was usually charged against "snow and ice control."

84. Hand brooming winter sand into piles to be shoveled into truck. This method used in built up sections.

85. Cleaning sand from expressway median strip with rotary broom.

CLEAN UP WINTER SAND WITH CONVEYOR LOADER ATTACHMENT

A typical crew consisted of the following:

Equipment:	1 Rotary broom
	1 Tow truck
	1 Patrol grader with belt loader attachment
	5 Dump trucks
Labor:	3 Foremen
	1 Broom operator
	1 Assistant to the broom operator
	6 Truck drivers
	1 Patrol grader operator
	1 Belt loader operator
	2 Flagmen at the loader
	6 Men brooming at the loader
	2 Men shoveling at the dump area
Total	27 (Including foremen)

The areas cleaned consisted of the center strip on the parkways, curbs, gutters, and ditches. The usual procedure was as follows: hand raking of the center strip; brooming of the center strip with the rotary broom; and blading and loading of the sand by the patrol grader with a conveyor loader attachment. The waste sand was used to patch eroded sections and build up slopes for future elimination of guide rail.

Approximately a 9-hour study was made on the rotary broom while being used to clean winter sand from the grassed areas on the parkway center strip. The broom was considered as auxiliary equipment; no overall record was kept of the time spent on brooming work throughout the year.

The broom was towed by a 3-ton dump truck with an offset hitch so that the truck traveled on the lane to the right of the five foot median strip. An average of 5 passes on an 8,400 foot center strip constituted a total of 41,300 feet of brooming during the period of study.

The distribution of the working time for the Rotary Broom during the study was as follows:

Distribution of Equipment-Hours of Working Time of Rotary Broom

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Brooming of center strip	34	
5.2 Travel through cross-overs	10	
5.2 Maneuver around obstructions	2	46
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage		17

Item	Percent	
7.0 Waits and delays		
7.2 Attach and detach broom	11	
7.2 Broom repair	12	
7.4 Excess lunch	4	
7.5 Idle	5	
7.6 Personal	1	
7.9 Traffic delays	1	
7.9 Other	3	37
Total		100

The patrol grader with the conveyor loader attachment followed directly behind the brooming and hand raking operations. Winter sand and other debris was scraped into a windrow by the blade and elevated into the following dump trucks by the belt loader attachment on the rear of the grader.

During the 52-week period the patrol grader with conveyor loader attachment was used for this operation a total of 28.1 hours. Studies covering a period of 13.0 hours give the following time distribution.

Distribution of Equipment-Hours of Working Time
of Motor Patrol Grader with Conveyor Loader Attachment

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel ahead loading	38	
5.2 Travel ahead not loading, trucks in position	7	
5.3 Exchange trucks	6	51
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	5	
6.3 Travel to new work site	7	
6.4 Minor moves, turns, and maneuvers	6	18
7.0 Waits and delays		
7.1 Shortage of trucks at loader	1	
7.2 Adjust blade on grader	4	
7.2 Clean out spiral feeder	3	
7.2 Maintenance of grader-loader	1	
7.2 Repairs to grader-loader	9	
7.3 Instructions and inspections	3	
7.4 Start late, excess lunch, quit early	4	
7.6 Personal	1	
7.9 Traffic delays	2	
7.9 Other	3	31
Total		100

Under the observed conditions, the motor patrol-conveyor unit will blade and clean 84 cubic yards of sand from 15.7 miles of gutter. The average truckload was estimated to contain 3.0 cuvic yards of material.

86. Picking up sand from expressway gutters with patrol grader loader attachment. Note movement against traffic and flagman in background.

87. Picking up sand from expressway gutters with patrol grader loader attachment. Movement here is with traffic, flagman in background.

The trucks used for cleaning up winter sand followed more or less the same pattern of operation as described for cleaning and edging shoulders.

During the 52-week period, 7 trucks were employed for a total of 133.5 hours on hauling from the loader while cleaning up winter sand. The distribution of working time obtained from detailed studies covering 23 loads (3.0 yards each) over a period of 51 hours of work is as follows:

Distribution of Equipment-Hours of Working Time
of Trucks Hauling from Grader-Loader

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Exchange trucks at grader-loader	1	
5.1 Load, backing up	9	
5.2 Haul to disposal area	7	
5.3 Manuever and dump at disposal area	1	
5.4 Return to work site	10	28
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	9	
6.4 Minor moves, turns and maneuvers	1	
6.5 Put out and pick up signs	3	
6.6 Load and unload men and tools	2	
6.9 Pick up and bury dead animals	1	
6.9 Miscellaneous work items	1	17
7.0 Waits and delays		
7.1 Wait to be loaded, moving	10	
7.1 Wait to be loaded, stopped	29	
7.1 Wait on other operations	1	
7.2 Maintenance and repair of grader-loader	6	
7.2 Maintenance of truck	1	
7.3 Instructions	2	
7.4 Start late, excess lunch, quit early	2	
7.5 Idle	1	
7.6 Personal	1	
7.9 Other	2	55
Total		100

Travel speeds observed during the study were as follows:

Haul	26 miles per hour
Return	22 miles per hour

The average mileage driven by each truck each day according to the studies was as follows:

Item	Average miles driven per day
Travel to and from the garage	28
Haul and return	42
Follow grader while awaiting to load and loading	9
Other	13
Total	92

The average loading distance was 0.6 miles.

CLEAN UP WINTER SAND WITH PICKUP BROOM

Four types of major equipment were required for cleaning up winter sand with the pickup broom: the pickup broom itself, a front end scoop-loader, hauling units and a water truck. The pickup broom was rented from the Connecticut Department of Aeronautics. It was a three-wheel, self-propelled unit.

In operation, the pickup broom moved ahead along the shoulder sweeping sand and debris from the edge of road into a hopper which was contained within the machine. When a maximum of about one-third cubic yard of sand had been picked up (or less where the distribution was heavier), the sweeping was not thorough so the hopper was emptied. By raising the sweeper broom and moving ahead several feet, the sand was dumped in a pile on the shoulder of the road. When the broom was lowered, sweeping was continued. Only one man was required for the broom's operation.

The scoop-loader consisted of a dump truck with a scoop mounted on its front end which was raised and lowered by operating the truck's dump mechanism. With the scoop lowered to the pavement, the truck moved forward scooping up the piles of sand dumped by the pickup broom. When the scoop was loaded, it was raised high enough for one of the hauling units to back underneath whereupon it was dumped. After the hauling unit had moved forward, the truck lowered its scoop and proceeded to the next pile. Drivers only were needed for the operation of the scoop-loader and hauling units; however, accompanying them were a flagman to direct traffic and a laborer to hand shovel the sand missed by the pickup broom during the dumping operation. Generally, two hauling units were all that were required.

During dry weather, it was necessary to sprinkle the shoulders with water to keep down dust. This was done in two ways. The pickup broom, itself, held one hundred and forty gallons of water which was sprinkled onto the shoulder from spray jets mounted on the broom's front end. The tank was refilled periodically by a water truck. As a second means of preventing dust, the water truck proceeded just ahead of the pickup broom, also wetting down the dust. Besides a driver, the water truck usually carried a crew leader who directed operations. The water truck consisted of a 550-gallon skid mounted tank and a small auxiliary pump mounted on a 7-ton dump truck. Water was obtained from any convenient source, usually a small stream.

During the 52-week period, the 550-gallon water truck with 4-foot s spray bar was used in conjunction with the pickup broom a total of 108.0 hours. Distribution of time obtained from detailed studies covering a period of 25.2 hours is as follows:

Distribution of Equipment-Hours of Working Time
of Water Truck

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Fill tank with water	4	
5.2 Haul water to work site and return	6	
5.3 Fill broom truck	2	
5.4 Travel ahead, spraying	9	
5.4 Travel ahead, not spraying	17	38
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	12	
6.3 Travel to new work site	6	
6.4 Minor moves, turns and maneuvers	1	
6.5 Put out and pick up signs	1	20
7.0 Waits and delays		
7.1 Await arrival of other equipment on job	2	
7.1 Wait to refill broom	13	
7.1 Wait for broom to catch up	3	
7.1 Wait on other operations	3	
7.2 Maintenance of water truck	2	
7.2 Maintenance of pickup broom	1	
7.2 Repairs to pickup broom	4	
7.3 Instructions	4	
7.4 Start late, excess lunch, quit early	4	
7.6 Personal	2	
7.9 Other	4	42
Total		100

88. Picking up sand from shoulder with self-propelled pickup broom, water truck in foreground.

89. Scoop-loader picking up piles of sand left by pickup broom, crew leader acting as flagman.

During the three days of study, the truck hauled four loads of water of which 1330 gallons were loaded into the pickup broom and 750 gallons were sprayed in advance of the broom. The mileage distribution of the water truck for the average day was as follows:

Item	Average mileage per day
To and from garage	23.3
To new worksite	9.2
Haul and return	10.4
Spraying	1.5
Deadheading	3.5
Other	2.2
Total	50.1

The distribution of the time of the pickup broom in accordance with 27.0 hours of detailed study is as follows:

Distribution of Equipment-Hours of Working Time of Pickup Broom

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel ahead brooming	33	
5.2 Maneuver while brooming	1	
5.3 Stop and raise broom	2	
5.4 Dump load of sand	2	
5.5 Move ahead lowering broom	2	40

Item	Percent	
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	4	
6.1 Travel to and from overnight parking area	1	
6.2 Reload water tank	4	
6.3 Travel to new work site	8	
6.4 Minor moves, turns and maneuvers	1	18
7.0 Waits and delays		
7.1 Parked awaiting travel of operator to and from garage	18	
7.1 Await arrival of water truck	4	
7.2 Maintenance of pickup broom	5	
7.2 Repairs to pickup broom	3	
7.2 Replace broom element	4	
7.3 Instructions	2	
7.4 Start late, excess lunch, quit early	1	
7.5 Idle	1	
7.6 Personal	2	
7.9 Other	2	42
Total		100

During the three days of study, the pickup broom averaged 12 cubic yards of sand per day from 8.4 miles of shoulder. This required 121 hopper loads at an average of 0.1 cubic yard and to keep down the dust 520 gallons of water were sprayed on the road. The average daily mileage of the pickup broom was distributed as follows:

Item	Average mileage per day
To and from garage	4.1
To and from overnight parking area	1.1
To new work site	8.8
Travel ahead brooming	8.3
Travel ahead not brooming (deadheading)	0.1
Total	22.4 miles

While brooming, the machine traveled at a speed of 2.80 miles per hour.

The scoop-loader that was garaged closest to the work site was used so that each worked part of the time with the pickup broom. During the 52-week period, 172.5 hours of scoop-loader time, exclusive of major delays, were put in on this operation. Distribution of time obtained from detailed studies covering a period of 23.7 hours is as follows:

Distribution of Equipment-Hours of Working Time of Scoop-Loader

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Travel ahead following broom, scoop down	25	
5.2 Scoop up sand and debris	3	
5.3 Raise scoop	3	
5.4 Move ahead and dump scoop	2	
5.5 Back up and lower scoop	2	35
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	13	
6.3 Travel to new work site	7	
6.4 Minor moves, turns and maneuvers	4	
6.6 Load and unload men and tools	1	25
7.0 Waits and delays		
7.1 Wait for broom operator to arrive on job	2	
7.1 Wait for other equipment to arrive on job	4	
7.1 Wait while pickup broom loads water	6	
7.1 Wait for pickup broom to work ahead	8	
7.1 Wait for hand shoveler to heap up pile	2	
7.2 Adjust spray bar on water truck	1	
7.2 Repair and maintenance of pickup broom	4	
7.2 Hook scoop cables for traveling	2	
7.2 Attach scoop-loader to truck	1	
7.3 Instructions	1	
7.4 Start late, excess lunch, quit early	6	
7.9 Other	3	40
Total		100

The scoop-loader on the three days studied (not concurrent with pickup broom studies) averaged 12.2 cubic yards of material loaded in 7.7 miles of shoulder. The mileage distribution of the scoop-loader on this operation was as follows:

Item	Average mileage per day
To and from garage	23.2
To new work site	10.1
Minor moves, turns and maneuvers	0.8
Follow broom, load and deadhead	6.9
Total	41.0 miles

During the 52-week period, 6 trucks worked 364 hours on hauling away sand and debris picked up by the pickup broom. The distribution of time obtained from 44.9 hours of detailed study is as follows:

Distribution of Equipment-Hours of Working Time of Trucks

Item	Percent	
5.0 Operating cycle items on assigned task		
5.1 Hauling unit exchange	1	
5.1 Wait for scoop-loader to scoop up sand and debris	3	
5.1 Wait for scoop-loader to raise scoop and move ahead	1	
5.1 Back under scoop	1	
5.1 Receive sand and debris from scoop-loader	1	
5.1 Travel ahead to next pile	12	
5.2 Haul to dump site	4	
5.3 Maneuver and dump at disposal site	2	
5.4 Return to work site	4	29
6.0 Related items including travel and preparatory work		
6.1 Travel to and from garage	15	
6.3 Travel to new work site	4	
6.4 Minor moves, turns and maneuvers	1	
6.5 Put out and pick up signs	5	
6.6 Load and unload men and tools	1	
6.9 Miscellaneous work	1	27
7.0 Waits and delays		
7.1 Await arrival of other equipment on job	7	
7.1 Wait while filling pickup broom with water	2	
7.1 Wait on operation of pickup broom	4	
7.1 Follow scoop-loader awaiting turn to load, moving	3	
7.1 Follow scoop-loader awaiting turn to load, stopped	12	
7.2 Repair and maintenance of pickup broom	5	
7.3 Instructions	2	
7.4 Start late, excess lunch, quit early	4	
7.6 Personal	2	
7.9 Other	3	44
Total		100

During the three days studied, two trucks working with the pickup broom hauled 39 cubic yards of sand and debris in 14 loads or an average of 2.3 loads per truck per day at an average of 2.8 cubic yards per load. The mileage distribution of the trucks was as follows:

Item	Average mileage per day
To and from garage	27.9
To new work site	7.4
Put out and pick up signs	6.0
Waiting to load	2.2
Loading	2.9
Haul	7.0
Return	6.0
Other	1.4
Total	60.8 miles

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