

96
19

IMPROVING THE QUALITY OF HOT
BITUMINOUS TYPE WINTER PATCHING MATERIALS

FINAL REPORT

George Indahl
Principal Engineer, Research

March 1978

Prepared by
New Jersey Department of Transportation
Division of Research and Development
in cooperation with
U. S. Department of Transportation
Federal Highway Administration

New Jersey State Library

1. Report No. 78-012-7743		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Improving the Quality of Hot Bituminous Type Winter Patching Materials				5. Report Date March 1978	
				6. Performing Organization Code NA	
7. Author(s) George W. Indahl				8. Performing Organization Report No. 78-012-7743	
9. Performing Organization Name and Address New Jersey Department of Transportation Division of Research and Development 1035 Parkway Avenue Trenton, New Jersey 08625				10. Work Unit No. NA	
				11. Contract or Grant No. NJ HPR Study 7743	
				13. Type of Report and Period Covered Final Report	
12. Sponsoring Agency Name and Address Federal Highway Administration Washington, D. C.				14. Sponsoring Agency Code	
15. Supplementary Notes None					
16. Abstract <p>This report details the results of a study to improve the quality of hot bituminous type winter patching material.</p> <p>The principal material investigated was hot plant mix surface course material (meeting NJDOT Mix #5 grading) produced in McConnoughay portable pugmill mixers.</p> <p>The report discusses mix design, equipment modifications and changes in operating procedures which had to be made in order to achieve a durable patch material.</p> <p>To achieve maximum results, mineral filler had to be added to the mix aggregates and a heated trailer used to transport the material in order to minimize heat loss.</p> <p>The report includes the results of a survey of asphalt plants designed to investigate the feasibility of obtaining plant mixed material in winter. An economic evaluation of comparative costs of patching material obtained from commercial asphalt plants, McConnoughay portable pugmills, and small user operated drum mixer plants is included.</p>					
17. Key Words Pavement; Patching, Failures, Hot Mix Mix Design Dryer Drum Asphalt Economic Analysis			18. Distribution Statement No Restrictions		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 98	22. Price

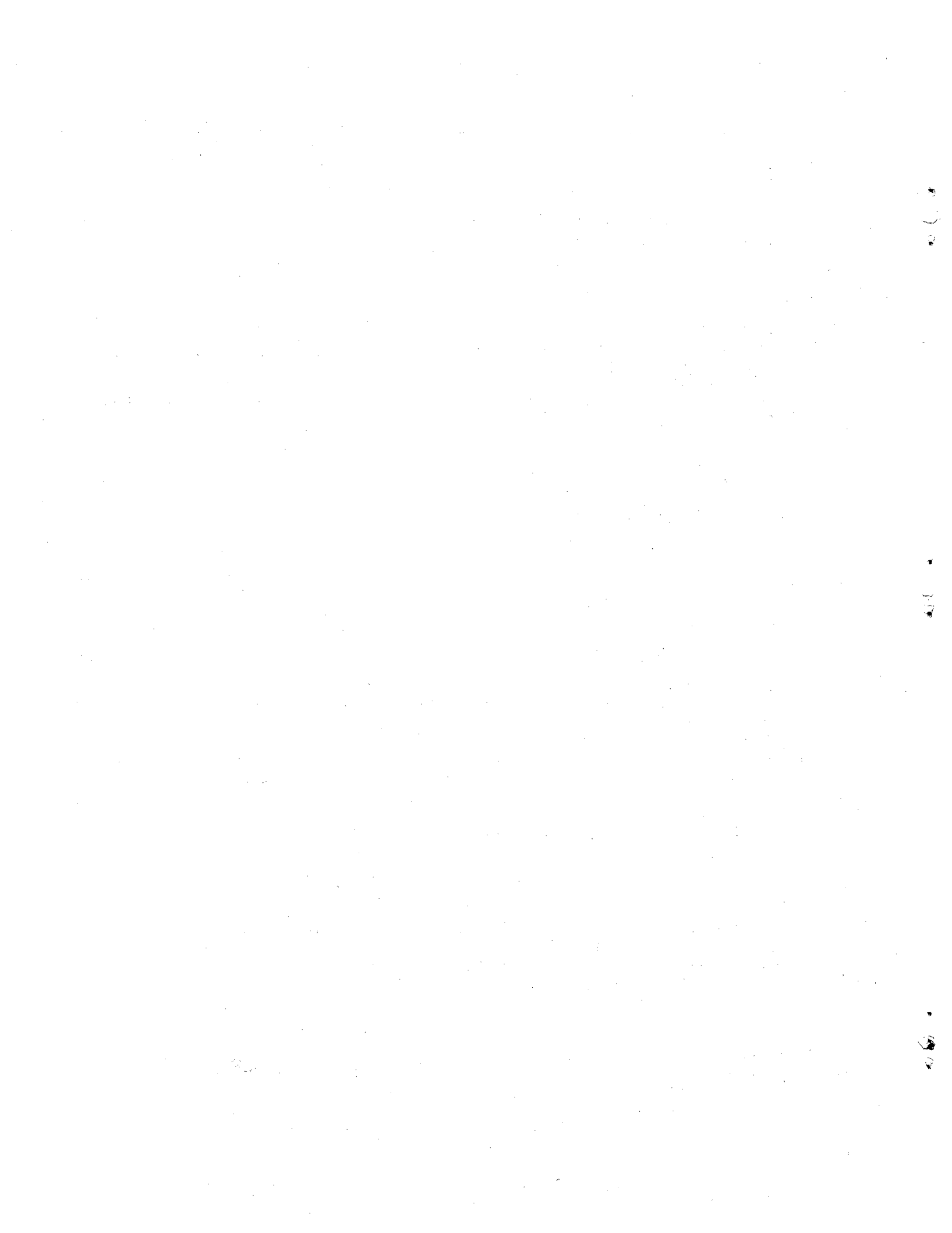


TABLE OF CONTENTS

	<u>Page</u>
Abstract.....	v
Conclusions.....	vii
Recommendations.....	ix
I. Introduction.....	1
A. Specific Aim.....	1
B. Objectives of the Study.....	1
C. Background.....	1
II. Method of Procedure.....	4
A. General.....	4
B. Field Tests.....	4
1. Study Location.....	5
2. Monitoring.....	6
3. Data Collection.....	8
C. Laboratory Tests.....	10
D. Evaluation of Alternate Methods.....	12
III. Results and Discussion.....	13
A. Evaluation of the McConnoughay Operations.....	13
1. Woodbridge Maintenance Yard.....	13
2. Ridgewood Maintenance Yard.....	14
3. Newark Maintenance Yard.....	20
4. Other Maintenance Yards.....	23
B. Laboratory Test.....	25
1. Mix Ratios.....	25
2. Production Samples.....	34

TABLE OF CONTENTS (CONT'D)

	<u>Page</u>
C. Heat Loss.....	37
1. General.....	37
2. Heated Trailer.....	38
3. Temperature Cutoff.....	41
D. Field Performance of Patches.....	41
1. RC-800.....	44
2. Heated Trailer.....	44
3. MC-800.....	47
E. Drum Dryer Mixer Plants.....	49
F. Survey of Commercial Asphalt Plants.....	53
G. Asphalt Cement Storage Tank and Metering System.....	61
H. Economic Analysis of Production Methods.....	62
1. General.....	62
2. Development of Cost Data.....	63
3. Ridgewood Yard.....	65
4. Newark Yard.....	67
5. Drum Dryer Mixer Plant.....	70
6. Commercial Asphalt Plant.....	72
IV. Implementation of Findings.....	74
V. Bibliography.....	75
Appendices.....	76
Operating Manual.....	A1

LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
1	Summary of Lab Tests 1:1 Sand/Stone Ratio - No Filler Added.....	27
2	Summary of Lab Tests 1:1 Sand/Stone Ratio With 5% Filler Added.....	28
3	Summary of Lab Tests 1:2 Sand/Stone Ratio - No Filler Added.....	29
4	Summary of Lab Tests 1:2 Sand/Stone Ratio With 5% Filler Added.....	30
5	Summary of Lab Tests 1:1 Sand/Stone Ratio - No Filler Added - Change in Aggregate Sources.....	31
6	Aggregate Gradations.....	32
7	Production Samples Average Gradation.....	35
8	Results of Marshall Tests on Production Samples - Ridgewood.....	36
9	Number of Patches Placed and Failure Totals for Ridgewood.....	45
10	Adjusted Failure Rate for Heated Trailer.....	46
11	Nearby Drum Dryer Mixer Asphalt Plants.....	51
12	Asphalt Plant Questionnaire Results.....	54
13	Winter Asphalt Usage.....	57
14	Distance to Nearby Asphalt Plants.....	58
15	Maintenance Yards Near Open Asphalt Plants.....	60
16	Production Expenses.....	64
17	Daily McConnoughay Production Expenses for Ridgewood Maintenance Yard.....	66
18	Potential Savings for the Ridgewood Operation.....	68
19	Daily McConnoughay Production Expenses for Newark Maintenance Yard.....	69
20	Estimated Production Expenses for a Drum Dryer Mixer Type Plant.....	71
21	Expenses to Obtain Material from a Nearby Open Asphalt Plant.....	73

LIST OF FIGURES

<u>Figure No.</u>		<u>Page</u>
1	Test Site Locations.....	7
2	Data Sheet for Monitoring of Patch Life.....	9
3	Location of Maintenance Yards in Relation to Open Asphalt Plants.....	59
A1	McConnoughay Parts List with Update.....	A18

ABSTRACT

This report details the results of a study to develop the production techniques, equipment, and handling procedures necessary for the improvement of the quality of hot bituminous type winter pothole patching material. The study was conducted during two winters (1975-76 and 1976-77) and at three different locations throughout New Jersey (Woodbridge, Ridgewood, and Newark).

The principal material investigated was hot plant mix surface course material (meeting Addenda A Mix #5 grading) produced in Department owned **McConnoughay portable pugmill mixers**.

Overall, this hot material revealed a greater durability and increased resistance to failure than did previously investigated cold patch materials. To obtain this level of quality, certain equipment modifications and changes in operating procedures which are discussed in detail in the **report**, have to be undertaken. However, to obtain the optimum patch durability, mineral filler should be added to the mix aggregates and the hot material should be transported in a heated trailer. Extensive lab tests were conducted to obtain the proper mix design ratio for the aggregates and asphalt cement content.

A survey was made of the asphalt plants in New Jersey asking whether they would remain open during the winter months to supply maintenance crews with hot material. The tabulated results of the survey are included.

An economic investigation into the feasibility of the Department owning and operating a drum dryer mixer asphalt plant was undertaken. This analysis was extended to include a comparison of all

ABSTRACT (CONT'D)

the alternate methods of obtaining hot mix available to the Department. The methods considered were: mix produced through the Department's McConnoughay mixers, open commercial asphalt plants, and a user operated drum dryer mixer plant.

The operating manual for the McConnoughay mixer was also updated and revised. A copy is included as an Appendix to this report.

CONCLUSIONS

Based on the information and experience gained in this research the following conclusions can be offered:

1. The McConnoughay hot mixed patches are very durable as compared to previously studied cold mix patches.
2. With proper training and guidance of operating personnel, a typical McConnoughay mixer can produce quality hot patch material.
3. Before the desired level of product quality can be obtained with the McConnoughay unit, a number of changes in the operating procedure and equipment modifications have to be made.
4. It is more cost effective to utilize open asphalt plants when available within a travel radius of 20 miles than for the Department to produce its own material with a McConnoughay mixer.
5. Although insufficient field data was obtained to determine the MC-800's performance characteristics under all winter type conditions, nothing detrimental to its use as a replacement for RC-800 was evident during the period (April to May) evaluated.
6. Heat loss of the hot patching mix is a significant problem during the winter months.
7. Placing the hot patch in a heated storage trailer increased the patch life.
8. Adding mineral filler to the mix improved patch durability.
9. Based on an analysis of costs and production capabilities the use of a drum dryer mixer plant was found to be more cost effective than operating a McConnoughay mixer.
10. A consideration of equipment and installation costs

CONCLUSIONS (CONT'D)

indicates the addition of an asphalt cement storage tank and metering system to the McConnoughay pugmill is too costly for the low McConnoughay output achievable.

11. Laboratory results showed that a 1:1 ratio of sand and stone with 5% mineral filler mixed with 5.5% asphalt cement produced the best overall mix.

RECOMMENDATIONS

A. General

1. Efforts to obtain hot mix from commercial suppliers for winter patching operations should be increased. In this vein, it is proposed that during the summer of each year meetings with the asphalt industry be held to establish which plants might remain open during the winter months. This information should then be combined with anticipated materials needs to develop special supply contracts for hot mix covering only the winter period. Our current procedure of annual contracts does not insure the contracting of suppliers who will continue production through the winter. Also, by treating the winter season separately more plants might be induced to stay open as they could include the higher winter operating costs in their bid prices.

2. Further investigation into the actual field operation of the drum dryer mixer plants should be undertaken. More information is needed on their winter operation characteristics before a purchase should be contemplated.

3. Additional insulated/heated storage units should be purchased to increase the present fleet to at least one per yard that has hot mix available during the winter, whether produced in a **McConnoughay pugmill or picked up at a nearby open asphalt plant.**

4. The use of cold patch material for winter use should be discontinued or minimized. Greater reliance should be placed on obtaining and using hot patching material for winter pothole patching.

5. At least 5 more yards should switch to MC-800 for the next winter's operation to obtain a larger data base from which to judge its performance characteristics. The safety benefits of using

the MC-800 rather than the RC-800 currently employed warrants its further evaluation.

6. Mineral filler should be added to the McConnoughay mix.

7. The mix design ratio used should be 1:1 of sand and stone with 5% mineral filler (1 bag per batch) mixed with 5.5% asphalt cement (8.5 gallons per batch).

8. In order to obtain the desired level of product quality with the McConnoughay mixer, the following changes in operating procedure should be incorporated:

- a. Old McConnoughay's, without the asphalt injection, should only be used to reheat cold patch.
- b. The asphalt tank should only be replenished before starting to mix patch.
- c. The aggregate must be dried properly before mixing with asphalt.
- d. The McConnoughay should not be used as a batch plant attempting to supply several crews.
- e. Minor spare parts should be readily available.
- f. A program should be initiated to test the asphaltic oil before being accepted for delivery.
- g. A clean supply of 55 gallon drums used for storage of the asphaltic oil should be purchased.
- h. The sand and stone aggregates should be premixed.
- i. The McConnoughay should be located adjacent to the premix stockpile.

- j. A policy should be established whereby the McConnoughay operator could start work one hour earlier.
- k. A better repair policy for the McConnoughay pugmill should be initiated.
- l. Spent fire extinguishers should be replaced more quickly.
- m. A permanent operator should be assigned to the McConnoughay.
- n. The asphalt pump has to be calibrated individually.
- 9. Overnight storage of hot material in the heated trailer should be avoided.
- 10. Hot patching material having a temperature of less than 150°F should not be used for pothole repairs.
- 11. The revised operating manual should be adopted by the Department and copies distributed to every McConnoughay operator and his foreman.
- 12. A training program should be initiated to introduce the operators to the new modifications and operating procedures.

B. Proposed Equipment Modifications to the McConnoughay Mixer:

The following modifications to the McConnoughay are recommended to improve the overall operating efficiency. Some are minor, others are major modifications. Our research has shown that if maximum productivity is to be obtained from this machine, a certain amount of expenditures on equipment improvements will be necessary.

1. Extension wings should be added to the hopper. This will enable a front end loader to charge the hopper with aggregate rather than having it shoveled in by hand. Plans for the extension wings are available from the Bureau of Equipment.

2. When the hopper extension wing walls are mounted, it will be necessary to first reverse the location of the hinge rod for the

hatch cover. Without this reversal it would not be possible to remove the hatch door without removing the extension wings.

3. A small chute (steel plate) should be mounted at the exit gate so that as material is being discharged from the pugmill, it will fall down this chute into the front end loader and not straight down onto the ground.

4. The gate valves on the asphalt supply line should be replaced with ball valves which require only a 90° turn of the handle to open or close.

5. Electric band type heaters that wrap around a 55 gallon drum should be purchased to heat the asphaltic material so that it will flow faster. Depending upon the availability of an electric outlet, the heated drum should either be placed on top of the asphalt tank for direct charging of the tank or in a shed for emptying into five gallon pails which can be dumped in the tank.

6. Direct reading dial type asphalt thermometers should be given to every yard with a McConnoughay mixer. Since the mix quality depends to a great degree on the mix temperature, the pugmill operator should have this item available for proper control of mixing operations, particularly mixing time.

7. The heated asphalt tank is unlined and the supply lines are not insulated or jacketed, which results in a high temperature loss for the asphalt. Therefore, to reduce this heat loss, the tank should be lined or double-walled and all the supply lines, including the pump, should be either jacketed or wrapped with an insulating material.

8. Small ball valves should be installed near the fuel pump and supply tank to provide a positive, quick shut off in case of line breakage or fire. The valves presently installed should be used only to regulate the amount of fuel supplied to the burners.

9. There is no drain hole on the pugmill. Rain and snow easily enter through the hopper opening. A 2" - 3" diameter plug should be installed on the bottom of the pugmill. When not in use, it would be left off to allow water to drain. When using the machine, it would be capped. In the winter months, water that enters the pugmill collects on the bottom and freezes. It is both time consuming and damaging to the equipment to remove the ice which can be up to 1 foot thick in places.

10. For safety purposes a longer hose should be installed on the asphalt tank burner so that it can be lit on the ground.

11. The present asphalt tank thermometer is situated just above the tube that supplies the heat to the asphalt. It does not give a good representation of the temperature of the asphalt in the tank. Either the thermometer should be relocated to a better position or a magnetic surface thermometer supplied so that the temperature could be monitored at more than one location.

12. A small open top container is welded on the left side near the rear of the McConnoughay, it has no apparent function. However, being in that location it often fills to the top with water and freezes. Either this item should be removed or a drain hole put in it.

C. Modification Expenses:

It is estimated that the above equipment modifications would cost approximately \$700 to \$800 including installation charges per

unit.

Outside of the hopper extension, the discharge plate, and the cradle to mount the asphalt tank on top of the unit, which have to be fabricated, the rest of the modifications require standard commercial items which should be obtainable locally.

Item	Quantity per Machine
Ball valve 1 1/4" brass	1
Ball valve 1 1/2" brass	2
Thermometer, dial 0-350°F	1

I. INTRODUCTION

A. Specific Aim:

The purpose of this investigation was to develop the production techniques, equipment, and handling procedures necessary for the improvement of the quality of hot bituminous type winter pothole patching material. It had been expected that this effort would result in an increase in patch durability and an increase in the efficiency of production over the present method used at local maintenance yards.

The scope of this project was limited to production of hot bituminous materials to repair potholes developed during the winter season when the regular asphalt plants are usually closed. Production of the material to repair such failures is presently accomplished with McConnoughay mixers under prevailing adverse conditions, such as near or below freezing temperatures, precipitation in the form of rain or snow, and with water soaked aggregate.

B. Objectives of the Study:

To achieve the desired end result, the following objectives were established for this study:

1. Develop the equipment and method of procedure necessary to increase the efficiency of operation and the quality of the mix produced by the McConnoughay mixer.

2. Determine the quantity requirements of sand, stone, filler, and asphalt to obtain a suitable mix based on laboratory tests.

3. Determine if arrangements could be made with any asphalt plants in the state to remain open during the winter months.

4. Obtain operating characteristics of the heated trailer unit for transporting and short term storage of hot mix material.

5. Determine if a small (10 to 40 tons/hr.) drum dryer type plant would be more economical to own and operate for production of hot material than the present system utilizing the McCounoughay pugmill.

C. Background:

While it had been proved in a previous research study(1) that hot bituminous material is an improvement over the alternate - cold patch materials, the present method of operation leaves a lot to be desired.

The present method of producing hot bituminous material in the McCounoughay pugmill not only is time consuming, but results in a mix which varies from batch to batch.

Two men shovel the aggregate from the dump body of a truck into the McCounoughay hopper. One shovels sand, the other stone. To obtain the "proper" proportioning, each man counts the number of "shovels-full" thrown into the hopper, stopping when a predetermined number is reached. It is usually left up to the man shoveling to determine what a "shovel-full" represents.

The quantity of asphalt injected into the mix is measured by means of a gallon meter and is usually kept constant for each batch. Since there is no way of weighing the amount of aggregate in the pugmill, too much shoveled in would result in a mix with a low asphalt

(1) Indahl, G. et al, Pavement Patching Techniques and Materials, New Jersey Department of Transportation, Report No. 75-010-7742, 1975.

content and conversely, for a mix with too little aggregate, a high asphalt content will occur.

Therefore, it seems likely that with the proper proportioning equipment and operating guidelines, the efficiency of operating the McConnoughay pugmill should be increased and a more uniform product with greater durability should be produced.

On the other hand, few maintenance yards have use of a McConnoughay pugmill and have to rely on the normally available cold patch material for, to date, practically all asphalt plants are closed during the winter months. Also, based on another conclusion from the previous study(1), even if hot plant mix was obtainable, a heated or insulated storage container would be necessary to transport the material as it must be kept hot to be effective.

However, the Department had purchased five heated storage trailers that were available for use during the winter of 1976-77 in transporting hot mix produced in a McConnoughay pugmill or from an asphalt plant. Also included as part of the original study was a survey of all asphalt plants in New Jersey to determine if any would be interested in supplying hot plant mix during the winter. Figures 1 and 2 are copies of the cover letter and questionnaire that were sent to the asphalt plants.

At the conclusion of this research effort, it was anticipated that procedures would have been developed whereby an improved hot bituminous patching material could be made available during the winter months to the maintenance crews. This would be possible either by crews making the mix in their own small pugmill or by picking up the material at a nearby asphalt plant where arrangements have been made to stay open (depending upon economic and logistics study of each location).

II. METHOD OF PROCEDURE

A. General:

The study required a time span of two years to complete. During the first phase of the study, an investigation was made into the present McConnoughay operations and how they could be improved through equipment modifications and changes in the operating procedure.

As part of this research effort, laboratory tests were undertaken to obtain a suitable mix design ratio and to determine the physical characteristics of the production mixes. Also developed was an updated, revised operating manual for the McConnoughay mixer.

The second phase of the study was concerned with evaluating alternate means of obtaining hot winter patching material, such as utilizing an open commercial asphalt plant and a state owned and operated drum dryer-mixer type plant.

B. Field Tests:

As part of the first phase, a preliminary investigation of the McConnoughay mixer was conducted during the winter of 1975-76 at the Woodbridge Maintenance Yard, which had previous experience with the McConnoughay. The operation was monitored and analyzed; any important operating characteristics or problems noted, and production samples taken for lab tests.

After preliminary observations were carried out at the Woodbridge Yard, it was decided to conduct the intensive equipment modification and field testing phase at a yard which had minimal previous exposure to the McConnoughay mixer. Of a number of possible sites, the Ridgewood Yard was chosen.

There were many factors that led to this decision. First, this yard hadn't any previous operating experience with the McConnoughay mixer and there weren't any preconceived notions on how it should be operated. Second, during a previous research study conducted there, the foreman was extremely cooperative and showed a willingness to experiment. Third, there was a familiarity with that section of Route 17 developed from the previous study.

For the winter of 1976-77 a new McConnoughay mixer was assigned to the Ridgewood Yard and various equipment modifications were made. The field tests were conducted here. Trial patches were placed utilizing hot patch material obtained from Ridgewood's McConnoughay mixer. Problems in the production and patch handling phases of the operation were recorded. The patches were monitored to obtain their related life. Some of the modifications to the present McConnoughay system that were investigated were adding mineral filler to each batch, replacing the RC-800 asphaltic oil with MC-800, and transporting the hot mix to the job site in an insulated/heated storage trailer.

While these field tests were being conducted at Ridgewood, observations of Newark Maintenance Yard's operation were also being made. Their operation was analyzed, problem areas recorded, and the output sampled for lab testing.

The specific details of the method of procedure for the field test portion of the study were as follows:

1. Study Location:

To carry out the final field evaluation phase of this study a 14 mile section of Route 17 in the vicinity of Paramus with an average two way AADT of approximately 60,000 was chosen as the field

test site for winter of 1976-77 (See Figure 1). Route 17, in this area, varies in width from two to three lanes in each direction and from portland cement concrete pavement to portland cement concrete overlaid with bituminous concrete to 100% bituminous concrete.

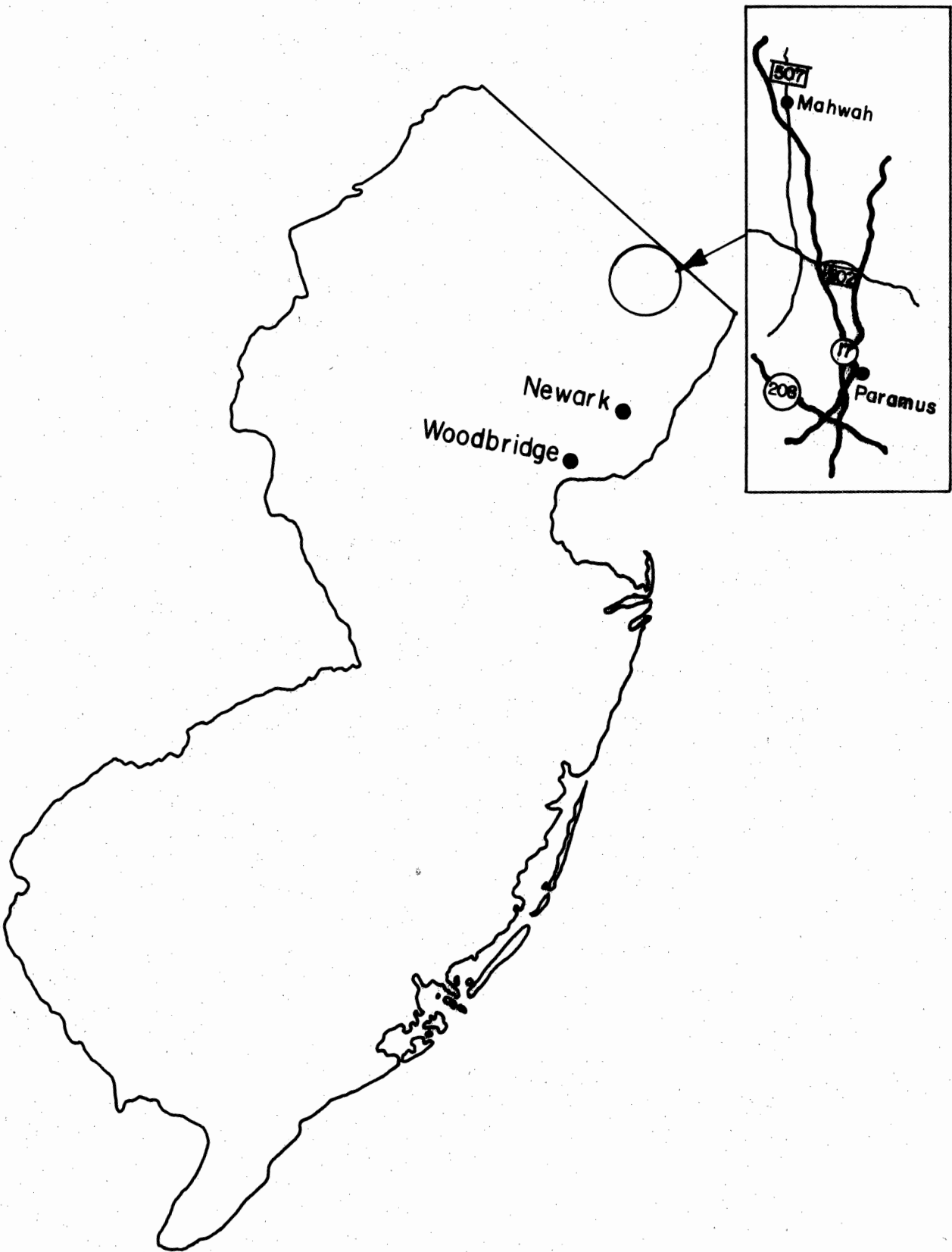
All patching materials for the Route 17 test area were supplied from the Ridgewood operation. Two other patch production sites, Woodbridge and Newark, were also evaluated during the study. However, no field tests were conducted with materials from Woodbridge or Newark McConnoughay units. Only samples were taken of their output for laboratory tests.

2. Monitoring:

A research technician was present whenever a hole was patched by the maintenance crew assigned to the research study. His function was to fill out the data sheet (Figure 2) for each hole, noting the hole condition, weather and material-techniques used. In addition, he was responsible for the numbering of each patch in sequential order, and supervising the installation of each material and the application of each technique making sure that the proper procedure was used.

Placing a serialized number on the pavement adjacent to the pothole and on the data sheet insured proper identification of the patch. It also facilitated an accurate locating of the patch during subsequent performance surveys. When the technician later examined the particular patch, he would rate it as to its degree of failure and record its condition on the back of the data sheet along with the rating data.

As each patch failed, the technician removed the appropriate data sheet and transferred the information to a data processing form for the keypunching of a computer card.



Winter
1976-77
Test Site

Figure 1 - TEST SITE LOCATIONS

A weather matrix listing the snowfall, precipitation, and freeze-thaw cycles for all possible combinations of placed and failed dates was developed using U. S. Department of Commerce climatological data taken from the nearest weather station to the patched area.

A technician would transfer the individual weather data from the weather matrix to the data processing form for each patch placed.

3. Data Collection:

a. Information recorded on the data sheet (Figure 2) for each patch series at time of installation were:

- 1) Date, route, lane (outside, center, inside, northbound, southbound, etc), pavement types, milepost, municipality, county, and other references to determine location of patched pothole.
- 2) Ambient air temperature.
- 3) Relative moisture condition in pothole (dry, water in hole, snow, ice).
- 4) Relative moisture condition of surrounding pavement (dry, damp, wet, snow, ice).
- 5) Weather (clear, overcast, raining, snowing).
- 6) Source of control mixture (sample to be taken for testing).
- 7) Description of experimental patch material (sample to be taken for testing).
- 8) Temperature of mix from the McConnoughay portable mixer (when used).

b. Data obtained after installation for evaluation and analysis of each patch series were:

- 1) Two way AADT volumes.

Figure 2

Data Sheet for Monitoring of Patch Life

POT HOLE EVALUATION SHEET

<u>DIRECTION</u>	<u>LANE</u>	ROUTE <u>17</u>
NORTHBOUND <input checked="" type="checkbox"/>	INSIDE <input type="checkbox"/>	HOLE NO. <u>255</u>
SOUTHBOUND <input type="checkbox"/>	OUTSIDE <input checked="" type="checkbox"/>	MILEPOST <u>19.3</u>
EASTBOUND <input type="checkbox"/>		DATE <u>3/3/77</u>
WESTBOUND <input type="checkbox"/>		AIR TEMP. <u>47</u>

MOISTURE CONDITIONS

<u>WEATHER</u>	<u>POT HOLE</u>	<u>SURROUNDING PAVEMENT</u>
CLEAR <input checked="" type="checkbox"/>	DRY <input checked="" type="checkbox"/>	DRY <input checked="" type="checkbox"/>
OVERCAST <input type="checkbox"/>	WET <input type="checkbox"/>	WET <input type="checkbox"/>
RAINING <input type="checkbox"/>	WATER IN HOLE <input type="checkbox"/>	SNOW <input type="checkbox"/>
SNOWING <input type="checkbox"/>	SNOW <input type="checkbox"/>	ICE <input type="checkbox"/>

<u>TYPE OF PAVEMENT</u>	<u>MATERIAL</u>	<u>METHOD</u>
CONCRETE <input checked="" type="checkbox"/>	RC 800 1:1	HEATED TRAILER <input type="checkbox"/>
BITUMINOUS <input type="checkbox"/>	WITH FILLER <input type="checkbox"/>	OPEN DUMP <input checked="" type="checkbox"/>
OVERLAY <input type="checkbox"/>	WITHOUT FILLER <input checked="" type="checkbox"/>	TACK & TAMPER <input checked="" type="checkbox"/>
	MC 800 1:1	OTHER <input type="checkbox"/>
	WITH FILLER <input type="checkbox"/>	
	WITHOUT FILLER <input type="checkbox"/>	

DATA TAKEN BY G. W. J.

- 2) Percentage of total truck traffic.
- 3) Number of days to failure of the experimental and control patch. Each experimental and control patch was inspected at least once a week after being placed and the condition of each patch noted on the data sheet. The inspection continued until either a failure was observed or the monitoring phase was considered ended. A patch was considered to have failed when the pothole had to be repatched.
- 4) U. S. Department of Commerce climatological data from the nearest weather station to the patched area was obtained for the time period from installation to failure. Such items as daily precipitation, daily temperature (maximum and minimum), and daily snowfall was used in the analysis.
- 5) Cost records of experimental materials and control mixes was maintained. Man-hours and special equipment required in excess of that normally used for the controls was also recorded.

C. Laboratory Tests:

During the summer and fall of 1976, extensive laboratory tests were conducted to determine the quantity requirements of sand, stone, filler, and asphalt necessary to obtain a suitable mix. The facilities used were the Bureau of Quality Control's Trenton and Freehold material testing laboratories. Various sample mixes of differing sand/stone ratios, filler content, asphalt percentage and

source of sand and stone were tested as shown below:

<u>Mixture Variables</u>	<u>Levels of Variables</u>	
Sand/Stone Ratio:	1:1 and 1:2	
Mineral Filler Content:	None and 5%	
Asphalt Cement Percentage:	4% to 6%	
Sand Source:	Brickwall Sand Lakehurst, N. J.	and Lockhart Sand Burr Mills, N. J.
3/8" Stone Source:	Somerset Crushed Stone Bernardsville, N. J.	and Glasgow Quarries King of Prussia, PA.

The following tests were performed on the sample mixes:

1. Stability and flow of Marshall specimens
2. Percent of air voids
3. Density
4. Aggregate gradation and bitumen content.

The sand/stone ratios used were limited to those that would be easily mixed together by a front end loader operator. Therefore, 1:1 and 1:2 were chosen (one bucketfull of sand to one of stone or one of sand to two of stone) in place of exacting ratios like 43%/57%.

Besides the mix design tests, samples were taken of the McConnoughay production mixes of the various yards investigated for laboratory analysis. Representative samples were taken and sent to the Trenton Materials Laboratory for aggregate gradation and residual bitumen content analysis. Also, Marshall specimens were molded to obtain the mix Marshall strength and flow values.

D. Evaluation of Alternate Methods:

Included as part of the second phase of this study was an economic analysis of drum dryer mixer asphalt plant that the Department would own and operate. Cost figures, estimated yearly maintenance, and operating characteristics were obtained from area representatives of the various manufacturers of the drum plants. Field trips were made to observe the actual operation of two nearby drum plants in Long Island, New York.

A great potential source of hot winter mix exists in the numerous commercial asphalt plants throughout the state, if they could be persuaded to remain open. To determine if any would be interested in supplying hot plant mix during the winter months, to nearby maintenance crews, a survey was conducted of all the asphalt plants in New Jersey.

To aid in deciding which of the various production methods investigated to obtain hot patching material during the winter months is most advantageous, an economic analysis of the methods studied was undertaken.

Cost data for the equipment, the manpower, and the material requirements were obtained. Average waiting and operating times for the men and equipment were developed based on the information obtained from the daily reports made out during the production phase of the study.

This data was used to obtain the tonnage cost figures for the McConnoughay mixer, a drum dryer mixer plant, and an open commercial asphalt plant.

III. Results and Discussion

A. Evaluation of McConnoughay Operations:

1. Woodbridge Maintenance Yard:

Preliminary investigation of the McConnoughay operation was conducted at the Woodbridge Maintenance Yard. Of all the yards in the state this one was judged to have the most experience with the McConnoughay mixer.

At Woodbridge a premix of sand and stone is used for charging the McConnoughay mixer. A front end loader mixes the sand and stone on an asphalt pad - one bucket of sand to one bucket of stone. The loader operator mixes the sand and stone until it appears to be uniformly mixed. Then it is placed and stored in a vacant salt bay to keep it dry. The resultant mix obtained by this method is a fairly uniform 1:1 mixture.

To load the McConnoughay mixer with aggregate, a front end loader puts about 3-4 buckets full of premix material on the back of a dump truck, which is in turn driven to and backed up against the pugmill's charging hopper. Two men then climbed into the back of the truck and shoveled 25 + "shovels-full" each into the hopper.

In all types of weather, two men were shoveling in material while the loader sat idle. This would have been an ideal candidate for the addition of wing walls to extend the hopper and enable a front end loader to charge the pugmill. However, to accomplish this in the particular yard involved would have meant moving the McConnoughay mixer closer to the premix stockpile to minimize loader travelling time. The McConnoughay mixer and the stockpile were at opposite corners of the yard.

A skilled operator was assigned to run the McConnoughay mixer. He appeared to have the equipment's operation down to a fine science and kept the machine in very good mechanical repair. This was evident in the type of patch material produced; sample analyses confirmed that the mix was of fairly uniform quality. (Only gradation and asphalt content analyses were made. No samples for stability evaluation were taken.)

However, there was one significant problem with the Woodbridge operation. None of the RC-800 samples taken from the tank and the storage drums could meet the required specifications when tested in the laboratory. This problem was to plague each of the three yards where samples were taken (Woodbridge, Newark and Ridgewood) - no sample would pass laboratory tests, for they were contaminated by a foreign substance. In Woodbridge, the substance could have possibly been kerosene or another hydrocarbon. In Newark and Ridgewood, water was the main problem. The occurrence of this contamination could be directly attributed to a lack of quality control on delivery and storage of the RC-800. There wasn't any representative sample taken for testing from any shipment before acceptance of the lot and there was a problem obtaining clean 55 gallon drums for storage.

2. Ridgewood Maintenance Yard:

After carrying out preliminary observations at the Woodbridge Yard, it was decided to conduct the intensive equipment modification and field testing phase at the Ridgewood yard during the winter 1976-77 season.

A completely new McConnoughay mixer obtained from a recent shipment was assigned to the yard. One of the first modifications

made to this equipment was to add wing wall hopper extensions. To accomplish this, the unit had to be towed into the Trenton welding-machine shop. The necessary shop plans for changes were developed and the extension fabricated. For ease and safety when towing, the extension was designed to be bolted on, thus making it relatively easy to remove. If in the future all DOT McConnoughay mixers are modified in this fashion, it seems that every unit would have to be brought into the shop in order to fabricate the extension. Almost every unit is built slightly different - necessitating a custom fit. Therefore, one standard size extension could not be made in the shop for every unit.

To accommodate the Ridgewood testing program a supply of RC-800 was picked up from the nearby Lodi Maintenance Yard. When the drums arrived at the yard and were off-loaded, they were found to be in very poor condition. Problems noted included large dents, leaking seams and no plugs. Also, some drums had varying percentages of water inside - a result of being left outside with only rags stuffed into the plug holes. Before using any of the drums, the water was drained from the top. If a considerable amount of water was in the drum, the contents were disposed of.

One of the first problems encountered with operating the McConnoughay mixer was the filling of the asphalt tank. To soften up the RC-800, a few drums at a time were brought inside the heated garage. (No problem would be experienced refilling the asphalt tank during the warm weather of summer when the asphalt cutback would flow freely. However, during the cold winter months this material is nearly a solid and refuses to flow until heated to at least 60°F).

After being in the building for about a week, a drum was put on a cradle, a pour spout attached, and the drum tipped over on its side.

The RC-800 would trickle slowly into the five gallon buckets, which would later be brought outside and dumped into the asphalt tank on the McConnoughay mixer. Since the procedure was far from being efficient the yard foreman devised a system to speed up the process. An air chuck was screwed into the small drum plug hole while it was on its side on the cradle. An air hose was attached to it and connected to a "T" fitting that was installed on a truck's air brake system. When 4-5 lbs. pressure was put into the drum, the hose was disconnected and the material flowed faster (relatively). When the flow slackened, more air was pumped into the drum.

There were several precautions taken when using this system. First, only warm drums were used and not any frozen ones. Second, a laborer kept watch on the operation and continually change the five gallon buckets as they filled up. After all the buckets were filled (a minimum of ten buckets were on hand at all times) and the drum emptied, the buckets were carried out (two at a time) to the McConnoughay mixer and dumped into the tank. Only two at a time were taken out since that was all that could be placed in the tank opening at one time. If all the buckets were brought out at one time, the material would cool rapidly and there would be great difficulty in getting the material out of the five gallon buckets. The whole process up to this point had been very messy (the asphalt eventually got over everything - floor, doors, door knobs, the side of the McConnoughay mixer) and time consuming - from 1/2 day to a whole day to replenish the asphalt tank.

It was decided that if the drums were to be continued to be used as storage tanks for the RC-800, a better system had to be devised. A number of yards have unsafe methods of loading the tank. One precariously dangles the 55 gallon drum in the asphalt tank hatch door opening - only a small lift ring acts as a wedge stopping the drum from tumbling six feet to the ground. Another welded a few pieces of angle iron in the form of a cradle on the side of the tank. However, this method makes the already top heavy McConnoughay mixer even more top heavy. The full drum weight is about 500 lbs. and the center of gravity of this weight would be outside of the wheel base of the axle - a tremendous load for the brackets and the McConnoughay mixer.

Both of these procedures are inherently dangerous and should be discontinued. A better solution would be to mount the drum on top of the asphalt tank with a cradle.

It was noticed that while mixing patch in Ridgewood's McConnoughay mixer the asphalt injectors plugged up. Although the pump counter was turning, the asphalt was not going into the pugmill. Therefore, a procedure was initiated whereby, when the pump was engaged, someone looked thru the inspection hole to signal the operator when asphalt started to come out of the injectors. The operator would then adjust the counter total to take into consideration the number of counter turns when no asphalt came out.

Another problem encountered in Ridgewood work was the lighting of the asphalt tank burner. In the manufacturer's recommended procedure for lighting this burner, liquid fuel is squirted out of the nozzle until the coils become hot enough to vaporize the fuel. The area surrounding the burner was in flames due to the liquid

fuel shooting out. If it was mounted on the machine the liquid would be inside the heating chamber and once ignited, flames would be all over the machine. Therefore, a longer hose was added so that the burner could be lit on the ground until it started to operate properly, then it was carefully clamped back on the machine. It was felt that this whole process would be eliminated if a propane burner was used instead of the kerosene one.

As the asphaltic oil in the tank heated up it expanded, raising the possibility of it overflowing. To take care of this expansion, the operator was instructed not to fill it any closer than 12" to 18" from the top.

Occasionally, while the McConnoughay mixer was running, unusual operating noises were heard. At the time no one knew the cause, but soon discovered that these unusual noises were signs of imminent part failure or other malfunctions. In one incident, rocks the size of oranges were mixed into the stone pile. In another case, the paddle arm bolts were loose. The cause of this particular noise was learned the hard way the first time - the bolts sheared off sending the arms crashing about the inside of the pugmill until the motor could be shut off. After these incidents the operator was cautioned to be alert to any unusual operating noises and to determine the cause and remedy it before major damage is done.

As a safety precaution, the asphalt tank on top of the machine was replenished before starting to mix patch. If asphalt was needed, the burners were shut off and the asphalt in the tank allowed to cool down before replenishing. It was judged that suddenly adding cold RC-800 into a relatively hot tank would be hazardous.

It was discovered early in the Ridgewood evaluation that the aggregate had to be dried properly so that the asphalt would adhere to the aggregate. To insure this, the dry mixing time (the time the aggregate is in the pugmill before asphalt is added) was varied according to the moisture content of the aggregate. If the aggregate was extremely dry, such as was the case for material that had been stored in a shed, minimal mixing time was required. However, if the aggregate was stored in the open and contained a high amount of moisture, the dry mixing time was increased.

As the study progressed, a method of procedure was developed to alleviate the problem of the wet aggregate. When it wasn't possible to store premix in a shed to dry (as would be the case with most yards) a quantity of it was run thru the pugmill to dry while the operation was being delayed waiting for the burner to heat up the asphalt in the tank. Once the premix was run thru it was stockpiled on a nearby dry asphalt pad to be used for that day's production. As an operating precaution the aggregate was not preheated to too high a temperature. At temperatures higher than 180°F the RC-800 flashed when it hit the stone - sending flames 8' - 10' high out of the exhaust stack.

It was felt that if the premix is dried ahead of time (either by storing it in a shed or preheating it) time would not be wasted when the production operation begins by taking time out to dry the aggregate before adding the asphalt.

On one occasion at Ridgewood the asphalt pump counter belt broke. Since a replacement was not readily available and without this small part the machine was inoperative, production was forced

to stop. It was eventually discovered that a suitable part substitute was a regular o-ring of the proper size. The cost estimate was 50¢ each when purchased in a lot of 100, which would be sufficient quantity for the entire state.

As another safety precaution the bolts that hold down the asphalt tank hatch door were left off while the machine was being used. If the asphalt caught fire, it would not be confined to the tank but open to the atmosphere thereby preventing pressure build up.

By the end of the winter the Ridgewood Yard had been transformed, through training and experience, from a yard that had minimal knowledge on the operation of the McConnoughay mixer to a well run operation. It is believed that this yard could be left on its own to produce a quality mix.

3. Newark Maintenance Yard:

The Newark Yard, on the other hand, was a disaster upon initial observations. The aggregate was not premixed, but shoveled into the hopper by two men on the back of a truck, shoveling in "so much" stone and "so much" sand. The aggregate even though stored out in the open was not preheated, but mixed wet with the asphalt. Also, the aggregates and the McConnoughay mixer were separated by a fence, necessitating the loader travelling to the gate and back-tracking to reload the dump truck with sand and stone. Plus, no filler was being added.

For the first samples taken from mix produced at the Newark Yard no stability could be achieved. As a matter of fact, some of the samples crumbled while being transported to the lab for testing. Of those that could be analyzed, the asphalt content was quite low.

All things being considered, the resultant mix appeared lifeless, being more on the order of black colored gravel. To compound the problem, this yard was expected to supply 5-6 trucks on any given patching day.

As stated previously, the McConnoughay mixer being used was in poor working condition. The asphalt pump was never calibrated, instead a set number of turns on the counter was being added to each batch with no idea as to the resultant asphalt content.

On the plus side, the operator was dedicated and did the best job he could under these circumstances. As suggestions to improve the operation were made, he readily accepted them. Also, the operator and his helper came in one hour earlier to enable the mix production to get underway by 8 a.m.

As a result of working with the yard and the operator many changes were made that greatly improved the operation. First of all, the front end loader was used to premix the sand and stone on an asphalt pad and store it in a vacant salt bay (after cleaning the bay out). Previously, the sand and stone on the back of the dump truck that wasn't needed for mixing patch was dumped back into either the sand pile or the stone pile - contaminating one or the other. An alternate plan to permit reuse of the premix was subsequently established. At the end of a patching day, the unused premix was dumped back on its own pile for use at another time.

A newer machine was obtained to replace the older one when the transmission broke. However, even though the newer unit had an extension hopper, men were still assigned to shovel in the premix due to the location of the McConnoughay mixer. To enable a front end

loader to charge the hopper, the machine would have to be moved out of the fenced in location to another one nearer to the stockpile of premix. An alternative would be to construct an asphalt pad nearby the McConnoughay mixer where the premix could be stored. Once either of these two moves are accomplished, the shoveling in of aggregate could be eliminated. The present situation was precipitated by yard limitations and a recently completed expansion which severely limited the available room left for the McConnoughway operation and storage of premix. However, with minor effort, this change over could be accomplished. As a side note, men were supplied from the truck getting patch to shovel in the aggregate so that the yard didn't have to supply any extra men for this phase of the operation.

The asphalt pump was calibrated and the amount of counter revolutions increased to achieve the desired asphalt content. The premix was preheated to remove the moisture in the aggregate before injecting the asphalt. A procedure was established for taking mix temperature and adjusting the operation accordingly.

Also, a number of batches were mixed using mineral filler and the procedure of adding it was established.

Once these minimal operational changes were accomplished, the resultant mix was greatly improved. From no strength to a value about half of that obtained with Ridgewood was obtained - a remarkable improvement in such a short period of time. Perhaps with a little more effort of time and capitol improvements, this yard could be producing both the quality and quantity of mix obtained in Ridgewood.

The situation that existed in Newark is probably very typical

of the situation that exists today in many of the other yards. Without any individual training or guidance, the yards could possibly attain operating characteristics that actually hinder the operation, on a divergent path from the correct procedure.

Although training and guidance played an important part in increasing production performance in Ridgewood and Newark, the attitude of the foreman and operator has to be taken into consideration. Both individuals must show a desire to improve the operation and to readily accept changes. The NHI (not invented here) syndrome will lead to poor overall operation.

4. Other Maintenance Yards:

During the course of this study, visits were made to a number of other yards that were making hot patch with the McConnoughay mixer. Besides observing their operation, an informal discussion was held with the operator and his foreman covering the McConnough mixer. From these visits a number of important items developed which are discussed next.

a. It was discovered that a number of yards are making hot patch utilizing the older McConnoughay units which lack the built in asphalt injection system to introduce asphalt into the mixing chamber. To mix patch with these older units, the asphalt must be poured into the mixing chamber by hand for charging. Since the RC-800 presently used has a relatively low flash point, this procedure could be quite hazardous. When pouring the asphalt into the hot chamber which contains an open flame, there is a high risk of flashing the RC-800 (which contains gasoline or naphtha).

These older units would appear to be best suited for reheating winter mix.

b. Group sessions were conducted to train the operators from many yards at the same time. Usually these resulted in 50 to 100 men milling around not paying too much attention to the factory instructor, who may not even have any practical field experience operating the unit. Therefore, they appear to be a waste of time.

Proper training of the operators and foremen individually on their own machines is believed to be one of the most important items needed to increase the overall quality of the mix. It may be advisable to initiate a program whereby each operator would have at least 3 days experience before being left on their own.

c. Fire on the McConnoughay mixer is always a cause of concern. If the machine's exterior is kept clean of asphalt and proper operating procedures followed, this problem will be minimized. If on the other hand asphalt covers the exterior it is apt to flash when it contacts the hot parts of the pugmill or the exhaust stack. A layer of sand and stone beneath the asphalt tank on top of the pugmill seems to be a good barrier and has worked satisfactorily at some yards. If the external asphalt does catch on fire, sand can be thrown on the flames to smother it. This is for small isolated fires. A more serious fire would require use of a fire extinguisher.

The case of a fire inside the machine is relatively easy to handle. First of all, another load of premix should be kept in the holding hopper at all times when the pugmill burners are lit. This not only prevents flames from shooting up the hopper, but in case of a fire this load can be dumped into the pugmill, smothering the fire inside. In such instances both burners should be shut off

immediately.

A new machine was destroyed by fire during the 1976-77 winter. Through operator error and panic, when the material caught on fire inside, the discharge gate was opened dumping flaming material out. It flowed around the machine igniting the tires and the gas tank. The entire machine was destroyed. This apparently was an inexperienced yard with a new piece of equipment.

Another dangerous practice that was observed was spraying kerosene to prevent asphalt build up on the McConnoughay mixer while it was running - when the kerosene came into contact with the hot parts, smoke billowed out, but luckily no fire. A better procedure would be to brush on a very small amount of kerosene when the burners weren't on.

It was also discovered that at some yards the spent fire extinguishers were not being replaced quickly and the McConnoughay mixer was being operated without a replacement available.

B. Laboratory Tests:

1. Mix Ratios:

During the summer and fall of 1976, extensive laboratory tests were conducted to determine the quantity requirements of sand, stone, filler, and asphalt necessary to obtain a suitable mix. The facilities used were the Bureau of Quality Control's Trenton and Freehold material testing laboratories. Various sample mixes of differing sand/stone ratios, filler content, asphalt percentage and source of sand and stone were tested as shown on the following page.

<u>Mixture Variables</u>	<u>Levels of Variables</u>
Sand/Stone Ratio:	1:1 and 1:2
Mineral Filler Content:	None and 5%
Asphalt Cement Percentage:	4% to 6%
Sand Source:	Brickwall Sand and Lockhart Sand Lakehurst, N.J. Burr Mills, N.J.
3/8" Stone Source:	Somerset Crushed Stone and Glasgow Quarries Bernardsville, N.J. King of Prussia, PA.

The following tests were performed on the sample mixes:

1. Stability and flow of Marshall specimens
2. Percent of Air Voids
3. Density
4. Aggregate gradation and bitumen content

The sand/stone ratios used were limited to those that would be easily mixed together by a front end loader operator. Therefore, 1:1 and 1:2 were chosen (one bucketfull of sand to one of stone or one of sand to two of stone) in place of exacting ratios like 43%/57%.

A summary of the lab tests is given in Tables 1 through 6. Tables 1 through 5 list the test results obtained varying the ratio of sand and stone. The stability, flow and percent air voids are given for various asphalt contents.

Table 6 is a list of the gradation of the aggregates for the varying ratios and suppliers.

As can be seen in Table 1, samples tested of the present mix design (1:1) resulted in low stability and high air void content. Mineral filler was added to increase the mix strength and lower the air voids to an acceptable level. Five (5) percent of filler was added to each batch which is equivalent to one 50 lb. bag being added to a McConnoughay batch. Introducing the mineral filler to

TABLE 1

SUMMARY OF LAB TESTS

1:1 SAND/STONE RATIO - NO FILLER ADDED

<u>Asphalt Cement Content (%)</u>	<u>Stability (lbs.)</u>	<u>Flow (Inches)</u>	<u>Percent Air Voids (%)</u>
4	405	13	13.1
5	491	11.7	10.2
5.5	571	12	9.4
6	835	12.7	7.1
Top Mix Specifications	1200 min	6-16	2-6

Aggregate Sources: Sand - Brickwall Sand Co., Lakehurst
Stone - Somerset Crushed Stone Co.,
Bernardsville

TABLE 2

SUMMARY OF LAB TESTS

1:1 SAND/STONE RATIO WITH 5% FILLER ADDED

<u>Asphalt Cement Content (%)</u>	<u>Stability (lbs.)</u>	<u>Flow (Inches)</u>	<u>Percent Air Voids (%)</u>
4	1137	13.3	9.2
5	1147	12.3	7.0
5.5	1308	10.7	6.7
6	1245	12.3	4.8
Top Mix Specifications	1200 min	6-16	2-6

Aggregate Sources: Sand - Brickwall Sand Co., Lakehurst
Stone - Somerset Crushed Stone Co.,
Bernardsville
Mineral Filler - Limestone Products, Limecrest

TABLE 3

SUMMARY OF LAB TESTS

1:2 SAND/STONE RATIO - NO FILLER ADDED

<u>Asphalt Cement Content (%)</u>	<u>Stability (lbs.)</u>	<u>Flow (Inches)</u>	<u>Percent Air Voids (%)</u>
4	808	11.7	9.9
5	967	11.3	7.8
6	1152	12.3	4.7
Top Mix Specifications	1200 min	6-16	2-6

Aggregate Sources: Sand - Brickwall Sand Co., Lakehurst
Stone - Somerset Crushed Stone Co.,
Bernardsville

TABLE 4
SUMMARY OF LAB TESTS

1:2 SAND/STONE RATIO WITH 5% FILLER ADDED

<u>Asphalt Cement Content (%)</u>	<u>Stability (lbs.)</u>	<u>Flow (Inches)</u>	<u>Percent Air Voids (%)</u>
4.5	1094	14	7.7
5	1015	13.7	6.2
5.5	1126	15.7	6.2
6	1293	15.3	3.9
Top Mix Specifications	1200 min	6-16	2-6

Aggregate Sources: Sand - Brickwall Sand Co., Lakehurst
Stone - Somerset Crushed Stone Co.,
Bernardsville
Mineral Filler - Limestone Products, Limecrest

TABLE 5
SUMMARY OF LAB TESTS

1:1 SAND/STONE RATIO - NO FILLER ADDED -
CHANGE IN AGGREGATE SOURCES

<u>Asphalt Cement Content (%)</u>	<u>Stability (lbs.)</u>	<u>Flow (Inches)</u>	<u>Percent Air Voids (%)</u>
4	504	18	12.3
5	556	8.3	9.8
6	625	8.7	7.5
Top Mix Specifications	1200 min	6-16	2-6

Aggregate Sources: Sand - Lockhart Sand Co., Burr Mills
Stone - Glasgow Quarries Co., King of
Prussia, PA.

TABLE 6
 AGGREGATE GRADATIONS
 (PERCENT PASSING)

Sieve Size	Brickwall Sand		Somerset Stone		Lockhart Sand		Glasgow Stone	
	Mix Ratios							
	1:1	1:1 With Filler	1:2	1:2 With Filler	1:1	Specifications* Min.	Specifications* Max.	
1/2	100	100	100	100	100	100	-	
3/8	97	97	96	96	98	80	100	
#4	67	69	56	58	61	55	75	
#8	54	56	41	44	52	30	60	
#16	44	47	32	36	49	-	-	
#50	12	16	9.4	14	19	10	30	
#200	11.8	16.1	2.0	6.3	2.7	4	10	

*Specified gradation range for Addenda A Mix #5, Surface Course.

the mix in this fashion would facilitate the field operation and eliminate the need to handle partially emptied bags.

An asphalt cement (AC-20) was used in making all the sample mixes even though cutbacks (RC-800) would be used in the actual field production operation. It was decided that it would be too difficult and dangerous to work with the RC-800, which contains gasoline or naphtha, at the required elevated temperatures in the laboratory and AC-20 would be used in its place for all lab mixes. The test results would represent the maximum obtainable under ideal conditions and would be used to compare to test results on McConnoughay produced mixtures.

When comparing the results of the 1:1 ratio with filler to the 1:1 without filler (Tables 1 and 2) it is observed that the stability was increased approximately 130% and the percent air voids was decreased approximately 30%. The flow values remained basically the same.

Adding filler to the 1:2 ratio increased the stability less than 10%, the flow was approximately 20% higher, and the voids were decreased by approximately 20%.

Of all the ratios, the 1:1 with 5% filler appeared to be the best combination tested: the strengths were higher, the flow lower, just a slight increase in air voids over that obtained with the 1:2 ratio, and field mixing operations would be simplest.

Based on the examination of the results of tests conducted on the sample mixes, it was established that the mix design should be:

Sand/Stone Ratio	1:1
Filler Content	5%
Residual Bitumen Percentage	5.5%

Also varying the source of the sand and stone didn't appear to greatly affect the test results as can be seen by comparing Tables 1 with 5. The strength and percent air void values are almost identical. The only difference was that the samples with the second aggregate source produced approximately 30% lower flow value. Since the results of the 1:1 ratio without filler from both aggregate sources was so close, it was decided to discontinue further comparison tests.

2. Production Samples:

Samples for testing were also taken of the production mixes in the Ridgewood and Newark Yards. Marshall specimens were molded and a representative sample taken for almost every production day for analysis at the Trenton laboratory. Table 7 is a list of the aggregate gradations and bitumen content for the various mixes produced in both Ridgewood and Newark Yards. Table 8 is a list of the results of the Marshall tests on the samples taken of production material from Ridgewood. Although Marshall samples were taken in Newark, practically everyone that was sent to the laboratory for testing fell apart in transit; the mix was that unstable. The few that did survive were considered unreliable data.

The material produced with filler added (Table 8) was within the required specifications for a surface course, Mix #5 material. The strength was more than adequate and the flow and percent air voids was within the allowable range. The results for the samples produced without filler were almost within the specifications except the percent air voids were excessive. Adding the filler resulted in a 42% increase in stability with a 24% decrease in percent air voids.

TABLE 7
PRODUCTION SAMPLES AVERAGE GRADATION
(PERCENT PASSING)

Sieve Size	Ridgewood				Newark	
	RC-800		MC-800		RC-800	
	<u>Without Filler</u>	<u>With Filler</u>	<u>Without Filler</u>	<u>With Filler</u>	<u>Without Filler</u>	<u>With Filler</u>
3/8	96	96	96	96	96	94
4	59	64	67	62	64	64
8	46	51	53	48	57	56
50	15	19	14	18	11	14
200	5.4	9.5	5.4	9.5	2.7	6.9
Residual Bitumen Content	4.6	4.4	4.2	4.7	5.0	4.1
Number of Samples	85	40	3	7	36	3

TABLE 8
RESULTS OF MARSHALL TESTS ON PRODUCTION SAMPLES

RIDGEWOOD

RC-800

	<u>Without Filler</u>	<u>With Filler</u>	<u>Specifications</u>
Stability (lbs.)	1474	2092	1200 min
Flow (inches)	8.6	13.1	6-16
Percent Air Voids (%)	7.5	5.7	2-6
Number of Samples	12	15	

C. Heat Loss:

1. General:

While the modifications discussed in the previous sections will help to improve the production efficiency of the McConnoughay pugmill, there is still the problem of heat loss. In cold weather, the mix was found to lose heat at the surface of a load at the rate of approximately 100°F per hour when placed in the body of an open dump truck. The minimum temperature at which the mix could be used was approximately 150°F. Below that the material was unworkable and minimal patch life was encountered. Since the desired safe mixing temperature for an RC-800 mixture is 250°F, it is apparent that patching from an open dump truck is not a very effective approach.

There are a number of possible solutions to alleviate this problem. In place of the common procedure of loading enough hot material on an open body dump truck to last the entire day, a limit could be set on the load size. Only enough patch would be placed on the truck to last through the morning. After lunch the McConnoughay mixer would be started up to make more patch for use that afternoon. While this will not limit heat loss, it would enable the patch crew to have relatively hot workable material for both the morning and afternoon.

An alternative would be to supply the crew with an excess of material for the entire day. When patch material is needed, a worker would dig a tunnel with his shovel into the mound of material to get at the hot material inside.

However, neither of these two methods are practical. Returning to the yard during the day for more material will result in wasted man

hours. Putting an excess of material on the truck will result in throwing a lot of material away at the end of the day.

To reduce the heat loss, there are a number of simple methods available. A sheet of plywood could be placed on the floor of the dump body to act as insulation. Also, a tight form fitting piece of canvas could be placed directly on top of the mound of asphalt mix. Whenever material is needed, a worker would lift up the end of the canvas and take a shovelful. This method is preferred over relying only on the canvas that covers the entire dump body for there is too much air space left between the mix and the canvas.

Timing in the production of the hot mix is also an important consideration. It does not make much sense to load a truck with hot material right before lunch time only to have it sit idle for at least one half hour before it goes out on the patching operation. It would be much better (at least from a heat loss standpoint but possibly not from a man power utilization view) to detain the truck and mix a fresh batch for it right after the lunch break.

2. Heated Trailer:

The optimal solution to the heat loss problem appears to be the insulated/heated storage trailer. Currently, the Department owns five 4TSU Powerray Portable Asphalt Storage Units. The heat loss rate for the material in one of these units was minimal. Based on tests conducted, the material remained at the mixing temperature during the entire working day even though the ambient temperature dropped into the twenties. These four ton capacity trailers can be used no matter where hot material is obtained. When used in conjunction with the McConnoughay mixer, each batch can be put into the

unit and the doors closed to keep the material hot until it is filled. When hauling material out of an open asphalt plant, the use of these units will markedly slow down the rate of material heat loss and resulting oxidation. This is most important when the asphalt plant is a long distance from the job site.

To keep the material hot, either two or three burners can be lit, depending upon ambient temperature. Besides its heat retaining ability, it is more convenient to patch with the heated trailer. Material is obtained from two small doors at the rear which are at waist level making it easy to shovel material into potholes. This requires less effort than trying to obtain material from a shoulder high dump body.

A word of caution is necessary to those using the heated trailers. The main purpose of the heated trailer is to permit material placed in it in the morning to remain usable the rest of the day. It is apparent that overnight storage, either of material made early in the morning or in late afternoon should be avoided. For while the temperature of the mix will remain fairly high on the second day, a lab analysis of the material revealed that the asphalt content has been reduced (stripped from prolonged exposure to heat) and the resultant strength showed a reduction directly proportional to the time left in the unit (longer the time in, the lower the strength).

The trailer is fairly versatile in that it should be able to see service year round and not only during the winter months. To utilize the trailer during the hotter months, the burners would be left off and the unit used as an insulated body.

If the instructions in the manufacturer's service manual, which are very concise, clear, and well written are followed the unit should prove to be very easy and simple to use. The only major area that needs consideration is the propane tanks. If for some reason material has to be left in overnight, care must be taken to insure that there is a sufficient supply in the tanks, for if there isn't and the burners go out on a cold night, the material will have hardened to a rock like mass by morning. If this ever happens, the material should not be chiseled out for the unit will be damaged in the process. A liberal amount of kerosene should be applied to soften the material for removal. There is little chance of this occurring if the recommendation for avoiding overnight storage is adhered to.

While the experience in use of the heated trailer was generally quite favorable, the need for a few equipment modifications did evolve. The top doors should be reversed for in its current location, in order to open the top, a worker has to stand on the traffic side of the machine. Reversed, the door could be opened from the shoulder side. Although opening the top door will be done infrequently, the material does periodically hang up and needs to be pushed down towards the rear doors.

Also, the front dolly wheel does not appear strong enough for a fully loaded unit. It is hinged and offset. A sturdier screw type jack with a dolly wheel should be mounted on the center line of the trailer just behind the hydraulic surge brake unit.

From this research it would appear a wasted effort to increase the production rate and quality of McConnoughay mixer hot material only to place it on the back of an open body dump truck in sub-freezing

weather where the material will become lifeless within 2 hours under such conditions. The use of hot winter patching material seems to go hand in hand with the use of insulated/heated storage units.

3. Temperature Cutoff:

For the majority of this study the lowest temperature of patch material that was used to patch mainline pavement potholes was 150°F. A technician was present at all times during the patching operation and periodically monitored the material temperature on the truck. Once the material dropped to 150°F, patching of mainline pavement stopped. The remaining material, usually between 1/4 to 1/2 ton was either brought back to the yard to be dumped in the waste pile or thrown into nearby shoulder potholes.

During the first few days of patching in the beginning of the winter season it was noticed that a number of patches were failing within only a few days. It was then discovered that these patches were the last placed on that day. As a result of this, the 150°F cutoff was established. This figure is not an exact number. Perhaps it should be higher, such as 180°F. But it was felt that 150°F was a satisfactory lower limit considering material workability and patch durability.

D. Field Performance of Test Patches:

In attempting to finalize this study a problem arose as to how to evaluate the field performance of the various test patches. For unlike the previous Department patching investigation, where most of the patches had failed by the end of the monitoring phase at the time of this report's preparation, very few patches had actually failed. Of the total patches placed only 20 - 25% had

failed as of the last inspection.

Also in contrast to earlier studies, the patches gradually stopped failing. Initially, during the colder winter months, the failure rate was relatively high as would be expected. However, as time progressed the failure rate decreased substantially. A plot of the failure occurrences reveals a curve that is very similar to that of an exponential decay curve.

The patches that survived the extremely harsh winter months had evolved into fairly permanent patches even though developing a permanent patch was not one of the project goals.

Quite a number of the patches placed did not fail according to failure modes identified in the past study. For example, a large number of patches would be expected to fail immediately following a heavy rainfall and especially if this coincides with a sizable drop in ambient temperature down near or below the freezing mark. However, failure of the patches placed during this study could not be predicted. After every heavy rain, the monitoring technician would check the condition of all the patches, thoroughly examining those patches whose condition was previously noted as deteriorating. Quite often this monitoring was done as a supplement to the regularly scheduled monitoring cycle. Usually less than five failures were observed, 1% of a total of approximately 450 patches. With experience obtained from our past patching research(1), one would have expected at least 5% or more to have failed after a heavy rain and/or temperature drop below freezing.

Of course, the present investigation differs considerably from

the previous study. That study was conducted using predominately winter mix - cold patch material. By its very nature it would be susceptible to degradation from heavy downpour and freezing temperatures.

It is important to note that with a significant number of the McConnoughay patches the actual failure mechanism seemed to be different from that experienced with the cold patches. Normally, in time, a cold mix patch would develop cracks which would in turn open up and the material would become very brittle. Larger pieces would start to come out and then the patch would have to be repatched as the hole became bigger. In contrast, it was observed that a fair number of patches during this study did not fail by means of this mechanism, but gradually wore away. Traffic would erode the top surface of the patch to a point where it would be depressed in the center. This eroding action would continue until a dish shaped depression was formed and once it became deep enough the pothole would be repatched.

This action quite possibly could in part be attributed to the bond (or lack of it) between the asphalt and the aggregate which in turn could be directly related to the relative overall quality of the mixing operation. A few possible causes could be the use of an asphaltic oil that did not meet the required specifications, not having the proper amount of asphalt in the mix, too high a mixing temperature, or too low a placement temperature. Perhaps through training and experience these modes of failure could be eliminated - making the performance of the hot patching material that much better than the cold patch mixes.

Due to the relatively low patch failure rate it was decided to use only two performance indicators in analyzing the adequacy of various mixes produced by the McConnoughay mixer. The percent of patches failed and the average time to fail for those that did fail appeared to be the best measure of performance to consider in our analysis.

1. RC-800:

RC-800 is the standard asphaltic oil used in N. J. with the McConnoughay mixer. It was used predominately most of the winter in the Ridgewood test location until a supply of MC-800 could be obtained. Also, a shipment of mineral filler was purchased for addition to the mix to increase the resultant strength and lower the percent air voids.

Table 9 lists the total patches placed for the various mixes with the number that failed and the associated failure percentage plus the average days to failure for those patches that failed.

Although both the RC-800 with filler and without filler mixes had the same percent of failure, the average days to failure showed a remarkable spread. The time for a failure to occur with the RC-800 with filler was 53% greater than that obtained without using any filler.

2. Heated Trailer:

The heated trailer was utilized to investigate the effect on patch durability of keeping the material hot all day. Analyzing the test data revealed certain unusual results. As can be seen in Table 9, the failure rate for the heated trailer was 26% which was higher than obtained transporting the material on the open body dump truck. Also, the average time to failure was nearly identical to that on the open truck. This finding was contrary to the

TABLE 9
NUMBER OF PATCHES PLACED
AND
FAILURE TOTALS FOR RIDGEWOOD OPERATION

<u>Mix Process</u>	<u>Number Failed</u>	<u>Number Placed</u>	<u>Percentage Failed</u>	<u>Days To Failure</u>
RC-800				
Open Truck Without Filler	46	234	20	36
Open Truck With Filler	18	88	20	55
Heated Trailer Without Filler	23	90	26	40
MC-800				
Open Truck With Filler	0	42	0	-

TABLE 10
ADJUSTED FAILURE RATE FOR HEATED TRAILER

<u>Patch</u>	<u>Number Failed</u>	<u>Number Placed</u>	<u>Percentage Failed</u>	<u>Days to Failure</u>
First	3	39	8	51
Second (Overnight storage)	20	51	40	38

performance anticipated. It was not until the heated trailer data was broken down into days failed with corresponding dates placed that the reason for this was discovered.

The material in the trailer that was not used at the end of the day was being left in overnight for consumption the next morning. At the time, it was felt that there was nothing wrong with this process for the mix temperature was maintained into the afternoon.

However, after analyzing when the failed patches were placed it was discovered that practically every one was placed the second day (Table 10). Out of the 23 failed patches, 20 were placed on the second day. The second day also had a relatively high failure rate - out of 51 placed, 20 failed (40%) whereas with the first day only 3 failed out of 39 placed (8%). The failure rate was extremely excessive when using material left in the trailer overnight. Also, the time to failure was reduced 25% by leaving the material in overnight.

The probable cause for this occurrence was that the asphalt had been gradually stripped from the material after being exposed to prolonged heating overnight.

3. MC-800:

A supply of MC-800 was obtained from a nearby asphalt distributor for use with the McConnoughay mixer. Consideration of this type material was prompted by a concern over safety aspects of hot mixing with a rapid curing cutback. Before using MC-800 material the asphalt tank and supply lines on the McConnoughay mixer were thoroughly cleaned out to remove all traces of the RC-800 which had been used previously.

To alleviate a potentially hazardous situation, these materials should never be mixed together.

It wasn't until late in the patching season when trial batches were mixed (beginning of April). Shortly thereafter the weather turned considerably milder. Therefore, the MC-800 patches were not exposed to the harsh winter environment as were the RC-800 patches.

Over forty patches were placed with the MC-800 and as of the writing of this report (6 months after placement) no failures have occurred. At the end of the monitoring phase, over 80% of the patches were rated either excellent or very good.

The question arises as to the relative durability of patch material produced with MC-800 if these MC-800 patches had been placed during the winter months. At this time it cannot be answered. Therefore, it appears advisable that several yards which have experience and a good operating background with the McConnoughay mixer switch to using the MC-800 asphaltic oil for this coming winter. If after using it the comments from these yards are favorable, then strong consideration should be given to the use of MC-800 in all future patching materials produced with the Department's McConnoughay mixers.

Based on this limited investigation of the use of MC-800, the following observations can be stated. The mixing, handling, and patch compaction seemed to be nearly identical with that of the RC-800. One of the major differences noted was that the flaring up experienced with the RC-800 when the asphaltic oil was injected did not occur when the MC-800 was used. When the RC-800 was being injected, flames shot out of the exhaust stack and any other opening.

While the MC-800 didn't emit flames, it did produce black smoke coming out of the exhaust stack but the amount of smoke emitted was comparable to that put out using the RC-800.

The MC-800 should be a safer product to use since the solvent is fuel oil while the RC-800 contains highly inflammable naphtha or gasoline.

Since none of the patches placed with MC-800 failed during the observation period, no evaluation of its patch life can be made. However, based on observations of the mixing operation there wasn't anything evident that would indicate that its patch performance should be any different from that of the RC-800. Further field testing and evaluation is necessary to verify this initial impression.

E. Drum Dryer Mixer Plant:

Included as part of this study was an assessment of the feasibility of a drum dryer mixer asphalt plant being purchased and operated by the Department.

Cost figures, estimated yearly maintenance, and operating characteristics were obtained from area representatives of the various manufacturers of the drum plants. After reviewing the literature and talking with industrial representatives, the size of the unit studied was limited to the 50 + tons per hour range. It was felt that this size would be most useful in that the production operation could proceed at a smooth pace without extensive waiting delays and that the hourly production capacity of this unit did not greatly exceed the typical patching demand. The units that are currently available range from 12 t.p.h. all the way up to 300 t.p.h.

In a subsequent section of this report (Economic Analysis of Production Methods) an economic analysis of a typical drum plant's operation is given. As stated there, although the drum's estimated cost per ton was higher than that calculated for a commercial asphalt plant, it was far less than that of operating the McConnoughay mixer.

It was decided to include in the drum investigation observations of actual field operations of a nearby drum plant. Unfortunately, the drum dryer mixer plant is relatively new to the East coast. Only three units of the 50 + t.p.h. range are operating in nearby states. Two are on Long Island, New York and one is in Rhode Island. Table 11 lists the owner, his address, and the type of unit as obtained from the respective company files.

Field trips were conducted to observe the operation of both the Hempstead and the Center Moriches plants. Both these plants have very successful operations. The respective tonnage rates were fairly high, the units were easy to operate, there were minimal production difficulties and the quality of the final product looked very good.

Based on visits to both these plants, there are general guidelines that can be stated as to the planning and operation of a typical drum plant.

To achieve a desired usage factor, this type of plant should be centrally located in a high tonnage area where its continued use could be economically justified. Two yards which immediately come to mind are the Newark and Lodi Yards. There exists within 20 miles of these two locations numerous crews with a high winter tonnage requirement that rely almost entirely upon the McConnoughay mixer for

TABLE 11

NEARBY DRUM DRYER MIXER ASPHALT PLANTS

<u>Owner and Address</u>	<u>Type of Unit</u>
J. T. Montecalzo Construction Center Moriches, L.I., N.Y.	Addco 6026
Hempstead D.P.W. Hempstead, L.I., N.Y.	Addco 5426
Abbie Bituminous Contractor Riverside, R.I.	Wylie 3140

hot winter patching material.

The actual operational control of such a state owned plant would be under the Bureau of Maintenance, which would set up and schedule the plant's operation around pothole patching. This type of an arrangement would be just the opposite of a commercial plant, for the daily patching quantities that are normally needed are quite low as compared to the plant's average daily production. Also, a not too infrequent occurrence is for the commercial plant either not to be mixing top course on that day or not to be operating at all when patch is needed. Since the principal use for the state owned drum plant would be producing material for pothole patching, it is hoped that most of these problems would be eliminated. Along the same line of thought, problems with outside contracts, delivery, availability, and other penalty clauses could be avoided with a state owned drum plant.

It must be stated that with the size of the unit recommended (50 + ton per hr.) only patching operation could be supplied, paving of any type would be out of the question. The delays involved would be too great.

A typical drum dryer mixer plant of the type observed would be a relatively easy unit to operate. One man would operate the control panel which electrically controls practically the entire operation. To begin production, a start up sequence is followed. Any deviation from the prescribed procedure results in the automatic interlocks taking over to shut everything off. Also, if anything should happen while the unit is operating, such as running out of aggregate, the interlocks again take over. Therefore, the operation is relatively safe.

A front end loader operator would be required to replenish the aggregate supply. Sand would be placed in one side of the two bin hopper and stone in the other. An adjustable gate at the bottom of the hopper can be positioned to regulate the flow of aggregates to achieve the proper proportions needed.

The entire asphalt supply lines are jacketed including the asphalt pump through which a special heated oil is circulated. Also, the asphalt supply tank contains its own heat source to bring the asphalt up to a working temperature when it can be pumped into the injectors. Therefore, a true asphalt cement could be used without fear of line blockage in cold weather caused by solidifying asphalt cement.

However, it must be pointed out that this type of plant is not a panacea for the winter hot mix problems. As stated in other sections not all the yards which now have a McConnoughay mixer or use of hot mix would get a drum plant. Its output and cost could not justify that. It should be assigned only to a few selected yards in a high patching area where the use of the unit could justify its purchase.

F. Survey of Commercial Asphalt Plants:

All the asphalt plants in New Jersey were surveyed to determine if any would be interested in supplying hot plant mix during the winter months to nearby maintenance crews.

Table 12 is a tabulation of the replies received. Out of 67 firms contacted 49 questionnaires were returned. Of those, only 13 stated that they would be open all or part of the winter months. Three of these stated they would be open all winter, the rest would close at various times for at least one month. Of the 13, nine had

TABLE 12
 ASPHALT PLANT QUESTIONNAIRE RESULTS
 SURVEY QUESTIONS

<u>Asphalt Plant and Location</u>	<u>#1 Dates Operating</u>	<u>#2 Minimum Demand To Remain Open</u>	<u>#3A Store Materials In Silos</u>	<u>#3B How Long</u>	<u>#4 NJDOT Contract</u>	<u>Comments</u>
Arawack Paving Co., Inc. Hammonton	March 15 to December 31	500 tons	No	-	Yes	
Barrett Asphalt Bound Brook	No reply.					
Barrett Asphalt Oldwick	Plant not in operation for 1976 season.					
Barrett Paving Materials Summit	April 20 to December 20	No	No	-	Yes	
Barrett Asphalt, A.E. Trenton	April 1 to December 1	No	No	-	Yes	Plant Closed
Barrett Inc., G.A. Woodbine	No reply.					
Bergen Asphalt Corp. Bogota	April 1 to December 30	300 tons/day 5 days/week	No	-	No	
Bordentown Materials, Inc. Bordentown	No reply.					
Bossert R. & Co., Inc. Newark	March 1 to February 1	100 tons	Yes*	5 days	No	*Under guarantee pick-up only
Brick-Wall Corp. Lacey Twp.	March to December	300 tons	Yes	18 hours	Yes	

TABLE 12 (CONT'D)

Burlington Asphalt Corp. Mt. Holly	Weekdays, Intermittent during winter	500 tons	Yes	4 days	Yes	
Clemente, A., Inc. Upper Penns Neck Twp.	February 1 to December 31	No	No	-	No	
DeSorte Assoc. Co. Albion	April to November	No	No	-	Yes	
Earle Asphalt Co. Jackson	No reply.					
Edison Asphalt Corp. Edison	March 1 thru December 31	500 tons	Yes	4 days	Yes	Wants to bid separately on winter Material
Edgewood Bit. Prods. Atco	No reply					
Ferrante & Sons, Inc. Bernardsville	To December 1*	200 tons	No	-	Yes	*Either plant will open during Jan., Feb., & March de- pending upon Main- tenance schedule & weather conditions
Ferrante & Sons, Inc. Flemington	To December 15*	200 tons	No	-	Yes	
Flanders Asphalt & Concrete Co. Flanders	No reply.					
Garwood Asphalt, Inc. Westfield	April to December	No	No	-	No	
Hamburg Quarries, Inc. Hamburg	April 1 to November 30	100 tons	No	-	No	
Houdaille Const. Matis., Inc. Morristown	No reply.					

TABLE 12 (CONT'D)

Intercounty Paving, Inc. Mt. Olive	April 1 to December 24	No	No	-	Yes	
J&D Bituminous Prods., Inc. Berlin	March to January	50 tons	No	No	No	
Jackson Asphalt & Concrete Co. Jackson Twp.	No reply.					
Johnson Const. Co. Bayville	All year.	-	Yes	1 day	No	
Kramer Asphalt Corp. Pequest	March to November	Yes	No	-	No	
Lafferty Asphalt Co., Inc. Voorhess Twp.	No reply.					
Limestone Products Lafayette	April 15 to December 1	250 tons	No	3 days	Yes	
Little Ferry Asphalt Little Ferry	Open all year*	200 tons	Yes	3 days	Yes	*Closed two weeks in January.
Lyncar Corp Howell Twp.	Closed Feb. Open other 11 months	20 tons/day 5 days/week	No	-	Yes	
McDowell Inc., Fred Farmingdale	No reply.					
Meckel and Sons, Inc. Norma	April 1 to January 15	100 tons	No	-	Yes	
Mededith Paving Co. Cinnaminson Twp.	May 1 to December 15	Yes	Yes	2-3 days	No	

TABLE 12 (CONT'D)

Milford Asphalt Hewitt	March to December	No*	No	-	Yes	*Will not open in winter months
Mount Hope Mats. Corp. Wharton	March 1 to December 31	500 tons	No	-	Yes	
National Bituminous, Inc. Berlin	No reply.					
Newark Asphalt Corp. Newark	April 1 to January 7	No*	No	-	No	*Will not open in winter months
Newton Asphalt Co. Andover	March to December	No*	No	-	Yes	*Will not open in winter months
Nicol Asphalt Co. Lakehurst	March 1 to December 31	No*				*Will not open in winter months
Oldbridge Land Development Co., Inc. Oldbridge	Open all year	-	Yes	Depends on Demand	No	
Penn-Jersey Paving Mats., Inc. Mt. Bethel, Pa.	March 15 thru December 10	1000 tons	Yes	1 week	No	
Preakness Asphalt Corp. Totowa Boro	March to December	No	No	-	Yes	
So. Brunswick Asphalt, Inc. Dayton	Closed in winter	400 tons	Yes	72 hours	Yes	
South State, Inc. Bridgeton	March 1 to December 15	300 tons	No	-	Yes	
South State, Inc. Downer	No reply					
Stavola Const. Co., Inc. New Shrewsbury	Open all year*	300 tons (Total all customers)	Yes	-	Yes	*When temperature is 30°F or higher

TABLE 12 (CONT'D)

Stone, Inc., A.E. Pleasantville	No reply.					
Trap Rock Ind. Columbus	March 1 to December 1	100 tons*	No	-	Yes	*With two days notice
Trap Rock Ind. Kingston	"	"	"	"	"	"
Trap Rock Ind. Lambertville	"	"	"	"	"	"
Trap Rock Ind. Runnemede	"	"	"	"	"	"
Trap Rock Ind. South River	"	"	"	"	"	"
Tri-County Asphalt, Inc. Hopatcong	March 15 to December 15	-	No	-	Yes	
Tri-County Asphalt, Inc. Rockaway	March 1 to January 31	-	No	-	Yes	
Tri-County Asphalt, Inc. Roseland	February 1 to December 31	-	No	-	Yes	
Turvan Asphalt Co., Inc. Kearney	No reply.					
Twin Bridges, Inc. Keasbey	No reply.					
Union Paving Co. Delair	March 15 to December 15	No*	No	-	Yes	*Would not open during the winter
Uniset Asphalt Sales Co. Watchung	Open all year	10 tons	No	-	No	
Versaggi Bros. Constr. Co., Inc. Whitesboro	March 15 to December 31	No*	No	-	No	*Would not open during the winter
Warner Co. Morrisville, Pa.	April 1 to beginning of cold weather	No*	No	-	No	*Would not open during the winter

TABLE 12 (CONT'D)

Warren Brothers Co. Prospect Park	March 15 to January 30	Yes	Yes	1 day	Yes
Warren Brothers Co. Secaucus	No reply.				
Warren Limestone Co., Inc. Oxford	No reply.				
Warren Paving Co. Stewartsville	No reply.				
Weldon Asphalt Corp. Linden	April 15 to December 1	No*	-	-	*Would not open during winter

Department Maintenance contracts for asphalt mix, four did not have any contract.

Of the 36 who would not be open, 16 stated that they would not open under any circumstance, whereas the rest could be persuaded to open up for a certain minimum guaranteed pick up order, which ranged from 100 tons per week to 1000 tons per day. A number of the plants which responded stated that they wanted to bid on hot winter mix separately from the normal hot mix supplied the rest of the year. It is assumed that the price for the material would be increased accordingly. Therefore, to entice other plants to consider remaining open, a special contract for the purchase of hot winter patching material may have to be drawn up.

To utilize those plants that would remain open during the winter a number of obstacles have to be overcome. The supply logistics have to be worked out for the maintenance yards. Since most of the open plants do not remain open all year long, more than one plant may have to be combined to obtain coverage for the entire winter months. Penalties have to be assessed for a plant not opening when there is a demand for patch material. The Department may have to guarantee that a minimum quantity of material will be picked up each week.

As a side note, it was planned during the winter 1976-77 to obtain hot material from a nearby asphalt plant that was supposed to remain open. However, that particular plant never opened until spring. This was true of other nearby plants contacted. It appears that the severity of the winter of 1976-77 forced many of the commercial plants to change their minds about remaining open. It appeared that few if any statewide were open at all.

To analyze which open plant would best serve what yard, numerous tables were developed. Table 13 lists the statewide winter of 1975-76 asphalt usage for each maintenance yard. As can be seen, some yards have a very low requirement for patch (15 to 30 tons per season) whereas others have an extremely high quantity (460 to 610 tons per season).

Table 14 lists all the yards by district and how far away from the various open asphalt plants they are (straight line distances). A "20" means that the yard is anywhere from 1 to 20 miles away from the plant. Twenty miles was decided to be the maximum allowable one way travel distance to pick up hot mix. Over that it is felt that too much time would be lost in travelling plus the material would lose too much heat on the back of the open dump truck. A "25" means that the yard is between 21 and 25 miles away from the asphalt plant. An "X" indicates that the distance involved was greater than 25 miles.

Table 15 is a compilation of all the open asphalt plants and a listing of the maintenance yards within 20 to 25 miles away plus the corresponding winter patching tonnage used.

A map was developed from all this data showing all the maintenance yards statewide and the open asphalt plants within a twenty mile radius (Figure 3). The information presented in this map and the various tables of this section could be used as the basis for developing contracts with asphalt plants for winter patching materials.

Analysis of it reveals that of the 66 statewide maintenance yards, supply of hot winter material to 28 of them is questionable. Eighteen yards have a definite supply problem for they probably will be unable to obtain hot material from any nearby asphalt plant.

TABLE 13
WINTER ASPHALT USAGE

<u>District I</u>		<u>District II</u>		<u>District III</u>		<u>District IV</u>	
<u>Yard</u>	<u>Tonnage</u>	<u>Yard</u>	<u>Tonnage</u>	<u>Yard</u>	<u>Tonnage</u>	<u>Yard</u>	<u>Tonnage</u>
Bedminster	375	Clifton	70	Bordentown	175	Bridgeport	150
Bloomsbury	85	Elizabeth	210	College Farm	135	Buena	75
Branchville	55	Fort Lee	110	Edgewater Pk.	35	Cherry Hill	260
Butler	115	Jersey City	100	Four Mile	155	Cumberland	75
Clinton	125	Lodi	295	Freehold	760	Deepwater	185
Columbia	75	Newark	370	Hazlet	105	Deptford Twp.	185
East Hanover	465	Paterson	160	Hightstown	260	Elmer	220
Flemington	25	Ridgewood	65	Kingston	115	Folsom	75
High Point	15	Secaucus	110	Lakehurst	230	Glassboro	460
Netcong	180	Springfield	315	Lawrenceville	610	McKee City	210
Rockaway	385	Totowa	215	Manahawkin	200	Middle Twp.	100
Somerville	385	West Orange	<u>25</u>	Metuchen	160	Pennsauken	30
Sussex	115	TOTAL	2,045	Ocean Twp.	165	Petersvurg	75
Washington	50			Parkway	50	Pomona	170
W. Amwell	80			Red Lion	320	W. Berlin	160
Yellow Frame	<u>185</u>			Robbinsville	155	W. Deptford	<u>110</u>
TOTAL	2,715			Sandhill	50	TOTAL	2,540
				Sayreville	195		
				Toms River	215		
				Wall Twp.	295		
				W. Trenton	185		
				Woodbridge	<u>70</u>		
				TOTAL	4,640		

TABLE 14
DISTANCE TO NEARBY ASPHALT PLANTS (MILES)

DISTRICT I

Yard	Ferrante Bernardsville	Ferrante Flemington	Tri-County Rockaway	Tri-County Roseland	Uniset Watchung	Little Ferry Asphalt Little Ferry	Oldbridge Land Development Madison Township	Bossert Newark
Bedminster	20	20	20	25	20	X	25	X
Bloomsbury	25	20	X	X	X	X	X	X
Branchville	X	X	25	X	X	X	X	X
Butler	25	X	20	20	25	20	X	25
Clinton	20	20	25	X	25	X	X	X
Columbia	X	X	X	X	X	X	X	X
East Hanover	20	X	20	20	20	25	X	20
Flemington	25	20	X	X	25	X	X	X
High Point	X	X	X	X	X	X	X	X
Netcong	20	X	20	25	X	X	X	X
Rockaway Twp.	20	X	20	20	25	X	X	X
Somerville	20	20	25	25	20	X	25	X
Sussex	X	X	25	X	X	X	X	X
Washington	20	20	25	X	X	X	X	X
West Amwell	X	20	X	X	X	X	X	X
Yellow Frame	25	X	20	X	X	X	X	X

TABLE 14
(CONTINUED)
DISTRICT II

Yard	Ferrante Bernardsville	Tri-County Rockaway	Tri-County Roseland	Uniset Watchung	Little Ferry Asphalt Little Ferry	Oldbridge Land Development Madison Township	Bossert Newark
Clifton	X	20	20	20	20	X	20
Elizabeth	20	25	20	20	20	20	20
Fort Lee	X	X	20	X	20	X	20
Jersey City	X	X	20	20	20	X	20
Lodi	X	25	20	25	20	X	20
Newark	25	25	20	X	20	25	20
Paterson	X	25	20	25	20	X	20
Ridgewood	X	25	20	X	20	X	20
Secaucus	X	25	20	25	20	X	20
Springfield	20	20	20	20	20	25	20
Totawa	25	20	20	25	20	X	20
West Orange	20	20	20	25	20	X	20

TABLE 14

(CONTINUED)

DISTRICT III

Yard	Stravola New Shrewsbury	Lyncar Howell Twp.	Uniset (Weldon) Watchung	Ferrante Bernardsville	Ferrante Flemington	Tri-County Rockaway	Tri-County Roseland	Little Ferry Asphalt Little Ferry	Johnson Con- struction Bayville	Oldbridge Land Development Madison Twp.	Bossert Newark	Burlington Asphalt Mount Holly
Bordentown	X	X	X	X	X	X	X	X	X	X	X	20
College Farm	25	X	20	20	25	X	X	X	X	20	25	X
Edgewater Pk.	X	X	X	X	X	X	X	X	X	X	X	X
Four Mile	X	X	X	X	X	X	X	X	25	X	X	20
Freehold	20	20	X	X	X	X	X	X	X	20	X	X
Hazlet	20	20	20	X	X	X	X	X	X	20	25	X
Hightstown	25	20	X	X	25	X	X	X	X	20	X	25
Kingston	X	X	25	25	20	X	X	X	X	20	X	X
Lakehurst	20	20	X	X	X	X	X	X	20	X	X	X
Lawrenceville	X	X	X	X	20	X	X	X	X	25	X	20
Manahawkin	X	X	X	X	X	X	X	X	20	X	X	X
Metuchen	25	X	20	20	X	X	20	X	X	20	20	X
Ocean Township	20	20	X	X	X	X	X	X	25	20	X	X
Parkway	X	X	20	20	X	25	20	25	X	20	20	X
Red Lion	X	X	X	X	X	X	X	X	X	X	X	20
Robbinsville	X	25	X	X	25	X	X	X	X	25	X	20
Sandhill	X	X	20	25	20	X	X	X	X	20	X	X
Sayreville	20	25	20	25	X	X	25	X	X	20	20	X
Toms River	25	20	X	X	X	X	X	X	20	X	X	X
Wall Twp.	20	20	X	X	X	X	X	X	20	25	X	X
West Trenton	X	X	X	X	20	X	X	X	X	X	X	20
Woodbridge	25	X	20	20	X	X	20	X	X	20	20	X

TABLE 14
(CONTINUED)
DISTRICT IV

Yard	Burlington Asphalt Mount Holly	Clemente Upper Penns Neck Township
Bridgeport	X	20
Buena	X	X
Cherry Hill	20	X
Cumberland	X	X
Deepwater	X	20
Deptford Township	20	25
Elmer	X	20
Folsom	X	X
Glassboro	X	20
McKee City	X	X
Middle Township	X	X
Pennsauken	20	X
Petersburg	X	X
Pomona	X	X
W. Berlin	20	X
W. Deptford	25	25



NOTES

- Maintenance Yard
- △ Open Commercial Asphalt Plant.
Shaded area is covered by
an open asphalt plant within
a 20 mile radius

TABLE 15

MAINTENANCE YARDS NEAR OPEN ASPHALT PLANTS

Ferrante - Bernardsville

<u>Yards Within 20 Mile Radius</u>		<u>Winter Tonnage</u>
Bedminster		375
Clark (Parkway)		50
Clinton		125
East Hanover		465
Elizabeth		210
Metuchen		160
Netcong		180
North Brunswick		135
Rockaway Twp.		385
Somerville		385
Springfield		315
Washington		50
West Orange		25
Woodbridge		70
	Subtotal	2,930
<u>21 - 25 Mile Radius</u>		
Bloomsbury		85
Butler		115
Clifton		70
Flemington		25
Kingston		115
Newark		370
Sand Hill		50
Sayreville		195
Totowa		215
Yellow Frame		185
	Total	4,355

TABLE 15 (CONT'D)

Ferrante - Flemington

<u>Yards Within 20 Mile Radius</u>		<u>Winter Tonnage</u>
Bedminster		375
Bloomsbury		85
Clinton		125
Flemington		25
Kingston		115
Lambertville		80
Lawrence Twp.		610
Sand Hill		50
Somerville		385
Washington		50
West Trenton		185
	Subtotal	2,085
 <u>21 - 25 Mile Radius</u>		
Highstown		260
North Brunswick		135
Robbinsville		155
	Total	2,635

Tri-County - Rockaway

<u>Yards Within 20 Mile Radius</u>		<u>Winter Tonnage</u>
Bedminster		375
Butler		115
Clifton		70
East Hanover		465
Netcong		180
Rockaway Twp.		385
Springfield		315
Totowa		215
West Orange		25
Yellow Frame		185
	Subtotal	2,330
 <u>21 - 25 Mile Radius</u>		
Branchville		55
Clark		50
Clinton		125
Elizabeth		210
Lodi		295
Newark		370
Paterson		160
Ridgewood		65
Secaucus		110
Somerville		385
Sussex		115
Washington		50
	Total	4,320

TABLE 15 (CONT'D)

Stavola - New Shrewsbury

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>
Freehold	760
Hazlet Twp.	105
Lakehurst	230
Ocean Twp.	165
Sayreville	195
Wall Twp.	295
Subtotal	1,750
<u>21 - 25 Mile Radius</u>	
Hightstown	260
Metuchen	160
North Brunswick	135
Toms River	215
Woodbridge	70
Total	2,590

Lyncar - Howell Twp.

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>
Freehold	760
Hazlet Twp.	105
Hightstown	260
Lakehurst	230
Ocean Twp.	165
Toms River	215
Wall Twp.	295
Subtotal	2,030
<u>21 - 25 Mile Radius</u>	
Robbinsville	155
Sayreville	195
Total	2,380

TABLE 15 (CONT'D)

Tri-County - Roseland

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>	
Butler	115	
Clark	50	
Clifton	70	
East Hanover	465	
Elizabeth	210	
Fort Lee	110	
Jersey City	100	
Lodi	295	
Metuchen	160	
Newark	370	
Paterson	160	
Ridgewood	65	
Rockaway Twp.	385	
Secaucus	110	
Springfield	315	
Totowa	215	
West Orange	25	
Woodbridge	70	
	Subtotal	3,290
<u>21 - 25 Mile Radius</u>		
Bedminster	375	
Netcong	180	
Sayreville	195	
Somerville	385	
	Total	4,425

TABLE 15 (CONT'D)

Uniset - Watchung

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>
Bedminster	375
Clark	50
Clifton	70
East Hanover	465
Elizabeth	210
Hazlet Township	105
Jersey City	100
Metuchen	160
Newark	370
North Brunswick	135
Sand Hill	50
Sayreville	195
Somerville	385
Springfield	315
West Orange	25
Woodbridge	70
Subtotal	3,080
<u>21 - 25 Mile Radius</u>	
Butler	115
Clinton	125
Flemington	25
Kingston	115
Lodi	295
Netcong	180
Paterson	160
Rockaway Twp.	385
Secaucus	110
Totowa	215
Total	4,805

TABLE 15 (CONT'D)

LITTLE FERRY ASPHALT - LITTLE FERRY

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>
Butler	115
Clifton	70
Elizabeth	210
Fort Lee	110
Jersey City	100
Lodi	295
Newark	370
Paterson	160
Ridgewood	65
Secaucus	110
Springfield	315
Totowa	215
West Orange	25
Subtotal	2,150
<u>21 - 25 Mile Radius</u>	
Clark	50
East Hanover	465
Total	2,675

Johnson Construction - Bayville

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>
Lakehurst	230
Manahawkin	200
Toms River	215
Wall Twp.	295
Subtotal	940
<u>21 - 25 Mile Radius</u>	
Four Mile	155
Ocean Twp.	165
Total	1,260

TABLE 15 (CONT'D)

Clemente - Upper Penns Neck Twp.

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>
Bridgeport	150
Deepwater	185
Elmer	220
Glassboro	460
Subtotal	1,015
<u>21 - 25 Mile Radius</u>	
Deptford Twp.	185
West Deptford	110
Total	1,310

Oldbridge Land Development - Madison Twp.

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>
Clark	50
Elizabeth	210
Freehold	760
Hazlet Twp.	105
Hightstown	260
Kingston	115
Metuchen	160
North Brunswick	135
Ocean Twp.	165
Sand Hill	50
Sayreville	195
Woodbridge	70
Subtotal	2,275
<u>21 - 25 Mile Radius</u>	
Bedminster	375
Lawrence Twp.	610
Newark	370
Robbinsville	155
Somerville	385
Springfield	315
Wall Twp.	395
Total	4,780

TABLE 15 (CONT'D)

Bossert - Newark

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>
Clark	50
Clifton	70
East Hanover	465
Elizabeth	210
Fort Lee	110
Jersey City	100
Lodi	295
Metuchen	160
Newark	370
Paterson	160
Ridgewood	65
Sayreville	195
Secaucus	110
Springfield	315
Totowa	215
West Orange	25
Woodbridge	70
Subtotal	2,985
<u>21 - 25 Mile Radius</u>	
Butler	115
Hazlet Twp.	105
North Brunswick	135
Total	3,340

Burlington Asphalt - Mt. Holly

<u>Yards Within 20 Mile Radius</u>	<u>Winter Tonnage</u>
Bordentown	175
Cherry Hill	260
Deptford Twp.	185
Edgewater Park	35
Four Mile	155
Lawrence Twp.	610
Pennsauken	30
Red Lion	320
Robbinsville	155
West Berlin	160
West Trenton	185
Subtotal	2,270
<u>21 - 25 Mile Radius</u>	
Hightstown	260
West Deptford	110
Total	2,640

These yards are predominately in the northwestern and the southernmost parts of the state. Ten yards may have an intermittent supply of hot winter mix - predominately in the lower central portion of the state - for the plants nearby will not remain open all winter and coverage could not be obtained from another nearby plant.

For these areas especially, another source of hot patch mix will have to be obtained, such as from assignment of a McConnoughay mixer or if justified, purchase of a centrally located state owned drum dryer mixer asphalt plant.

Coverage for the northeast and upper central areas of the state is excellent with usually two or more plants to choose from.

As stated previously, the logistics have to be worked out once the plants that will definitely remain open during the winter months are known as to which yard will obtain material from which open plant.

G. Asphalt Cement Storage Tank and Metering System:

If a true asphalt cement could be utilized in a McConnoughay mixer in place of the cutback asphalt oils currently used the quality of the mix should greatly improve. An investigation of the mechanics necessary to transfer this desire into reality on the McConnoughay mixer was undertaken.

To accomplish this, especially when dealing with the cold winter months, the asphalt cement must be kept quite hot (300 + °F) in order to circulate it through the asphalt supply system. This means that a separate heated storage tank would be required for the small tank on the McConnoughay mixer would be inadequate. Also, the

McConnoughay mixer's supply lines and asphalt pump are not jacketed. As soon as the hot asphalt cement was pumped into a non heated section, it would begin to solidify and block the entire line. Therefore, the entire present supply lines, including the asphalt pump would have to be replaced with a jacketed system in which a special heating oil would be circulated. This also would require another external heating unit separate from the McConnoughay mixer.

Various vendors were contacted and price quotes were obtained. After analyzing this information, the modification proved to be too costly (upwards of \$10,000) to be justified based on the output of the McConnoughay mixer. Then too, even if this item and others like it were purchased to be added to the McConnoughay mixer, the end result would be to have all the ancillary features of a hot mix asphalt plant without having the production capabilities of an asphalt plant. Therefore, it would be better to start off with a hot mix asphalt plant, than to try to turn the McConnoughay mixer into one.

H. Economic Analysis of Production Methods:

1. General:

There are various factors that must be taken into consideration when deciding which method of obtaining hot patching material during the winter months is most advantageous. Among these are the initial purchase outlay, the convenience (or inconvenience) of operation, and the actual cost per ton of material.

While the McConnoughay mixer purchase price is only approximately \$7,000 a considerable number of units would have to be purchased for effective statewide coverage.

The drum dryer mixer plant costs between \$50,000 to \$70,000 but has a production capability which would allow it to service at least 10 trucks an hour at an output of 50 tons/hr.

While the use of commercial asphalt plants requires no capital investment, there is also no assurance that hot mix will be available when required in the off season. During inclement or extremely cold weather it is simply not economically feasible for a producer to run his plant for the relatively small quantity of material required for patching.

The best situation would appear to be a combination of all three methods. If an asphalt plant is going to remain open during the winter (or even only part of the time) an agreement should be made that would enable nearby crews to obtain hot material from these open plants whenever material is available.

In those areas where the demand is great enough and no open plants exist, a drum dryer mixer plant should be purchased and set up at a centrally located yard. In the areas where there is not sufficient demand to warrant a drum plant, a McConnoughay mixer should be sufficient. Where the use of winter patch is so extremely low that even a McConnoughay mixer couldn't be justified and no other source is nearby, cold patch could be stockpiled.

2. Development of Cost Data:

To obtain the tonnage cost figures for the various production methods, the costs for the equipment, the manpower, and the material requirements must all be included.

Table 16 lists these expenses. The individual equipment costs were obtained from the Bureau of Equipment, while the Bureau of

TABLE 16
PRODUCTION EXPENSES

Manpower Costs

McConnoughay operator	\$38/day
Loader operator	\$42/day

Patch Crew

Truck driver & 3 laborers	\$18.25/hr.
------------------------------	-------------

Equipment Costs

Dump truck crew cab	\$3,50/hr.
McConnoughay	\$1.75/hr.
Loader	\$2.50/hr.

Supplies

Aggregates, asphaltic oil, fuel, and mineral filler for the McConnoughay mixer	\$15.00/ton of patch
--	----------------------

FABC hot mix purchased at a commercial plant	\$15/ton
---	----------

Maintenance supplied information on the personnel salaries and material costs.

To develop the final cost figures, average waiting and operating times for the men and equipment were developed based on the information in the daily reports made out during the production phase of the study. The waiting time represents that time lost to unproductive work commencing from the time the men start in the morning to when the loaded truck leaves the yard. If more than one truck was involved and had to travel to get to the plant site, its travel time is averaged in with the waiting time and that number is used for the cost calculations. It should be realized that when dealing with averages, half the trucks will leave before that time and the other half after that time, but totaled together, this is what they averaged. All the figures have been rounded out to the nearest 1/2 hour and whole dollar.

3. Ridgewood Yard:

Table 17 lists the McConnoughay mixer production expenses for the Ridgewood Maintenance Yard. These cost figures should be typical for other single operation yards.

Costs for four different cases were developed for the Ridgewood Yard, reflecting the original system and modifications to it.

The first case represents the present system. All the men start at 7:30 a.m. It takes approximately 2 hours to heat up the asphaltic oil and another 1 1/2 to 2 hours to mix three tons of patch material. It is very close to lunch time before the men leave the yard to patch. The actual cost per ton for this operation comes to \$76.

TABLE 17

DAILY MCCONNOUGHAY PRODUCTION EXPENSES

FOR RIDGEWOOD MAINTENANCE YARD

<u>Item</u>	<u>Case I</u> <u>(Present System)</u>	<u>Case II</u> <u>(1 hr. earlier)</u>	<u>Case III</u> <u>(2 tons + 1 hr.)</u>	<u>Case IV</u> <u>(dried agg. + 1 hr.)</u>
Salaries				
McConnoughay & Loader Operators	\$80	\$80	\$80	\$80
Patch Crew	\$73 (4 hrs.)*	\$36.50 (2 hrs.)	\$27 (1 1/2 hrs.)	\$27 (1 1/2 hrs.)
Equipment				
Dump truck crew cab	\$14 (4 hrs.)*	\$7 (2 hrs.)	\$5 (1 1/2 hrs.)	\$5 (1 1/2 hrs.)
McConnoughay mixer	\$7 (4 hrs.)*	\$7 (4 hrs.)	\$7 (4 hrs.)	\$7 (4 hrs.)
Loader	\$10 (4 hrs.)**	\$10 (4 hrs.)	\$10 (4 hrs.)	\$10 (4 hrs.)
Supplies	<u>\$45 (3 tons)</u>	<u>\$45 (3 tons)</u>	<u>\$30 (2 tons)</u>	<u>\$45 (3 tons)</u>
TOTAL	\$229	\$194.50	\$159	\$174
Cost/ton	\$76	\$65	\$80	\$58

*Waiting time.

**Actual operating time.

Modifying the present system by having the two operators come in one hour earlier (Case II) to heat up the asphaltic oil and prepare the unit drops the cost to \$65 per ton, a savings of 15% over Case I. No overtime for operators would be needed as the McConnoughay operations would be completed sufficiently early in the day to allow the men to leave one hour earlier.

If however only two tons of material is made (Case III), the cost jumps to \$80 per ton, a 23% increase over Case II.

If the aggregate is pre-dried and/or stored in a dry shed, at least one half hour, time to make the mix could be saved (Case IV). The resultant cost drops to \$58 per ton, an 11% savings over Case II and a 24% savings over the original process [Case I (Table 18)].

4. Newark Yard

Table 19 lists the cost figures for the Newark operation which would be typical for an operation where the McConnoughay mixer is used as a central batch plant for several yards. The operators in Newark already have been coming in one hour early to start the heating of the asphaltic oil. On the average, five trucks obtained a total patch load of 10 tons after travelling and waiting 2 1/2 hours.

Using these parameters, Newark's cost per ton was calculated at \$52 per ton, which is much lower than Ridgewood's figures. However, only two tons of material was placed on each truck as opposed to Ridgewood's three tons. The load of each of Newark's trucks was limited to 2 tons each to enable the last truck to leave the yard before lunch time. If each truck was to have more than two tons, the average waiting time would be increased meaning that the last truck would leave after lunch. Batching the loads (supplying more than one

TABLE 18
POTENTIAL SAVINGS FOR THE
RIDGEWOOD OPERATION

Case II	15% savings over Case I
Case III	23% mor costly than Case II
Case IV	11% savings over Case II
	24% savings over Case I

TABLE 19
DAILY MCCONNOUGHAY PRODUCTION EXPENSES
FOR NEWARK MAINTENANCE YARD

Salaries	
McConnoughay & Loader Operators Patch Crews (5)	\$80 \$228 (2 1/2 hrs.)
Equipment	
Dump truck crew cab (5) McConnoughay Loader	\$45 (2 1/2 hrs.) \$ 9 (5 hrs.) \$12.50 (5 hrs.)
Supplies	<u>\$150 (10 tons)</u>
TOTAL	\$524.50
Cost/ton	\$52

Operating factors: 5 trucks, 10 ton total, 1 hour
earlier, 2 1/2 hour average travel
and waiting time

truck) results in a lower cost per ton since the overhead, such as the time wasted during the preliminary task of heating up the asphaltic oil, is spread out over a larger quantity output.

The optimum is probably in the two to three truck range. With more than three trucks considerable time will be lost in waiting to be loaded. This would mean that the average McConnoughay yard would be most efficient if it produced mix for its own truck (or two) plus one from a nearby yards.

5. Drum Dryer Mixer Plant:

Table 20 lists the costs for a typical drum dryer mixer plant. The information related to this type of plant was collected during several field trips to Hempstead, New York where the township is operating an Addco drum dryer mixer. The costs were developed for ten patching crews travelling and waiting an average of 1 1/2 hours to pick up material. Cost figures were developed for both three ton load and five ton load. The 3 ton load was a normal load using the McConnoughay mixer whereas with the drum plant, a 5 ton load is possible without any noticeable increase in waiting time.

The depreciation and maintenance figures used in the calculations are only estimates obtained from industry representatives, as opposed to more exact figures obtained for the equipment and manpower hourly costs. This type of unit is too new and too few are in operation to have exact figures. The depreciation figure is based on an initial purchase price of \$50,000, a ten year estimated life, and use during a patch season of 100 days per year. The maintenance figure is based on an estimated cost of 5% of the initial purchase

TABLE 20
ESTIMATED PRODUCTION EXPENSES FOR
A DRUM DRYER MIXER TYPE PLANT

<u>Item</u>	<u>Cost</u> 3 ton load	<u>Cost</u> 5 ton load
Salaries		
Plant & Loader Operators	\$80	\$80
Patching Crew (10)	\$274 (1 1/2 hrs.)	\$274
Equipment		
Dump truck crew cab (10)	\$53 (1 1/2 hrs.)	\$53
Loader	\$5 (2 hrs.)	\$5
Supplies	\$450 (30 ton)	\$750 (50 tons)
Subtotal	\$862	\$1162
Depreciation* & Maintenance**	<u>\$75</u>	<u>\$75 (\$1.50/ton)</u>
TOTAL	\$937	\$1237
Cost/ton	\$31	\$25

*Based on 10 yr. life (est.) & 100 patching days per year.

**Based on an estimated cost of 5% of initial purchase price per year (\$50,000).

price per year.

The cost per ton for a three ton load was calculated as \$32. When a five ton load was used, the cost per ton dropped 22% to \$25.

As compared to the cost figures obtained from operating the McConnoughay mixer in the Ridgewood and Newark Yards, the drum plant's cost per ton is approximately 40 to 45% less.

6. Commercial Asphalt Plant:

As can be seen in Table 21, cost figures for a typical open asphalt plant, the five ton load has the lowest cost per ton of any other method - \$21.50 per ton. This figures is based on an average of 10 patching crews picking up five tons of material, travelling and waiting an average of 1 1/2 hours and an average purchase price of \$15 per ton for the hot mix.

The asphalt plant cost is 25% less than using a state owned drum dryer mixer plant based on a three ton output and 16% less comparing a five ton output.

Therefore, of all the methods, obtaining the hot patching material from an asphalt plant is the most cost effective. This is assuming that one can be found which is willing to remain open.

TABLE 21
EXPENSES TO OBTAIN MATERIAL FROM
A NEARBY OPEN ASPHALT PLANT

<u>Item</u>	<u>Cost</u>	<u>Cost</u>
Salaries	3 ton load	5 ton load
Patching crew (10 trucks per hour)	\$274 (1 1/2 hrs.) \$27.40 per truck	\$274 (1 1/2 hrs.) \$27.40 per truck
Equipment		
Dump truck crew cab (10 trucks per hour)	\$53 (1 1/2 hrs.) \$5.30 per truck	\$53 (1 1/2 hrs.) \$5.30 per truck
Waiting & travel cost/ton	\$11/ton	\$6.50/ton
Purchase Price	<u>\$15/ton</u>	<u>\$15/ton</u>
Cost/ton	\$26/ton	\$21.50/ton

IV. IMPLEMENTATION

To implement the findings of this report, the following should be undertaken:

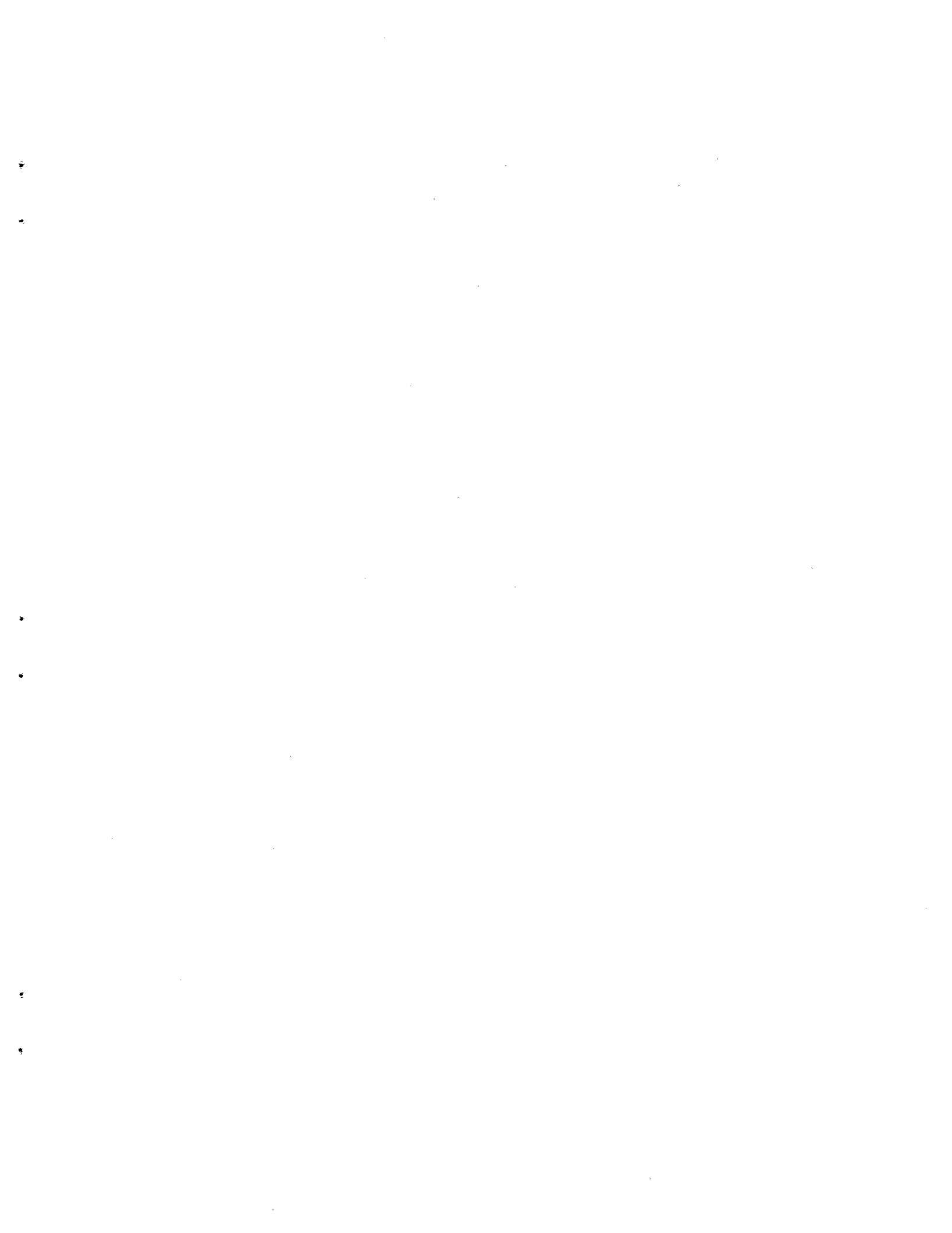
1. All the McConnoughay mixers statewide with an asphalt injection system should be updated according to the recommended modifications.
2. A training school to introduce the operators to the new modifications and operating procedures should be initiated.
3. Copies of the revised operating manual should be distributed to every McConnoughay operator and his foreman.
4. A meeting with the various asphalt producers should be held to finalize which plants will remain open during the upcoming winter.
5. Once it is determined which plant could be relied upon to remain open, the foreman of nearby maintenance yards would be instructed to obtain hot material from that source.
6. For those high usage areas not covered by an open plant, further thought should be given to assigning a state owned and operated drum dryer mixer asphalt plant.
7. The other yards not near an open asphalt plant would get hot material either from an assigned McConnoughay or from a nearby McConnoughay yard.

As this is being written, equipment modification of the McConnoughay fleet is getting underway. A number of them are being sent into the welding-machine shop for addition of the hopper extension.

V. BIBLIOGRAPHY

1. Indahl, G. W. et al, "Pavement Patching Techniques and Materials," New Jersey Department of Transportation, Report No. 75-010-7742, 1975.
2. "Poweray Model 4TSU - Portable Asphalt Storage Unit Parts and Service Manual," Poweray Infrared Corp., Farmingdale, New York, Undated.
3. "McConnoughay HTD-10 Mixer Operating, Service and Maintenance Manual," Asphalt Equipment Company, Fort Wayne, Indiana, Undated.
4. Manple, S. J., "Portable Drum Dryer Mixer for Maintenance," Idaho Division of Highways, 1975.

APPENDIX



OPERATING INSTRUCTIONS FOR MCCONNOUGHAY ASPHALT MIXERS

The following is the revised operating guide for the McConnoughay pugmill. The operator should familiarize himself with its contents and follow the instructions to achieve a quality mix.

It must be noted that the basis for this guide was the original instructions prepared by the McConnoughay manufacturer, which were amended with additional information obtained from this study.

A. Preliminary:

1. Service engine in accordance with Engine Manual. (Check and fill if necessary: engine fuel tank, burner fuel tank, asphalt tank, engine crankcase, etc.)
2. Service mixer in accordance with Service and Maintenance instructions (lubricate fittings, etc.).
3. Check the following items:
 - a. Asphalt supply line valves are closed
 - b. Asphalt pump is disengaged
 - c. Engine clutch is disengaged
 - d. Pugmill burner fuel line, asphalt tank burner fuel line and asphalt line flushing valves are closed
4. Start engine and allow to run at idle speed (Part #8)*

*Part number identifications refer to the illustrated parts list and update which is attached.

B. Heating Asphalt

1. Light asphalt tank burner (Part #6C)

Note: If a longer hose is attached to this burner, it will be possible to place it on the ground to light it. Raw kerosene partially on fire will be emitted by the burner until it becomes hot enough to vaporize the fuel. Once the burner is operating correctly, it can be placed back into position.

2. Since the asphalt tank temperature gauge (Part #6B) does not react instantaneously to temperature build-up, the burner should be shut off before the desired temperature is attained. If 175°F is desired, the burner should be shut off at approximately 140°F (this may vary from unit to unit and some experimentation may be required).

3. Since the asphalt material will expand when heated, care should be taken in not to overfill the tank. Keeping the level of material approximately 12"-18" from the top is desirable.

4. As the asphalt temperature approaches the cut-off point, the asphalt should be recirculated through the supply lines and back into the tank. To accomplish this, the following steps should be taken:

- a. Open asphalt valve by tank (Part #40)
- b. Close sampling line valve (Part #101)
- c. Open supply line valve upstream of injectors (Part #41)
- d. Open recirculating valve downstream of injectors (Part #102)

- e. Close both injector valves (Parts #103 & 104)
 - f. Engage asphalt pump (Part #39)
5. Once the asphalt reaches the proper temperature and mixing of material is to start, the recirculation of asphalt should stop.
- a. Disengage asphalt pump (Part #39)
 - b. Close recirculating valve downstream of injectors (Part #102)
 - c. Open both injector valves (Parts #103 & 104)

The asphalt supply system is now ready. The total time necessary to heat up the asphalt will take from 1 hour to 2 hours and possibly longer depending upon ambient temperature.

C. Mixing of Patching Material

1. Load the holding hopper at the front of the machine with premix aggregate. The leading and lowest edge of the hopper (not the hopper extension) equals the desired batch size (1000 lbs.[±]).
2. Light the main burner (Part #43) according to the Service and Maintenance Instructions Paragraph F-1. (Do not operate burner over two (2) minutes without material in the mixing chamber.)
3. Increase engine speed to maximum.
4. Open the inlet gate (Part #4A2) allowing the aggregate to enter the mixing chamber (pugmill). Close the gate and quickly refill the hopper with more aggregate.

Note: Whenever the main burner is lit, aggregate should be in the holding hopper. This precaution must be taken before injecting the asphalt into the pugmill, even if that aggregate in the hopper is not

needed for patch. This procedure not only prevents flames from shooting up the hopper when the burners are lit, but also in case of a fire this load could be dumped into the pugmill, smothering the fire inside.

5. Set the batch timer (Part #21B) for the desired length of heating time to dry the aggregate. The time necessary would depend upon the moisture content of the aggregate. Exceptionally wet aggregate (stored outside) would require approximately 3-4 minutes. The first load would need 4 minutes and 3 minutes for those that followed. If the aggregate was dry from being stored indoors, this step could be eliminated.

Note: To determine the proper time interval for aggregate drying, some experimentation is required. After the aggregate has been heated for the selected period of time, dump it out into the waiting front end loader. Insert a dial thermometer and read the temperature. For wet aggregate, a target value of 160-180°F is desired and the heating time should be adjusted accordingly to attain this value. If RC-800 is to be used in the patching mixture the aggregate should not be heated much higher than this value, as the RC-800 may flash when coming into contact with the overheated aggregate. Once the desired time interval is established, it should remain constant

for the rest of the season (unless the moisture content changes drastically).

Whenever material is being discharged, the main burner should be shut off before the discharge gate (Part #4B) is opened, to prevent the material from catching on fire as it is being dumped out. Relight the main burner before the inlet gate is opened.

The following steps have two versions depending upon - whether or not mineral filler is added.

I Mineral Filler Added

6. After heating the aggregate, dump it out into the front end loader.
7. Break a bag of mineral filler (70 lbs) on top of the aggregate in the loader bucket.
8. Open the inlet gate (Part #4A2), dumping in the aggregate that was in the holding hopper.
9. Preheat according to Step C.5.
10. Now dump the heated aggregate with mineral filler into the holding hopper.
11. After the second aggregate batch has been heated, dump it out, add filler, dump into pugmill first batch with filler, and place second batch back into hopper (Steps C.6,7,8,10).

12. Introduce the required amount of asphaltic material into the mixer by engaging the asphalt pump clutch for the required number of revolutions (which was determined from the pump calibration procedure) on the revolution counter (Part #44).

Note: The injectors should be checked for plugging when the pump is engaged. Look through the small inspection hole on the side to see if asphalt is being injected when the pump is engaged. The required number of revolutions should be added to the number on the counter when the asphalt starts to flow, otherwise not enough asphalt will be in the mix.

13. Disengage the asphalt pump clutch when the desired amount of asphalt has been introduced into the mixer. Reset the revolution counter to zero after each operation of the asphalt pump.

14. Set the batch timer for the desired mixing time. If the aggregate was preheated, the mixing time should be approximately 3 minutes (4 minutes for the first batch). If not preheated, 5-6 minutes would be required. The operator should take the temperature of the mix and adjust his times accordingly.

15. When the batch timer reaches zero, open the discharge gate, dumping the asphalt mix into the waiting front end loader for placement in a dump truck or a heated trailer.

16. Close discharge gate.

17. Open the inlet gate and dump in the second mineral filler- aggregate batch. Close the gate and quickly refill the hopper with more aggregate. Add asphalt and mix (Steps C.12 through 16).

Note: With this method two batches of aggregate are dried consecutively and then two batches mixed with asphalt consecutively.

The heated aggregate must be removed from the pugmill to add the filler. If the filler were added before the aggregate was dried all the filler would be blown out the stack during the drying process.

18. Repeat Steps C.1 through 17 as necessary to produce the desired number of batches.

II Without Filler

Omit Steps C-6,7,8,9,10,11 (C-6 through 11)

Follow Steps C-12,13,14,15,16 (C-12 through 16)

Then repeat Steps 1 thru 5, 12 thru 16 until required amount of material is produced.

19. For steps to follow in shutting down the mixer after each day's operation see Paragraph H of Service and Maintenance Instructions.

D. Operating Precautions

1. Do not operate the burners without material in the pugmill or asphalt tank.
2. Do not operate the fuel pump without fuel in the fuel tank.
3. Do not operate pump without liquified asphalt or fuel oil in it.
4. Keep V-belts tight by removing excess links.
5. Do not heat asphaltic materials above recommended temperatures.

6. If a cold mix is being reheated or rejuvenated, it may be necessary to leave the inlet gate open and shovel directly into the pugmill.

7. Discharge asphalt mix at approximately 250°F. Do not overheat as any asphalt mix will flash when heated excessively. Heat mixture at least to 225°F to drive off moisture.

8. Operate the asphalt mixer on firm and level ground.

9. Do not open asphalt tank lid while the burners are in operation.

SERVICE AND MAINTENANCE INSTRUCTIONS FOR MCCONNOUGHAY ASPHALT MIXERS

A. Engine (Part #8)

1. See Manufacturer's Recommendations in Wisconsin Engine Manual* for Service and Maintenance Instructions.

- a. Fill gasoline fuel tank with gasoline.
- b. Fill oil bath air cleaner with oil to the oil level mark.
- c. Fill engine crankcase with oil to mark on dip stick.
- d. Fill clutch housing with oil to oil level plug on side of clutch housing.

Note: To not start engine until the engine has been properly serviced.

B. Burner Fuel Tank (Part #21)

1. Fill fuel tank with kerosene.

*Included in Manual Packet supplied to yard when mixer is assigned.

C. Asphalt Tank (Part #6)

1. Fill asphalt tank with asphalt.
 - a. Do not overfill (keep asphalt level 12" to 18" from top to allow room for expansion of material when heated).
 - b. Do not operate tank burner (Part #6C) without asphalt in the tank to a level above the heater tube.

D. Lubrication

1. Mixer shaft bearings (Part #7)

Lubricate bearings on each end of mixer shaft (Part #7A) with a high temperature grease (heat resistant) such as Shell #HT-2, or Esso 4784.

- a. Lubricate every eight (8) hours of operation or more often if needed.
- b. Keep clean and free of excess grease and material.

2. Jack shaft bearings (Part #13)

- a. Lubricate bearings on each end of jack shaft (Part #12) with a good general purpose grease every eight (8) hours of operation.
- b. Keep clean and free of excess grease.

3. Blower and fuel pump jack shaft bearings (Part #36)

Lubricate bearings on each end of jack shaft every eight (8) hours of operation with a good general purpose grease.

4. Fuel pump shaft bearings (Part #22C)
 - a. Lubricate bearings on each end of fuel pump shaft every eight hours of operation with a good general purpose grease.
 - b. Keep clean and free of excess grease.
5. Asphalt pump (Part #39)
 - a. Lubricate daily.
 - (1) Use best grade of medium up grease for sleeve bearings and gland.
 - (2) Use bearing lubricant for thrust bearings.
 - b. Lubricate clutch grease fittings daily with a good general purpose grease.
 - c. Lubricate pump shaft bearings (Part #39A) daily with a good general purpose grease.
 - d. Keep all fittings and bearings clean and free of excess grease.
 - e. Do not operate the asphalt pump unless it contains kerosene.
6. Rubber counter belt (Part #46)

Keep clean and free of grease and material.

E. Adjustments

1. Engine (Part #8)

See Wisconsin Engine Manual.

2. Clutch

See Wisconsin Engine Manual.

3. V-Belts (Parts #20 & 31)

a. See Manufacturer's Recommendations.

b. Check often (daily for first week of operation) for tautness.

c. Remove excess links to increase tautness when deflection is greater than one (1) inch.

(1) Excessive looseness will cause:

(a) Excessive smoking of machine.

(b) Lack of fuel pressure on fuel gauges (Part #23)

(c) Incomplete burning of fuel in burner.

(d) Incomplete removal of solvents from cut-back asphalt used in the asphalt mix, resulting in the mix flashing when discharged from the asphalt mixer.

4. Roller chains (Parts #11 & 16)

All chains may be easily adjusted by moving the engine and/or jack shafts and coordinating one with the other.

5. Fuel pump (Part #22)

a. See Manufacturer's Recommendations

b. Pressure may be adjusted from 80 to 150 psi.

c. Normal use of 120 psi is satisfactory

6. Screws, nuts, bolts, pipe joints, allen screws, unions and pipe plugs.

Periodically tighten including the mixing blades cap screws (Part #7B).

7. Tires (Part #3A)
 - a. Periodically check tire pressure.
 - b. Inflate to manufacturer's recommended tire pressure.
8. Coil burner (Part #6C)
 - a. See Manufacturer's Recommendations

F. Burner Assemblies

1. Main burner assembly (Part #43)
 - a. Make a daily visual check to see that nozzles (Part #6A) are spraying properly.
 - b. Operate the burner at 100 psi to 120 psi on gauge (Part #23).
 - c. To light the burner, reduce the engine speed before opening valve (Part #38), and insert lighted torch through the hole with a sliding cover on the operator's side of the mixing chamber (pugmill). Do not open valve fully. Only open valve enough to light burner. Then open to achieve desired pressure.
 - d. Do not operate burner below 60 psi on gauge (Part #23), as it will drip fuel instead of atomizing it properly.
 - e. To clean the burner nozzles (Part #43A).
 - (1) Remove the cover plate (Part #43C).
 - (2) Withdraw the burner tube from the burner housing.
 - (3) Unscrew burner nozzles from burner tube.
 - (4) Clean both the nozzles and strainer screens.
 - (5) Reassemble by reversing the above procedure steps (5) through (1).

- f. Do not operate the burner over two (2) minutes without material (aggregate or asphaltic mix) in the mixing chamber.
- g. If asphalt mix is taking an excessive length of time to heat, follow the procedure in above paragraph e., also check tautness of V-belts (Parts #20 & 31).

2. Asphalt tank burner (Part #6C)

- a. Operate burner at approximately 20 psi on gauge (Part #23), but never operate above 30 psi.
- b. Do not operate burner unless the heat tube in the asphalt tank (Part #6) is completely covered with the asphaltic material.
- c. Operate burner only for the length of time needed to raise the temperature of the asphaltic material to the desired temperature, as shown on accompanying asphaltic temperature chart.

G. Calibration of Asphalt Pump (Part #39)

- 1. Calibration of the asphalt pump (Part #39) must be accomplished before the machine is put into operation.
- 2. Temperature of the asphaltic material in the asphalt tank (Part #6) must be at the working temperature as shown on the accompanying asphaltic temperature chart.
- 3. Calibrate the asphalt pump (Part #39) by the following method (with engine running):

- a. Shut off asphalt valve (Part #41) upstream of injectors.
- b. Open valve near tank (Part #40) and sampling line valve.
- c. Remove pipe plug.
- d. Engage asphalt pump clutch.
- e. Catch initial flow of asphaltic material in any suitable container for later use. When flow is uniform, quickly switch to a container of known capacity (a five gallon pail is suitable), noting the number on the revolution counter. When the container is full, disengage pump, and read the counter.
- f. Shut off sampling valve and replace plug.
- g. Divide the number of gallons in the container into the number of turns required to fill the container (difference between initial and final counter readings). The answer will be the number of revolutions needed to pump one (1) gallon of asphalt. (Number of turns divided by number of gallons equals number of revolutions needed to pump one (1) gallon.)

Note: By using the revolutions to the gallon obtained here, you can use any of several types of asphaltic material and obtain a satisfactory mix.

H. Cleaning Machine After Daily Usage

1. Allow the engine (Part #8) to idle for two or three minutes after the burner (Part #43) has been turned off. This will discharge any excessive heat and eliminate warping of the mixer.

2. After the burners have been turned off, introduce approximately one-half batch of aggregate into the mixing chamber (pugmill) to clean the mixing blades and pugmill. Discharge the material after approximately one (1) minute of mixing time and dispose of it.

3. Asphalt pump part (Part #39) and asphalt lines should be flushed with kerosene or fuel oil at the end of each day's mixing operation or the asphalt will harden and make the pump inoperative.

a. To flush asphalt pump and asphalt lines (with engine running):

- (1) Close the valve next to the asphalt tank (Part #40) and the valve upstream of the injectors (Part #41).
- (2) Open the sampling line valve and remove the pipe plug.
- (3) Place a container under opening to catch flow.
- (4) Open asphalt line flushing valve connected to the kerosene pump (Part #38).
- (5) Engage asphalt pump.
- (6) After the pump and lines have been flushed, disengage asphalt pump, shut off asphalt line flushing valve close sampling line valve, and replace plug.

- b. Allow some kerosene or fuel oil to remain in the pump and asphalt lines when flushing operation has been completed.

4. After the engine is stopped, remove any build-up of material behind and below inlet gate (Part #4A2) and close the gate when this operation is finished.

5. After the engine is stopped, open wide the discharge gate (Part #4B) and remove any build-up of material behind and below the gate. Leave the gate in the open position when the machine is not in use.

6. Clean any material that remains from the shoveling pan (Part #2) (if used) and spray with kerosene or solvent. Raise the pan and hook the supporting chains into the travel position.

7. Lubricate the machine according to the lubricating instructions, Paragraph D.

8. Fill fuel tank (Part #21) with kerosene.
9. Fill engine gasoline tank with gasoline.
10. Fill asphalt tank (Part #6) with asphaltic material.

ASPHALTIC TEMPERATURE CHART

<u>ASPHALT CEMENT</u>	<u>RECIRCULATION TEMP.</u>	<u>WORKING TEMP.</u>	<u>FLASH POINT</u>
AC 85-100 penetration	200 Deg. F.	300 Deg. F.	450 Deg. F.
AC 100-120 "	200 Deg. F.	300 Deg. F.	425 Deg. F.
AC 120-150 "	175 Deg. F.	300 Deg. F.	425 Deg. F.
AC 150-200 "	175 Deg. F.	300 Deg. F.	425 Deg. F.

CUT-BACK ASPHALT

RC 5 - 3000	105 Deg. F.	200 Deg. F.	80 Deg. F.
RC 4 - 800	75 Deg. F.	175 Deg. F.	80 Deg. F.
RC 3			

MC 5 - 3000	105 Deg. F.	225 Deg. F.	150 Deg. F.
MC 4 - 800	75 Deg. F.	200 Deg. F.	150 Deg. F.
MC 3	60 Deg. F.	175 Deg. F.	150 Deg. F.

ASPHALT EMULSION

RS 1	60 Deg. F.	120 Deg. F.	DO NOT HEAT
MS 1	60 Deg. F.	120 Deg. F.	ABOVE
MS 2	60 Deg. F.	120 Deg. F.	150 Deg. F.
MS 3	60 Deg. F.	120 Deg. F.	IN TANK

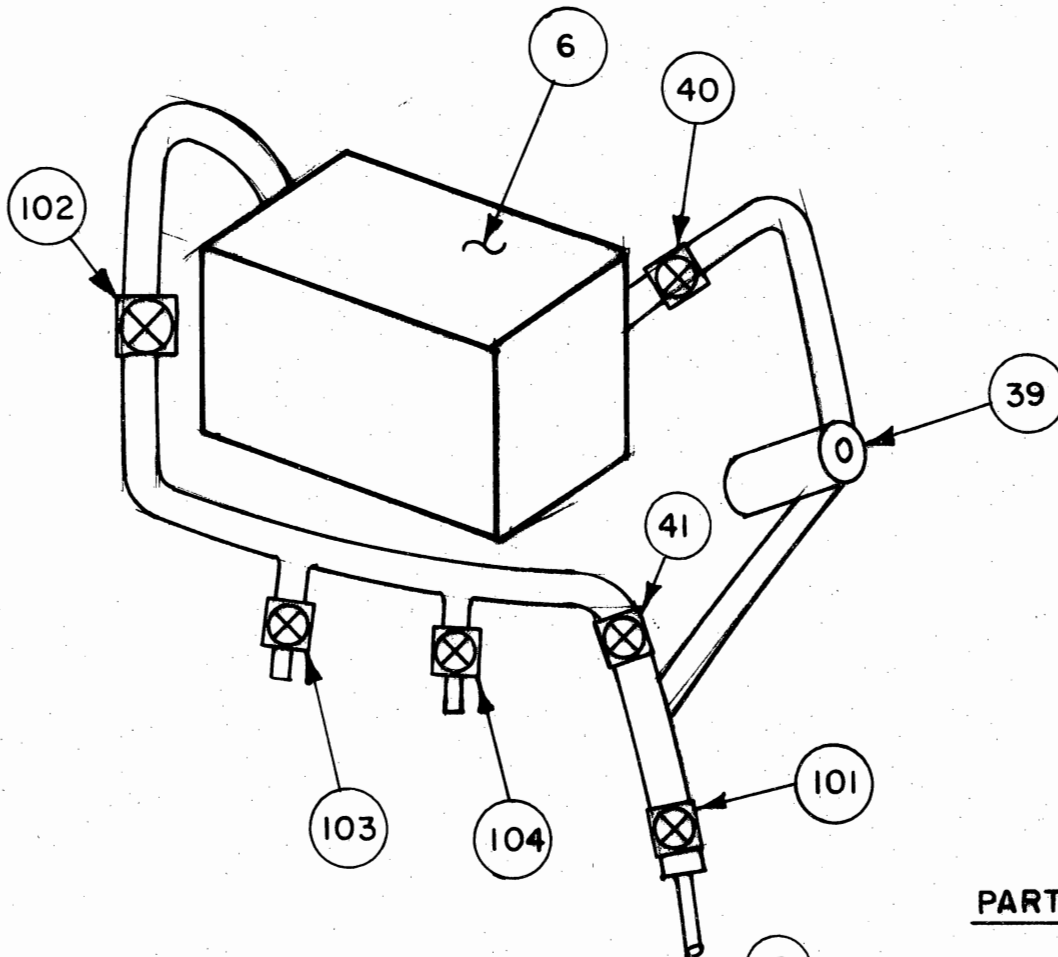
DO NOT CHANGE ASPHALTIC MATERIALS IN THE ASPHALT TANK FROM EMULSION TO CUT-BACKS OR EMULSIONS TO ASPHALT CEMENTS OR VICE-VERSA WITHOUT FIRST THOROUGHLY CLEANING AND DRYING THE ASPHALT TANK, AS THE ASPHALTS WILL FOAM WHEN MIXED WITH EMULSIONS AND HEATED.

Table Supplied By:

ASPHALT EQUIPMENT COMPANY, INC.
13333 Hwy. 24, West
FORT WAYNE, INDIANA 46804

Note: All of the above materials may be heated above 250 degrees F. in the mixing box of the McConnoughay mixer.

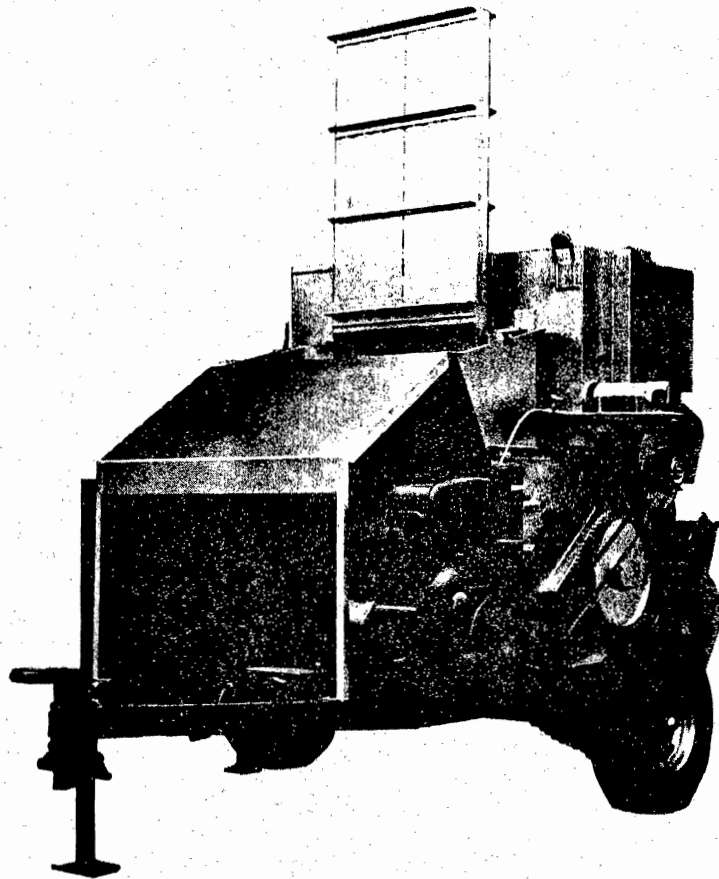
SCHEMATIC OF ASPHALT SUPPLY SYSTEM



PARTS LIST

- 6 ASPHALT TANK
- 39 ASPHALT PUMP
- 40 VALVE
- 41 VALVE
- 101 SAMPLING LINE VALVE
- 102 RECIRCULATING LINE VALVE
- 103 INJECTOR VALVE (LEFT SIDE)
- 104 INJECTOR VALVE (RIGHT SIDE)

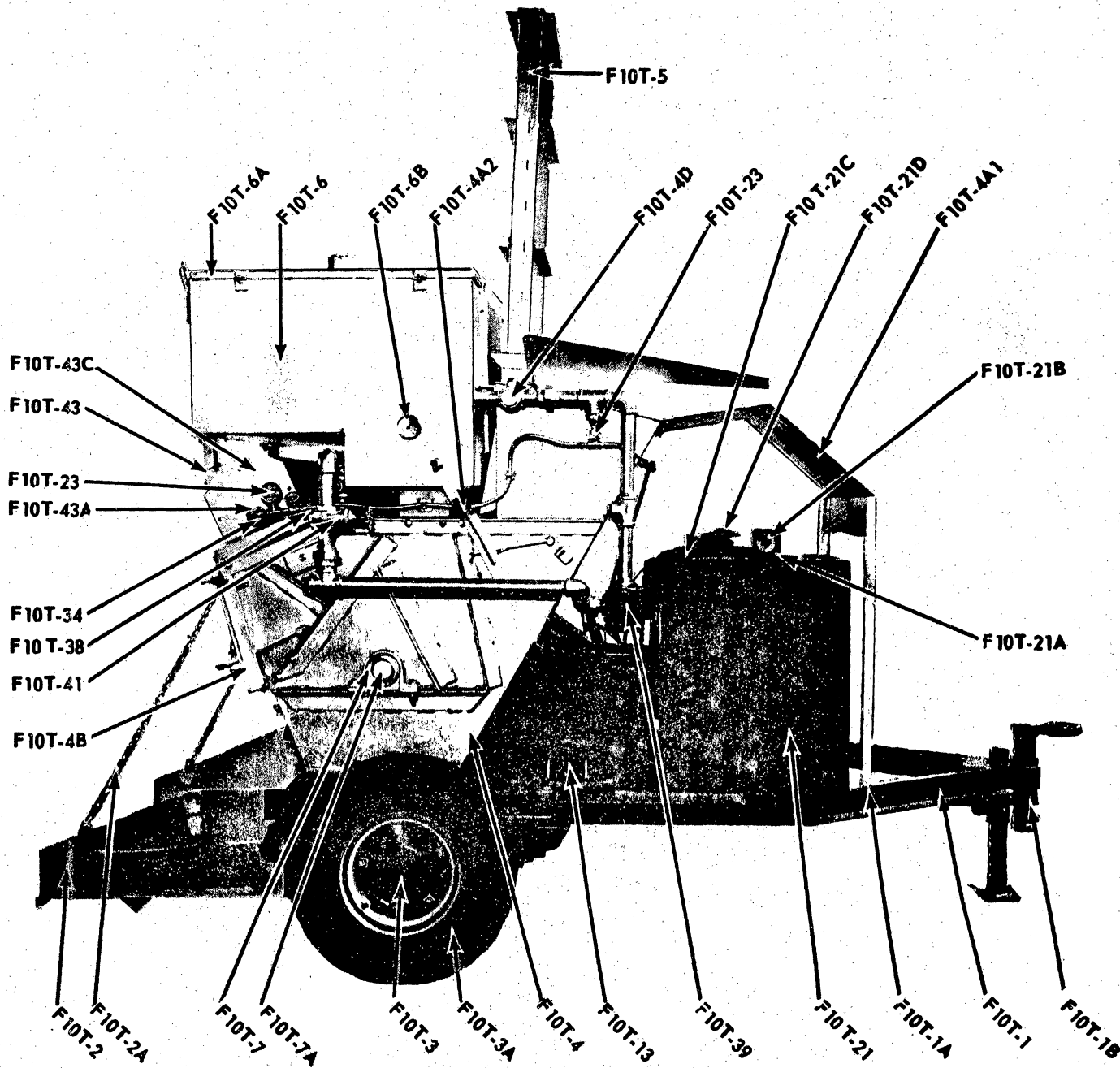
PARTS LIST
FOR MULTI-PUG PATCH MIXERS
HTD-F10T



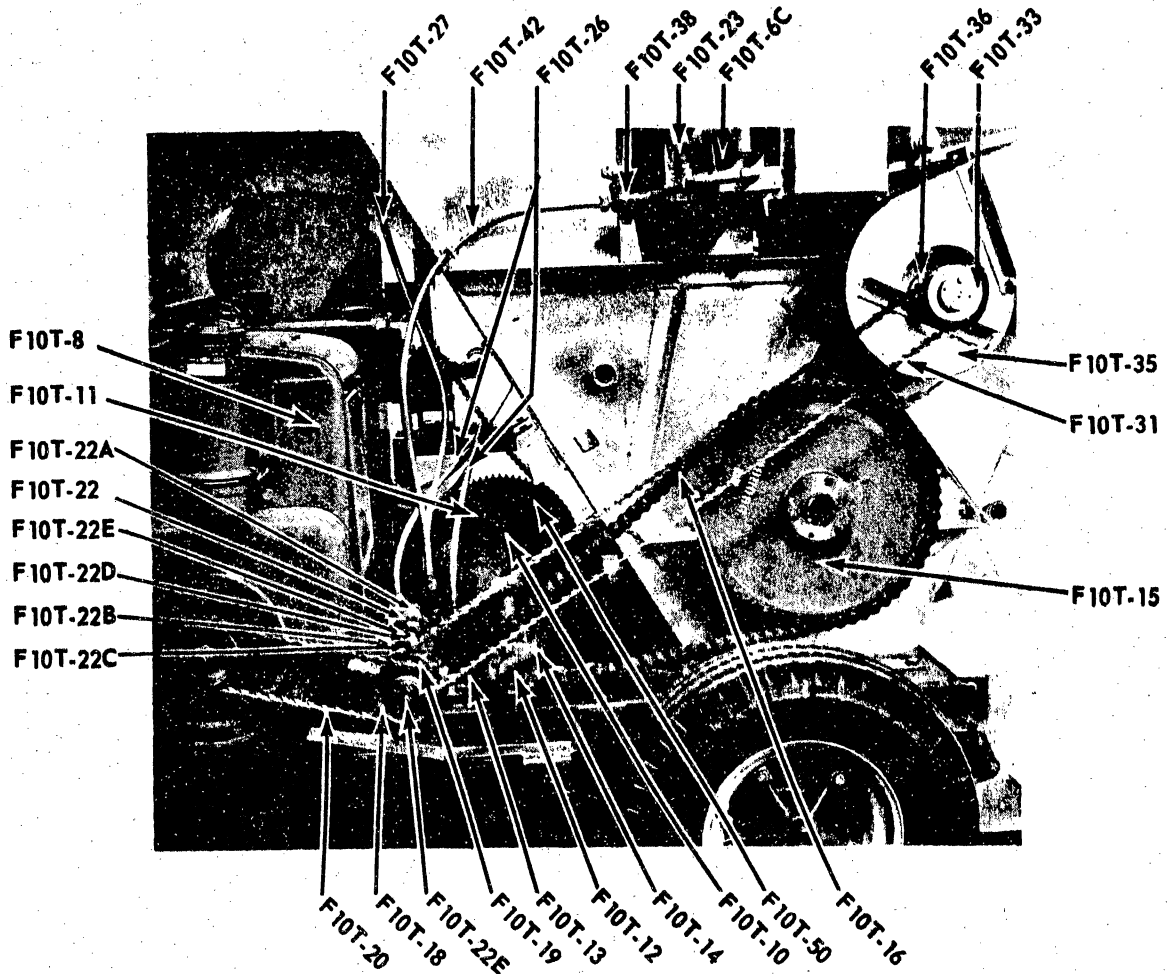
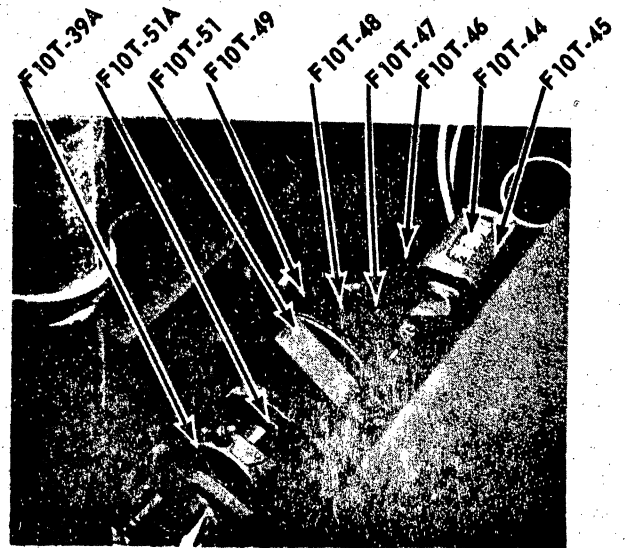
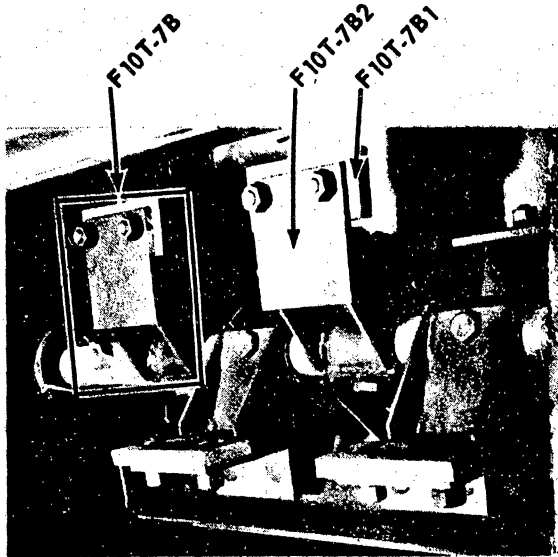
ASPHALT EQUIPMENT CO., INC.

FORT WAYNE, INDIANA 46804

F10T-1	Frame
F10T-1A	Jack only (each)
F10T-1B	Hitch Pin only (each)
F10T-2	Shoveling Tray
F10T-2A	Chain only, 47 Links (each)
F10T-3	Axle, Springs, Hangers, Hubs, Wheels & Tires
F10T-3A	Tire only (each)
F10T-4	Mixing Box, complete with Apron and Front Gate
F10T-4A	Liner only (each)
F10T-4A1	Apron, w/stands and shields (each)
F10T-4A2	Front Gate only (each)
F10T-4B	Discharge Gate, w/lever and bearing
F10T-5	Stack Extension, w/cap screws
F10T-6	Asphalt Tank, complete with Burner
F10T-6A	Lid only (each)
F10T-6B	Thermometer only (each)
F10T-6C	Oil Type Weed Burner only (each)
F10T-7	Mixer Shaft Bearings (each)
F10T-7A	Mixer Shaft
F10T-7B	Set of 8 Mixing Blades, complete with Tips
F10T-7B1	Ni-Hard Tip, only, w/5/8" Plow Bolts (each)
F10T-7B2	Paddle Arm only (each)
F10T-8	Wisconsin Engine
F10T-9	Sprocket, 80-Q-15, 1-11/16" bore, w/Q-1 bushing
F10T-10	Sprocket, 80-Q-54, 2-7/16" bore, w/Q-1 bushing
F10T-11	Roller Chain, Single RC-80, 1" pitch x 82" long
F10T-12	Jackshaft, 2-7/16" x 6 1/2" long, w/three 5/8" Keyways
F10T-13	Jackshaft Bearings, 2-7/16" x self-aligning (each) PB251
F10T-14	Sprocket, D-80-Q-15, 2-7/16" bore, w/Q-2 bushing
F10T-15	Sprocket, D-80-R-60, 2-7/16" bore, w/R-1 bushing
F10T-16	Roller Chain, Double RC-80, 1" Pitch x 92" long
F10T-18	Sheave, BK-60-H, w/H-5/8" Bushing
F10T-19	Sheave, BK-45-H, w/H-5/8" Bushinh
F10T-20	Jackshaft Veelos Link V-Belt, 50 Links, Type A
F10T-21	Fuel Oil Tank, 75 Gallon, w/1 1/2" Fill Cap & Strainer
F10T-21A	Timer Box, only (each)
F10T-21B	Timer, only (each)
F10T-21C	Strainer, only (each) # 521118-A
F10T-21D	Fill Cap, only (each) # GC-507
F10T-22	Fuel Oil Pump Assembly, Complete w/mounting
F10T-22A	Sundstrand # J6BA-200-3 Pump, only (each)
F10T-22B	Sundstrand # 102642 Foot Mount, only (each)
F10T-22C	5/8" Bearing, (each) PB251
F10T-22D	Love Joy # A-050-X Coupling, 7/16" x 5/8", only (each)
F10T-22E	Shaft, 5/8" Round x 16-3/4" Long
F10T-23	Fuel Oil Pressure Gauge, 0-200 #, 2 1/2" Face
F10T-26	Oil Hose, 1/4" x 42" long, w/1 male & 1 female ends (each)
F10T-27	Oil Hose, 1/4" x 72" long, w/1 male & 1 female ends (each)
F10T-30	Mixer Liner, Abrasion Resistant Steel (not illustrated)
F10T-31	Blower Link V-Belt, Veelos, 79 links, Type A
F10T-33	Blower Sheave, BK-40-H, w/H-5/8" Bushing
F10T-34	Oil Manifold, with nozzles
F10T-35	Blower Housing, with Fan only
F10T-36	Blower & Fuel Pump Jackshaft Bearings, 5/8" (each)PB251
F10T-38	Fuel Oil Needle Strainer Valve (each)
F10T-39	Viking Asphalt Pump
F10T-39A	Asphalt Pump Shaft 3/4" Bearings only (each)
F10T-40	Asphalt Valve, Lever Action (each)



- | | |
|----------|---|
| F10T-41 | Asphalt Valve, only (each) |
| F10T-42 | Tank Burner Hose (each) |
| F10T-43 | Tub Burner Assembly, complete |
| F10T-43A | Oil Manifold, only (each) |
| F10T-43C | Bolted End Plate, only (each) |
| F10T-44 | Counter, Durant, #4CS71LCLRP (each) |
| F10T-45 | Counter Sheave (each) |
| F10T-46 | Counter Belt, Rubber (each) |
| F10T-47 | Asphalt Pump Sheave (each) |
| F10T-48 | Pump Clutch Sprocket (each) |
| F10T-49 | Pump Drive Chain, Single RC-60, 3/4" pitch x 76 1/2" long |
| F10T-50 | Pump Driving Sprocket, 60-Q-72, 2-7/16" bore, w/Q-1 bushing |
| F10T-51 | Friction Clutch, Twin-Disc, complete Assembly |
| F10T-51A | Twin-Disc Clutch, only (each) |



ASPHALT EQUIPMENT CO., INC.

13333 U.S. Hwy. 24 West • Fort Wayne, Ind. 46804 • Telephone (219) 672-3422

