STUDY OF BITUMINOUS SURFACE TREATMENTS IN VIRGINIA

Phase II — Summer 1964: Distribution Characteristics of Materials — Effectiveness of One Size Aggregate — Setting Time

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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SUMMARY

Distribution Characteristics of Materials

Ten bituminous distributors and ten chip spreading operations were investigated — the former by cotton pad, cup, and trough tests; the latter by measuring the distance covered by a truckload and by placing pans in the road to catch the stone. A wide variation was found in the coverage consistency of the distributors and the aggregate distribution was found to vary between types of spreaders used.

Effectiveness of One Size Aggregates

Seven one size stone test sections were placed on portions of regularly scheduled surface treatment projects. Modified #8 and #78 stones were placed with three different types of chip spreaders and in different combinations with CAE-2, RC-2, AP-00, and RC-3 asphalts. The quantities of stone and binder were determined through a modification of a design method developed by F. M. Hansen of New Zealand. Insufficient time has passed to permit final evaluation of the test sections.

Setting Time, or Traffic Readiness

A centrifuge test fashioned after one used in California was used to evaluate lab and field treatments for aggregate whip off. From the results of this empirical test, which is probably much more severe than traffic at moderate speeds, it is believed that AP-00 asphalt is traffic ready in a much shorter period of time than are cutbacks and emulsions.

Proposed Investigations

From the work done to date in the surface treatment study it is proposed to:

(1) Bring four state asphalt distributors of different makes to Charlottesville for calibration and a later field check against other distributors. Also it is proposed to train the crews of these distributors in the maintenance, adjustment and operation of their machines.

(2) Place eight to ten one size stone test sections on Virginia's highest trafficked roads in the surface treatment schedules, including the Class B and C schedules.

(3) Include AP-00 in several of the one size stone test sections, and perform further lab work on aggregate retention.

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INTRODUCTION

This report covers Phase II of an extended investigation of bituminous surface treatments in Virginia. The general purpose of the overall study is to investigate the possibility of raising the quality of surface treatments in the State to the point that they have a longer and more serviceable life.

Phase I, completed in February 1964, consisted of (1) a literature review, (2) consultation with Virginia Department of Highways and Bureau of Public Roads personnel, and (3) the preparation of a working plan. It became apparent during this early work that many factors influence the serviceability and life of surface treatments. A comprehensive listing of these factors is given below.

<u>Aggregate</u>

- Hardness
- Porosity
- Moisture
- Cleanliness
- Particle Shape
- Gradation
- Electro Charge

<u>Binder</u>

- Viscosity
- "Set Up" Time
- Tenacity
- Electro Charge
- Liquifying Media
- Grade

<u>Control</u>

- Pavement Conditions
    - Patches
    - Cleanliness
    - Moisture
- Distribution Control
    - Aggregate
    - Binder

<u>Natural Elements</u>

- Ambient Temperature
- Surface Temperature
- Humidity
- Wind Conditions
- Cloud Conditions

Control (Continued)

Binder Aggregate Time Interval	Traffic
Compaction	Volume
Traffic Readiness	Weight
	Speed

In any attempt to improve upon surface treatments, the above listed factors should be isolated and studied separately. In the case of some, study may be too strong a word, since reason and experience will suffice. Patches are an example of this type of factor; i.e., anyone who has ever been involved in surface treatment work knows that if patches are fat they will bleed through the new treatment, and that if they aren't flush with the rest of the surface this unevenness will reflect through the new surface. These truths have been recognized for some time and to a great extent such bleeding and unevenness have been eliminated in Virginia.

Other factors can be examined experimentally, and still others will require theoretical study. The type of approach, that is, whether rational, experimental, or theoretical, does not matter near so much as that all the factors be considered in some manner.

Since all of the factors involved could not be studied simultaneously without employing an astronomical number of workers, the author selected three that seemed to offer the best possibility of immediate benefits for study during Phase II. Two factors, (1) control of binder and aggregate distribution, and (2) effects of aggregate gradation (one size vs. those presently used), were given the greatest attention, while a third factor, (3) setting time or traffic readiness, received preliminary investigation.

These three factors are reported in individual sections, each a unit in itself. A fourth section on a proposed investigation is also included. The order of these sections is as follows:

Section One

Control of Binder and Aggregate Distribution

Section Two

Installation of Test Sections Employing One Size Aggregate

Section Three

Setting Time or Traffic Readiness

Section Four

Proposed Investigations for 1965

The experimental work was conducted during the summer of 1964 on state roads, mostly secondary, through the cooperation of the Central Office and the field personnel of the Department of Highways. Ten bituminous distributors and ten chip spreading operations were investigated for distribution characteristics and seven one size stone test sections were placed.

SECTION ONE

CONTROL OF BINDER AND AGGREGATE DISTRIBUTION

Scope

The very best materials and design can go into a surface treatment and the results still be unsatisfactory unless the binder and aggregate are evenly distributed to the proper depth. Poor control of the applications could result in streaking, excess loss of cover stone, bleeding and, in fact, almost any of the types of failure common in surface treatments. Since this control is of utmost importance on every surface treatment job regardless of the characteristics of the aggregate or binder, the natural elements, or the traffic that the road will carry, then it is proper that it be one of the first factors investigated.

The intent here was (1) to determine the extent to which the bituminous and aggregate distributors used in Virginia give a uniform spread both transversely and longitudinally, and (2) to attempt adjustments to improve uniformity.

Binder

Procedures

Distributor Stationary. Two test methods were used to evaluate the lateral distribution of the spray bar while the distributor was stationary: One was a measure of the quantity of asphalt discharged from the individual nozzles, the other a measure of the distribution pattern across the bar. The quantity of asphalt is influenced by the nozzle discharge only, while the distribution pattern is influenced by both the nozzle discharge and nozzle angle.

The amount of binder discharged from the individual nozzles was measured by placing quart size paper containers under each nozzle and spraying into them simultaneously. A rack was used to keep the cups from turning over, see Figure 1. The following difficulties were encountered with this system.

(1) Although the binder was circulated through the bar for five minutes prior to shooting it was noted that the nozzles did not always come on at full force simultaneously. This could be due in part to clogged nozzles or to different sections of the bar not being activated simultaneously. However, another possible cause, which was suggested by leakage on many spray bars, was worn parts. With regard to these problems the error might have been much less significant if larger containers had been used.

(2) Difficulty was also encountered in placing the cups under the nozzles, because of unlevel working areas and untrue bar extension. In field

work it is almost impossible to find a level place on which to perform the test and on most distributors the header bars are not truly horizontal extensions of the spray bar. Therefore, in order to get the highest nozzles low enough to ensure shooting into a specific cup, other points along the bar were resting on cups. This interferred with the cutting on of the binder. It also bent cups, causing loss of binder, and, at times, turned cups partially over.

The second stationary method of checking the spray bar was a check on the distribution pattern of the binder. As mentioned earlier, this is influenced by both nozzle discharge and nozzle angle. Figure 2 shows the 12-foot metal trough used in this test. It is divided into forty-eight 3-inch sections 7 inches deep, and is 18 inches wide at the top and 9 inches wide at the bottom. The trough, which was modeled after a larger unit used in Pretoria, Transvaal, South Africa, for calibrating distributor spray nozzles and bars, can be disassembled into two equal units for transportation.

It was found early in the summer that this method of test is not adaptable to field operation. The following difficulties were encountered.

(1) The process was time consuming and tied the distributor up for longer periods of time than was desirable. This of course would hold up the entire surface treating operation.

(2) Because the distributor had to shoot into the trough every time an adjustment was made and there was no way to recover the binder, much of it was wasted.

(3) There was little success in finding a place for the distributor that was level enough to permit the top of the trough to be flush with the ground, a requirement of the test.

Distributor Operating. The lateral distribution of the spray bar was also evaluated while the distributor was in use on a job. The procedure is to glue cotton pads to sheets of paper which are in turn placed on metal sheets. The sheets are placed on the roadway just ahead of the distributor. The cotton prevents the binder from flowing until the sample can be weighed. The photographs in Figure 3 show cotton pads in use.

This method of checking lateral distribution is better suited to field work than is the trough. However, for calibration or major adjustments it would be much more desirable to use the trough if it could be centrally located and if the difficulties mentioned previously could be eliminated.

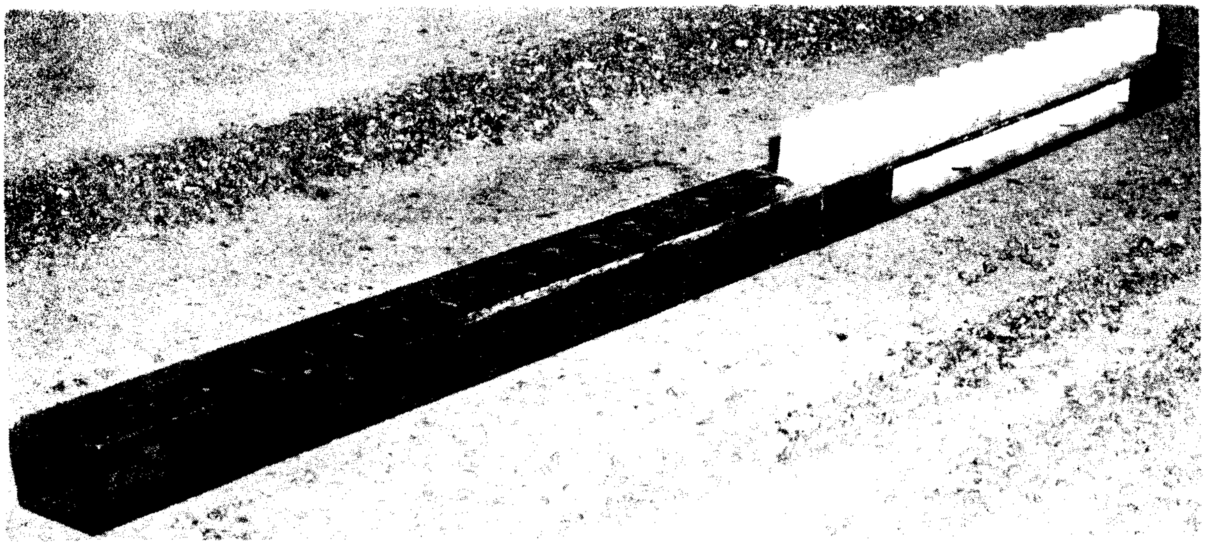

Figure 1. Paper cup arrangement for measuring nozzle discharge.

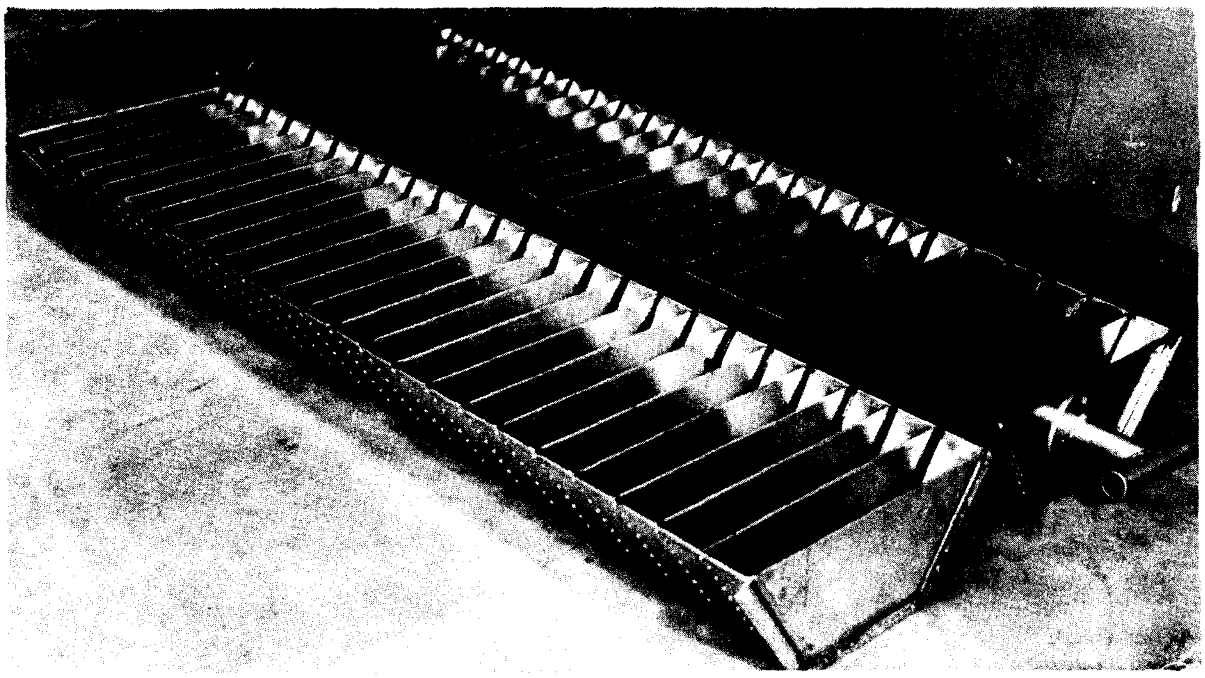

Figure 2. Calibration trough, disassembled.

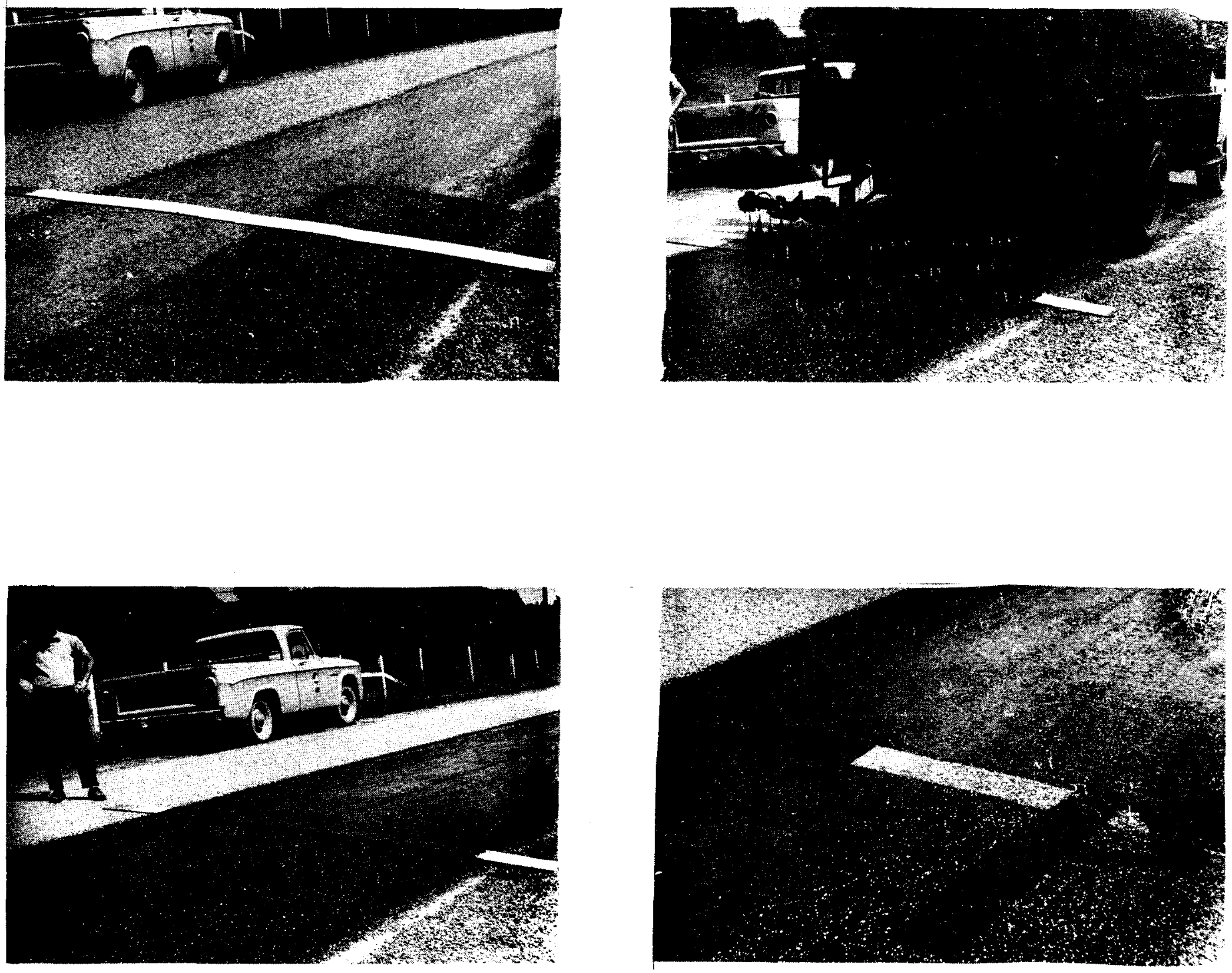

Figure 3. Cotton padded strips being used to measure lateral distribution of spray bar.

Attempts were made to adjust nozzles to improve the distribution pattern, based upon the results from the cotton pad tests, but they were not always successful. All the problems encountered had the common origin of motion. Because the distributor was moving, samples had to be transported to the field lab; distinguishing exactly which spray fans were covering specific pads was difficult; distinguishing which fans were not parallel to other fans was difficult; and the test should be made on a true cross section of pavement. In fact, because the tests to date have been conducted primarily on secondary roads, the results have sometimes been difficult to evaluate because of the effect of inconsistent road cross section.

To evaluate performance some standard is needed. Since a standard does not exist, it seems appropriate for discussion purposes to use as a criterion the best results in this study as a "standard" and apply the terms of "attained the standard" and "did not attain the standard" to describe the level of performance of individual distributors. These terms will be applied to the cotton pad and cup tests only, since the results of the trough test were extremely poor.

The following were attained in six cases on four distributors with cotton pad tests and five cases on four distributors with the cup test, and will be considered as the "standard".

(1) The mean deviation of the cups or pads included shall not be greater than 6% from the mean value.

(2) Not more than 5% of the cups or pads included shall deviate from the mean value by 12% or more. This means that since no cup or pad test had as many as 40 values that there shall not be more than one value deviating by 12% or more from the mean.

Note all cups are included in a test but the end pads that appear to be coated are omitted. The reason for this decision is that almost always the end pads receive binder from only one fan and are therefore quite low. The results of these tests follow.

Results

Machine 1. Machine 1, the first ont tested, was a Littleford model in the Amherst Residency. It was first worked with several days in late May in Nelson County to gain experience in the type of tests to be run. Although data were not kept, much information was gained in the way of determining work assignments for the individuals in the crew, the type of data sheets needed, and the kinds of problems to expect in this type of work.

The distributor was next tested in mid-June on the Residency lot. These tests consisted of the trough and the cups only; and it was at this time that the writer fully realized the problems involved in using the trough in the field.

The distributor was next tested on July 6 on Rt. 636, where two sets of cotton pads and one set of cups were run, and the following two days on Rt. 766, a special stone test section, where five sets of cotton pads were run, two on the control section and three on the test section.

The distributor was again tested in Nelson County on the 2nd of July on Rt. 6, where three sets of cotton pads were run. It should be noted here that two different distributor crews were employed while these tests were being made.

Two sets of nozzles of the types shown in Figure 4 were employed on this distributor. Nozzle A is the type which this crew normally uses, set so that the slot forms a 35° angle in the horizontal plane with the bar. Nozzle B is the type furnished with the distributor when bought. The instruction book supplied with the distributor specifies that the nozzles be set at a 15° angle.

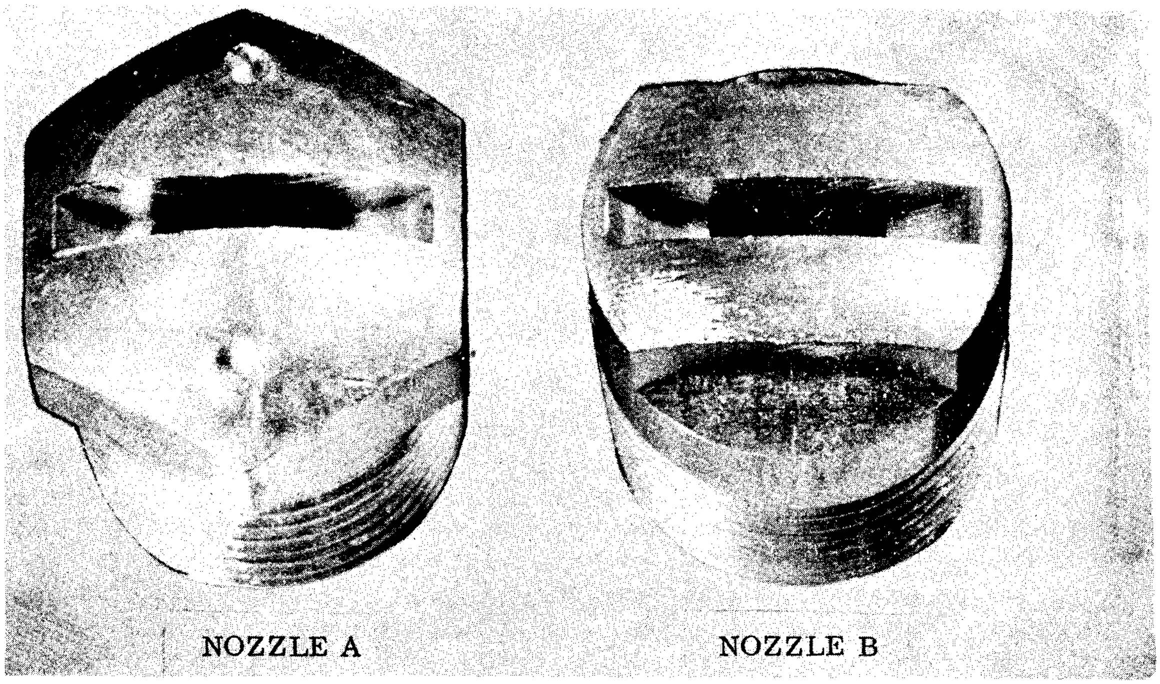

Figure 4. Two types of nozzles used on distributors in Amherst Residency.

Cotton Pad Test. Cotton pad tests 1 through 7 on Rt. 636 and 766 were made when an inexperienced crew was operating the distributor, while cotton pad tests 8, 9 and 10 on Rt. 6 were made with an experienced crew.

Tests 1, 2, 3, 4, and 10 were made with Nozzle A set at an angle of 35° to the spray bar. Tests 5, 6 and 7 were made with Nozzle A at an angle of 15°. Tests 8 and 9 were made with Nozzle B. For test 8 the angle was 15° and for test 9 it was 35°. CAE-2 asphalt was used in all of these tests.

The following table summarizes the cotton pad results from this distributor.

Test	Rt.	No. Pads	Nozzle	Nozzle Angle	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating over 12%
1	636	19	A	35°	.220	.195	.157	-19.49	7.85	3
2	636	19	A		.218	.193	.157	-18.65	6.76	4
3	766	24	A		.232	.190	.166	+22.10	7.10	4
4	766	24	A		.229	.200	.173	+14.50	6.52	3
5	766	24	A	15°	.291	.248	.201	-18.95	7.61	5
6	766	24	A		.418	.344	.264	-30.30	7.51	5
7	766	23	A		.353	.295	.231	-21.69	8.53	6
8	6	24	B	15°	.216	.194	.178	+11.34	4.94	0
9	6	24	B	35°	.237	.207	.166	-19.81	8.23	4
10	6	24	A	35°	.219	.195	.173	+12.31	4.55	1

It will be noticed that test 8, with Nozzle B set at a 15° angle as specified by the manual, and test 10 with Nozzle A at a 35° angle as normally used by this crew, "attained the standard". These two tests were performed while the experienced crew was operating. While one test should not be considered conclusive, tests 8 and 10 do suggest that both Nozzle B set at 15° or Nozzle A set at 35° are acceptable. However, in light of the fact that tests 1 through 4 "did not attain the standard" while an inexperineced crew was operating, and test 10 "attained the standard" with an experienced crew, and these tests were all made with the same nozzle (A) at the same setting (35°) the question arises as to whether the difference between experienced and inexperienced operators is significant. This question cannot be answered at present but should be kept in mind for future investigation. However, the results from tests 8 and 10 are a reasonable indication that this distributor can produce a consistent application.

Cup test. Three sets of cups were run with this distributor, two on the Amherst Residency lot, and one on Rt. 636 in Amherst County. The summary results from these tests are shown in the following table.

Test	Rt.	No. Cups	Range in Gallons High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	739	30	.175	.167	.157	- 5.99	2.25	0
2	739	30	.198	.179	.145	-18.99	6.01	4
3	636	29	.199	.189	.175	- 7.41	3.12	0

Test 2 does not give as good results as do 1 and 3. However, when considering the results from all three tests, it can be concluded that the discharge from the bar was acceptable.

Trough Test. Two tests were run employing the trough on the Amherst lot and using AP-00. Test 1 was with Nozzle A set at a 35° angle and test 2 was with Nozzle B set at a 15° angle. As previously mentioned the trough is not suitable for field work. Evidence of this is shown in the following table.

Test	No. Bins	Nozzle	Nozzle Angle	Range in Gallons High	Mean	Low	Greatest Deviation, %	Mean Deviation %	No. Deviating Over 12%
1	30	A	35°	.523	.400	.272	+30.00	12.03	19
2	40	B	15°	.694	.541	.272	-49.72	12.24	16

The writer feels that these poor results were due to the inability to find a level place for the distributor and to place the bins equally distant from the spray bar.

Machine 2. This distributor, a Littleford, was checked on two jobs. The first was on Rt. 730 in Floyd County on July 16, 1964, where one set of pads were run; and the second on Rt. 775 in Carroll County, September 3, 1964, where two sets of cotton pads were run. No cup nor trough tests were run.

Cotton Pad Test. No adjustments were made on this distributor and, although one set of tests "did not attain the standard", there is little question that the consistency requirements were met by this distributor. The data are summarized in the following table.

Test	Date	No. Pads	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	7/16	22	.290	.254	.225	-14.17	5.30	1
2	9/3	27	.304	.274	.235	-14.23	6.51	2
3	9/3	21	.272	.250	.218	-12.80	5.16	1

It should be mentioned that test 2, the one which fell out of the limits, was the only test on which a header bar was used; one of the pads that deviated by more than 12% was under the header bar, and all pads under it had less binder than the average amount across the pavement.

As previously mentioned, the pads from the extreme ends have been omitted in all cases. Further, it should be understood that the term "end pad" means the last pad on either end that appears to be covered. In other words, pads outside the end pads which are partially coated are also discarded. The reason for this is that the calculation for determining the gsy is dependent upon the area covered and unless the pad is completely covered the area is quite difficult to determine.

Since this distributor was found to be quite well adjusted it might be well to take a look at what happens to the results when the two end pads are included. The following table generalizes these results.

Test	Date	No. Pads	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	7/16	24	.290	.245	.135	-44.90	8.93	6
2	9/3	29	.304	.267	.143	-46.44	8.64	3
3	9/3	23	.272	.243	.160	-34.16	7.99	2

The purpose for showing these results is to remind the reader that a problem existed at both ends of a spray bar, since the nozzle discharges overlapped on two sides except those from the nozzles on the extreme ends.

<u>Machine 3</u>. This machine was also a Littleford, and was being used on a contract job in Fairfax County on Rt. 840, which was set up for .30 gallon application of CAE-2. One set of cotton pads and one set of cups were run.

Cotton Pad Test. The summary information from the cotton pads is shown in the following table.

Test	No. Pads	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation %	No. Deviating Over 12%
1	25	.362	.284	.233	+27.46	7.24	5

The average deviation was not bad but the number of pads, 5, deviating by more than 12% from the mean also "did not attain the standard" and the wide range of gsy, .23 to .36, was serious. For a better look at the deviations a bar graph is shown in Figure 5. From the data shown on this graph it seems quite likely that satisfactory nozzle angle adjustments could be made.

Cup Test. The data from the cups are shown in the following table.

Test	No. Cups	Range in Gallons High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	30	.207	.151	.119	#37.09	12.14	12

It is readily seen that the results of this test are less consistent than those from the cotton pads. However, the bar graph of these data, Figure 6, indicates the probable

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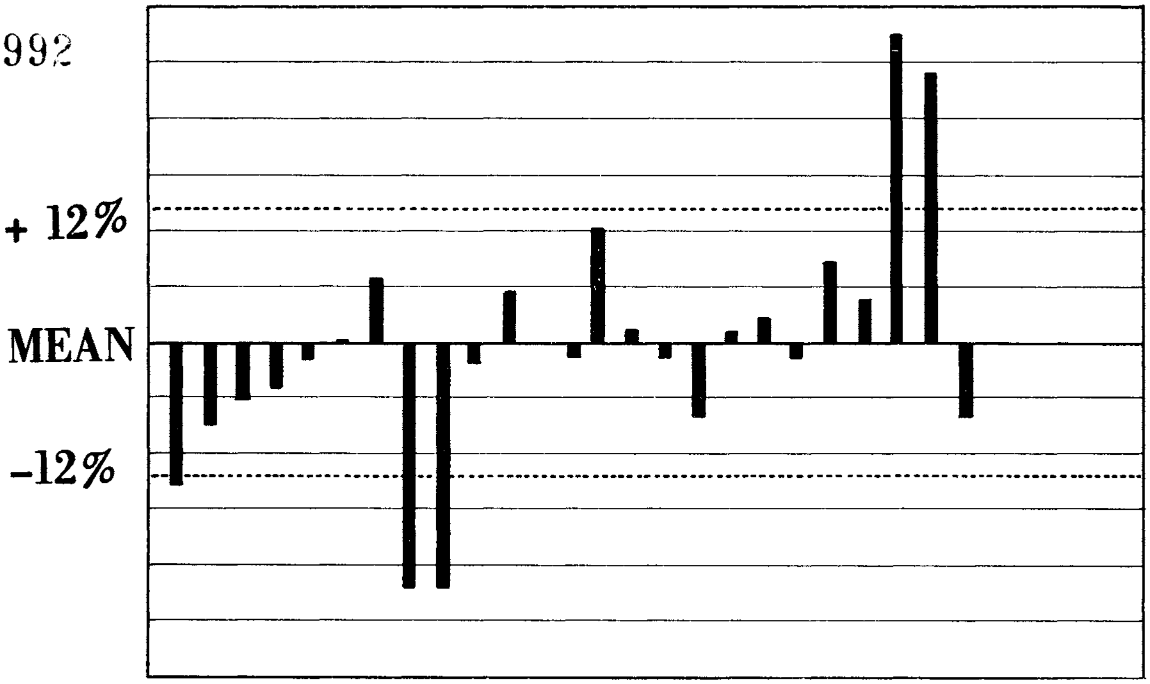

Figure 5. Lateral distribution pattern of Machine No. 3 as indicated by one cotton pad test.

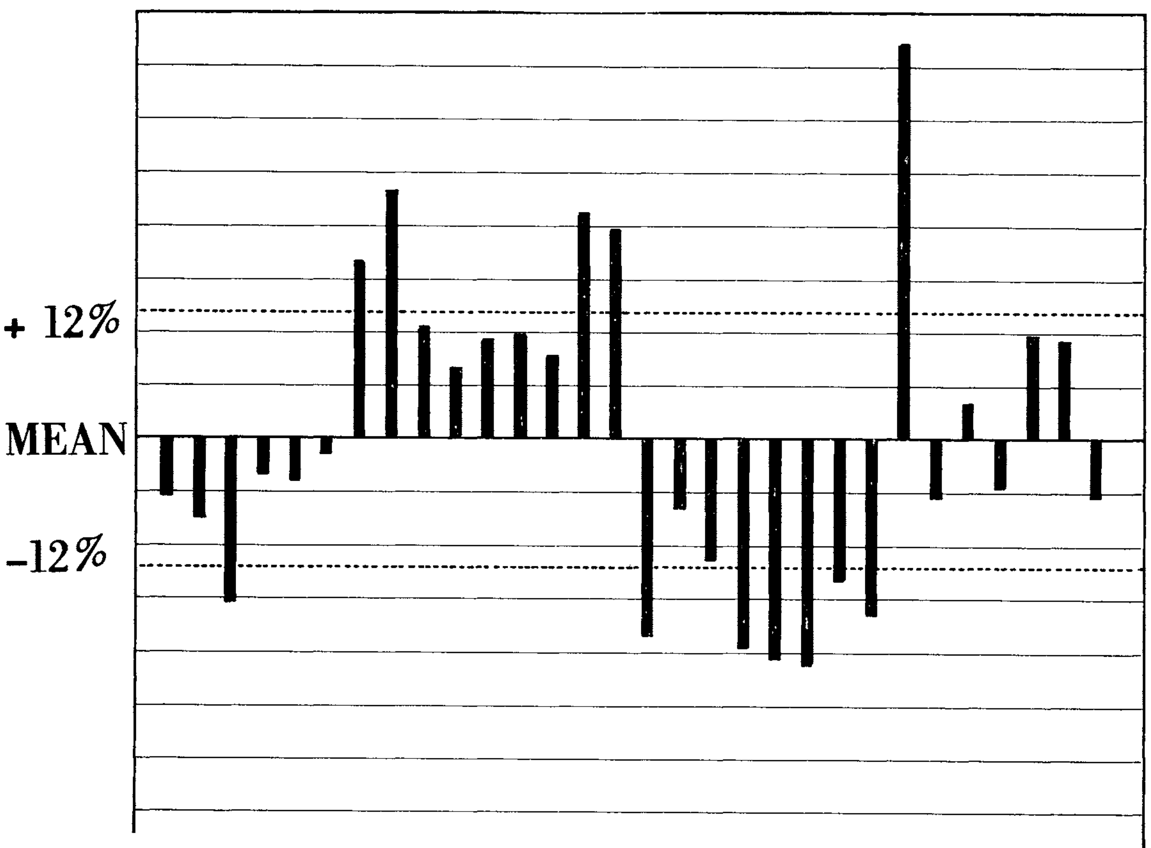

Figure 6. Nozzle discharge pattern of Machine No. 3 as indicated by one paper cup test.

cause of the disagreement in the two sets of data. In this graph, notice that the first six nozzles from the left are low, these are on the left header bar; the next nine nozzles are high, these are on the left side of the main bar; the next nine are low (except No. 9), these are on the right side of the main bar; and the last six, which are on the right header bar, have an average of about the same as that for the whole bar. A possible explanation for this is: first, the cups used hold only one quart and only seconds are required to fill them; each of the four sections of the bar, although activated by one lever, are cut on by independent draw bars. If the linkage from the main lever to the four bars is not precisely adjusted the four sections will not cut on at the same time. These data indicate that the left side of the main bar came on first, the right header bar came on second, and the left header bar and the right side of the main bar came on last. This malfunction should be rectified because of the inconsistency caused at the beginning or end of a shot.

Machine 4. In Tazewell County an Etnyre distributor was tested on two roads. On Rt. 637 an AP-00 was used in a penetration treatment and on Rt. 643, which was one of the special stone sections, an RC-3 was used. Three sets of cotton pads and one set of cups were run on Rt. 637 and three sets of cotton pads were run on Rt. 643.

Cotton Pad Test. After the first two cotton pad tests on Rt. 637 were run a new set of nozzles were put in the distributor bar for the remaining tests on both roads. Also, it should be noted that for tests 2 and 5 efforts were made to adjust the angles of the nozzles. The following table summarizes the cotton pad results.

Test	Rt.	No. Pads	Nozzles Adjusted?	Range in gsy High	Range in gsy Mean	Range in gsy Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	637	23	no	.688	.536	.450	+28.36	8.57	4
2	637	25	yes	.625	.521	.394	-24.38	9.20	7
3	637	25	New nozzles	.561	.494	.368	-25.51	6.99	5
4	643	22	no	.344	.310	.250	-19.36	6.63	2
5	643	22	yes	.372	.294	.187	-26.39	11.59	8
6	643	21	no	.355	.287	.242	+23.69	8.48	6

In order to demonstrate what the problem was a graph of the results from Rt. 643 is shown in Figure 7. It can be noticed from this bar graph that the portion of road under the middle of the bar received excess asphalt while at each end the amount of asphalt was light.

Cup Test. The above also shows up in the cup test, as can be seen in the summary table and Figure 8.

Test	No. Cups	Range in Gallons High	Range in Gallons Mean	Range in Gallons Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	27	.142	.132	.118	-10.61	2.13	0

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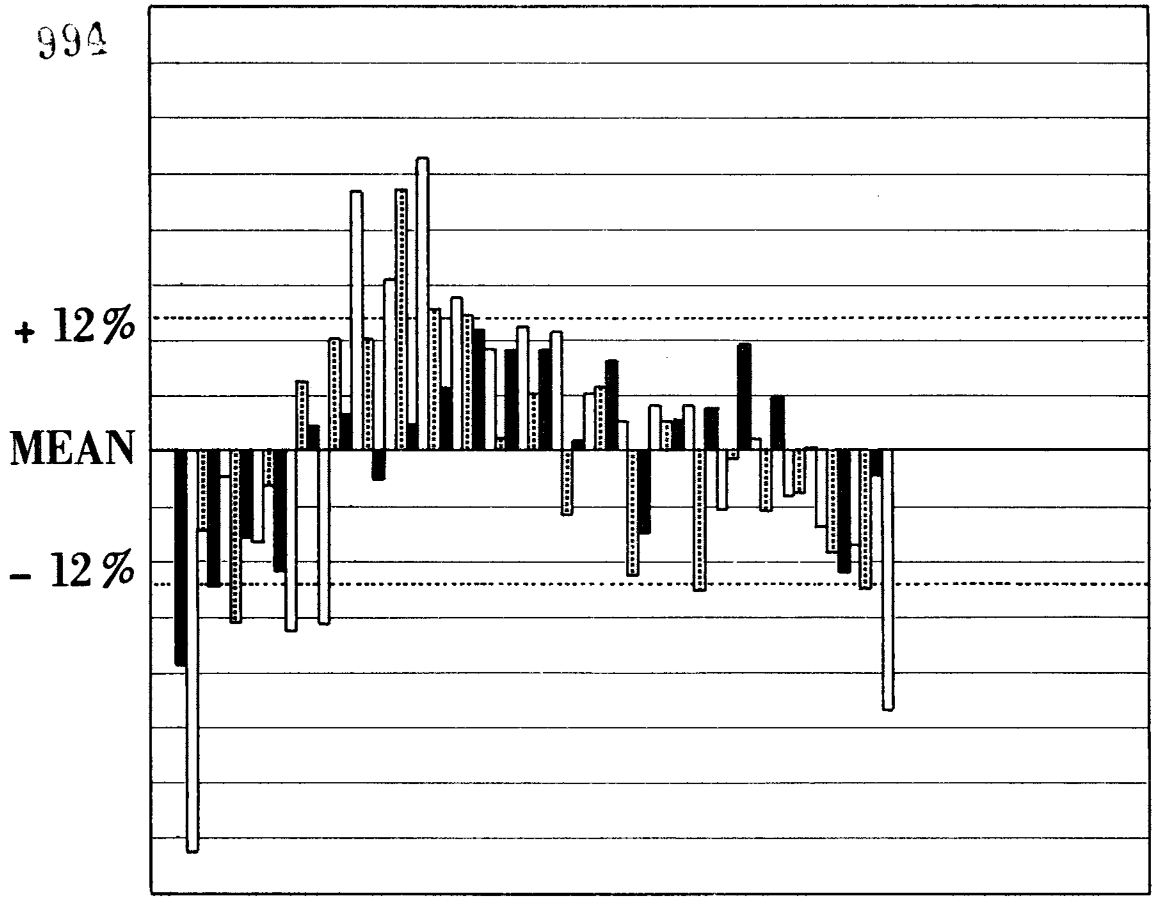


Figure 7. Lateral distribution pattern of Machine No. 4 as indicated by three cotton pad tests on Route 643 project.

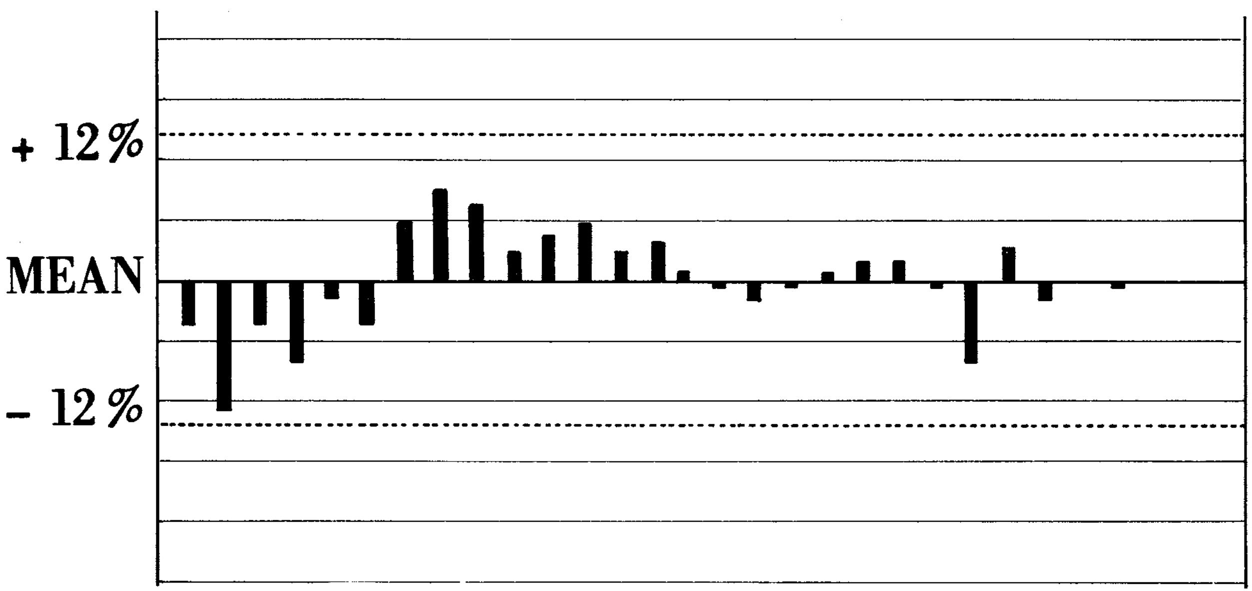


Figure 8. Nozzle discharge pattern of Machine No. 4 as indicated by one paper cup test on Route 643 project.

Since the results from the cups have much less deviation than those for the cotton pads, adjustments should improve upon the latter. It is obvious that more asphalt was being discharged from the middle of the bar than from the ends. Remembering that the cup test is not influenced by the angle of the nozzle, it becomes apparent that no amount of nozzle angle adjustment could completely correct the inconsistencies of the discharge. In other words, there appears to have been a minor malfunctioning within the bar. From the combined data of the cups and the pads it seems likely that the problem was different from that of the previous distributor, where different portions of the bar were being activated at different times. In this case, since both the cups and pads show the same trend, there appears to have been a circulation problem.

Machine 5. On Rt. 40 in Pittsylvania County the cotton pad test was run five times, three times without adjustment and twice with adjustment; the cup test was run once and the trough test twice. This distributor was an Etnyre and the binder used was CAE-2. The project on which the tests were run was a contract job containing one of the special stone test sections.

Cotton Pad Test. The first three pad tests were made on the control portion of the job, where the intended application rate was .30 gsy. No adjustments were made on the distributor. The last two tests were made on the test section, where the intended application rate was .20 gsy, and adjustments were made on the angle of the nozzles before each test. The following table summarizes the data from these five tests.

Test	No. Pads	Nozzles Adjusted?	Range in gsy High	Range in gsy Mean	Range in gsy Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	26	no	.415	.335	.262	+23.88	8.07	7
2	26	no	.350	.289	.227	-21.45	9.06	9
3	26	no	.371	.285	.214	+30.18	10.61	9
4	26	yes	.242	.207	.166	-19.81	7.89	7
5	26	yes	.219	.194	.164	-15.46	6.56	3

In looking at the high and low values from the first three sets of tests, and remembering that no adjustments were made between them it becomes apparent why there are problems with chip retention and bleeding on surface treatments. This job was set up for a .30 gsy application of binder but received from .21 to .41 gsy. It should also be noted that on one-third of the pavement the binder deviated from the mean by more than 12%. Since 12% of .30 is .036, if the intended rate of .30 had been realized over the project then one-third of the pavement would have received either less than .264 gsy or more than .336 gsy.

The fourth test was made after the nozzles had been adjusted but it is difficult to say that there was any improvement. However, after further adjustment, the fifth test was run and it is obvious that there was an improvement. Rather than almost one-third of the pavement receiving a 12% deviation in binder, only about one-ninth was outside the limits. Yet the mean deviation was greater than 6% and the results on three pads deviated by more than 12% from the mean. The writer is convinced that this distributor could be adjusted to "attain the standards".

Cup Tests. One cup test was run. The distributor had a capacity of 1580 gallons but was carrying only 100 gallons at the time, which would not seem to be ideal for the test. The following table shows the general results.

Test	No. Cups	Range in Gallons High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	29	.167	.140	.117	+19.29	6.87	5

Three of the five nozzles that deviated by more than 12% were in the right header bar. This could have been due to nozzle wear, plugged nozzles, poor circulation, or insufficient heat in the header bar.

Trough Test. Two tests were run with the trough, both prior to any nozzle adjustment. The reader will recall from earlier statements that the trough test is not suitable for general field work. One of the reasons cited was the difficulty in locating a level test area, and the field notes on the second of these trough tests contain a statement that the truck wasn't level. According to the notes the distances from the spray bar to the trough, looking from the rear, were 7 inches for the left side, 9 inches for the middle and 10 inches for the right side. A summary of the results of these tests is shown in the following table.

Test	No. Bins	Range in Gallons High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	35	.912	.747	.512	-31.46	10.08	12
2	38	.832	.665	.418	-37.14	9.92	11

The writer wishes to emphasize again that these results are not dependable but that there is a good chance that if used under controlled conditions the trough could be an excellent calibrating medium.

Machine 6. The distributor used on Rt. 647 in Culpeper County was an Etnyre; the work was done by a contractor; and the binder was an AP-00.

Cotton Pad Test. Two sets of cotton pads were run and the results are shown in the following table.

Test	No. Pads	Nozzles Adjusted?	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	23	no	.265	.230	.195	+15.22	7.62	5
2	23	yes	.285	.240	.203	+18.75	6.19	5

Both tests show that the distributor "did not attain the standards". It is felt that the problem in this case was either worn or maladjusted nozzles.

Cup Tests. The above is borne out by the results of the cup test shown in the following table. The results from the right header bar are not shown because this bar was cold. Its average deviation was 27% below the mean.

Test	No. Cups	Nozzles Adjusted?	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	26	no	.146	.133	.123	+9.77	3.09	0

The results indicate that the nozzles and left header bar were not stopped up and circulation was good.

Machine 7. This distributor was an Etnyre, and the oil a CAE-2. The treatment, on Rt. 746 in Halifax County, was placed by contract.

Cotton Pad Test. Two tests were run with the cotton pads on this project, with adjustments being made on the angle of the nozzles between the tests. The intended application rate was from .35 to .37 gsy whereas the measured rate was .42. Some improvement was realized with adjustments as can be seen in the results. However, even after adjustment the uniformity of the "standards was not attained".

Test	No. Pads	Nozzles Adjusted	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	24	no	.569	.421	.340	+35.15	10.07	9
2	24	yes	.498	.415	.368	+20.00	9.31	6

In this case 37% of the pads (9 of 24) deviated over 12% from the mean before adjustment and 25% after adjustment (6 of 24).

Cup Tests. One cup test was run on this distributor. The following table gives a general idea of the inconsistency between nozzles. Since the high-low range was so great, Figure 9, which gives the percent deviation from the mean, is presented to explain it.

Test	No. Cups	Range in Gallons High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	27	.180	.148	.038	-74.32	11.16	7

The right side of this graph represents the right header bar. It is quite obvious that this bar was not functioning properly. Also of significance are the extreme two low values produced from two of the nozzles on this header bar. This would seem to indicate that not only was the circulation in the bar poor, but also that these two nozzles were partially stopped up. If the values from these two nozzles were eliminated, the mean value would change and thereby show an improved consistency within the rest of the bar.

Machine 8. The same distributor, an Etnyre, was used on Rts. 798 and 665 in Montgomery and Giles Counties, respectively, to apply an AP-00.

Cotton Pad Test. Only one set of cotton pads was run on each road and as can be seen from the results, the distributor "attained the standards" on Rt. 798 but not on Rt. 665. However, since the results from Rt. 665 are borderline, adjustments should not be made prior to additional tests.

Rte.	No. Pads	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
798	26	.269	.244	.223	+10.25	3.17	0
665	22	.165	.144	.125	+14.58	6.03	3

The results from the tests on Rt. 798 were excellent. The graph for these results is shown in Figure 10.

Machine 9. The ninth distributor tested was a Rosco. The treatment,on Rt. 608 in Augusta County, was a penetration and seal, with an intended tack coat of .10 gsy AP-00 covered with 110 lb. of large stone, then .90 gsy AP-00 and 25 lb. of small stone.

Cotton Pad Test. Two sets of pads were run. The following table summarizes the data.

Test	No. Pads	Nozzles Adjusted?	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation %	No. Deviating Over 12%
1	22	no	.822	.682	.596	+20.53	7.13	3
2	22	yes	.737	.636	.512	-19.50	8.98	7

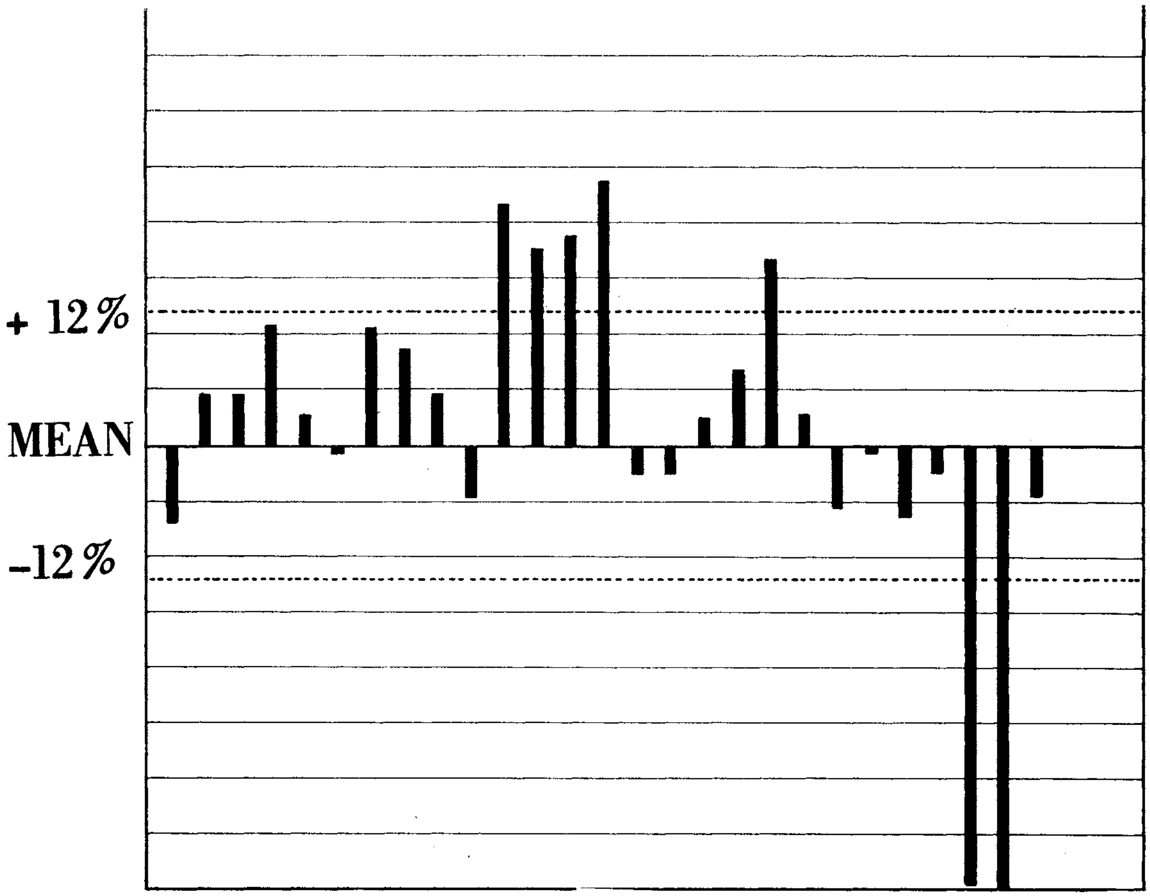


Figure 9. Nozzle discharge pattern of Machine No. 7 as indicated by one paper cup test.

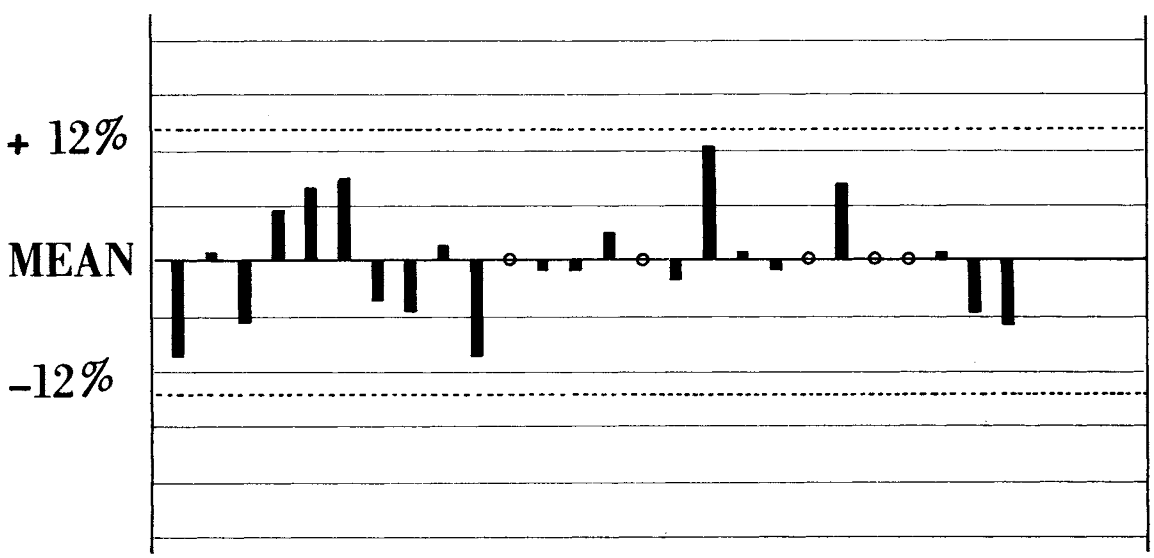


Figure 10. Lateral discharge pattern of Machine No. 8 as indicated by one cotton pad test on Route 798 project.

This is a case where the one attempt to adjust the nozzles did not indicate improvement in results. In fact the results were poorer after adjustment than before. However, the loss in consistency was only slight since, although not shown in the table, there were three pads in test one which deviated by 11.73% or more, but did not quite reach the 12% mark. If time had permitted additional adjustments the inconsistencies could probably have been compensated.

Cup Test. One cup test was run and, as can be seen from the following table, the results "attained the standards".

Test	No. Cups	Range in Gallons High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	18	.180	.155	.141	+16.13	5.38	1

Machine 10. A Rosco distributor was used to place two special stone test sections in Washington County. The same type of asphalt, an RC-2, was used on both jobs. Three sets of cotton pads and a set of cups were run on Rt. 75 and three sets of cotton pads were run on Rt. 609.

Cotton Pad Test. The following table contains a general summary of the cotton pad tests on both routes.

Test	No. Rte.	Pads	Nozzles Adjusted?	Range in gsy High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	75	24	no	.240	.210	.173	-17.62	6.55	3
2	75	24	yes	.251	.217	.168	-22.58	7.03	5
3	75	25	yes	.239	.215	.184	-14.42	5.92	1
4	609	26	yes	.273	.214	.148	-30.84	9.65	9
5	609	23	no	.216	.181	.141	-22.10	7.30	5
6	609	23	no	.217	.182	.152	+19.23	8.74	7

This is a case where the distributor was adjusted to give better consistency and then further adjusted although not intentionally to give a poorer consistency. However, it is felt that a factor which contributed to the poor results on Rt. 609 was the uneven cross section of the road. The original road was 10 feet wide and 4 feet were added on either side at a much later date. These shoulders had sunk, thus the distributor bar was at different elevations across the pavement.

Cup Test. Only one set of cups were run and these were between jobs, after work had been completed on Rt. 75 and before work was begun on Rt. 609. The summary results are in the following table.

Test	No. Cups	Range in Gallons High	Mean	Low	Greatest Deviation, %	Mean Deviation, %	No. Deviating Over 12%
1	20	.159	.137	.095	-30.66	7.74	4

As can be seen these results were not much better than those found on the cotton pads on Rt. 609.

Aggregates

Procedures

Aggregate distribution was checked when time permitted. Two methods were employed, both a check on the logitudinal distribution. In one method a determination of the average longitudinal distribution was made by measuring, with a hand pushed odometer, the distance a truckload covered. Unfortunately in only a few cases was the actual load weight known. Data will be shown from work done by one crew when load weights were known and from one job where the weight had to be assumed.

The second method employed was a spot check which required the placing of pans in the road to catch the stone as shown in Figure 11. To avoid having the pans run over by the wheels on the spreader or the truck, they were placed in the middle of the lane. Neither method gives an indication of the distribution across the road and many times it is this distribution which by visual observation appears to be poor. Typical data from the pan test are shown from two roads, one for each the buckeye and the automatic self-propelled chip spreaders.

Results

Load Average. On Rt. 75 in Washington County eight trucks were operating. Tailgate spreaders were being employed and a 25 psy application of stone was intended. Stone distribution checks were made on three different days. For simplicity the results from only two trucks are given along with the grand average of all trucks for each day. The two trucks given represent the extreme values measured. The following table summarizes the results.

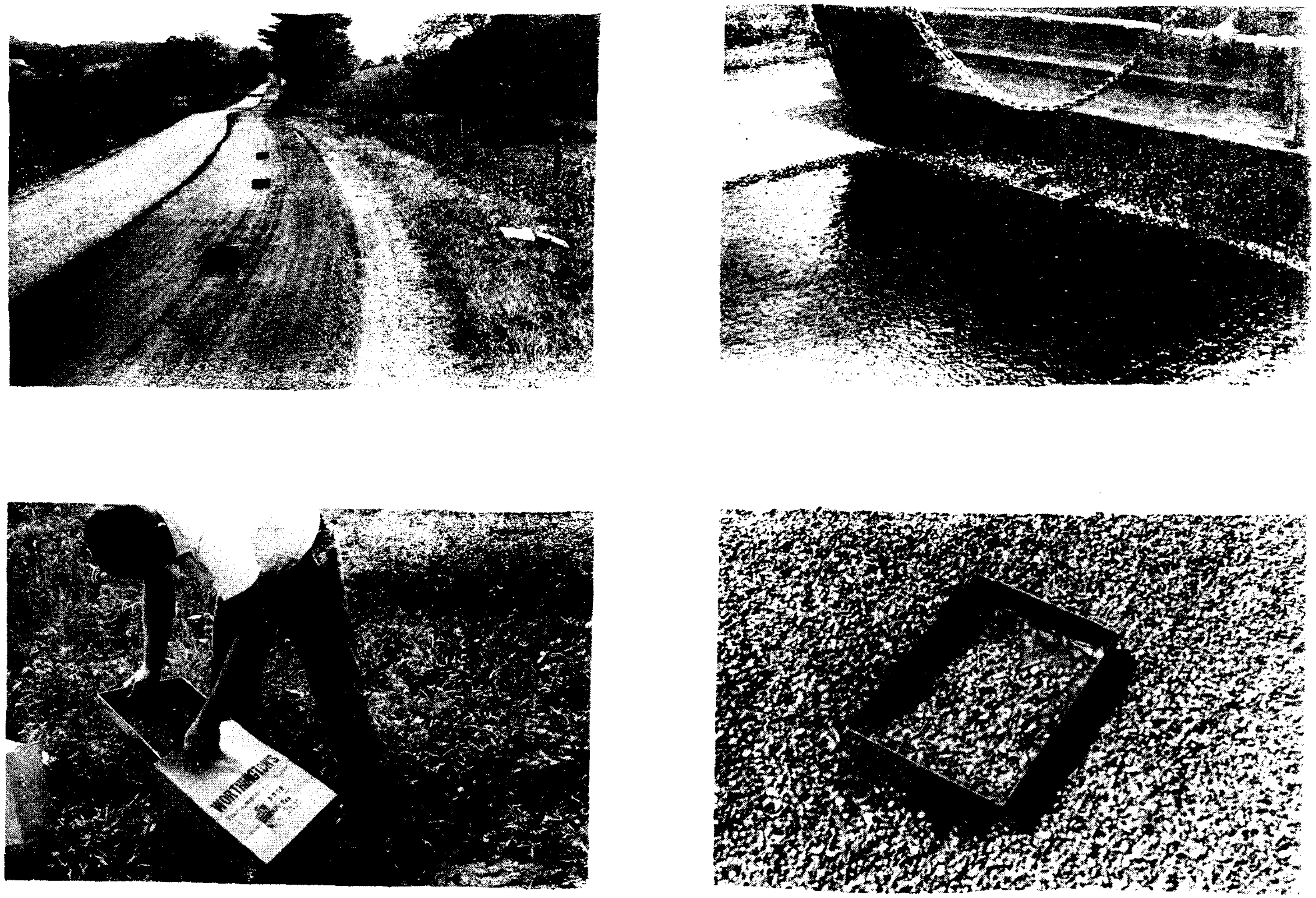


Figure 11. Check of longitudinal distribution of aggregate spreader by pan method.

Day	Truck	Application Rate in psy				
		Test 1	Test 2	Test 3	Average	Average of all Trucks
1	A	25.0	25.6	25.5	25.4	23.0
	B	18.8	20.7		19.6	
2	A	20.9	19.0	24.1	21.3	20.4
	B	20.6	18.3		19.6	
3	A	33.6	25.1		29.3	24.3
	B	21.5	19.8		20.7	
			Grand Average of A			25.3
			Grand Average of B			20.0
			Grand Average of all Trucks			22.6

The extreme values here are 18.3 psy on the second day (test 2, truck B) and 33.6 psy on the third day (test 1, truck A). While the averages are more representative of the deviations among trucks that are caused by different drivers, the extremes are most detrimental. However, as long as spreaders other than the self-propelled ones are employed and truck drivers inexperienced in surface treatment work are depended upon for control, the distribution is going to be poor.

To further demonstrate the influence of a driver, data from three trucks on Rt. 775 are given. The driver of truck C had one day's experience. The intended application rate was 33 psy. These trucks were not weighed so a 12,000 lb. load was assumed.

Truck	Application Rate in psy					
	Test 1	Test 2	Test 3	Test 4	Test 5	Average
A	28.6	29.1	30.4	34.4	30.8	30.7
B	25.4	25.2	26.7	30.9		27.1
C	36.5	46.5	46.3	46.5		44.0

These data cannot be depended upon as accurate indications of application rates since the load weights were assumed. However, the trucks were of the same capacity and from observation they appeared to be similarly loaded; therefore, it is reasonably safe to assume that the magnitude of the difference in relationship to each other is dependable, i.e., the application rate of truck C was about 50% greater than that of trucks A or B.

As previously mentioned the driver of the truck controls the rate of spread by the speed at which he backs up. It should be remembered that the driver is also responsible for alignment, i.e., he must make sure that he guides the truck such that the stone covers the asphalt. This requires the driver to have the door open and be turned in such a position that he cannot see the speedometer. In other words, the speed at which the driver backs up is gaged by guess or feel.

Pan Test. The second method of test, i.e., placing pans on the roadway before the stone is spread, is for the primary purpose of determining variations along a given line of the roadway from material within a given truck. Because of the emphasis being placed on other phases of surface treatment during the summer work and because of the time that would be consumed in making a thorough study of within load consistency, much was sacrificed in testing procedure and the results are, therefore, inconclusive. In order to evaluate the consistency of spread from any given truck, samples should be taken at the extreme ends of the truck run as well as in several places during the run. However, for the reasons given above, the most samples taken from any truck were three and these were spaced only about 20 feet apart. In other words, the trucks were not evaluated over the entire length of the load discharge. Therefore, the consistency in discharge from a load is probably not as good as the data indicate. At the beginning of a load discharge the load is heavy and at the end it has become quite light. Under these conditions it is difficult for a driver to hold a constant speed. Typical test data are shown in the following table for a buckeye and an automatic self-propelled chip spreader.

Test	Buckeye	Automatic
1	25.8 psy	23.7 psy
2	22.8	23.2
3	24.7	24.8
Average	24.4	23.9

Both sets of tests were performed alike and both indicate little deviation from the mean spread. However, intuitively it seems likely that the buckeye results would deviate to a much greater extent if the samples were taken between the extremes of the discharge rather than only 20 feet apart. Also it has been demonstrated by data that there can be a wide deviation among trucks. On the other hand, as long as there is no malfunction and the operator is proficient, the writer can see no reason for any appreciable increase in the deviation by the automatic self-propelled chip spreader from day-to-day, or job-to-job. If a consistent application is to be expected then the equipment placing the stone must be controllable, and if better surface treatments are expected the stone application must be consistent. However in discussing the desirability of self-propelled spreading, the rental rates should be mentioned. Tailgate spreaders have no rental rate, the buckeye's rate is $0.80 per hour and the Equipment Division estimates that a self-propelled chip spreader would rent for approximately $8.35 per hour. The writer feels this additional cost would be justified due to improved quality of the treatment provided the work was scheduled, planned, and performed in such a manner as to eliminate many of the delays that now occur in this type work.

Summary

Ten distributors and ten chip spreading operations were investigated for distribution characteristics on 17 surface treatment applications. Four of the distributors were owned and operated by contractors. Three of the contractors employed self-propelled chip spreaders.

Binder

An attempt was made to evaluate the distribution characteristics of bituminous distributors by three methods: the cotton pad test, the cup test, and the trough test.

The cotton pad test is a method of evaluating the lateral distribution of the binder while an application is being placed. The results depend on both nozzle output and nozzle angle.

The cup test is a method of evaluating the nozzle output while the distributor is stationary. The results are not influenced by nozzle angle but by output only.

The trough test is a method of evaluating the lateral distribution of the binder while the distributor is stationary and, like the cotton pad test, is dependent upon both output and nozzle angle.

Cotton Pad Test. All of the distributors were checked by the cotton pad test. A total of 39 of these tests were run and in six cases on four distributors the results were superior. These tests showed a mean deviation of less than 6% with not more than 5% of the values from the pads deviating by more than 12% from the mean. The results from these six tests formed the basis of a guide for determining the quality of distribution control that is attainable.

Graphs of one test each from four distributors showing the deviation from the mean application rate as plotted for the cross section of the road are shown in Figure 12. Each of these tests was run prior to any adjustments being made to the nozzles, i.e., these results indicate the normal distribution pattern of these operations. After nozzle adjustments the first two distributors gave the results shown in Figure 13. Improvement is shown in both cases. However, only two attempts were made to adjust the first distributor and only one attempt was made to adjust the second one. The writer can see no reason why all distributors couldn't perform as machines three and four in Figure 12, with proper maintenance and adjustments.

Cup Test. Eight of the ten distributors were checked in a total of ten cup tests. The results from these tests showed that in five cases on four distributors the desired or attainable results were realized. It should be remembered that this test is a measure of nozzle output, and is not affected by nozzle angle. Poor results in this test indicate malfunctions due to factors such as worn parts, clogged lines or bars, or poor circulation because of the lack of heat.

Trough Test. The trough test was tried with only two distributors. The results were so poor that this method was abandoned for field use. This test would probably be a very useful tool for calibrating distributors if the trough apparatus were centrally located where a level place could be built for the distributor to park on, the trough could be fixed such that its top were level with the ground and a sump be built so that the oil used as a testing medium could be pumped back into the distributor for reuse.

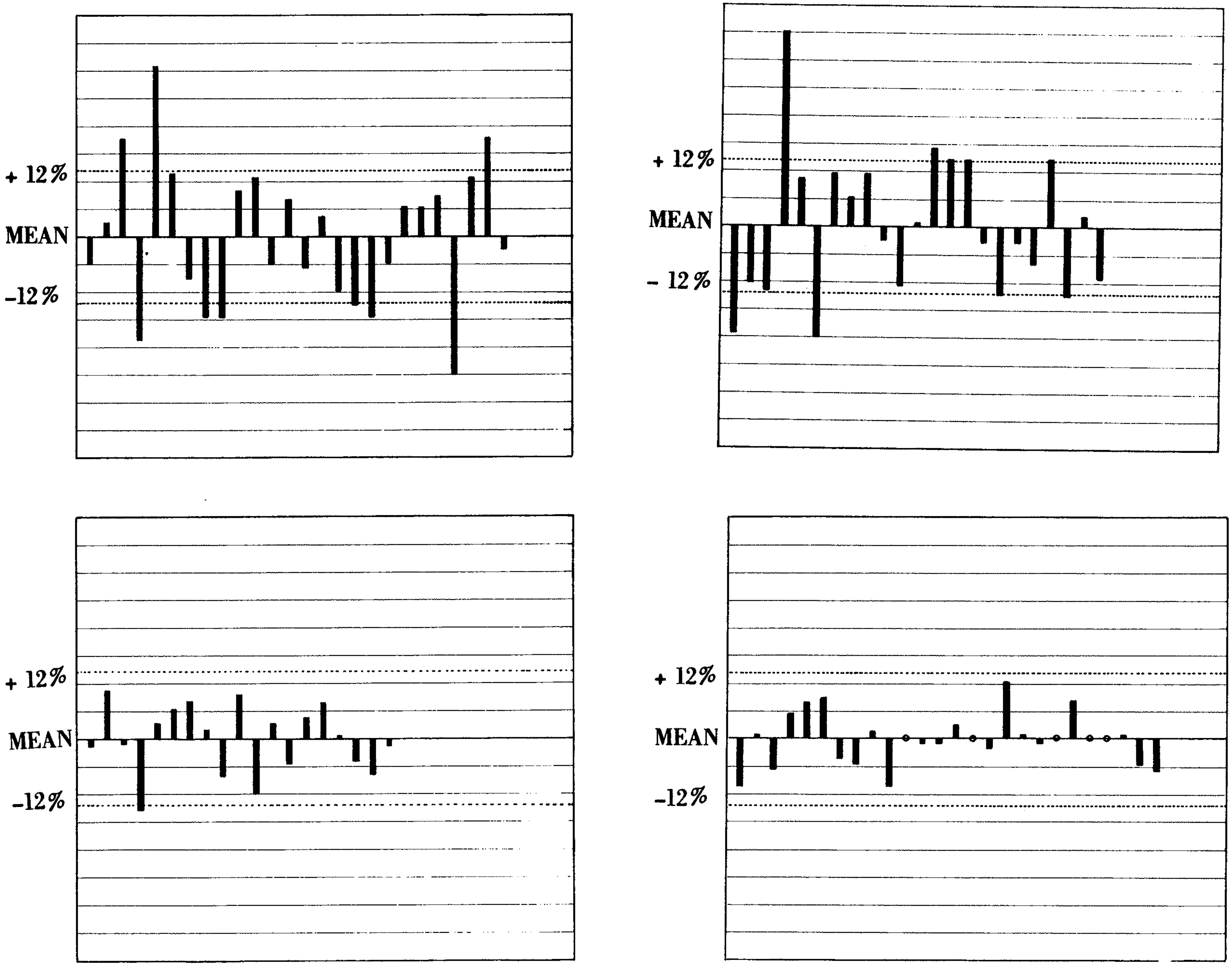
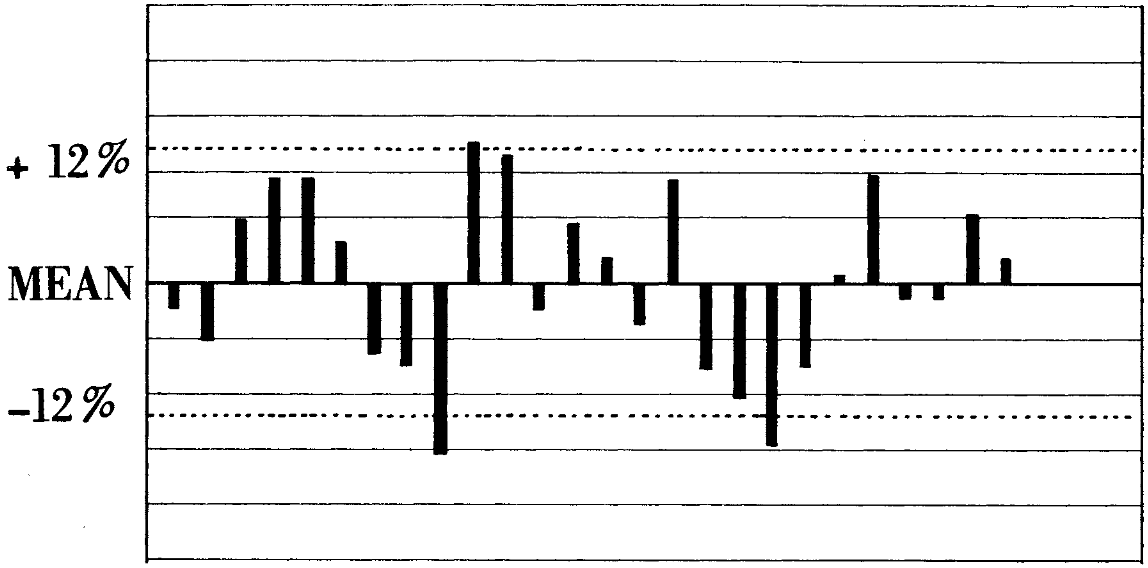


Figure 12. Lateral distribution patterns of four distributors as indicated by one cotton pad test of each. Tests made without nozzle adjustments.



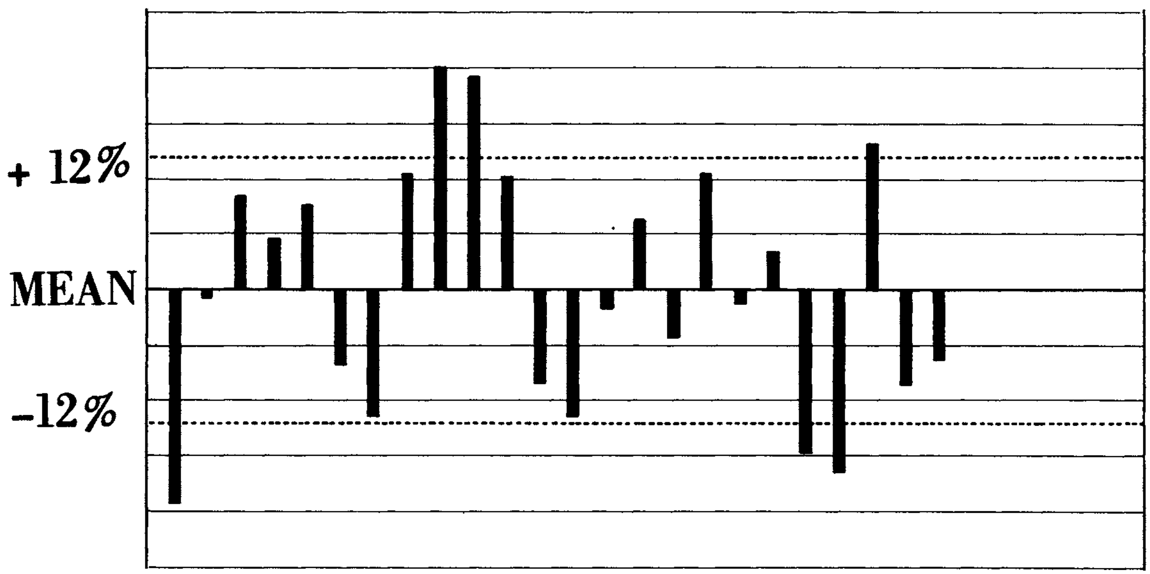


Figure 13. Lateral distribution patterns of first two distributors shown in Figure 12 after nozzle adjustments.

Aggregate

Aggregate distribution was checked when time permitted. Two methods were employed, both a check on the longitudinal distribution. One method was a determination of the average longitudinal distribution by measuring, with a hand pushed odometer, the distance a truckload covered. The second method employed was a spot check which required the placing of pans in the road to catch the stone. To avoid having the pans run over by the wheels on the spreader or the truck they had to be placed in the middle of the lane. Neither method gives an indication of the distribution across the road and many times it is this distribution across the road which by visual observation appears to be poor. Typical data from the pan test are shown from two roads, one each for the buckeye and the automatic self-propelled chip spreaders.

Conclusions and Recommendations

1. Of the bituminous distributors tested there was a wide variation in coverage consistency; some had a distribution pattern much superior to that of others. It is believed that improvements can be made through further study, improved equipment, improved maintenance of equipment, and education and training.

   The most immediate benefit can be derived by providing nozzle adjustment wrenches and slide calculators for determining distributor speed for desired application rates, both of which are provided with new distributors, and training of the supervisors and operators in their use.

2. The distribution of aggregate varies considerably when tailgate or buckeye type spreaders are used. This should be expected since the quantity placed is primarily dependent upon the driver of the truck.

   Consideration should be given to the purchase of automatic chip spreaders.

SECTION TWO

INSTALLATION OF TEST SECTIONS EMPLOYING ONE SIZE AGGREGATE

Scope

There has been much written in the last few years concerning the desirability of using "one size" stone in preference to graded aggregate in surface treatments. The quantity of asphalt required to hold the large stone in graded aggregate inundates the small stone, which in turn increases the depth of the asphalt and the possibility of bleeding. This problem is eliminated when one size stone is used because it is much easier to design the treatment from the asphalt content standpoint. Since this reasoning seems to be quite logical and other organizations have reported superior treatments with one size stone, it was decided to place test sections in Virginia with such stone. The one size stone for these test sections is defined by ASTM designation D448 as size 78 modified such that not more than 7% by weight passes the 1/4" screen and size 8 modified such that not more than 10% passes the #4 screen. In using these stones, a design criterion based on the original work of F. M. Hansen of New Zealand was employed.

Test sections were placed within the confines of seven surface treatment jobs on the regular schedule. On each job, a control portion was placed in the normal manner. For the experimental portion, it was intended that the stone used on the control be modified in accordance with the above description of one size stone. The asphalt was the same for both portions. The quantities of asphalt and stone used on the experimental portion were determined by the above mentioned design method.

It is too early to evaluate these test sections, however, a description of their installation follows.

Installation Data

Rt. 40 — Pittsylvania County

The entire length of this Class B treatment (state furnished material, contractor placed treatment) was 11.75 miles, beginning at the west corporate limits of Gretna and ending at the Franklin County line. The material was placed the week of June 22 and consisted of #8 stone from the Shelton Quarry and CAE-2 asphalt. The experimental, or one size stone portion, of the treatment began at the intersection of Rts. 40, 777 and 626 and extended one mile east toward Gretna. On this section the research crew was able to keep pace with the operation for the first half mile only, so it was from the above intersection to one-half mile east on Rt. 40 that the quantities of materials placed were measured.

On the control portion of the treatment .30 gsy of CAE-2 was applied and on the test section .20 gsy was applied.

The chip spreader was of the self-propelled type. The aggregate on the control portion was placed at an intended rate of 20 psy and on the test section at 18 psy. The pans placed on the roadway for measuring stone quantity were too shallow and therefore did not give what was believed to be an accurate measurement of the rate of application. Later in the summer deeper pans were employed and confidence was gained in this means of spot checking. The gradations for the stone placed on the control and test sections are shown in the following table.

Sieve Analysis in % Passing

Section	Size	3/8	1/4	4	3/8	30	50	100
Control	#8	96.2	59.1	31.4	1.9	0.8	0.8	0.7
Test	one size	95.0	38.3	6.9	-	-	-	-

As can be seen from the table the special stone met the gradation requirements for one size made from #8 stone; i.e., not more than 10% by weight passed the #4 screen.

Rt. 766 — Amherst County

The entire treatment on Rt. 766 covered 1.7 miles, beginning at the intersection with Rt. 29 and extending to the intersection with Rt. 130. The control and left lane of the test section were placed on July 7 and the right lane of the test section was placed on the 8th of July. All of the stone was quite dry. The left lane of the test section begins 0.7 mile from Rt. 29 and extends for 1 mile to Rt. 130. The right lane of the test section begins 1 mile from Rt. 29 and extends for one-half mile. The binder was CAE-2 and the stone was size 78 from the Blue Ridge Quarry in Lynchburg. The stone was placed with a buckeye type spreader. On this job the special size stone turned out to be further removed from one size than the regular #78, as can be seen in the following gradation table.

Sieve Analysis in % Passing

Section	Size	1/2	3/8	1/4	4	8
Control	78	94.2	63.7	29.0	11.1	1.1
Test	One size	95.6	67.9	30.5	14.2	5.6

In light of this, the special stone was used in the left lane of the test section only. On the right lane of the test section the same stone was used as on the control section, i.e., #78 from the Blue Ridge Quarry with the above gradations.

Again, the pans used to measure the stone were too shallow to do an adequate job, so it will have to suffice to say that the test sections received more stone than did the control portions.

The average asphalt distribution on the control section was 19.5 gsy. The average distribution on the test section was 25 gsy in the left lane and 32 gsy in the right lane.

Rt. 643 — Tazewell County

The surface treatment on Rt. 643 is 5.2 miles in length and extends from Rt. 655 to Rt. 644. The test section begins 0.5 mile from Rt. 655 and extends approximately one mile south. The stone was #78 from the Pounding Mill Quarry and the binder was an RC-3. A tailgate type chip spreader was used. The first half mile of the control and all of the test section were placed on August 13. The asphalt distribution on both the control and test sections was 30 gsy. All of the stone was wet from rain during the previous night. The gradations for both the control and test sections are shown in the following table.

Sieve Analysis in % Passing

Section	Size	1/2	3/8	1/4	4	8
Control	78	97.5	81.0	36.7	19.2	0.9
Test	one size	99.3	80.0	14.7	3.0	0.8

As can be seen from the table the one size stone did not meet the requirement that not more than 7% by weight pass the 1/4" screen when the stone is made from #78's. However, the test section stone did have quite a bit less passing the 1/4" and #4 screens than did that on the control section. Since both the control and the test sections received the same quantity of asphalt, this project should be a good one for determining whether a benefit is derived from having most of the stone close to one size. It should be mentioned though that neither of the stones had any appreciable quantity of fines. (Many engineers consider fines to be detrimental to surface treatments.)

Rt. 75 — Washington County

The project on Rt. 75 begins at the intersection with Rt. 677 and extends south for approximately 3 miles. It was placed on the 18th and 19th of August. The one size stone test section begins 0.75 mile from the south end of the project and extends north for 1.20 miles. The asphalt was RC-2 and the stone was #78 from the Lambert Brothers Quarry in Bristol. The gradations for both the regular and the special stones are shown in the following table.

Sieve Analysis in % Passing

Section	Size	1/2	3/8	1/4	4	8
Control	78	95.7	77.5	35.8	18.7	1.3
Test	one size	99.3	65.7	10.2	1.8	0.2

Again, a little more than 7% of the one size stone passed the 1/4" screen.

The first two thousand feet of the project beginning at the south end was covered with #8 stone rather than #78. This was not by intent but will provide a third stone variable to observe.

The asphalt distribution averaged .21 gsy for both the control and test sections.

The left lane of this road was shot fired; i.e., the distributor shot a half a load on the left lane and, after stone had been applied, squared up the right lane. The road was 19 feet wide for much of its length so 10 ft. was covered with binder on the left lane shot and 9 feet on the right lane shot. The chip spreader was the tailgate type, which covers only 8 feet, therefore two feet of binder in the middle of the road was left uncovered for long periods of time. This problem coupled with the long haul the stone trucks had to make extended this lapse of time between binder distribution and stone coverage to as much as two hours on these two feet in the center of the road. This portion of the pavement was bleeding badly the following day and was covered with additional stone. It is suspected that the center of this road will continue to be a problem area. This is one of the sections on which the measurement of the stone application rate was dependable, i.e., the pans were deep enough to retain the stone and the trucks were weighed. The average distribution was 22.5 psy from the area covered-load weight relationship of 49 truckloads. However the range was from 17 to 33 psy.

Rt. 609 — Washington County

The project on Rt. 609 extends from the main gate of Emory and Henry College for about 2 miles south to Rt. 80. The materials were placed on August 19 and 20 and the same equipment operators were employed as on Rt. 75. The special one size stone section extends from 0.15 mile south of Rt. 637 to Rt. 80. The binder was an RC-2 placed at an average of .19 gsy on both the control and test sections. The stone was #8 from the Meadowview Lime and Stone Company in Meadowview, and was placed by a tailgate type spreader. The following table gives the gradations of both the regular and special stones.

Sieve Analysis in % Passing

Section	Size	3/8	1/4	4	8
Control	#8	88.8	44.4	21.8	3.1
Test	one size	98.8	18.6	2.6	0.4

This special stone met the requirements of one size stone made from #8's in that less than 10% passed the #4 sieve.

As on Rt. 75 the stone distribution rate measurements were dependable. And also, as on Rt. 75, the results were about the same; i.e., the average stone rate was 23 psy with a range from 16 to 33 psy.

It should be mentioned here that the cross section of this road is very poor. The original road was 10 ft. wide and four feet shoulders, which have settled, were later added on each side.

Rt. 775 — Carroll County

The surface treatment project on Rt. 775 was placed on September 3 and extended from Rt. 52 for 3.6 miles south. The special size stone was used on the first mile beginning at Rt. 52. The asphalt was AP-00 and was applied at an average of .25 gsy on both the control and test sections. The stone was size #78 from Newman's Quarry and was placed by a buckeye type spreader. The gradations for both the regular and one size stones are given in the following table.

Section	Size	1/2	3/8	1/4	4	8
Control	78	98.3	79.7	47.1	29.6	5.5
Test	one size	99.0	51.5	10.5	3.1	

This special stone did not meet the gradation requirements for one size stone made from #78's in that more than 7% passed the 1/4" screen. However, as with the other projects which used 78 stone, the percent passing the 1/4" screen is greatly reduced from the regular gradation.

The right lane leaving Rt. 52 had a stone application rate of about 30 psy for the first half mile and about 23 psy for the second half mile of the test section. The left lane received about 30 psy for the first one-tenth mile and about 23 psy for the rest of the mile. The control section received about 23 psy for its entire length. It is noted here, primarily for reference purposes in discussing the treatment on Rt. 665 which follows, that according to the design procedure employed (which is based on the average size of the aggregate and the number of flat particles) the portion of this treatment which received the one size stone should have a .24 gsy application of asphalt and 33 psy of stone.

Rt. 665 — Giles County

Rt. 665 was surfaced treated on September 10, beginning at Rt. 100 and extending for about 3 miles south. The asphalt was an AP-00. The stone,from Virginia Limestone Quarry, was #78, but as can be seen from the gradation in the following table, it is closer to #8 than #78.

Sieve Analysis — % Passing

Section	Size	1/2	3/8	1/4	4	8
Control	78	100	83.1	48.5	26.5	2.1
Test	one size	100	95.0	47.5	18.8	1.3

Conclusions and Recommendations

1. The application quantities of both binder and cover material are presently selected through art rather than by science. A design method is under consideration and was employed experimentally on the seven special stone test sections placed during the summer of 1964. The writer feels that this method has merit and is an improvement over art; however, a final evaluation of this method at present would be premature.

2. With regard to the use of one size stone, it is too early to evaluate the test sections. However it is the writer's opinion that the elimination of the material passing the 1/4" or #4 screens, depending upon top size, can be quite beneficial.

SECTION THREE

SETTING TIME, OR TRAFFIC READINESS

Centrifuge Tests

The question of when a new surface treatment is ready for traffic is a perplexing one, and many factors will have to be dealt with and resolved before an answer can be found. During the past summer, a first step was taken when the most promising empirical test for rating whip off that could be found in the literature was experimented with.

This test method is fashioned after one used in California. The equipment consists of a centrifuge head fashioned so that two six inch by six inch metal plates can be fastened on it at an angle of 15° from the horizontal. This equipment is shown in Figure 14.

Plates are placed on the roadway to receive an application of surface treatment at the same time the pavement is treated. The plates are then tested for whip off by centrifuging at various time intervals after surfacing.

Preliminary tests in the laboratory indicated that the curing time was both a reasonably short time unit and quite distinguishable. About ten plates were prepared at one time. They were tested at different time intervals by being subjected to 100 rpm on the centrifuge head for one minute. The slope of the time-percent whip off curve underwent a radical change within a few hours after fabrication of the treatments; i.e., the percent whip off dropped rapidly for a given time and then appeared to become asymptotic. The time required for this change also indicated a dependency upon the type of asphalt.

The field experience was quite different. When plates were prepared early in the morning the percent whip off was often still 100% late in the afternoon. The only explanation that the writer can offer is that although both cutbacks and emulsions have initial rapid cure or break, they still, under normal summer atmospheric heat, remain quite liquid for an extended period of time, at least into the night of the first day, and often longer if the weather is extremely warm.

The exception to this experience was those instances when AP-00 was used. The plates with AP-00 had such a low percent whip off even after ten minutes of curing time that the speed of the centrifuge was increased to 300 rpm and at times to 500 rpm.

Conclusions and Recommendations

The whip off test is empirical and even when run at 100 rpm is probably much more harsh than traffic at moderate speeds. However, there is reason to believe if not conclude from this experience that AP-00 is traffic ready in a much shorter period of time than are the cutbacks and emulsions. Therefore, as will be set forth in Section Four, Proposed Investigations for 1965, the writer recommends that an AP-00 test section be placed on a high traffic volume road.

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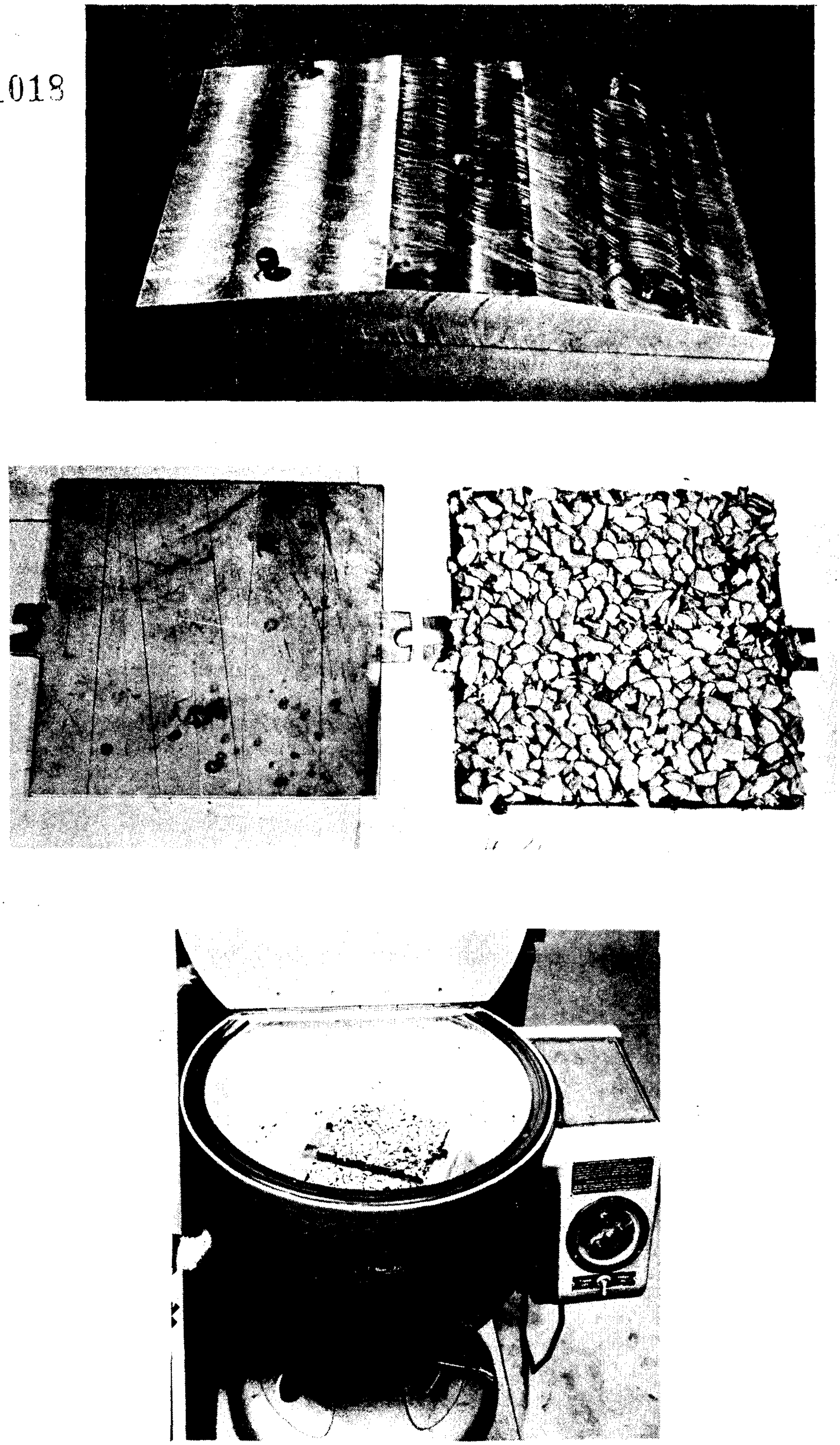

Figure 14. Centrifuge equipment for evaluating whip-off.

SECTION FOUR

PROPOSED INVESTIGATIONS FOR 1965

Bituminous Distributor Calibration

From the work done thus far it has been concluded that some distributors have a much better distribution pattern than do others. It is believed that this superiority is due to equipment maintenance, equipment adjustments, and workmanship. In order to determine whether distributors can be made to perform in a superior manner the writer proposes that four state distributors of different makes be selected and brought to Charlottesville, where every effort will be made to calibrate them and to train the two-man crews in proper maintenance, adjustment and operation. It is hoped that the manufacturer of each of the various distributors would send a man to Charlottesville to aid in this work.

These four distributors would be field checked against others (at least four) in order to evaluate the effects of calibrations and training in terms of performance.

The purpose of this investigation would be to determine what benefit if any can be derived from having centrally located distributor calibration stations.

Procedure

Facilities would be built in Charlottesville to permit the trough to be used for calibration purposes. This would require the building of a level place large enough for a distributor, an excavation for the trough so that its top would be at ground level, and provisions for a sump so that the used testing medium can be poured into it to be pumped back into the distributor for reuse. It is anticipated at present that #2 diesel oil would be used as the testing or calibration medium.

In addition to the anticipated aid of the distributor manufacturers, help will also be required from the Highway Department in the form of a mechanic who is familiar with distributors.

The following items would be checked and corrected during calibration.

(1) Spray bar alignment both horizontally and vertically with respect to bent bars and maladjusted header bars.

(2) All lines for leakage.

(3) Pump and pressure gages.

(4) Bitumenometer.

(5) Speedometer.

(6) Gage for determining quantity of oil in distributor tank.

(7) Nozzle discharge as measured by the cup test.

(8) Oil distribution pattern as measured by the trough test.

In addition to the above the operators of the distributors would be trained in the necessary care of and adjustments to the equipment and in the proper manner of operating it.

After the distributor leaves Charlottesville it will be followed to the field and tested using the cotton pad test. Additional distributors will also be field tested. The results from these field tests will be compared and a determination will be made concerning the feasibility of centrally located calibration and training centers.

One Size Aggregate Test Sections

One size aggregates were placed on seven short test sections (approximately one mile each) on secondary roads during the summer of 1964. It is of course too early to make a complete evaluation of the effectiveness of one size stone. However, the writer is of the opinion (based on the findings of others and the early appearance of the above test sections) — the test sections were visited by the writer, other research personnel, and field engineers the latter part of March 1965 — that one size stone test sections should be placed on Virginia's highest trafficked roads that are included in the surface treatment schedule. It is proposed that these test sections comprise an entire job rather than a short section within the confines of scheduled work. It is also hoped that selection of test sites will not be confined to the Class "A" schedule but can also be selected from Class "B" and Class "C". To fairly evaluate one size aggregate the writer feels that eight to ten sections covering twenty to thirty miles of road should be placed.

It should be remembered that while evaluating one size aggregate a design method is also being evaluated. This design method predetermines the quantities of binder and cover material from the aggregate size, gradation, and shape. This design method or a modification of it is being used in several countries, a few of the states, and has been endorsed within the last year by the Asphalt Institute.

Traffic Readiness

From the work done in 1964 on traffic readiness there was a strong indication that AP-00 has a much higher early retention strength than do cutbacks and emulsions. Results with AP-00 in surface treatments in Virginia have been poor on high traffic roads. This inferior quality has shown itself mostly in the form of bleeding. The writer feels that this condition can be corrected through the above mentioned surface treatment design method. If bleeding can be controlled or greatly reduced and if AP-00 does have high early retention power, then it might be the most desirable binder for high traffic roads. Test sections using AP-00 will be included in several of the aforementioned sections where one size stone is employed.

It is also anticipated that some lab work will be done on aggregate retention during the winter of 1965-66; however, this will be proposed at a later date.