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MICHIGAN  
STATE HIGHWAY DEPARTMENT  
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State Highway Commissioner

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MICHIGAN'S EXPERIMENT  
in  
SNOW AND ICE REMOVAL ON HIGHWAYS BY  
RADIANT HEAT  
PERFORMANCE AND COST INFORMATION FOR  
WINTER SEASON 1949 - 1950

Cooperative research project  
between the Michigan State Highway Department  
and the Detroit Public Lighting Commission

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MICHIGAN'S EXPERIMENT IN SNOW AND ICE REMOVAL  
BY RADIANT HEAT

Performance and Cost Data for Season 1949-1950

This is the third progress report related to Michigan's experiment in snow and ice removal on highways by radiant heat. Progress Report No. 1, published in January, 1949, described in detail the scope of the project and construction methods. Progress Report No. 2, published in May, 1949, presents performance information and cost data for operation of the system during the winter season of 1948-1949.

It is the purpose of this report to present similar performance and cost information for the winter season of 1949-1950. The past winter season is believed more nearly representative of a true Michigan winter in the Detroit area so far as snow and ice conditions are concerned and, therefore, the information presented should be representative of normal operating conditions.

Comments on Performance

Records on snow and ice melting started November 20, 1949 and continued to April 13, 1950 and indicate a total of 548.79 operating hours as compared to 506.69 hours for the 1948-1949 season. Minimum average air temperature encountered was +12° F. as compared to +19° the previous year. Total snowfall for the season was 41 in. as compared to 10.3 in. for 1948-1949. The cost per hour to operate the two 500-ft. sections was \$1.89 per hour as against \$1.31 for 1948-1949. A brief account of the performance of the two 500-ft. sections throughout the major storms follows.

November 21, 1949: During early morning hours, a 1/2-in. snowfall was recorded with temperatures ranging between + 26 and +28° F. At 8:00 A.M., the roads in the Detroit area were covered with a thin glaze of ice and packed snow. Traffic was moving very slowly with numerous tie-ups at lights

and intersections. On Eight-Mile Road, the heated areas were clear of snow, but were wet, and traffic was picking up the water, causing ice formation on the ends of the heated areas.

November 24, 1949: A snowfall of 2.6 in. was recorded in the Detroit area. The temperatures ranged from +26 to +35° F. with the snowfall in the afternoon being very wet. Being a holiday, there was very little traffic and roads, in general, were covered with wet snow until removed by plows. The heated areas were clear at all times.

December 1, 1949: A heavy, wet snowfall began at 5:00 P.M. and turned to ice during the night. This was followed by a light flurry of snow in the early morning. A total of 2 in. of snow fell with a low temperature of +24° F. The heated areas were clear of snow at all times.

December 7, 1949: Snowfall began at 6:00 P.M. and ended at 10:30 P.M. A total of 2 in. of snow fell with temperatures ranging from +29 to +34°. The snow melted fast and no dangerous driving conditions developed. The heated areas were clear at all times.

December 23 and 24, 1949: A light snowfall began in the afternoon of December 23 with a temperature of +20° F. and continued intermittently throughout December 24, 1949. A total of 1 in. of snow fell, but it was spaced so that no hazardous driving conditions developed. The heated areas were clear at all times.

January 6 to 8, 1950: A snowfall began at 6:00 A.M. on Friday and continued through until 5:00 P.M. Sunday with a total of 3.9 in. of snow falling. The temperatures ranged from +22 to +28° F. The snow lasted until Monday when rising temperatures and rain removed all of the snow. At 7:30 A.M. on Friday, a 1/2 in. of snow had fallen and the heated areas were clear on the bituminous section but were covered with slush

on the concrete section. It took until 8:30 A.M. Friday for the heated areas in the concrete section to become clear of snow. The balance of Eight-Mile Road was covered with packed snow until the salting crews cleared it. During the heaviest snowfall of Friday afternoon, the heated areas were clear. See Figures 1, 2, 3, and 4.

January 20, 1950: From 6:00 P.M. through to 10:00 P.M., a 3-in. snowfall was recorded with a temperature of +25° F. Roads and streets were generally covered with packed snow. The heated areas were clear in the morning but had some ice ridges along their edges.

January 30 and 31, 1950: A snowfall of 3 in. total began at 9:00 P.M. on January 30 and continued through to the early morning of January 31. The temperature was down to +15° F. during the night. At 7:30 A.M., the roads and streets were generally covered with packed snow and, in some places, were very slippery due to a thin film of ice under the snow. The heated areas at 7:30 A.M. were covered with slush on both bituminous and concrete lanes. By 10:00 A.M., the bituminous lanes were clear, but the ice ridges on the sides and ends were considerably heavier than at any time previous. See Figure 5. At 10:00 A.M., the south heated area on the concrete section had slushy snow on it while the north lane was entirely covered with packed snow and ice. Apparently the north lane was not working. The ice and slush conditions lasted until the salt from adjacent lanes and rising temperatures removed it. This was the most unsatisfactory performance of the heating system since its installation. See Figures 6 and 7.

The Detroit Public Lighting Commission, upon investigation, stated that the controls were not working properly on the concrete section. Consequently, to improve the accuracy of the concrete control, the

temperature control bulb in the concrete section was moved on February 8, 1950 to a point of near ground potential, thus eliminating the possibility of leakage currents heating the temperature control bulb in excess of pavement temperature. Furthermore, it was observed that the north heated track in the concrete section, which is adjacent to the unheated lanes, was being loaded with additional snow and ice thrown there by passing vehicles. This condition would no doubt exist on the south heated track of the bituminous section, but the bituminous section seemed to be able to handle the additional load satisfactorily. In an attempt to correct this condition on the concrete section, the power input was increased in that section on February 22, 1950 from 52 watts to 62 watts per square foot of heating element.

February 13, 1950: During early morning hours, a heavy snowfall began and at 8:00 A.M., 5 in. of snowfall with temperatures at 29° to 31° F. was recorded. Main roads and streets were covered with packed snow and traffic in general was moving very slowly. During the morning it was windy and the snow was being drifted but at noon it changed to rain. The rainfall continued throughout the afternoon and night of February 13 and removed the snow. The combined snow and rainfall caused floods throughout Wayne County. The heated areas were working very good and kept the lanes in both bituminous and concrete sections clear while the balance of Eight-Mile Road was covered with snow and slush. The rising temperature prevented any ice ridges from building up and probably helped the temperature in the unit to keep up with the heavy snowfall.

February 21 and 22, 1950: A snowfall began at 1:00 P.M. on February 21, 1950 and continued through the night and following day until a total of 6 in. was recorded. The temperatures ranged from 10° to 25° F. above

zero. Traffic, in general, was very slow with the main roads being slippery and the streets heavily traveled. The heated areas were working fair on the bituminous section, but in the concrete section, they were covered with slush. Apparently, the low temperature and heavy snowfall, plus the slush thrown from the other lanes just overwhelmed the heating elements. This was the heaviest snowfall at the lowest temperatures that the heating project had experienced.

February 24, 1950: During early morning hours, a snowfall of 2 in. with temperatures around 20° F. above zero was recorded. This new snowfall added to the remains of the previous snowfall made driving conditions difficult in the morning. The heated areas were working good in the bituminous section but they were slow-acting in the concrete section and had slush along the edges.

March 11 to 13, 1950: During Friday night and Saturday morning, a snowfall of 3 in. with temperatures of 28 to 33° F. was recorded. This later changed to rain and all of the snow was gone by Sunday. The heated areas on the bituminous section were working but the concrete section was covered with slush. A snowfall of 1 in. with temperatures of 18 to 23° F. was recorded in the morning of the 13th. The general driving conditions were slippery in the early morning. The heated areas in both sections were clear.

March 17, 1950: A snowfall of 2.5 in. with temperatures around 24° F. was recorded in the morning. However, it was very windy and the loose snow was being whipped around. Generally slippery road conditions prevailed. The bituminous heated section had ice built up on the edges and ends due to the blown snow being continually melted on the heated

areas. The concrete lane had some ice formed on the ends but the edges were mostly slushy; otherwise, the heated areas were clear. See Figures 8 and 9.

#### Operation Costs and Information

Complete cost data and operation conditions for the 1949-1950 winter season will be found in Table I. This information was furnished by the Detroit Public Lighting Commission. Table II has been compiled to show comparative operating data by months for the winter seasons of 1948-49 and 1949-50. Further, in Table III, there is presented a summary of comparative operating information including the two winter seasons in which the system has been operating.

The data obtained this past winter season has disclosed several significant facts worthy of mention.

1. The cost for power consumed for the entire installation was \$1,041.02 which is within the estimate range predicted for a normal winter snowfall of approximately 40 in. The snowfall for the 1949-50 season was 41 in.
2. The power consumption for the bituminous section was again greater than that of the concrete section. This season it was approximately 5% greater as compared to 9% for the 1948-49 season. This consistent difference in power consumption between the two sections is believed to be due to two things: first, the variation in depth of the heating elements in the two sections which are approximately 2 in. and 1-1/4 in., respectively, concrete and bituminous and, second, the relative thermal conductivity (BTU per sq. ft., per degree F., per inch, per hour) of the bituminous and concrete pavements,

the ratio being 8.0 to 6.1, respectively. These values were obtained from laboratory tests on pavement mixtures similar to those used in the two heated sections.

3. The power consumed per 500-ft. section, per sq. ft. of heated area is approximately one-half of the design value, which is 52 watts for the bituminous section and now 62 watts for the concrete section. This would indicate that the heating elements are "ON" only about one-half of the operating time. This can also be detected on control record graph. See Figure 9.
4. It must be remembered that the pavement heating installation on Eight-Mile Road was designed to be used on ramps which would have the necessary run-off facilities for handling the melted snow. In the present installation, the pavement grade is comparatively flat and no special drainage for water from the melted snow is provided. Therefore, the water tends to form an insulating layer over the heated areas, preventing efficient transfer of heat to the freshly fallen snow, thus imposing an added burden on the heating installation.



TABLE I  
SUMMARY OF OPERATING DATA AND COSTS FOR SEASON 1949-50

Data furnished by Detroit Public Lighting Commission

SYSTEM IN OPERATION		Time Hr. Min.	CONCRETE SECTION		BITUMINOUS SECTION		PRECIPITATION		PAVEMENT TEMPERATURE		
From	To		Energy Consumed Kwh	Cost P.L.C. Rate	Energy Consumed Kwh	Cost P.L.C. Rate	Snowfall Sleet Inches	Water Equivalent Inches	Average Mean Temperature At site °F.	At Control Concrete ° F.	Bituminous ° F.
NOVEMBER											
9:54PM	11/20/49	1:30PM 11/21/49	240		280		0.5	0.05	32	37	35
7:57AM	11/24/49	3:10PM 11/25/49	1040		1200		2.6	0.56	31	41	35
4:37PM	11/26/49	12:30AM 11/27/49	700		800		1.4	0.15	32	41	35
Total for November		66:42	1980	\$46.80	2280	\$53.55	4.5	0.76			
DECEMBER											
5:25PM	12/ 1/49	5:30PM 12/ 2/49	580		800		2.0	0.20	32	40	37
5:29PM	12/ 6/49	5:00PM 12/ 7/49	580		680		2.0	0.24	33	40	37
12:30PM	12/10/49	7:45AM 12/11/49	580		780		T	0.01	33	40	37
4:08AM	12/24/49	8:50PM 12/24/49	340		520		0.7	0.03	28	40	37
Total for December		83:33	2080	\$49.05	2780	\$64.80	4.7	0.48			
JANUARY											
5:40AM	1/ 6/50	4:55PM 1/ 8/50	2080		2680		3.9	0.29	22	43	37
6:10PM	1/20/50	2:45AM 1/22/50	1160		1200		2.7	0.27	26	48	40
8:30PM	1/30/50	9:10PM 1/31/50	1160		1320		2.6	0.15	13	48	40
Total for January		116:30	4400	\$101.25	5200	\$118.18	9.2	0.71			
FEBRUARY											
11:15AM	2/ 2/50	5:00PM 2/ 2/50	0		160		T	T	32	48	40
4:54AM	2/13/50	10:00PM 2/13/50	1260		960		5.0	1.15	31	40	40
5:00AM	2/21/50	9:25AM 2/21/50	340		400		2.0	0.15	23	38	41
2:09PM	2/21/50	11:55AM 2/23/50	3480		3080		3.6	0.25	18	38	42
3:52AM	2/24/50	6:00PM 2/25/50	2080		1880		2.0	0.15	18	38	43
5:17AM	2/28/50	10:13AM 3/ 1/50	1400		1480		T	0.59	30	40	41
Total for February		140:06	8560	\$175.95	7960	\$165.60	12.6	2.29			
MARCH											
11:44AM	3/ 1/50	2:45PM 3/ 1/50	100		120		T	T	25	42	43
11:25PM	3/1 /50	7:40PM 3/ 2/50	1160		1360		0	0	12	40	42
5:12PM	3/ 8/50	6:00PM 3/ 8/50	0		0		T	0.07	25	40	43
12:48AM	3/11/50	1:10PM 3/13/50	1860		1840		7.1	0.50	30	40	43
6:15AM	3/17/50	8:30PM 3/18/50	1720		1640		2.5	0.24	29	40	43
Total for March		122:41	4840	\$111.24	4960	\$114.10	9.6	0.81			
APRIL											
6:15PM	4/ 5/50	9:30AM 4/ 6/50	580		680		0.4	0.4	28	40	42
6:25AM	4/13/50	10:25AM 4/13/50	340		0		T	T	24	40	42
Total for April		19:15	920	\$ 22.95	680	\$ 17.55	0.4	0.4			
Season Totals		548:47	22780	\$507.24	23860	1533.78	41.0	5.09			

\*Note Control temperatures fluctuated 1° of value given in table. Concrete Section temperature Control Set to operate between 41-43 degrees, Asphalt Section to operate between 39-41 degrees

TABLE II

## SUMMARY OF OPERATING TIME, ENERGY CONSUMPTION, AND WEATHER CONDITIONS

Years 1948-49 and 1949-50

Month	Time "ON"		KWH Consumption				Weather Conditions during Operation					
	1948-49 hours	1949-50	1948-49		1949-50		1948-49			1949-50		
			Concrete	Asphalt kwh	Concrete	Asphalt	Snowfall inches	Water Equiv.	Mean Air Temp. °F.	Snowfall inches	Water Equiv.	Mean Air Temp.
November	0.00	66.70	0	0	1980	2280	- - -	- -	- - -	4.5	0.76	32
December	79.65	83.55	2590	2180	2080	2780	0.50	0.49	38	4.7	0.48	33
January	190.93	116.50	5010	5600	4400	5200	4.6	0.26	35	9.2	0.71	30
February	142.01	140.01	3540	3770	8560	7960	3.1	0.39	25	12.6	2.29	25
March	94.00	122.69	2670	3470	4840	4960	2.1	0.11	25	9.6	0.81	24
April	0.00	19.25	0	0	920	680	- -	- -	- - -	0.4	0.40	26
Total	506.69	548.79	13810	15020	22780	23860	10.3			41.0	5.09	

TABLE III

SUMMARY OF COMPARATIVE OPERATING DATA FOR TWO SEASONS

	<u>1948-49</u>	<u>1949-50</u>
Total Time "ON"	506.69 hr.	548.79 hr.
Total kwh Consumption	28,830 kwh	46,640 kwh
Concrete section	13,810	22,780
Asphalt section	15,020	23,860
Total Cost (DPLC rate)	\$663.42	\$1,041.02
Concrete section	319.66	507.24
Asphalt section	343.76	533.78
Energy Consumption per 500-ft. section per hour of operation:		
Concrete section	27.3 kwh	41.5 kwh
Asphalt section	29.7 kwh	43.5 kwh
Energy Consumed per 500-ft. section per hour per sq.ft. of heating surface:		
Concrete section	18.4 watts	27.9 watts
Asphalt section	20.0 watts	29.3 watts
Cost per 500-ft. section per hour of operation:		
Concrete section	\$ 0.63	\$ 0.92
Asphalt section	\$ 0.68	\$ 0.97
Cost of system per hour of operation	\$ 1.31	\$ 1.89
Total Snowfall	10.3 in.	41.0 in.



▲ FIGURE 1. BITUMINOUS SECTION  
( 1 - 6 - 50 ) HEATED AREAS CLEAR



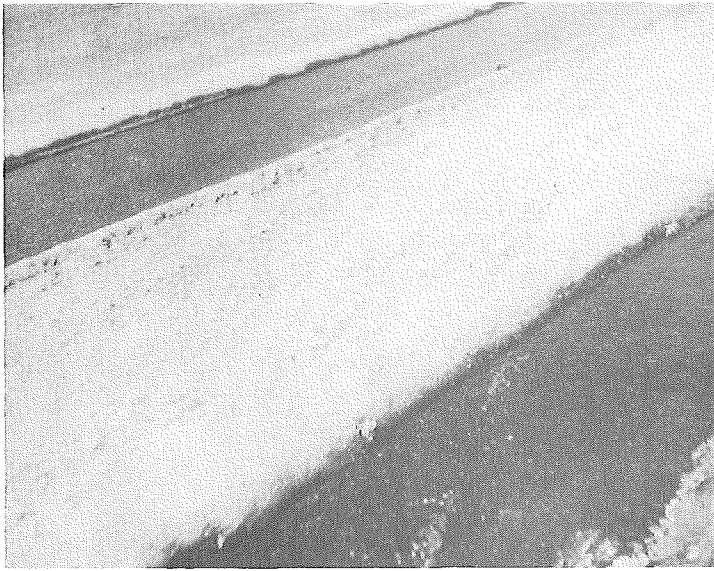
▲ FIGURE 2. BITUMINOUS SECTION ( 1 - 6 - 50 )  
ICY CONDITION AT END OF SECTION



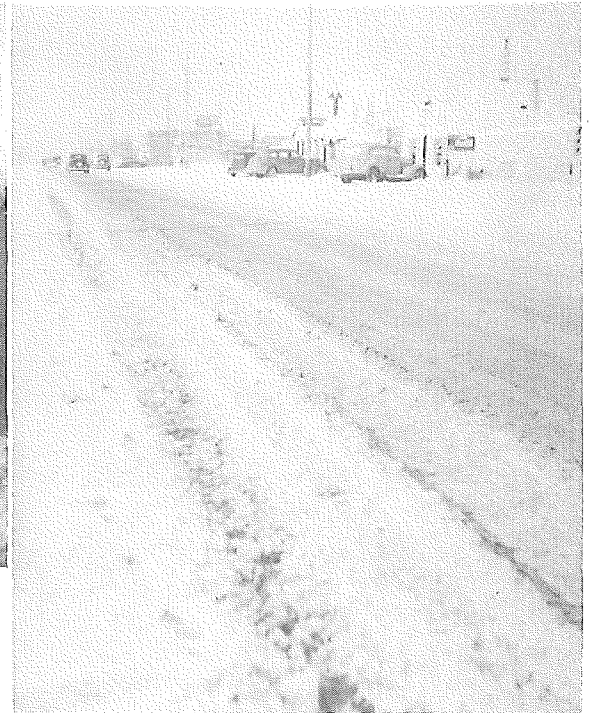
▲ FIGURE 3. CONCRETE SECTION ( 1 - 6 - 50 )  
ICY CONDITION AT END OF SECTION



▲ FIGURE 4. CONCRETE SECTION ( 1 - 6 - 50 )  
HEATED AREA PARTIALLY CLEARED



▲ FIGURE 5. BITUMINOUS SECTION, TYPICAL  
CONDITION DURING HEAVY STORM OF ( 1-31-50 )



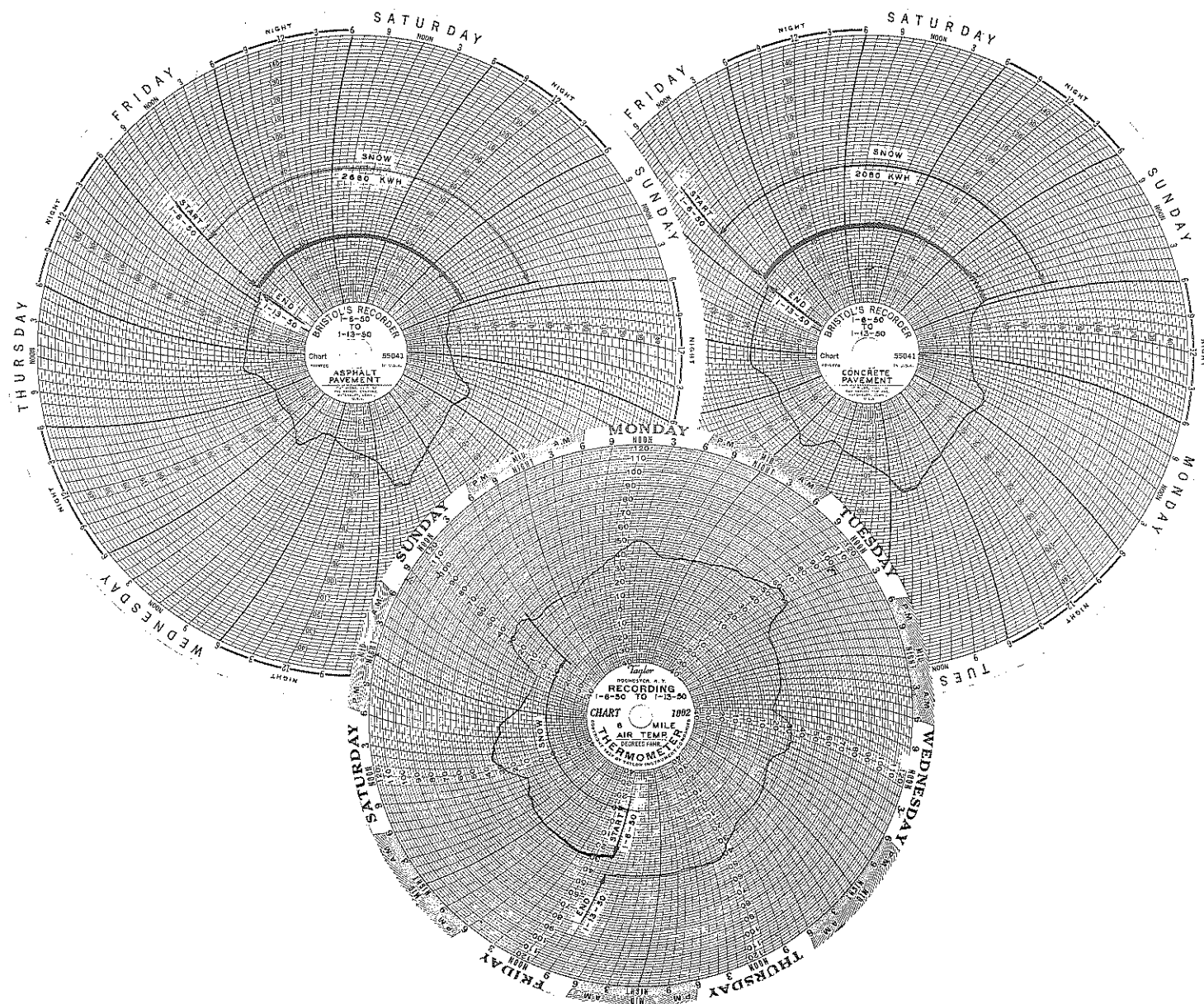
▲ FIGURE 6 CONCRETE SECTION,  
DURING STORM (1-31-50) SOUTH TRACK  
PARTIALLY MELTED, NORTH LANE COVERED  
WITH SLUSH



▲ FIGURE 7. CLOSE VIEW OF CONCRETE  
SECTION DURING STORM ( 1-31-50 )



▲ FIGURE 8. VIEW OF HEATED BIT-  
UMINOUS SECTION ( 3-17-50 ) J.A.W.



OPERATION OF HEATING SYSTEM DURING STORM OF JANUARY 6-8, 1950