

Highway Materials Research Laboratory  
132 Graham Avenue, Lexington, 29, Ky.

December 13, 1949

C.2.4  
D.1.7

Memo. to: Dean D. V. Terrell  
Director of Research

Re: Concrete Pavement without Transverse Joints,  
U. S. 31-W, Franklin-Tennessee State Line Road

Early in the past construction season the Department completed the surfacing of U. S. 31-W on the Franklin-Tennessee State Line Road. This, as you know, consisted of a portland-cement concrete pavement having an eight-inch uniform thickness, but there were no transverse joints except for the necessary construction joints at the end of each run. Early observations showed that cracks were forming as expected, but some of these cracks were much more prominent and severe than had been reasonably anticipated.

You will recall that during an inspection trip the latter part of August which included this project, we discussed the crack formation with Mr. Bray and suggested that at least the most prominent cracks be grooved to a uniform section by means of a grooving machine, and filled with the mastic type of crack and joint filler. Mr. Bray concurred in this suggestion to the extent that only part of the cracks be treated in this manner, it being his wish that at least half of those that had developed at that time be left to the normal type of sealing operations in order to see how the pavement would perform without this special treatment. Accordingly, arrangements were made through the Division of Maintenance to seal a portion of the cracks with mastic filler in about the same way it was being done on several miles of concrete pavement elsewhere in the state.

The attached report by W. B. Drake, Research Engineer, gives an account of this operation, and records precisely the pattern of crack development up to the time of the third survey on November 18. It is interesting to note the way in which the crack interval has been reduced from an average ranging between 165 and 415 feet (depending on age) in June, to corresponding high and low averages of 86 and 126 feet respectively in November. The greatest change, of course, occurred in those sections where the concrete was youngest (or had not even been poured) at the time of the June survey; but even so, the oldest portion of the job changed from an average interval of 165 feet in June to an

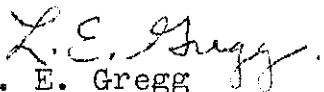
Memo. to: Dean D. V. Terrell -- 2

December 13, 1949

interval of 93 feet five months later. It is highly probable that this rate of change will be much slower from now on, however, in view of the extremely long crack interval recorded for some sections at early ages.

Diagrams prepared and placed in the Appendix of this report will make it possible to follow crack development and other features of this project very closely in the future, and provide a sound basis for evaluating the effects of simple application of asphalt sealer as opposed to more elaborate maintenance with the mastic filler.

Respectfully submitted,

  
L. E. Gregg  
Associate Director of Research

LG:vk

Copies to: Research Committee Members  
Mack Galbreath

Commonwealth of Kentucky  
Department of Highways

Report No. 2

on

A CONCRETE PAVEMENT WITHOUT  
TRANSVERSE JOINTS

by

W. B. Drake  
Research Engineer

Highway Materials Research Laboratory  
Lexington, Kentucky

December - 1949

## LIST OF FIGURES

<u>Fig. No.</u>		<u>Following Page No.</u>
1.	Layout Map of the Project . . . . .	1
2.	Class "A" Type Crack . . . . .	3
3.	Class "B" Type Crack . . . . .	3
4.	Class "C" Type Crack . . . . .	3
5.	Class "D" Type Crack . . . . .	3
6.	Crack Filled with OA Filler (Asphalt Cement)	5
7.	Tennant Concrete Grooving Machine in Operation	6
8.	Crack That Has Just Been Cut . . . . .	6
9.	Cleaning Crack with Compression Air . . . . .	6
10.	Mixing Cold Mastic Filler. . . . .	7
11.	Filling a Crack with Cold Mastic Filler. . .	7
12.	An Example of a Spalled Class "A" Type Crack Ready for Filling . . . . .	7 7
13.	Covering Filler with Paper . . . . .	8
14.	Photo of Crack Two Weeks After Sealing Opera- tion . . . . .	8 9

## INTRODUCTION

This is a report of observations and operations pertaining to a concrete pavement without the usual transverse joints constructed during the summer of 1949.

The project which is on U. S. 31-W is designated as Simpson County, FI-239 (4), and runs from Station 9+11 at the Tennessee State Line to Station 31+40 at the city limits of Franklin (See Fig. 1 for layout). It consists of a 22-foot concrete pavement underlain by 1-1/2-inches of compacted crushed limestone (Size No. 10) for insulation and leveling. The slabs are of air-entrained concrete made with the agent interground in the cement. There is a longitudinal joint at the center which is of metal with 1/2-inch deformed tie bars, but there are no transverse joints except for butt type joints at the end of each run. The paving was completed about the first of July 1949.

After this pavement was built it was suggested by the Bureau of Public Roads and the Division of Construction that the Research Laboratory make observation on the general performance of this pavement. Following the first detailed observations and general inspection of the road it was decided that the pattern of crack development and particularly the character of some of the cracks warranted attention from the standpoint of crack sealing methods. Accordingly some experimental installations of crack sealing compound included in conjunction with normal routine maintenance on the road was suggested.

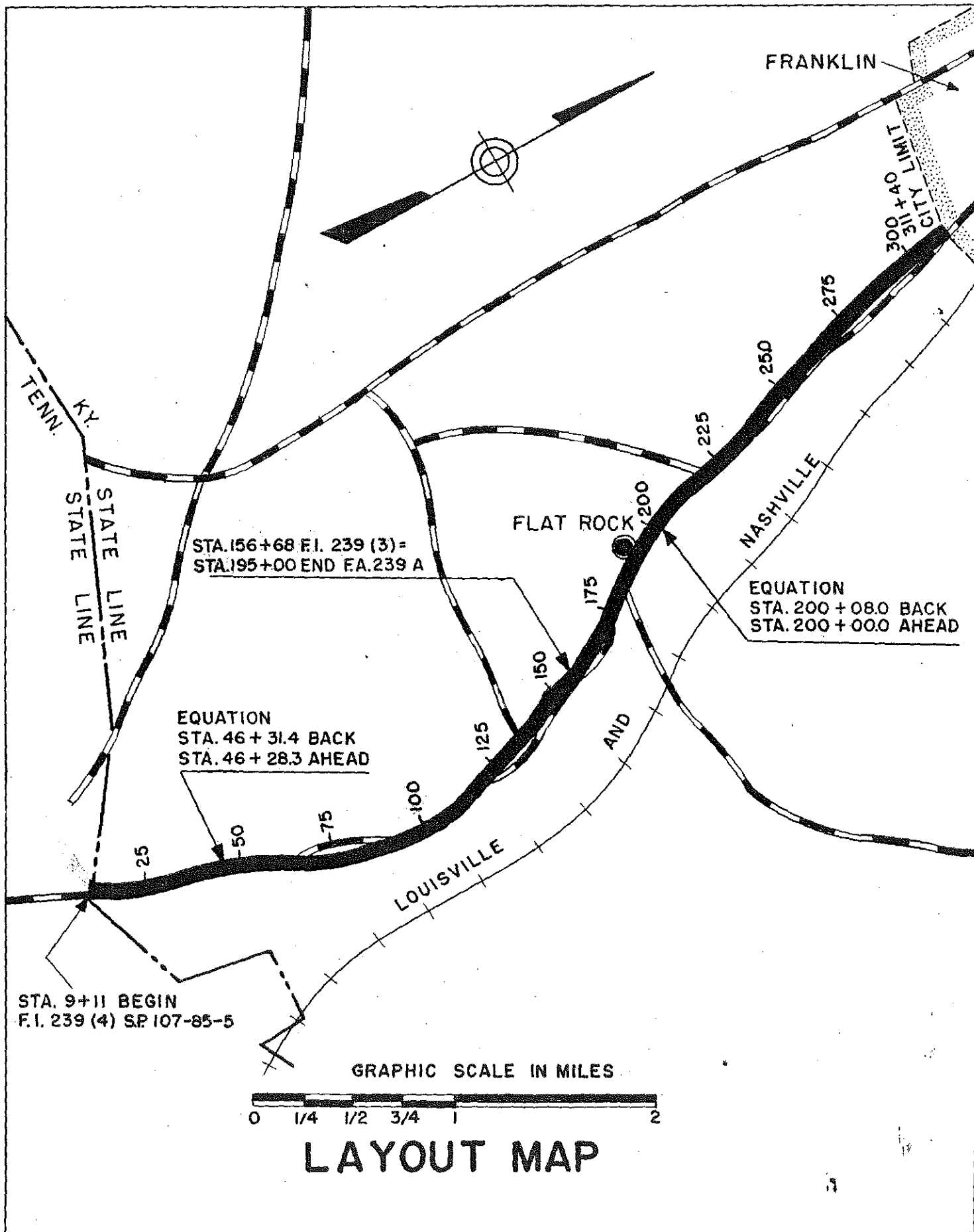


Fig. 1

## CRACK SURVEYS

June 23, 1949

On Thursday, June 23, a crack survey on the pavement from the beginning of the project to Station 255+00 was made. At that time the paving machine was in the vicinity of Station 270+00, and the intervening concrete was too green to consider. Table 1 is a listing of the number of cracks and the general crack interval at that time.

Table 1  
Summary of Crack Distribution  
June 23, 1949

Section (Stations)	Approx.* Distance in Feet	No. of Construction Joints	No. of Cracks	Approx. Avg. Crack Interval in Feet Discount in Joint
9+11 to 50+00	4089	8	25	165
50+00 to 100+00	5000	6	18	275
100+00 to 150+00	5000	7	22	225
150+00 to 200+00	5000	5	12	415
200+00 to 225+00	-	-	None	-

(Approx.)

\*Distances are computed without regard to equations noted on layout plot.

September 7, 1949

On Wednesday, September 7, a second and more detailed crack survey was made. For this a strip map of the road was prepared showing the location and shape of the cracks with a designation as to the size of each crack itself (Appendix 1). All cracks were classified into four groups according to their severity, Class A being the most severe with Class D being a crack that was just becoming visible. Table 2 describes the

classification of cracks, and all the classes are illustrated in Figs. 2, 3, 4, and 5.

Table 2  
Classification of Cracks

Class of Crack	Characteristics
A	Open crack with spalling
B	Open crack without spalling
C	Fine crack total width of both lanes
D	Fine crack only part way across road

Table 3 is a summary of the data from the second crack survey. The average crack interval including the construction joints at that time was 109 feet. There were 40 construction joints in the entire project so the average crack interval neglecting construction joints was 127 feet.

It will be noted in Table 3 that even though the crack interval did vary some throughout the project, there was a tendency for the interval in the newer sections of the pavement to be considerably greater than in the older portions. This would indicate that the cracking was still progressing. The age of the pavement increases in the opposite order of the station numbers, with that near the Tennessee State Line being the oldest.

A listing of the cracks located in cut or fill sections is included in Table 3. It is important to note that at that time there were 159 out of a total of 238 cracks, or 66.8 per cent of the cracks, located in fill sections of the road. There were 72 or 30 per cent of the cracks located in cut sections.



TABLE 3

SUMMARY OF DATA FROM SECOND CRACK SURVEY, SEPTEMBER 7, 1949

Section (Stations)	Approx.* Distance in Feet	Number of Construction Joints	Number of Cracks	Class of Crack				Location of Grade Line			Approximate Avg. Crack Interval In Feet Discount Constr. Joint
				A	B	C	D	Cut	Fill	00	
9+11 To 50+00	4089	8	35	5	17	11	2	10	24	1	117
50+00 To 100+00	5000	6	31	9	14	6	2	13	18	-	161
100+00 To 150+00	5000	7	47	9	19	10	9	16	31	-	106
150+00 To 200+00	5000	5	50	9	17	16	8	9	40	1	100
200+00 To 250+00	5000	6	34	8	10	14	2	12	18	4	147
250+00 To 300+00	5000	6	34	7	21	2	4	12	21	1	147
300+00 To 311+40	1140	2	7	6	1	-	-	-	7	-	163
TOTALS	30230	40	238	53	99	59	27	72	159	7	127

\*Distances are computed without regard to equations noted on layout plot.

Average Interval Total Cracks and Construction Joints =  $\frac{30230}{278} = 109$  feet



Fig. 2. This is an example of a class A, open type of crack with spalling. The crack is very pronounced. The location of this crack is at Station 193+22.



Fig. 3. This is an example of a B class crack at Station 20+90. It is a prominent crack with little evidence of spalling.



Fig. 4. This is an example of a class C type of crack. The crack is fine, but does extend across the total width of the pavement.

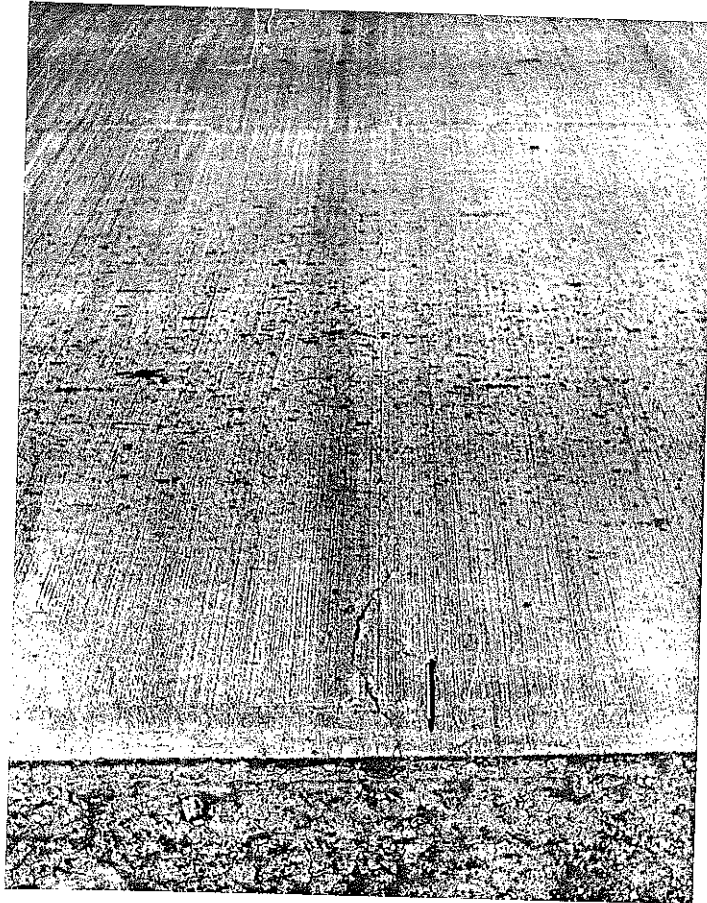


Fig. 5. An example of a class D type crack at Station 110+44. The crack extends only part way across the pavement and portrays the earliest visible form.

The remaining 3.2 per cent were located at ground line. Fill sections of the road composed 60 per cent of the total roads length, the other 40 per cent being in Cut Sections. The amount of pavement at ground line was so short it was considered negligible.

November 18, 1949

On November 18, about two months after the second inspection, a third crack survey was made. More cracking had developed. There was a decided increase in the number of "C" and "D" cracks throughout the project. Table 4 is a listing of the data from the November survey.

The total crack count had increased from 238 to 318. The average crack interval had decreased from 127 feet to 95 feet. The most decided change in number of cracks was in the C and D classes. The number of C and D cracks had approximately doubled. The increase in C and D cracks was about evenly distributed throughout all the section without regard to age of pavement, while the number of A and B type remained about the same as they were at the time of the September survey.

More of new cracks had developed in cut sections than in fill sections since 193 out of 318 cracks, or 61 per cent of the total cracks were located in fill sections, whereas, in comparison 118, or 37 per cent were in cut sections. The remaining cracks were at 00 grade and ground line. There were 124 stations located in Cut Sections or 40 per cent of the total road length, therefore, 60 per cent of the pavement was located on fills.

TABLE 4

SUMMARY OF DATA FROM THE THIRD CRACK SURVEY, NOVEMBER 18, 1949

Section (Stations)	Approx.* Distance In Feet	Number of Construction Joints	Number of Cracks	Class of Crack				Location of Grade Line			Approximate Avg. Crack Interval in Feet Discount Constr. Joint
				A	B	C	D	Cut	Fill	00	
9+11 To 50+00	4089	8	44	5	17	15	7	15	28	1	93
50+00 To 100+00	5000	6	47	12	15	14	6	24	23	-	106
100+00 To 150+00	5000	7	58	9	19	13	17	21	36	1	86
150+00 To 200+00	5000	5	58	9	17	24	8	13	45	-	86
200+00 To 250+00	5000	6	57	8	20	22	7	26	27	4	88
250+00 To 300+00	5000	6	45	7	21	11	6	19	25	1	111
300+00 To 311+40	1140	2	9	6	1	2	-	-	9	-	126
TOTALS	30230	40	318	56	110	101	51	118	193	7	95

\*Distances are computed without regard to equations noted on layout plot.

Average interval both cracks and construction joints =  $\frac{30230}{358} = 84.5$  feet

### Summary

The strip map of this project with the cracking up to the third survey is shown in Appendix 1. The cracks that developed after the second survey are marked in red. The cracks are located and classified, and construction on joints shown. The grade line and existing ground line are plotted opposite each section.

### CRACK FILLING OPERATION

As a result of interest that developed regarding the formation of cracks in this pavement, and the obvious need for filling at least the most prominent cracks as maintenance measures, the experimental features of the project were extended to include some crack filling operation. In addition to the application of OA-2 (asphalt cement) filler in the normal manner, a cold mastic type filler (covered by Special Specification No. 46) used to considerable extent on maintenance projects this year was included. Beyond that, four trial formulations of mastic filler developed by one producer of this material were introduced as added factors.

The OA-2 filler was applied throughout the job sometime prior to the experimental installation on November 16 and 17, and this application included practically all the cracks as well as the few transverse, butt type joints. For that operation there was no grooving or cleaning of the cracks in advance. A Class "C" crack at Station 82+51, illustrated in Fig. 6, is typical of cracks sealed with this material. All but 132 cracks and 8 joints on the project were left with this type of filler intact.





Fig. 6. A type C crack filled with OA-2 (Asphaltic Cement) filler at Station 82+51. This filler failed to penetrate the crack, and the opening is evident the entire width of the pavement.

### Cutting

Two Tennant Concrete Grooving Machines were used for the cutting process (State No. 24 and 25). This type of machine has a high speed wheel with 6 cutting bits attached around the circumference. These bits, which are replaceable in the field, have eight fingers on a loose fitting axle. The fingers have a 1/4-inch cutting dimension - 1/2-inch thick and 1-inch long. Fig. 7 is a picture of one of these machines in operation. Fig. 8 is a picture of a crack that has been cut by one of these machines.

The average life of the bits was 495 lineal feet of crack per set. There are six bits in a set and the approximate cost of a set of bits is \$5.76. The cost of bits, then, would be \$.0116 per lineal foot cut.

Although this machine was not self-propelled, the cutting process pulled it along the pavement. This made it possible for a single operator to use the machine even though it was quite large. The apparatus was adequately powered for the cutting job with a self-starting gasoline engine of about 13 horse-power rating.

### Cleaning

Upon completion of the cutting, each crack was blown out with compressed air. Fig. 9 is a photo of this phase of the job. Cleaning with an air jet along<sup>e</sup> did not conform with the procedure used on other maintenance projects where a power driven wire brush was used to remove most of the coarser matter. The crack was then washed out with water to remove the dust film and allow the filler to bond with the newly cut concrete.

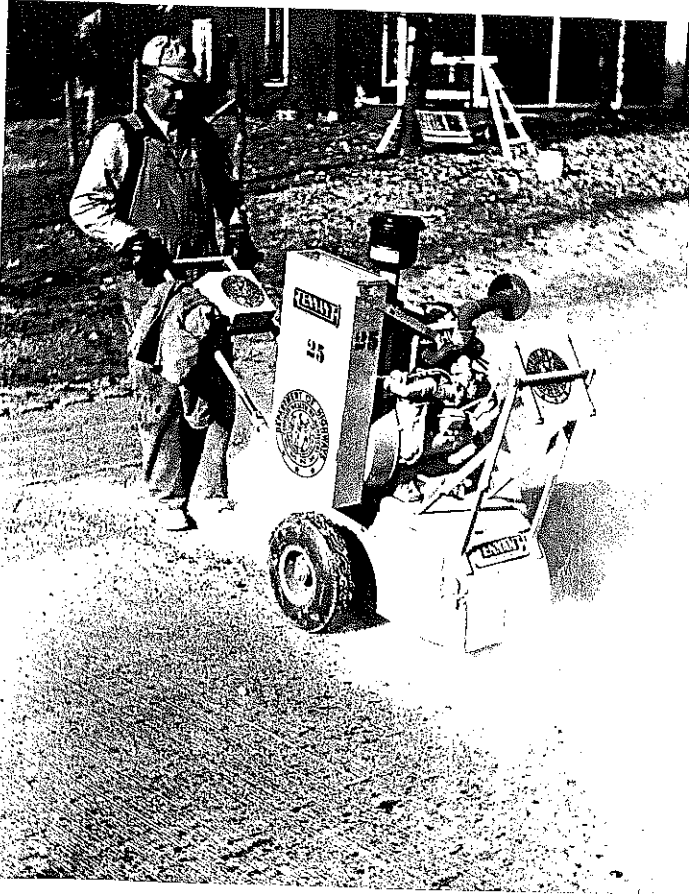


Fig. 7. A photograph of the cutting machine in operation. The mirror mounted on the front of the equipment allows the operator to see the crack and the painter just above the cutting wheel. The flexibility of the bits on the cutting wheel allowed the machine to cut a fairly irregular crack without excessive spalling.

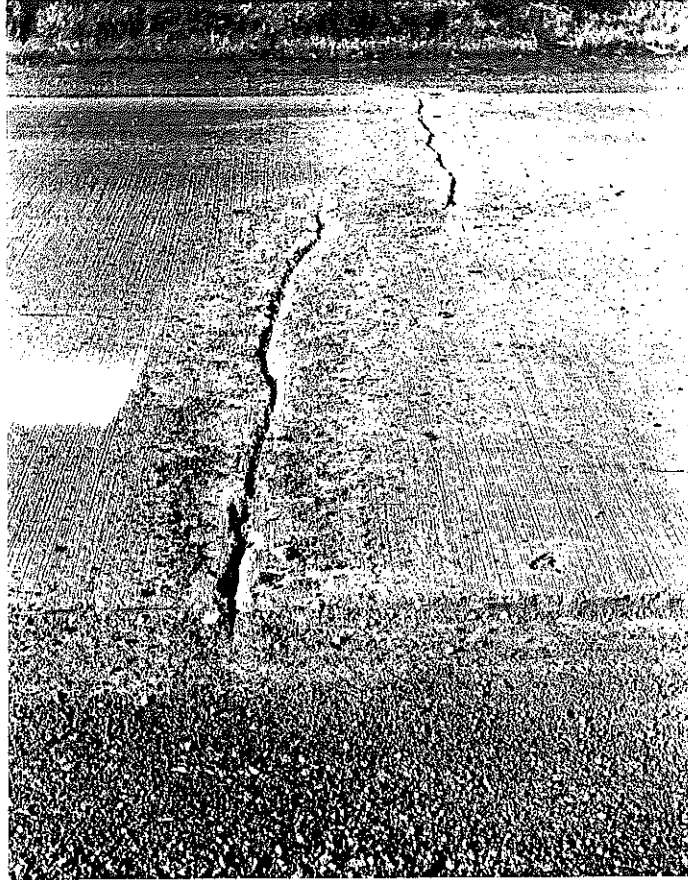


Fig. 8. A crack that has just been cut located at Station 304+00. This photograph was taken in advance of the cleaning operation.



Fig. 9. This illustrates process of blowing out the foreign material with compressed air. In the background is the special mixing and extruding machine for filling cracks.

### Filling

The crack was then ready to be filled with the cold mastic filler. The Prestite Engineering Company furnished a machine especially designed for mixing and applying the filler. This was a small gasoline powered pugmill with an extruding mechanism. The material came in two separate units which upon combination, produced a 90-pound batch. Separately, the ingredients were a 51-pound bag of dry powdered asphalt and a 39-pound drum of rather viscous asphaltic and rubber liquid supplemented with a plasticizer.

The first step in the mixing process was pouring the liquid into the hopper of the mixing and extruding equipment. Then the powder was added and mixing was carried on for about 5 minutes. During this period a clutch on the drive shaft was disengaged to prevent extrusion of the material. Fig. 10 shows the hopper of the pugmill type mixer.

The clutch was then engaged for extrusion of the filler into the cracks. This process is shown in Fig. 11. The rate of extrusion was controlled by a hand throttle on the machine, but the amount of filler in each crack was governed mainly by the rate of movement of the machine across the pavement.

Sufficient material was placed in each crack to fill it level with the pavement surface in its finished form. This amount varied somewhat because the cracks were not uniform. In some instances the cracks extended to a greater depth than the desired 1-inch. In other cases, because of spalling or chipping of the pavement, the cracks were wider than the 1-inch that was desired. The photograph in Fig. 12 shows one of the larger

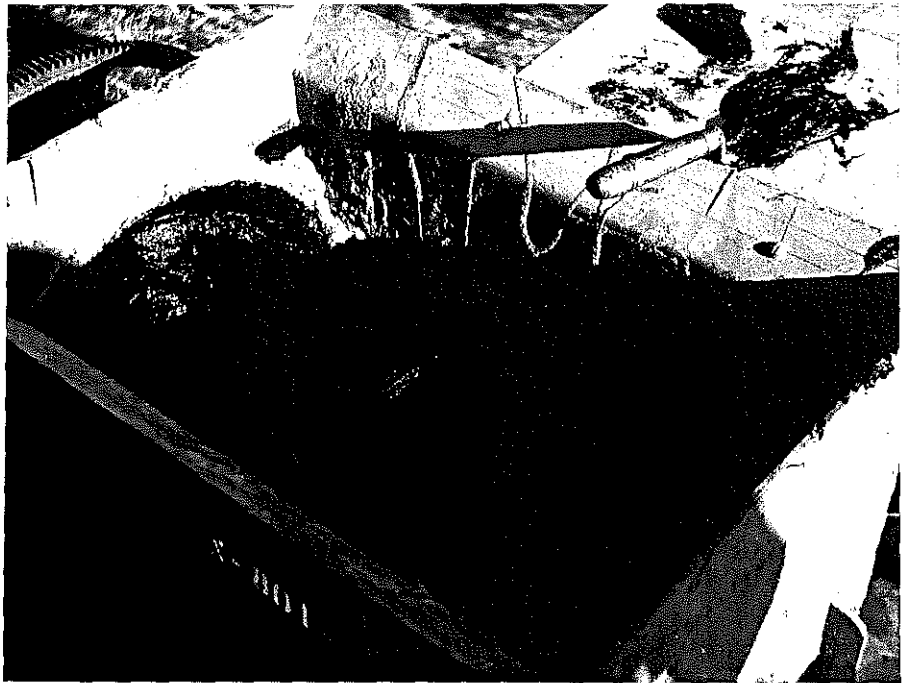


Fig. 10. Close up of the hopper showing the pugmill type mixer. Complete mixing of the two ingredients was accomplished easily in five minutes. The pugmill also operates continuously throughout the extrusion process.

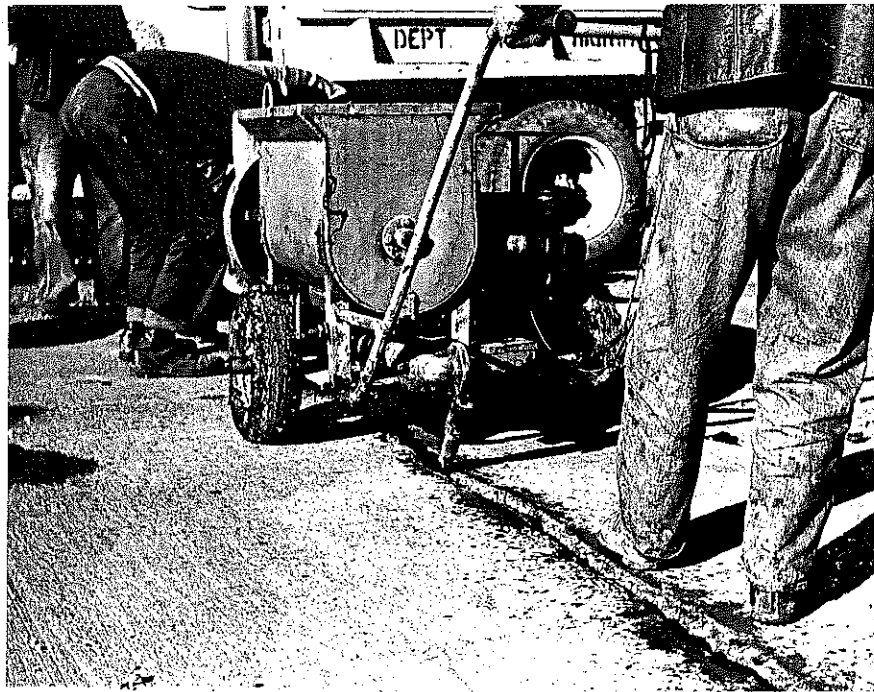


Fig. 11. Rear view of the mixing and extruding machine, showing the relation between nozzle, pavement surface, and crack. An average of 2 to 3 minutes was required for filling a crack. The machine was operated by a  $3/4$  horse power gasoline engine but was not self propelled.





Fig. 12. Class A crack that has been prepared for filling. The spalling is evident in the near portion of the crack. The dust has just been washed out with water causing the wet places shown.

spalled-type, Class A cracks after it had been prepared for filling.

As rapidly as a crack was filled it was covered with a strip of wrapping paper in order to prevent tracking of the filler by traffic. This operation is shown in Fig. 13.

A total of 129 full-width cracks and joints, and 11 one-lane cracks were filled. With but few exceptions all the cracks and joints between Stations 185+80 and 311+40 were treated in this manner. Approximately 2970 lineal feet of cracks and joints were filled using 22 units or 1980 pounds of filler. An average of 0.667 pounds of material was required per lineal foot of crack or joint.

From Station 204+00 to Station 311+40 the cracks were sealed with the regular Enamelite 332.88. From Station 200+00 to Station 204+00 a total of 5 cracks were filled with special formulation 332.88A. Two cracks were filled between Stations 198+50 and 200+00 with special formulation 332.88B. This material was very dry and difficult to extrude with the machine causing the shearing pin on the drive shaft to be sheared. Most of the batch was dumped from the machine after that.

Between Stations 191+00 and 198+50, seven cracks were filled with special formulation 332.88C. This material was very viscous upon being extruded. Bond between it and the pavement was very poor. The filler from three of the cracks, at Stations 193+20, 196+80 and 196+95, was whipped from the cracks by the action of the traffic. Those three cracks were refilled with special formulation 332.88D. Also, 5 cracks from Station 185+80 to Station 191+00 were filled with 332.88D.



Fig. 13. The operation of covering the freshly filled crack with a strip of wrapping paper. This prevented the traffic from tracking out the filler which was very sticky at this time.

There were 121 cracks filled with regular enamelite filler 332.88; 5 with special filler 332.88A; 2 with special filler 332.88C, and 8 with special filler 332.88D.

### Summary

While passing over this route on December 3, 1949, a quick check was made as to the condition of the filler. The filler was in place and intact. The material was soft and plastic after two weeks in place, Fig. 14 was taken at this time.

The roughness of this particular section was checked with the aid of a special roughometer rented from the Virginia Department of Highways\*. The roughness number for this section was 136 which was an average-run reading. Highway U.S. 27 from Falmouth to Antioch Mills in Pendleton County, completed in 1947, had an average reading of 141. The Ghent-Carrollton Road, U.S. 42, in Carroll and Gallatin Counties, built in 1932, had an average roughness index of 131.

\*See Research Laboratory Report No. 1 on "Measurements of Surface Irregularities and Riding Qualities of High Type Bituminous Pavements", December 1949.

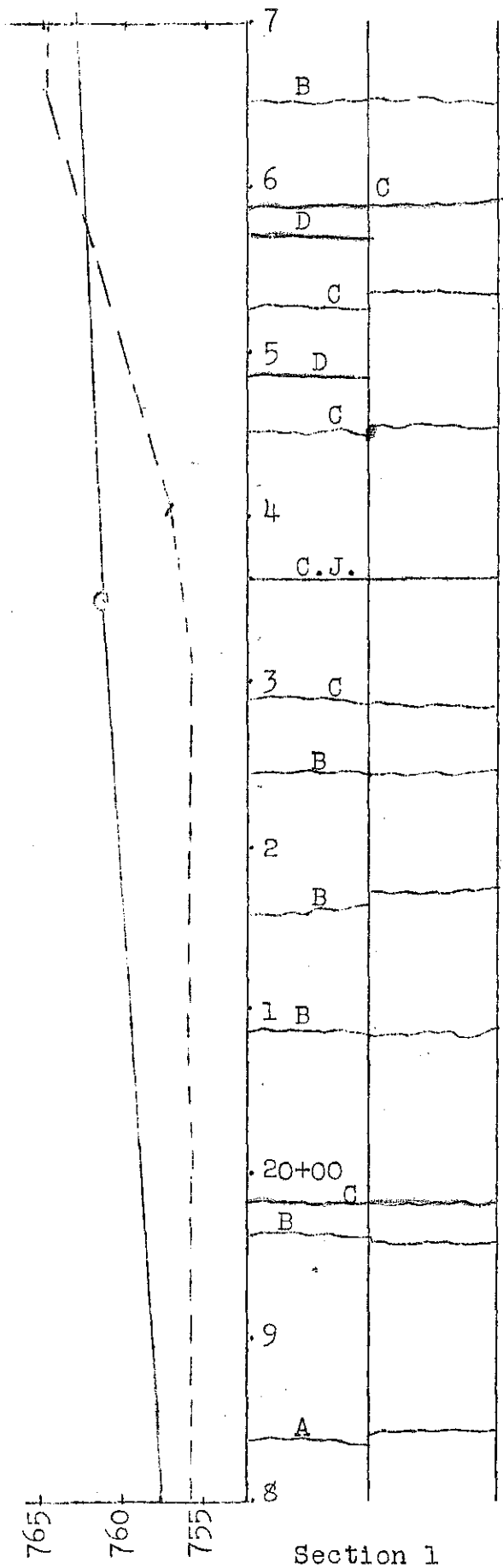
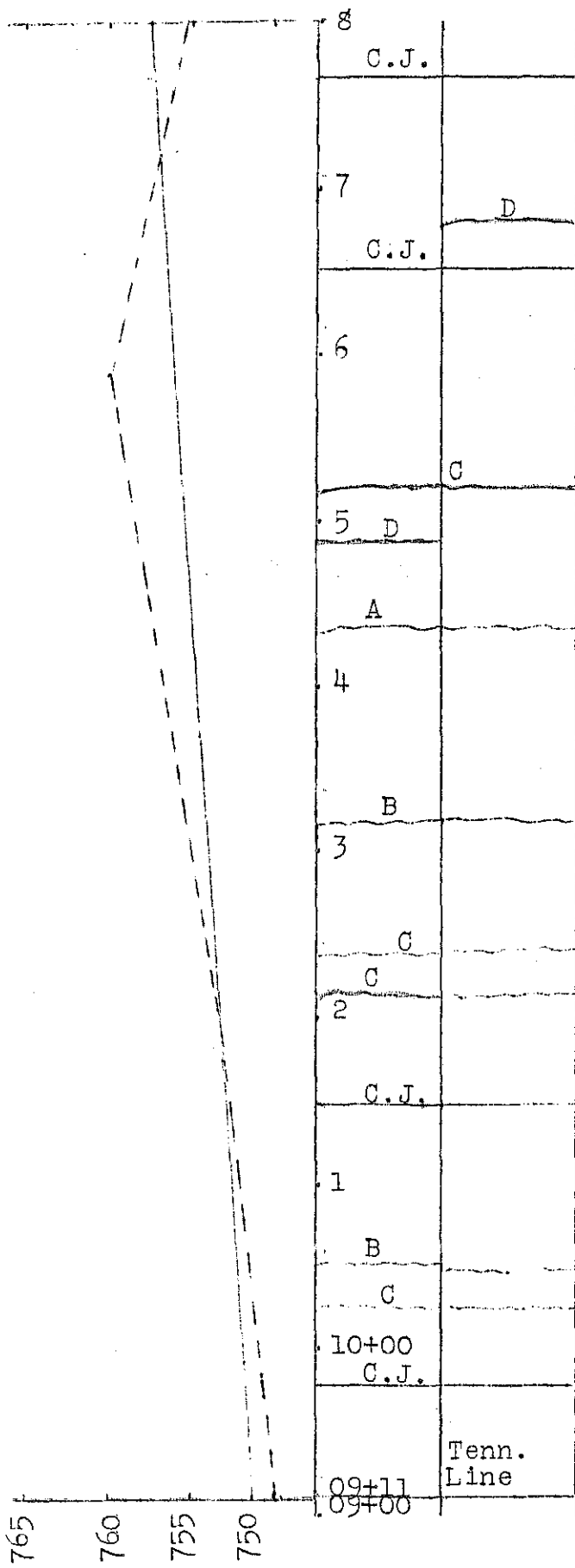


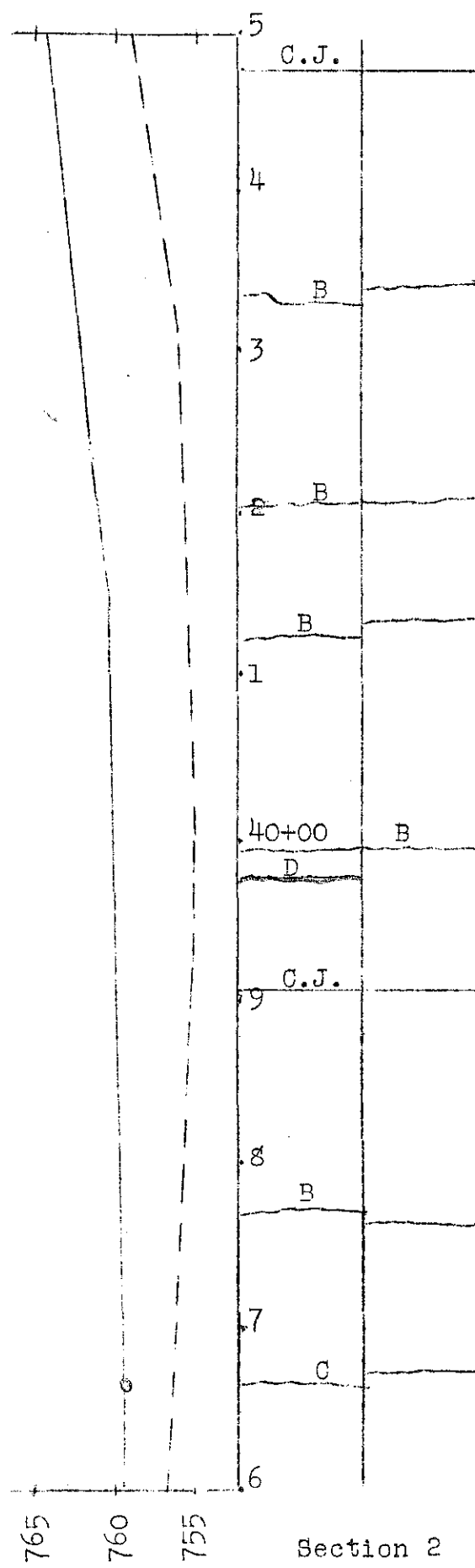
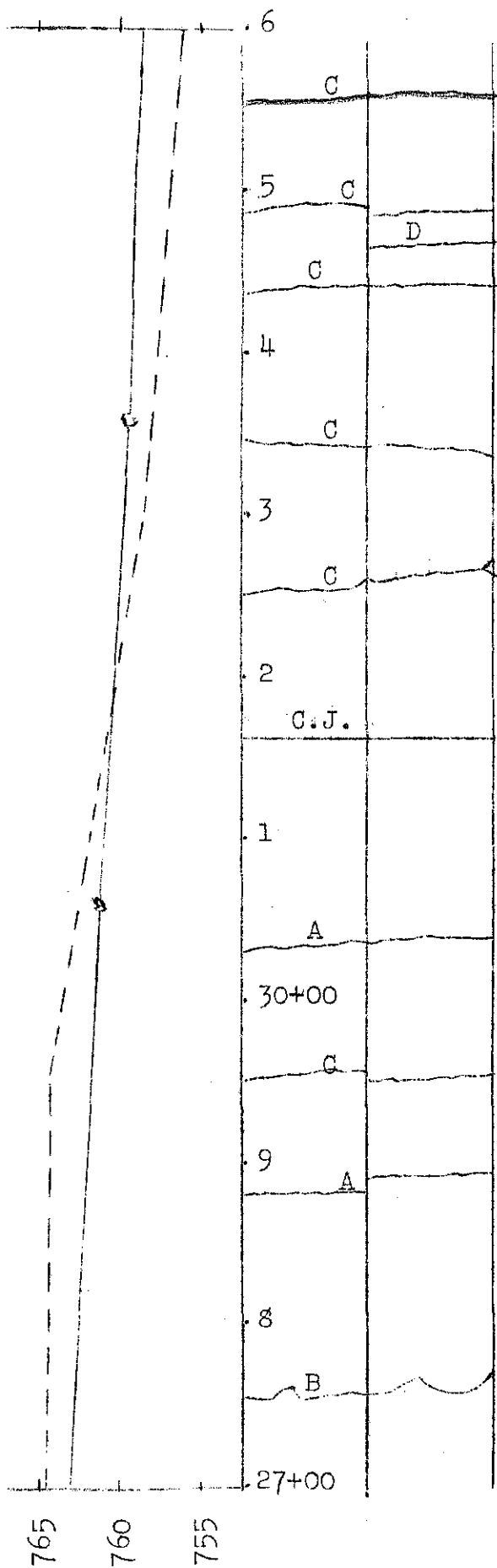
Fig. 14, A photo taken two weeks after the filling operation. The black material on top of the pavement is what was left of the original OA-2 (Asphaltic Cement) filler. The enamelite was very pliable and most of the paper is still intact.

## APPENDIX I

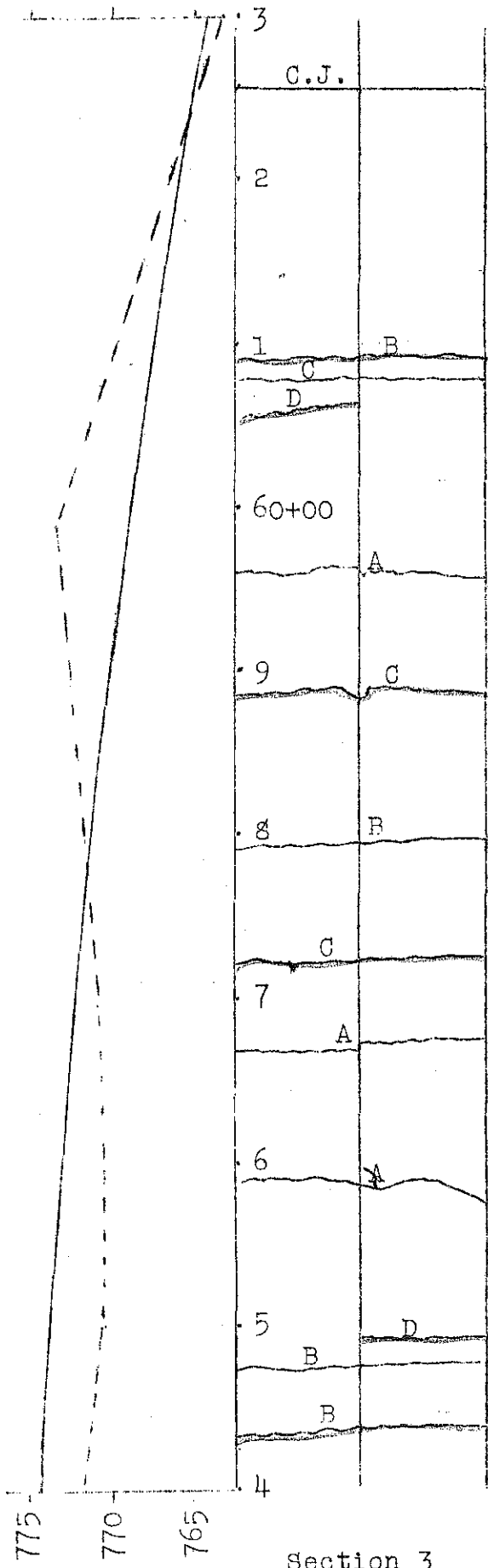
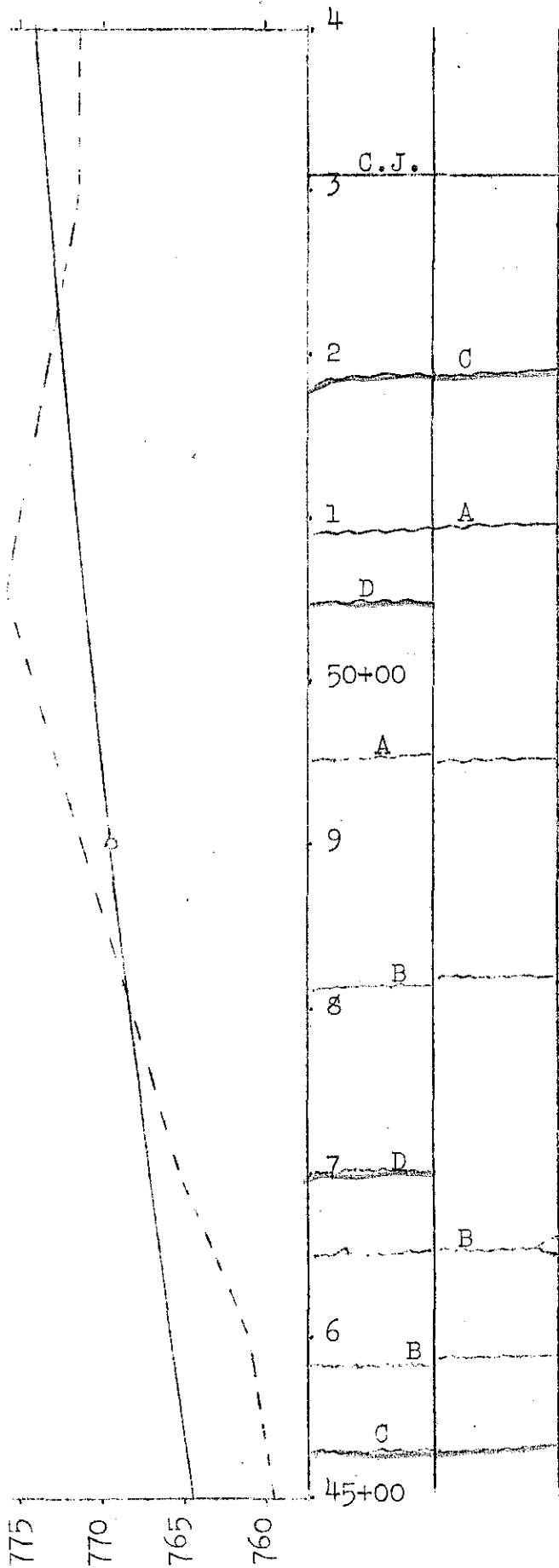
### STRIP MAP OF PROJECT

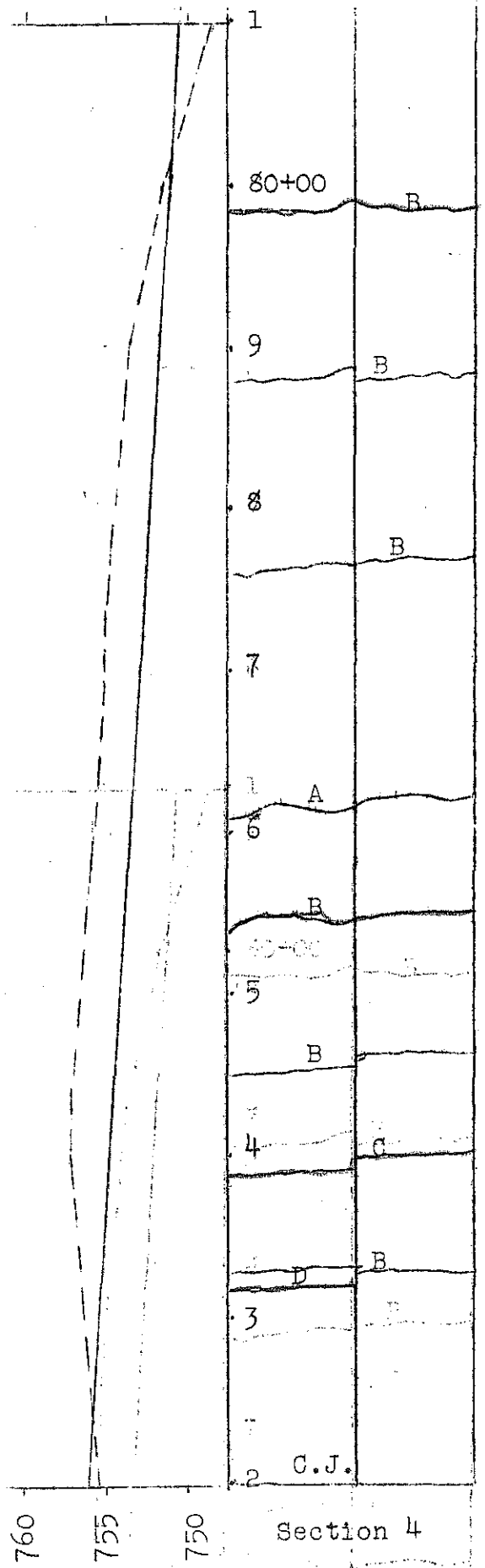
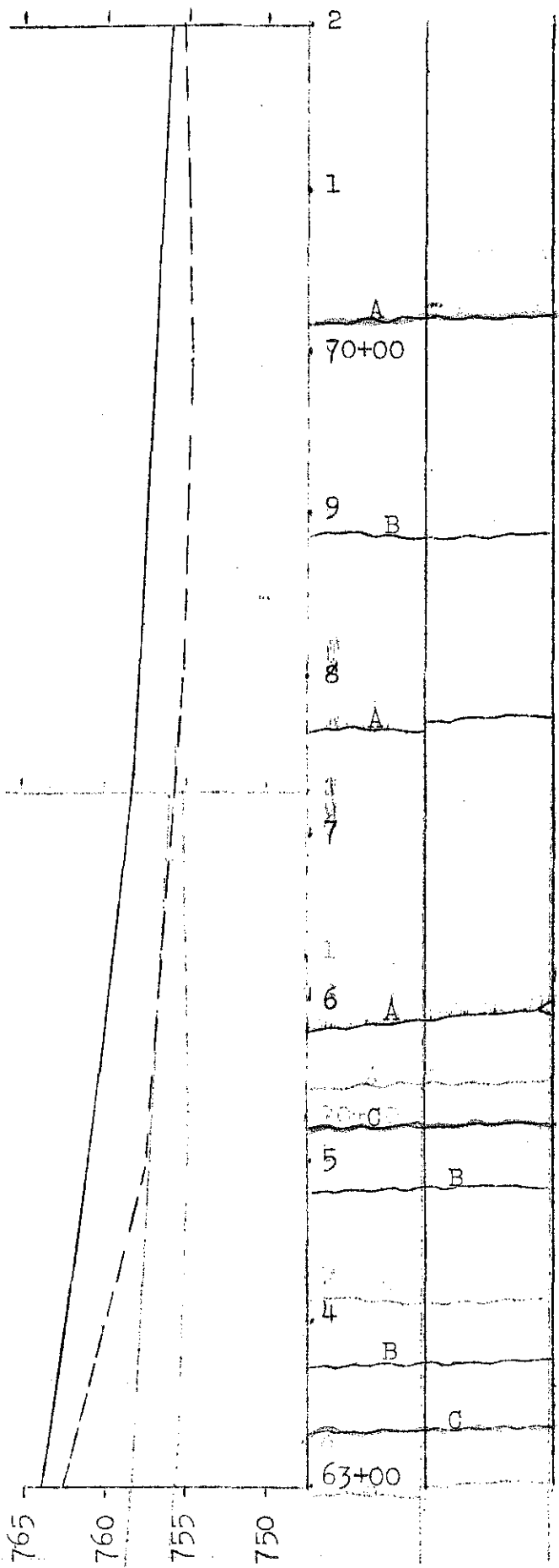
Cracks marked in red occurred between September 7, 1949, (second survey) and November 18, 1949, (third survey). The class of the crack is noted by the letter A, B, C or D. Construction joints are marked C. J. The grade line of the road is shown with each section. Ground line is shown dashed.



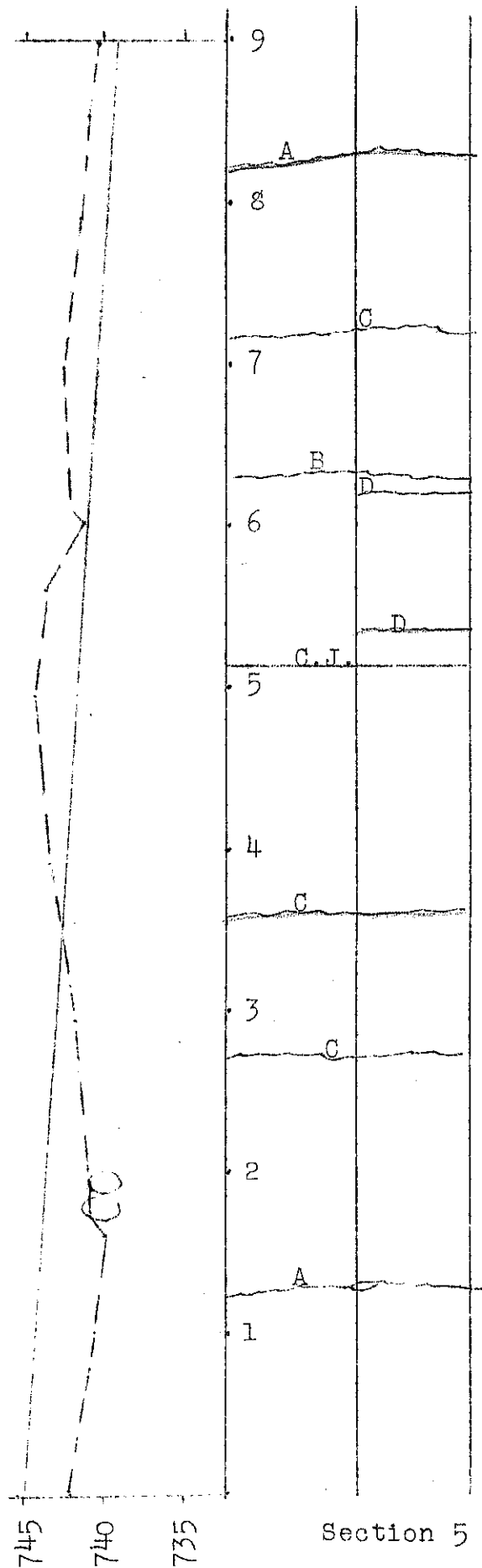
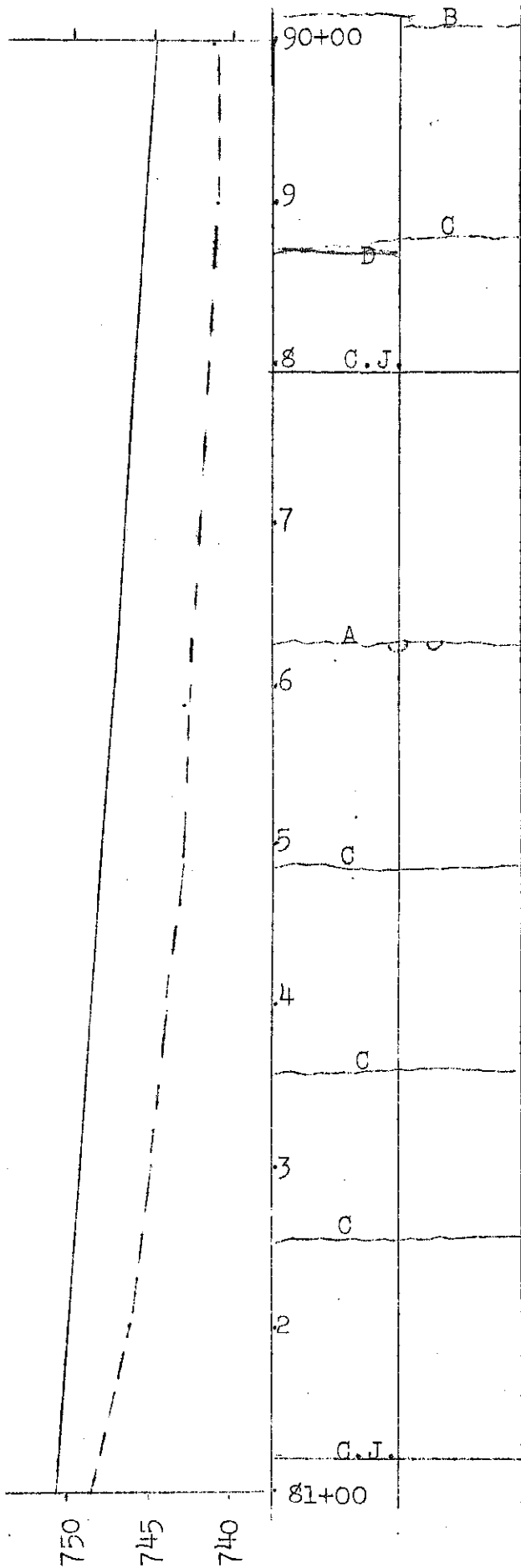


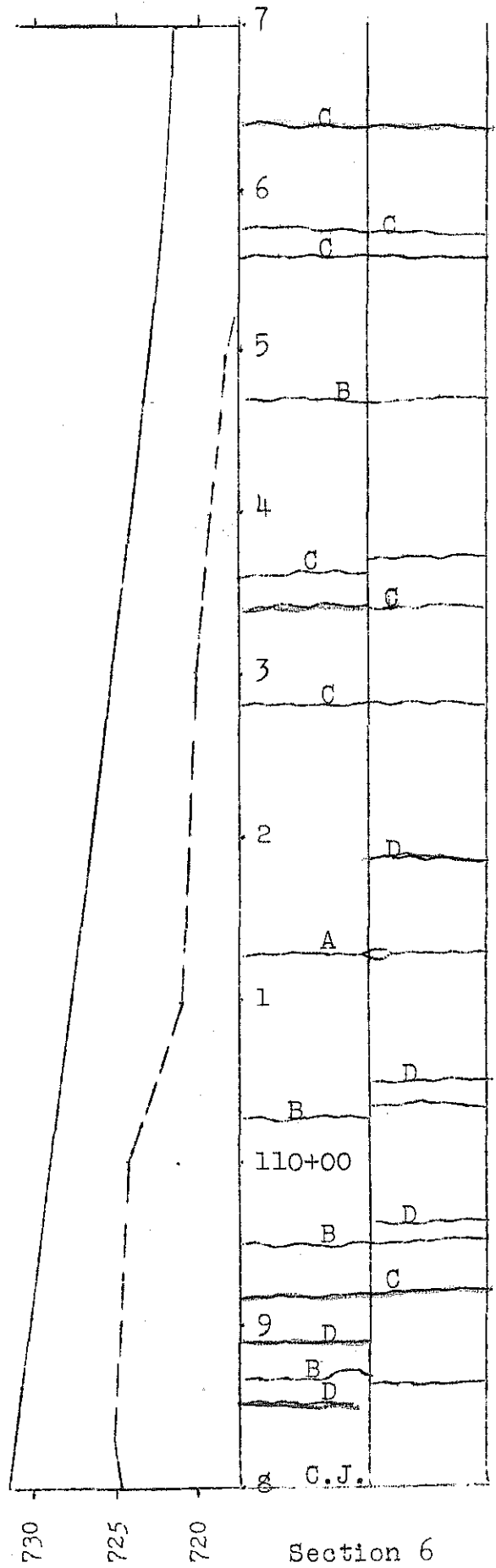
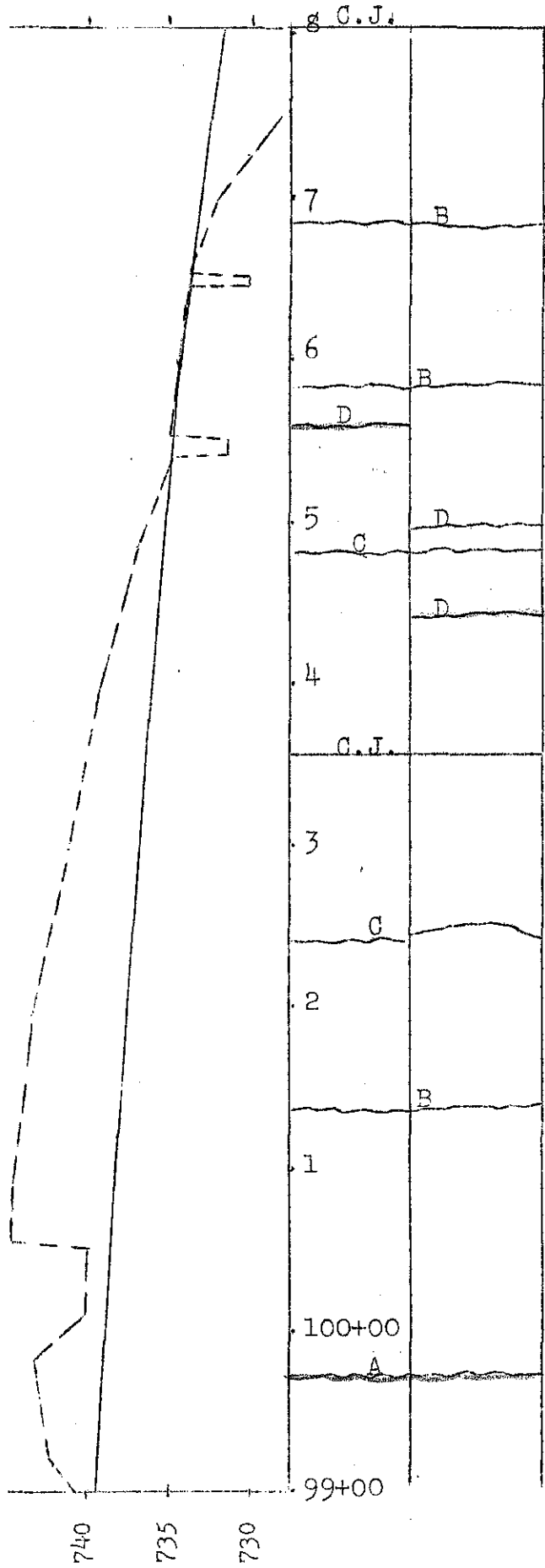




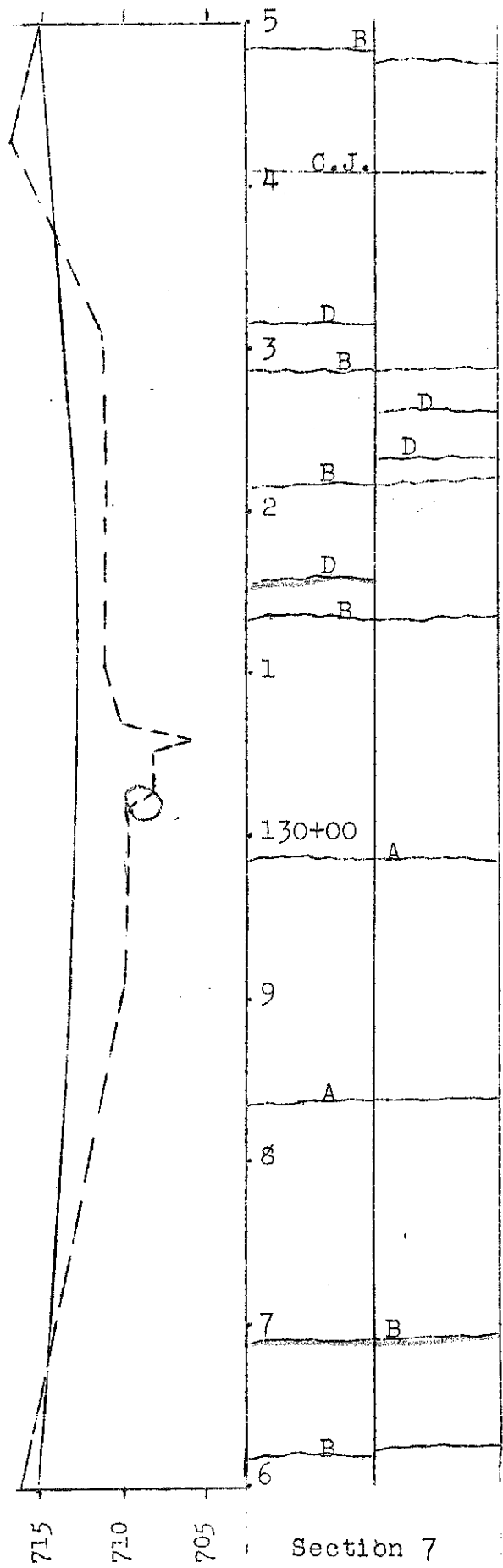
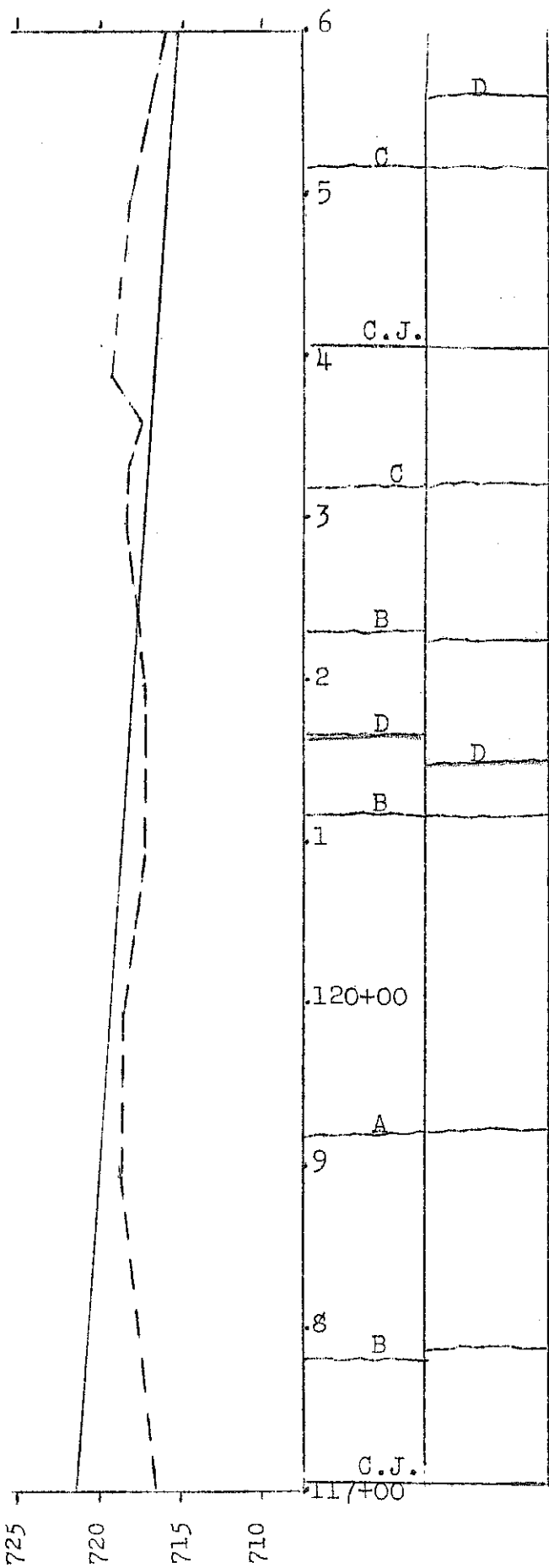


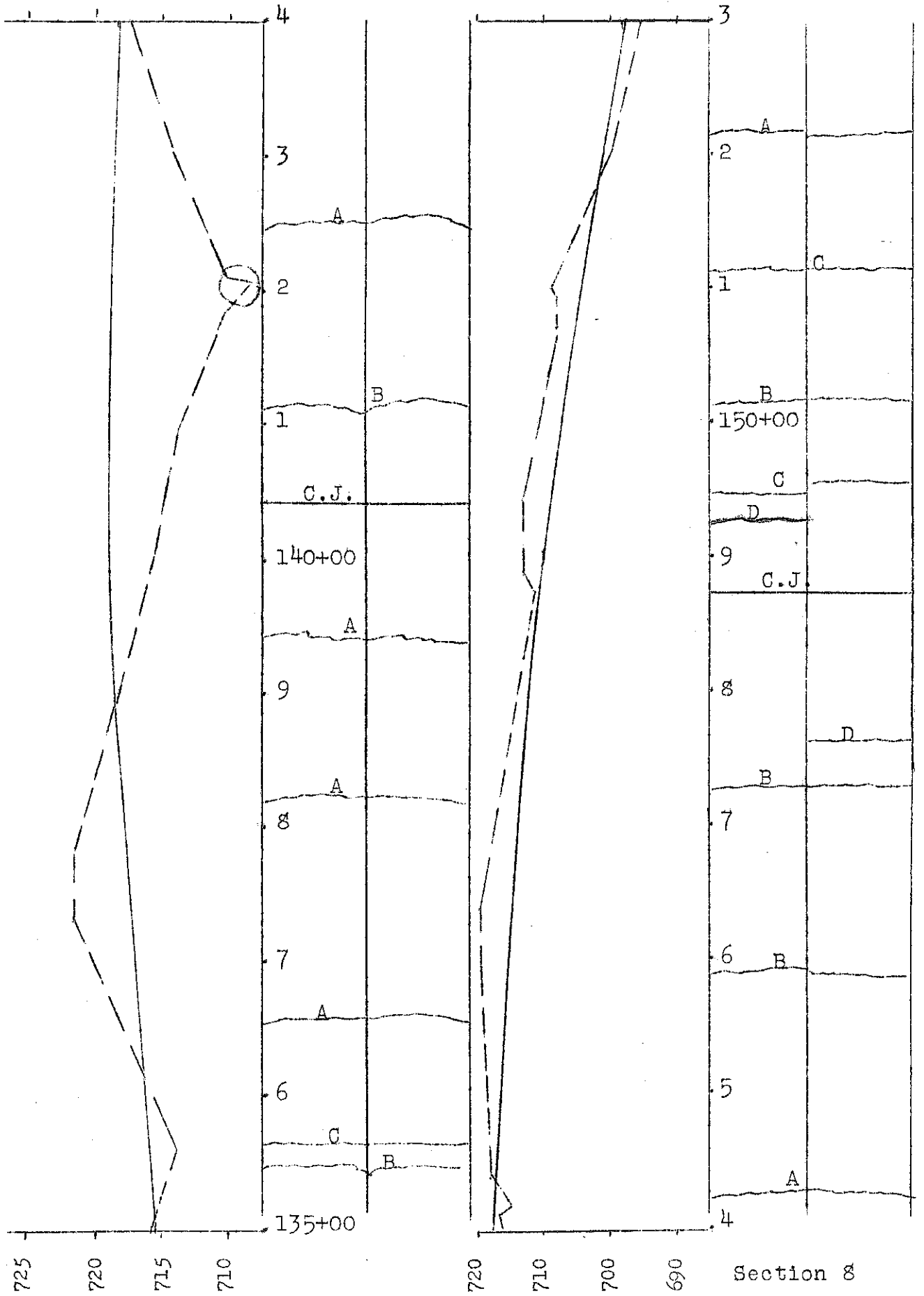
Section 4



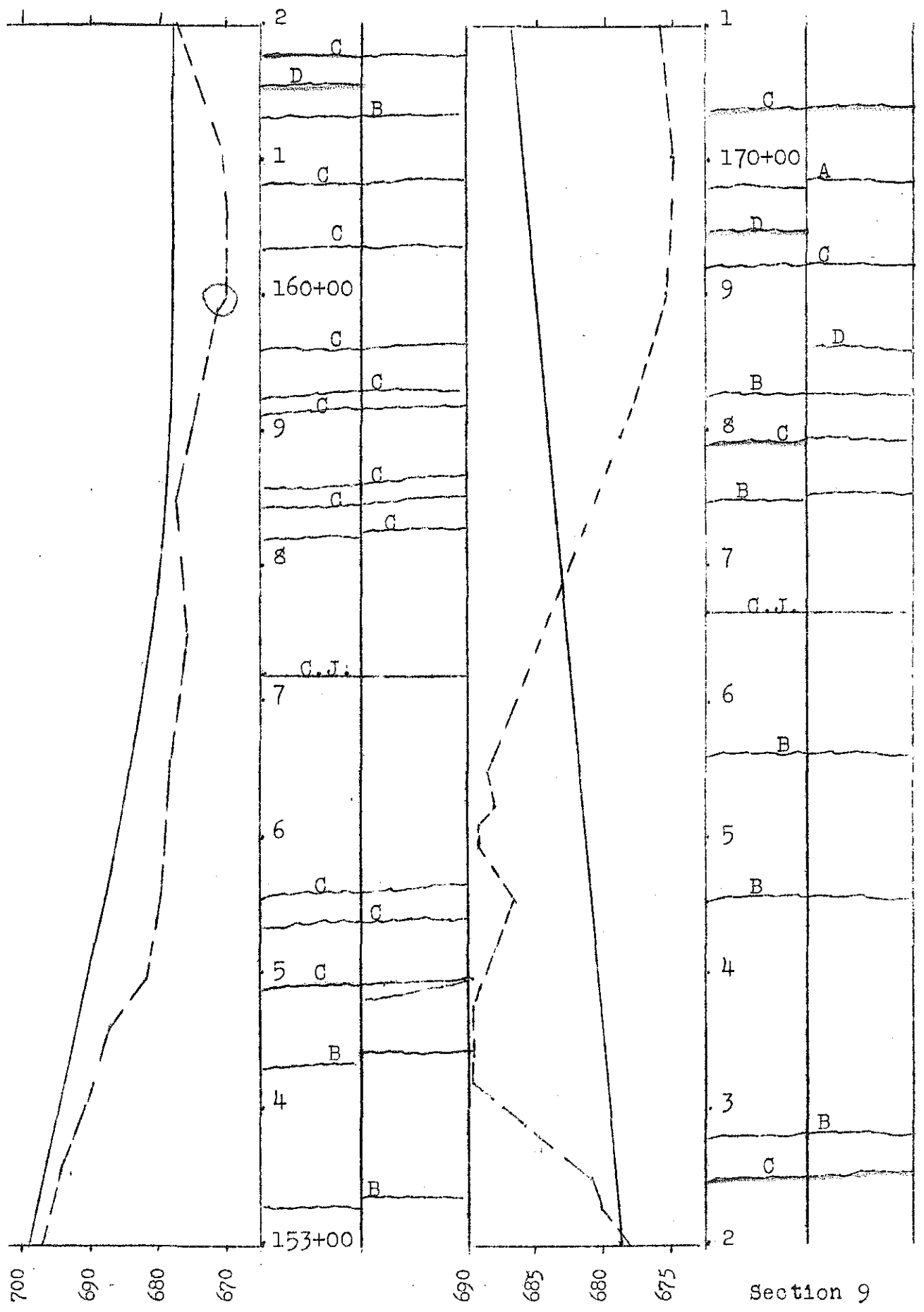


Section 6

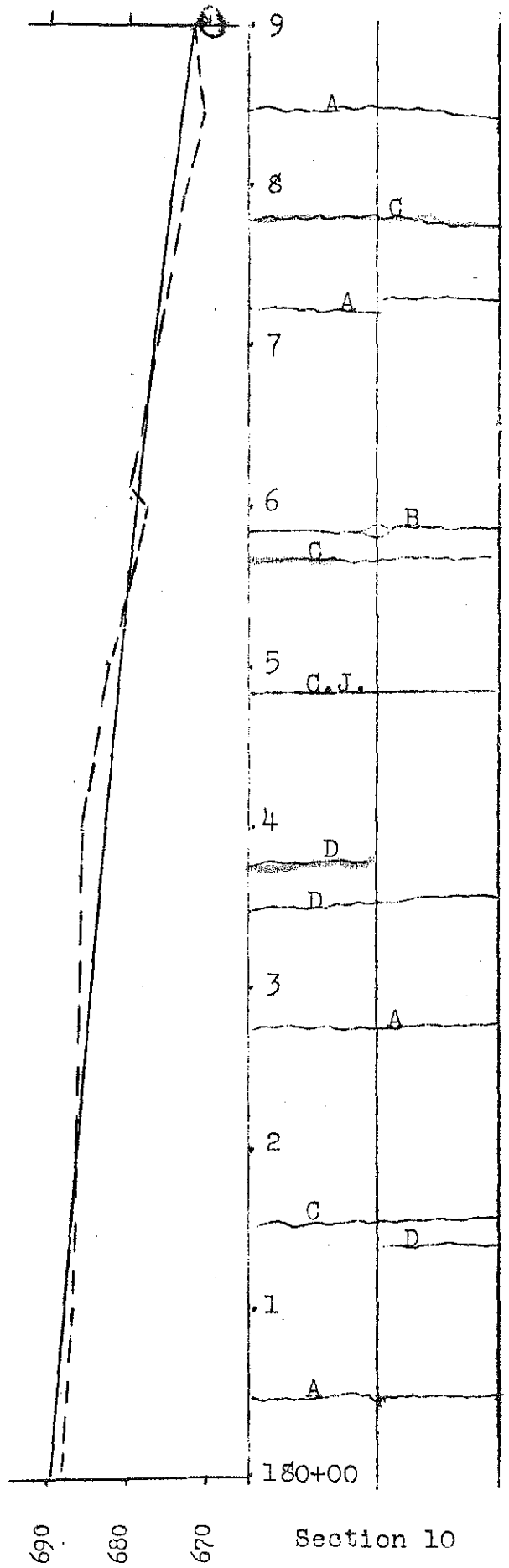
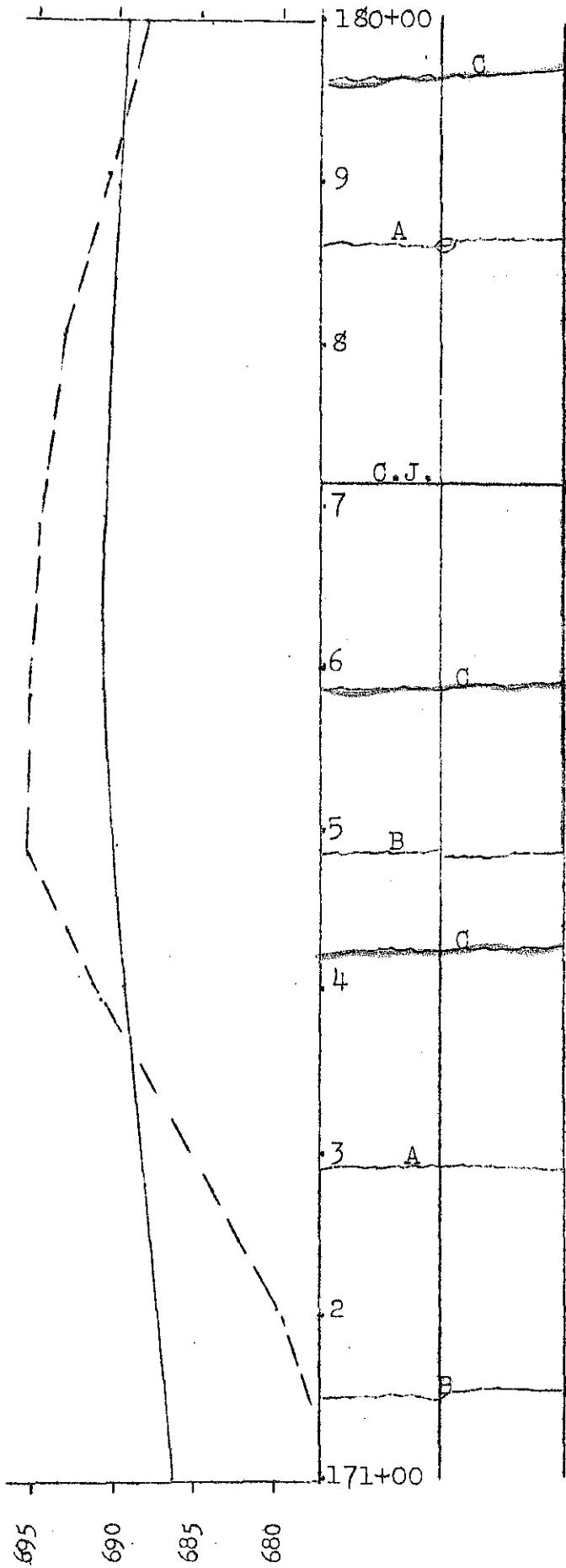




Section 8

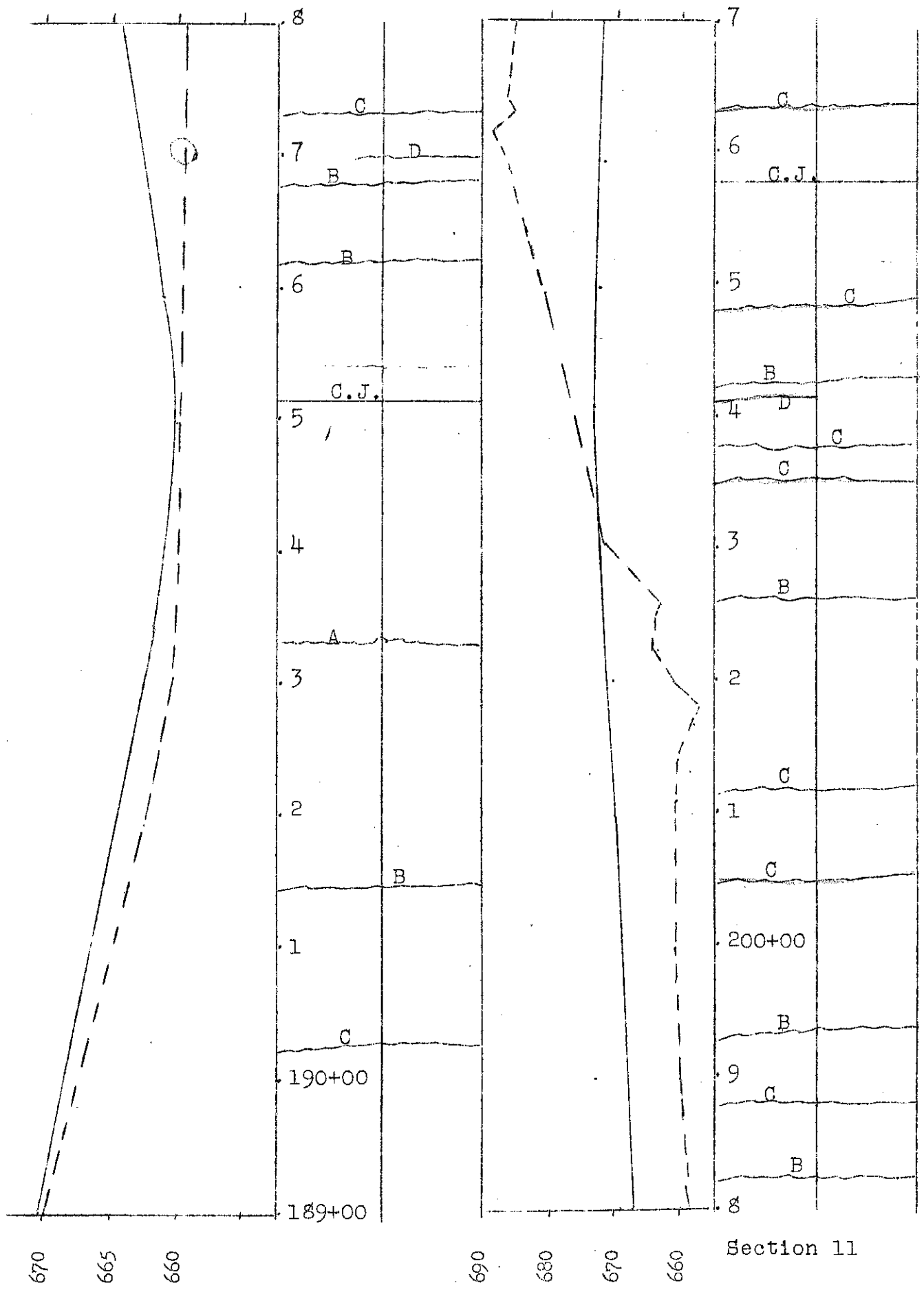


Section 9

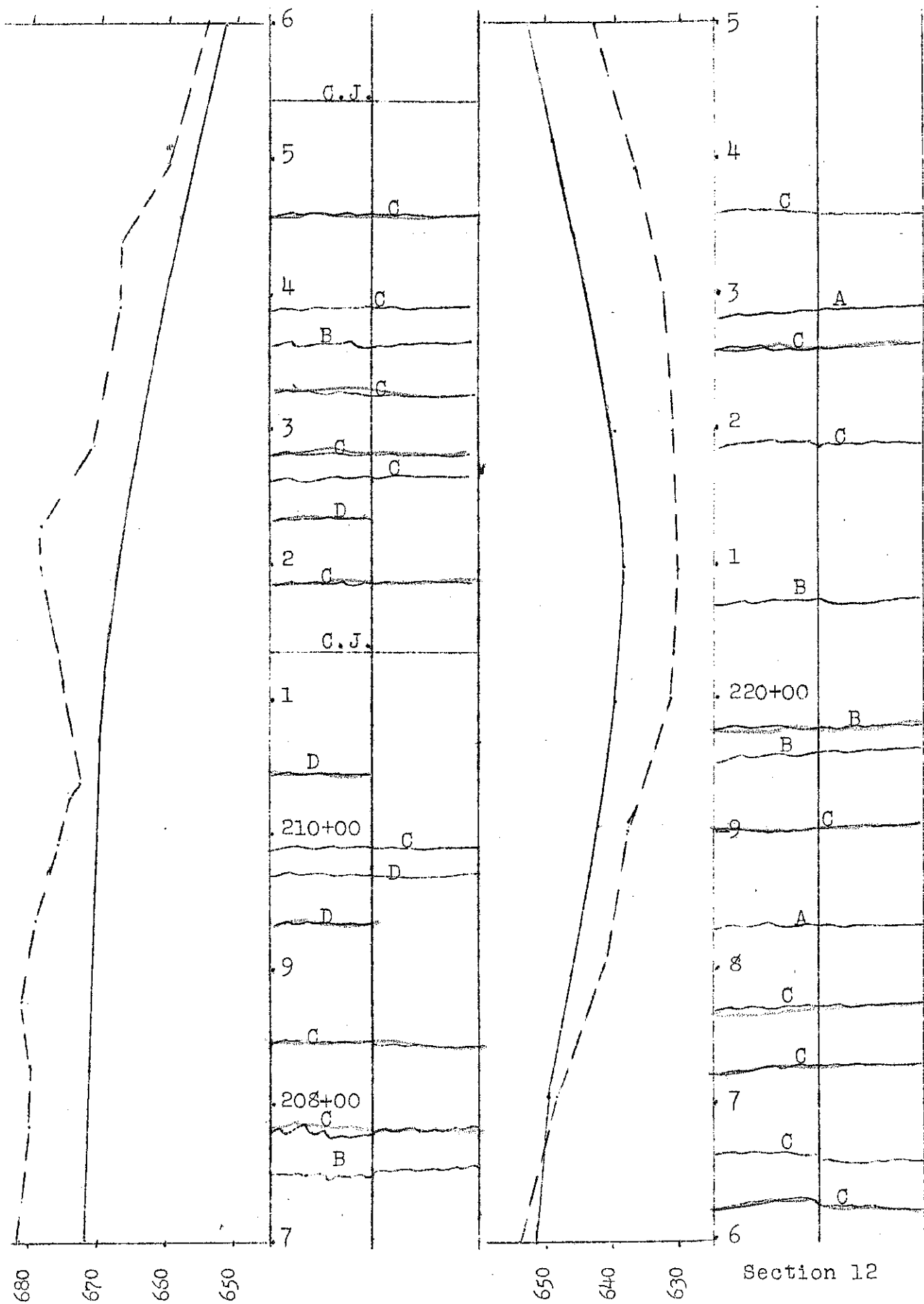


Section 10

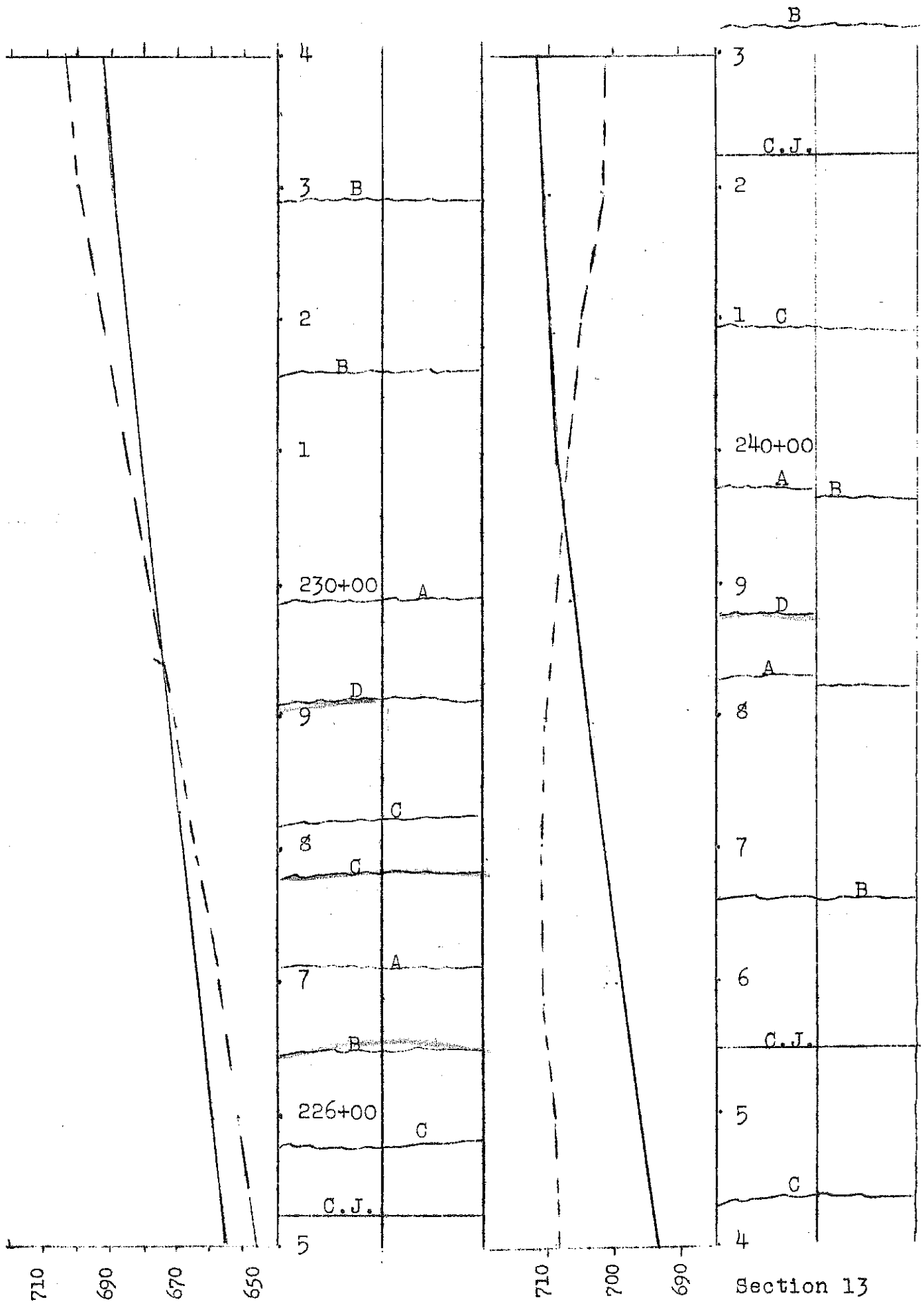


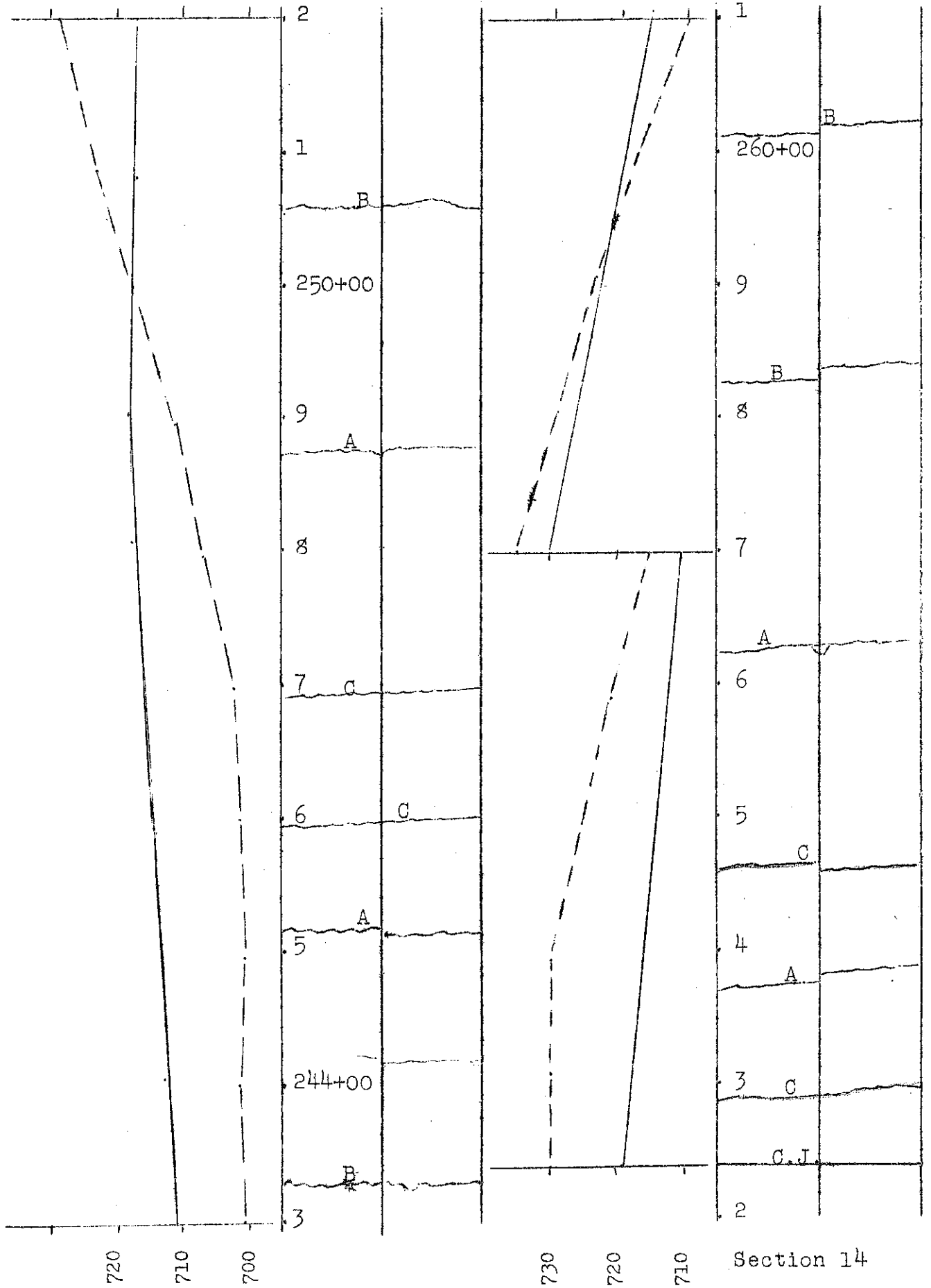


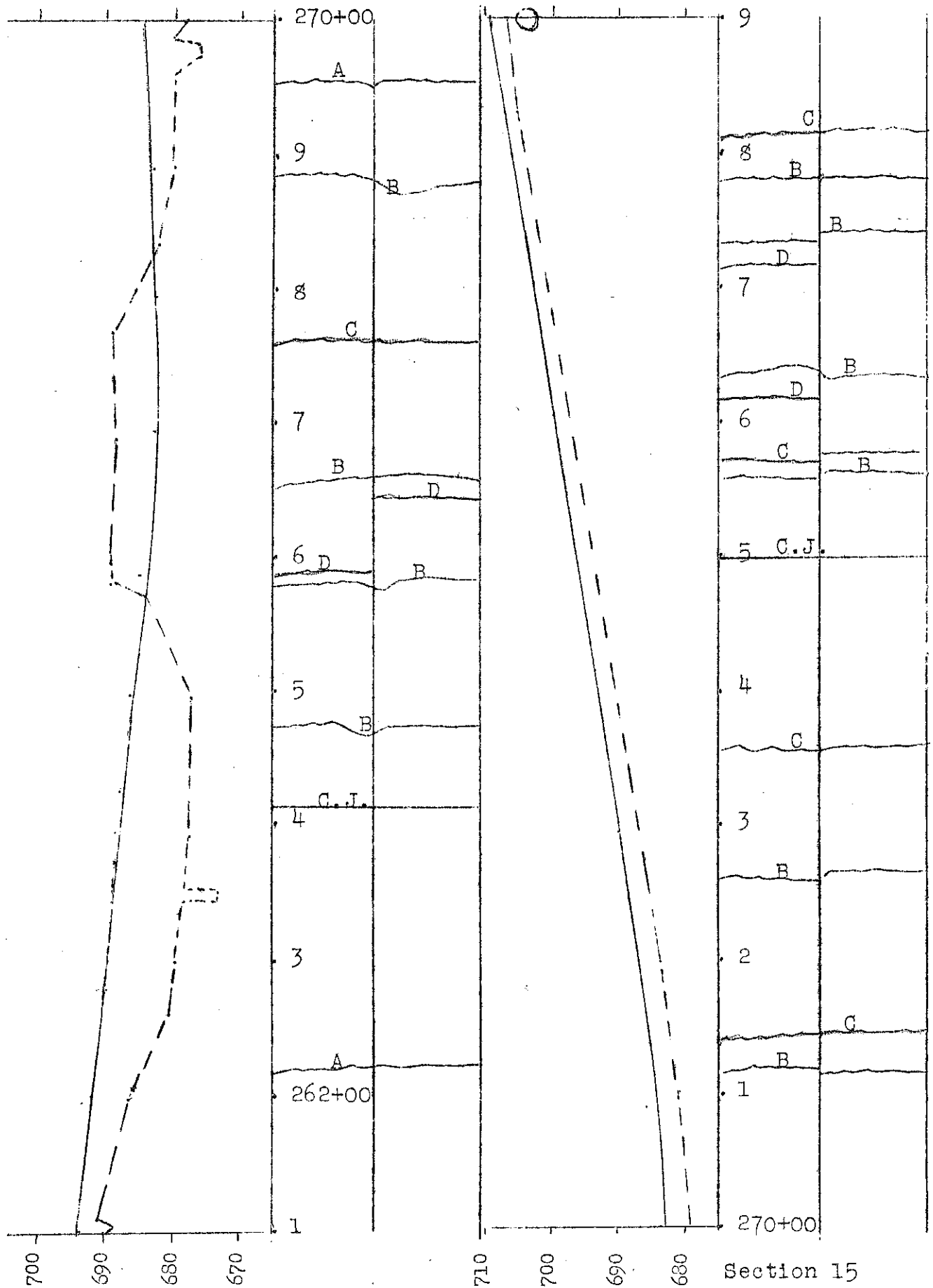
Section 11

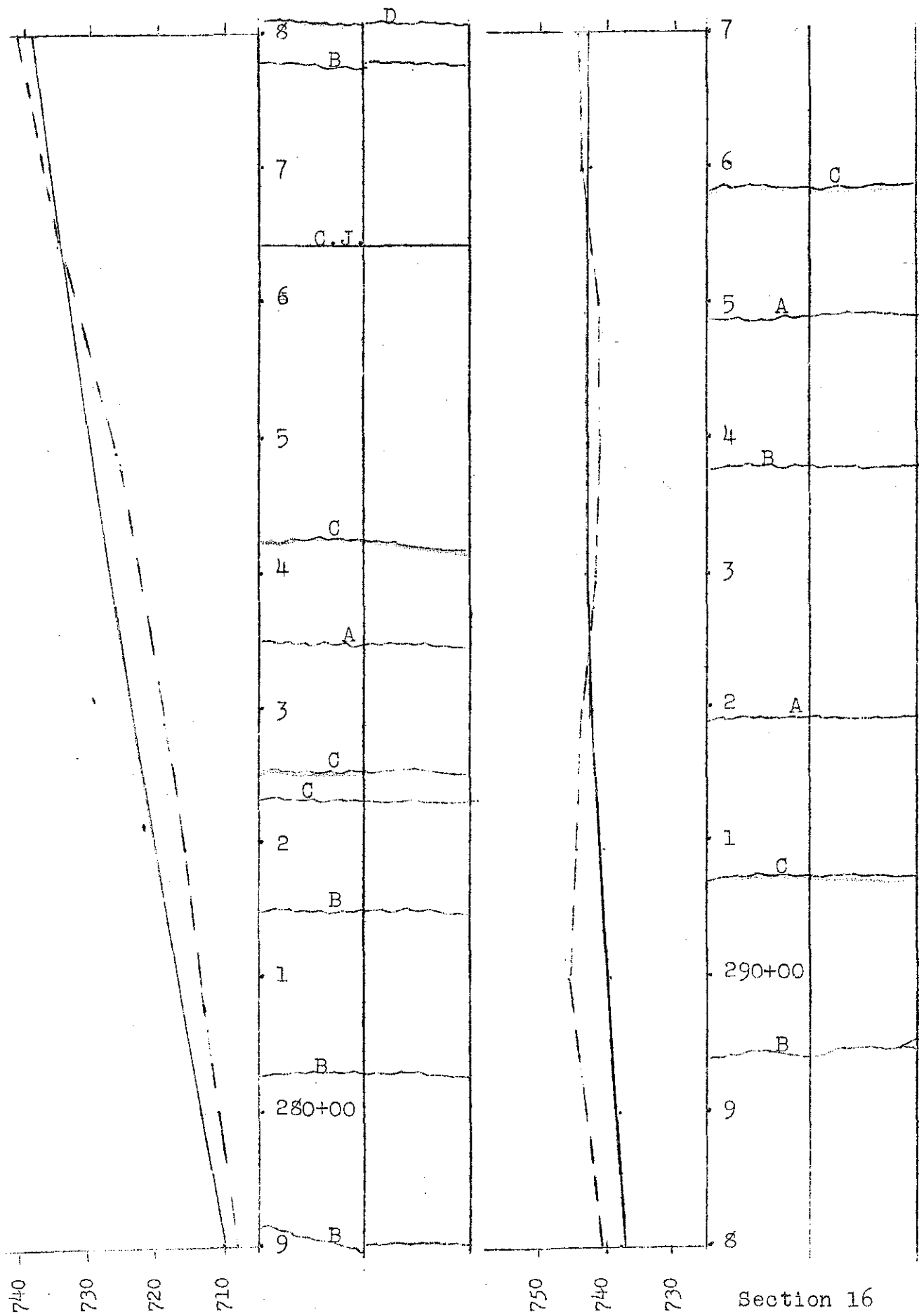


Section 12









Section 16

