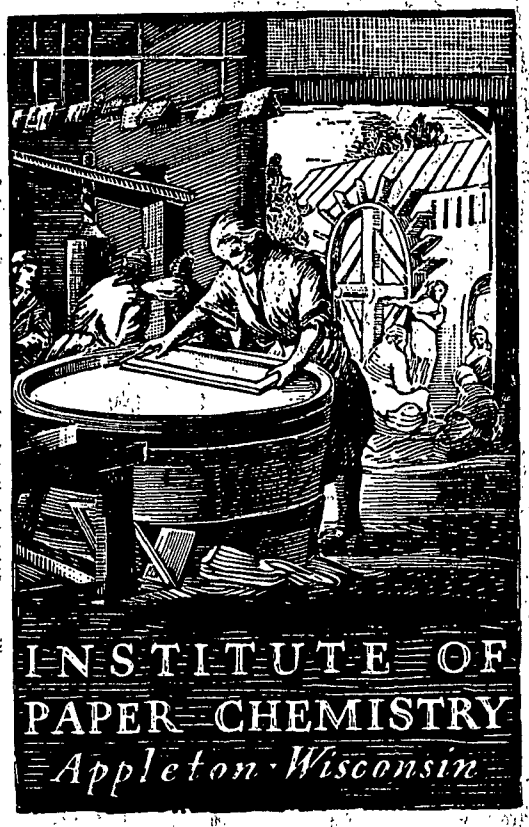

AN INVESTIGATION OF LINTING AND FLUFFING OF OFFSET NEWSPRINT

Project 2949

Report Two

A Progress Report

to

MEMBERS OF GROUP PROJECT 2949

February 21, 1972

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

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Bowaters Southern Paper Corp.

International Paper Company

Southwest Forest Industries, Inc.

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THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

AN INVESTIGATION OF LINTING AND FLUFFING OF OFFSET NEWSPRINT

SUMMARY

Quantitative determinations have been made of blanket lint and ink train lint collected during printing tests on the Didde-Glaser Apollo press for both felt and wire sides of seven newsprints. Replicate runs on the same paper surface in general showed good agreement as compared to the differences encountered between different papers.

The felt side of the newsprint always provided more lint than the wire side. To a surprising degree, the papers showing the greatest linting from the felt side exhibited the least linting from the wire side, and those showing the least linting from the felt side showed the greatest linting from the wire side. The one newsprint which was made on a twin wire machine showed near equal linting from both sides and the least total lint.

Only two northern newsprints were tested but from this limited sample there is no indication of any great difference between southern and northern newsprints in so far as the amount of lint is concerned. The northern newsprint which was made on a conventional paper machine had the greatest linting from the felt side and the least linting from the wire side of all papers tested. The twin wire paper, which was also manufactured in the north, exhibited low linting from both sides in keeping with the low linting from the wire side of other papers.

Accumulation of lint during the press runs was, in most cases, accompanied by decreased print quality. This change in print quality was most noticeable as a loss in the evenness or smoothness of tones which was most noticeable in solids and dark halftones. There was also a tendency for the halftones to

increase slightly in density and for solids to decrease in density. The changes occurring during the run and in many cases the appearance of the prints indicated that the lint was responsible for the degradation in quality. However, no general relationship for all of the papers was evident for correlating quality degradation with the amount of lint collected. If only the four sides of the two northern papers are considered, where the papers probably represent a similar furnish, the final quality does correlate inversely with the amount of lint. Consequently, it has been tentatively concluded that the nature of the lint may be of greater importance than the amount of lint in so far as quality degradation is concerned. Quantitative linting tests may be more useful in monitoring changes in a single newsprint where the nature of the lint may be relatively uniform than in comparing dissimilar newsprints. In either case, due attention should be given to the printing quality and to the way printing quality changes during the run.

INTRODUCTION

The first progress report on this group project dealt with the development of test methods for printing and quantitatively isolating the lint from the press blanket and the ink train. The methods used in this report are described in Progress Report One.

Progress Report Two provides comparative linting data for the papers which have been supplied by the cooperating members of this group project and includes the results obtained with two northern newsprints — one of which was manufactured on a twin wire machine. These quantitative lint data are supplemented by subjective and objective studies of the prints and of the degree of printing quality degradation which occurs during printing as a result of lint accumulation. These data indicate that not all lint is equally objectionable from a print quality standpoint. Progress Report Three will provide information concerning the nature of the lint accumulated from the various newsprints.

PAPERS TESTED

Members of the group project supplied five different newsprints, two of which were designated as regular newsprints and three of which were offset newsprints. All of these papers were manufactured in the south. After testing was well advanced it was decided that a comparison with northern newsprints would be desirable. Therefore, two northern newsprints were secured. One of these was manufactured on a conventional fourdrinier machine and the other on a twin wire machine.

A simplified coding system has been adopted to identify the papers. The first letter of the code is the letter A, B, C, D, or F for the southern newsprints and H or I for the northern newsprints. (The letters E and G were used for the papers of Progress Report One.) For convenience in easy identification, a second letter R or O has been added to the code of the southern newsprints to indicate whether they are regular or offset grades. The second letter in the northern newsprint codes is C or T to indicate whether the paper was manufactured on the conventional or twin wire machine. Most of the cooperators furnished five 12-inch rolls of each paper. Therefore, when reference is made to a particular roll a digit 1-5 follows the two letters. Each of the members of the group project is being supplied with a code key for the particular papers furnished by that company only. This code can be used to convert any roll code to the manufacturer's own roll number.

One roll of each newsprint was sampled for fiber analyses. Results are shown in Table I.

TABLE I

FIBER ANALYSIS OF THE PAPERS TESTED

Paper A02

60% softwood groundwood. Principal species: southern and/or jack pine identification group — prefer southern; traces of Douglas-fir and spruce and/or hemlock identification group
36% softwood lightly bleached kraft. Principal species: southern and/or jack pine identification group — prefer southern; trace of spruce and/or hemlock identification group
4% softwood lightly bleached kraft; Douglas-fir
Trace hardwood kraft; Populus group — prefer Populus genera

Remarks: The chemical furnish exhibits little or no cutting and fibrillation. The groundwood is generally a coarse grade. Groundwood appears to form two groups, (1) shives or coarse fiber bundles with 3-4+ fibers per shive; and (2) fines. There seems to be no gradation in between.

Paper D04

62% softwood groundwood; species southern and/or jack pine identification group — prefer southern.
38% softwood lightly bleached kraft; species southern and/or jack pine identification group — prefer southern

Remarks: The kraft exhibits little cutting but moderate fibrillation. The groundwood appears to be a medium grade. Shives or fiber bundles are of limited length and size, with 2-3 fibers per bundle. Many groundwood fines.

Paper BR2

56% softwood groundwood; species southern and/or jack pine — prefer southern
42% softwood lightly bleached kraft; species: southern and/or jack pine identification group — prefer southern
2% hardwood kraft. Mixed species: Populus group; evergreen magnolia and gum identified.

Remarks: Chemical furnish shows little cutting or fibrillation. Groundwood slightly coarser than D04. Shives or fiber bundles are of limited length and size, with 2-3 fibers per bundle. Many groundwood fines.

Paper C01

18% hardwood groundwood. Species: gum, maple and/or basswood, Populus, beech, oak and/or chestnut identified.
40% softwood groundwood. Species: southern and/or jack pine identification group — prefer southern

TABLE I (Continued)

FIBER ANALYSIS OF THE PAPERS TESTED

42% softwood lightly bleached kraft. Species southern and/or jack pine identification group — prefer southern; trace of white pine identification group.
Trace hardwood kraft — species not determined.

Remarks: Chemical furnish exhibits limited cutting and fibrillation. Groundwood: medium to fine grade. Few shives 1-2 fibers thick but may be fairly long. Very many groundwood fines.

Paper FR5

24% hardwood groundwood. Mixed species: oak and/or chestnut, Populus, beech, maple and/or basswood, gum and yellow poplar identified.
39% softwood groundwood. Species: southern and/or jack pine identification group — prefer southern
37% softwood lightly bleached kraft. Species: southern and/or jack pine identification group — prefer southern
Trace hardwood kraft, species not identified.

Remarks: Chemical furnish exhibits limited cutting and fibrillation. Groundwood medium to fine grade with few shives, 1-2 fibers thick; however, shives may be fairly long. Very many groundwood fines.

Paper E of Progress Report One

14% hardwood groundwood. Mixed species: yellow poplar, gum, maple, and/or basswood, and oak and/or chestnut identified.
42% softwood groundwood. Species: southern and/or jack pine identification group — prefer southern
42% softwood lightly bleached kraft. Species: southern and/or jack pine — prefer southern
2% hardwood kraft. Mixed species: beech, oak and/or chestnut, and gum identified.

Remarks: Chemical pulp exhibits little cutting or fibrillation. Groundwood is a medium to fine grade. Few shives 1-2 fibers thick but may be quite long. Very many groundwood fines.

Paper G of Progress Report One

22% hardwood groundwood. Mixed species: gum, oak and/or chestnut, beech, Populus and yellow poplar identified.
34% softwood groundwood. Species: southern and/or jack pine identification group — prefer southern
42% softwood lightly bleached kraft. Species: southern and/or jack pine identification group — prefer southern
2% hardwood kraft. Mixed species: Populus and oak and/or chestnut identified.

TABLE I (Continued)

FIBER ANALYSIS OF THE PAPERS TESTED

Remarks: Chemical furnish exhibits little cutting or fibrillation. Groundwood medium to fine grade. Few shives 1-2 fibers thick but may be quite long. Many groundwood fines.

Paper HC2

72% softwood groundwood. Species: spruce and/or hemlock identification group
28% softwood unbleached sulfite, medium cook. Species: spruce and/or hemlock identification group.

Remarks: Chemical furnish exhibits little or no cutting or fibrillation. Groundwood has many long fiber aggregates one to two fibers thick but a fair number of shives, four to five fibers thick, also exist. Several shives containing up to possibly twelve fibers were also observed. A limited to moderate number of fines were present.

Paper IT2

76% softwood groundwood. Species: spruce and/or hemlock identification group
24% softwood unbleached sulfite, medium cook. Species: spruce and/or hemlock identification group
Trace softwood bleached kraft. Species: southern and/or jack pine identification group.

Remarks: Chemical furnish exhibits little or no cutting or fibrillation. Groundwood has many long fiber aggregates one to two fibers thick but a fair number of shives, four to five fibers thick, also exist. Several shives containing up to possibly twelve fibers were also observed. A limited to moderate number of fines were present.

QUANTITATIVE LINTING TESTS

All the newsprints were printed on the Apollo press and the blanket lint and ink train lint deposited in 2500 impressions at 18,000 impressions per hour were determined. The printing conditions and isolation methods are given in Report One. To prevent the drying of the dampening rolls when the press was idle overnight or longer and to avoid the need of a seasoning run at the start of the day to bring these rolls to equilibrium conditions, the rolls were removed from the press at the end of the day and wrapped in foil. Contact prints were made of the lint-bearing wax and these are reproduced in the Appendix. The Appendix also contains actual prints from near the start, near the center, and near the end of the press run. The amount of lint collected in each determination is show in Table II. At least three printing tests were made of each side of each paper. The order of these first three tests was randomized and is indicated by the run number, but all data for each paper are grouped in the table for convenience. The blanket used, the order of the test in the day, and the day of the test are includ in order to permit detection of any effects of these variables on the test result. The possible bias of results by these variables is considered in the Appendix. It is concluded that any effect, if present, is small and probably does not signif. cantly affect the results.

One roll of each paper was selected at random from the rolls which were received. This roll was run until a roll change was necessary and then a new roll was selected. Roll changes were usually needed before a roll was exhausted. The usual reason for a roll change was jamming in the sheet delivery because of curling of the cut sheets. This usually became a problem in printing rolls of small diameter on the wire side because moistening of the wire side aggravated the curl already present in the roll.

TABLE II

COMPARISON OF LINT QUANTITY AND PRINT QUALITY DATA

Run	Paper & Roll	Side Printed[a]	Day	Order in Day	Blanket	Decurl Bar[b]	Lint Collected, g. Blanket Lint	Ink Train Lint	Total Lint	Evenness[c] of 90% Tone Start	Center	End	Evenness of Solid Start	Center	End	Density Change During Run 20% Tone Increase	Solid Decrease	Contrast Loss
30	A02	F	1	3	F		0.2015	0.1351	0.3366			(0)			0	0.031	0.016	0.047
35	A02	F	2	3	G		0.2219	0.1749	0.3968			(0)			0	-0.006	0.076	0.070
57	A01	F	6	5	H		0.2374	0.1063	0.3437	36	3	0	50	3	0	0.031	0.028	0.059
62	A01	F	7	5	H		0.2403	0.0730	0.3133			(31)			(4)	0.025	0.004	0.029
Average							0.2253	0.1223	0.3476			8			1			0.051
42	A02	W	3	5	E		0.0795	0.0299	0.1024	66	45	42	57	38	42	0.006	0.030	0.036
45	A02	W	4	3	D	Y	0.1041	0.0425	0.1466			(25)			(7)	0.012	0.076	0.088
48	A01	W	5	1	H	Y	0.1021	0.0464	0.1485			(4)			(4)	0.012	0.032	0.044
Average							0.0952	0.0373	0.1325			24			18			0.056
29	D04	F	1	2	E		0.1991	0.1007	0.2998			(8)			(6)	-0.003	0.040	0.037
47	D01	F	4	5	F		0.2178	0.0870	0.3048	63	34	24	78	20	16	0.018	0.054	0.072
51	D01	F	5	4	F		0.2387	0.0637	0.3024			(17)			(12)	-0.018	0.066	0.048
74	D01	F	10	2	E		0.2416	0.0360	0.2776			(32)			(40)	-0.002	0.028	0.026
Average							0.2243	0.0719	0.2962			20			19			0.046
37	D04	W	2	5	D		0.0940	0.0647	0.1587	64	26	18	56	20	21	0.007	0.016	0.023
39	D04	W	3	2	G		0.0876	0.0549	0.1425			(6)			(5)	0.019	0.000	0.019
40	D04	W	3	3	H		0.0882	0.0458	0.1340			(9)			(7)	0.006	0.034	0.040
Average							0.0899	0.0551	0.1451			11			11			0.027
28	BR2	F	1	1	D	Y	0.2219	0.1099	0.3318	52	5	4	49	8	5	0.031	0.018	0.049
36	BR2	F	2	4	H		0.1913	0.0897	0.2810			(12)			(6)	0.011	0.058	0.069
54	BR1	F	6	2	E		0.2276	0.0599	0.2875			(14)			(10)	0.012	0.076	0.088
58	BR1	F	7	1	D		0.2194	0.0487	0.2681			(31)			(30)	0.012	-0.040	-0.028
77	BR1	F	10	5	D		0.2522	0.0444	0.2966			(45)			(40)	0.000	0.032	0.032
Average							0.2225	0.0705	0.2930			27			23			
43	BR2	W	4	1	G	Y	0.1101	0.0471	0.1572	48	12	11	26	8	9	0.016	0.018	0.034
52	BR2	W	5	5	G	Y	(0.1079)					(34)			(11)	0.004	0.058	0.062
55	BR1	W	6	3	F	Y	0.0984	0.0487	0.1471			(15)			(7)	-0.012	0.060	0.048
52A	BR3	W	6	6	G	Y	0.1012	0.0443	0.1455			(32)			(13)	-0.001	0.058	0.057
Average							0.1032	0.0467	0.1499			23			10			0.050
38	C01	F	3	1	F		0.1785	0.0766	0.2551			(5)			(6)	0.020	0.050	0.070
41	C01	F	3	4	D		0.1773	0.0494	0.2267	51	26	13	45	26	14	0.012	0.012	0.024
46	C01	F	4	4	E		0.1807	0.0532	0.2339			(52)			(33)	0.027	-0.008	0.019
73	C02	F	10	1	F		0.1964	0.0500	0.2464			(45)			(39)	-0.007	0.036	0.029
Average							0.1832	0.0573	0.2405			29			23			0.036
31	C01	W	1	4	G		0.0836	0.0610	0.1446			(41)			(37)	0.018	0.004	0.022
44	C01	W	4	2	H	Y	0.1131	0.0366	0.1497			(38)			(35)	0.015	0.010	0.005
53	C02	W	6	1	D	Y	0.1338	0.0269	0.1607	50	39	28	63	32	22	0.011	0.010	0.021
Average							0.1101	0.0415	0.1516			36			31			0.016

See end of table for footnotes.

TABLE II (Continued)

COMPARISON OF LINT QUANTITY AND PRINT QUALITY DATA

Run	Paper & Roll	Side Printed[a]	Day	Order in Day	Blanket	Decurl Bar[b]	Lint Collected, g. Blanket Lint	Lint Collected, g. Ink Train Lint	Lint Collected, g. Total Lint	Evenness[c] of 90% Tone Start	Evenness of 90% Tone Center	Evenness of 90% Tone End	Evenness of Solid Start	Evenness of Solid Center	Evenness of Solid End	Density Change During Run 20% Tone Increase	Density Change During Run Solid Decrease	Density Change During Run Contrast Loss
32	FR5	F	1	5	H		0.1245	0.0585	0.1830			(48)			(38)	0.012	0.052	0.064
34	FR5	F	2	2	F		0.1412	0.0472	0.1884			(38)			(34)	0.017	0.030	0.047
50	FR5	F	5	3	E		0.1720	0.0402	0.2122	78	72	73	64	55	50	0.026	0.028	0.054
65	FR2	F	8	3	G		0.2604	0.0536	0.3140	(65)	(69)	(46)			(48)	0.015	-0.010	0.005
75	FR2	F	10	3	G		0.2819	0.0546	0.3365			(33)			(39)	0.008	0.020	0.028
76	FR2	F	10	4	H		0.2980	0.0569	0.3549			(39)			(40)	0.016	0.020	0.036
78	FR5	F	11	1	F		0.1764	0.0689	0.2453	(63)	(63)	(47)			(52)	0.024	0.026	-0.002
79	FR1	F	11	2	E		0.2502	0.0748	0.3250	(64)	(49)	(46)			(36)	0.006	0.032	0.038
80	FR4	F	11	3	G		0.2497	0.0815	0.3312	(72)	(55)	(47)			(35)	0.025	-0.006	0.019
Average							0.2171	0.0596	0.2767			46			41			0.032
33	FR5	W	2	1	E		0.0963	0.0322	0.1285			(63)			(46)	0.001	0.032	-0.031
49	FR5	W	5	2	D		0.1189	0.0308	0.1497	72	38	27	67	38	28	0.017	0.028	0.055
56	FR2	W	6	4	G		0.1076	0.0288	0.1364			(64)			(47)	-0.011	0.068	0.057
Average							0.1076	0.0306	0.1382			51			40			0.027
59	HC1	F	7	2	E		0.2817	0.0508	0.3325			(33)			(39)	0.013	0.028	0.041
63	HC1	F	8	1	E		0.2775	0.0940	0.3715			(25)			(26)	0.024	0.020	0.044
69	HC1	F	9	2	G		0.3812	0.0482	0.4294	27	26	14	67	39	27	0.026	0.022	0.048
Average							0.3135	0.0643	0.3778			24			31			0.044
66	HC2	W	8	4	H	Y	0.0768	0.0181	0.0949			(73)			(69)	-0.001	0.024	0.023
67	HC2	W	8	5	D	Y	0.0700	0.0167	0.0867	65	76	74	81	70	77	0.013	0.004	0.017
72	HC2	W	9	5	E	Y	0.0819	0.0158	0.0977			(74)			(69)	-0.005	0.036	0.031
Average							0.0762	0.0169	0.0931			74			72			0.024
60	IT1	T	7	3	F		0.1129	0.0190	0.1319			(61)			(56)	0.020	-0.026	-0.006
64	IT1	T	8	2	F		0.1133	0.0325	0.1458			(67)			(74)	0.011	0.006	0.017
71	IT2	T	9	4	D		0.1201	0.0225	0.1426	65	59	72	72	68	76	0.003	0.032	0.035
Average							0.1154	0.0247	0.1401			67			69			0.015
61	IT1	B	7	4	G		0.1159	0.0332	0.1491			(45)			(47)	0.000	-0.010	-0.010
68	IT1	B	9	1	F		0.1271	0.0503	0.1774	58	30	30	64	40	41	0.004	0.018	0.022
70	IT1	B	9	3	H		0.1201	0.0470	0.1671			(45)			(44)	0.002	0.036	0.038
Average							0.1210	0.0435	0.1645			40			44			0.017

[a] The felt and wire sides are indicated by F and W, respectively. In the case of the paper made on the twin wire machine the outside surface of the paper as received was arbitrarily designated as the top and indicated as T. The inside or bottom side is indicated by B.

[b] Runs in which the decurl bar was used are indicated by Y.

[c] Evenness values are given for the start, center, and end of the run. Individual values not enclosed in () were obtained by pair comparison and are expressed on a scale having a maximum possible range of 0 to 82. Values shown in () were established using the previously graded samples as standards for comparison with interpolation when needed.

The initial three tests on each side of the southern newsprints were completed well before the northern newsprints were received. Therefore, to guard against some variable which might change with time, a fourth test on the felt side only of each of the southern newsprints was included with three tests on each side of each of the northern newsprints in a new set (Runs 58 through 74) of randomized experiments. In this series of tests, printed densities were slightly lower but the amount of lint deposited on four out of the five southern papers checked satisfactorily with the previous results. In the case of paper FR a considerably greater amount of lint was recovered and checking this determination with additional tests (Runs 75 and 76) confirmed this greater amount of lint. Study of the rolls used showed that only in the case of CO (felt side) and FR (felt side) had the same roll of paper been used in all three of the initial tests. Roll changes with the other three papers were not accompanied by any significant change in the amount of lint collected. In the case of CO where CO1 was used in the initial three determinations and CO2 was used in the fourth determination, good agreement was found. However, in the remaining case where FR5 gave an average value of 0.1457 gram blanket lint in the initial three determinations, FR2 gave an average value of 0.2801 gram blanket lint in three subsequent determinations. The stub roll of FR5 was then tested and a value of 0.1764 which checks closely with the highest of the three original determinations. Single tests made on FR1 and FR4 gave values of 0.2502 and 0.2497 which are very slightly lower than the lowest value obtained in the three tests of FR2. Therefore, it is concluded that the variation in linting tendency encountered in tests upon this paper is in large part due to roll-to-roll variation. Encountering roll-to-roll variation in lint determinations on one paper but not on the other six papers raises questions concerning the sampling procedures which should be followed to obtain samples for quantitative linting tests. It would be helpful

if all members of the group provide information concerning the exact position o the rolls they supplied with respect to the full cross-machine width and the machine sequence and interval if the paper in the individual rolls was not produced simultaneously.

There is a striking tendency for papers which are low in wire side linting to be high in felt side linting. This is shown in Table III which lists the papers in order of decreasing average amount of total lint from the wire sid With the exception of the results with FR this is also the order of increasing average amount of total lint from the felt side (using the first three determinations in all cases). If the values obtained with FR5, which could not be duplicated with other rolls, are excluded and the values available for FR2 are used the increasing order of wire side linting is identical with the decreasing order of felt side linting. Even the two sidedness of the twin wire newsprint can be made to fit this pattern if an arbitrary choice is made concerning the assignment of "felt side" characteristics as has been done on the last line of Table III. One possible hypothesis is that this inverse order of linting betweer wire and felt sides is due to fines. The greater the tendency is for the fines to be washed out of the wire side during manufacture, the greater will be the concentration of recirculating fines to be retained eventually on the felt side. However, it is surprising that the inverse order of linting tendency would hold for different pulps made from different species which might be expected to vary in the amount of fiber of lint producing potential. The extent of agreement may be somewhat fortuitous.

TABLE III

RELATIONSHIP BETWEEN FELT AND WIRE SIDE LINTING

Paper Code	Total Lint	
	Wire Side	Felt Side
HC	0.0931	0.3778
AO	0.1325	0.3590
FR	0.1382[a] (0.1364)[b]	0.1945[a] (0.3351)[b]
DO	0.1451	0.3023
BR	0.1499	0.3001
CO	0.1516	0.2386
IT	(0.1645)[c]	(0.1401)[c]

[a] Average of first three tests.

[b] Roll FR2 only.

[c] Twin wire results included to show the effect of substantial reduction of two-sidedness.

EFFECT OF LINT ON PRINT QUALITY

Linting would be undesirable from a sales standpoint even if it did not affect print quality, simply because it would give the customer a cause for complaint. However, if lint causes print quality to deteriorate to the point that the blankets must be washed during a run, the complaint becomes serious. The most obvious change which occurred during the test runs was that the prints became rougher in appearance. This was most noticeable in the solid and 90% printing tints where small bits of paper debris caused the greatest effect. Consequently, one run for each side of each of the seven papers was selected for quality studies.

SUBJECTIVE COMPARISONS

Three prints, one each from near the start, near the center (1250 impressions), and near the end (2500 impressions) were selected for comparison. The pertinent portion of each print was mounted and provided with a code number. The first comparison was restricted to the largest 90% tone area and a subsequent comparison was made of solid areas.

The method of pair comparison in which each print was compared with each of the 41 other prints was used. In each of these individual comparisons, the print judged to be superior in evenness or smoothness of tone was given a grade of two and the inferior print was given a grade of zero. If neither print was judged superior to the other each was given a grade of one. The sum of these individual grades then provided a quality scale with possible maximum range of zero to eighty-two.

The same prints were compared by Judges 1 and 2. Judge 1 compared the prints twice (comparison 1A and 1B). In rating 1A, white light was used and in rating 1B, green light was used in order to accentuate unevenness in distribution of the magenta ink. It was decided that the green light was helpful so Judge 2 also used green light. However, correlation between ratings 1A and 1B was at least as good as between 1B and 2 so all three values were included in the average quality figures. Figure 1, which is a plot of the three ratings against the average rating, shows the degree of agreement. These scale ratings have been retained rather than reducing the ratings to a rank order because increments in rating between prints provide somewhat greater information concerning significance of differences. In Table II, these average ratings have been rounded to the closest whole number and reported as the evenness of the 90% tone. After these comparisons were made the question of uniformity of quality between replicate runs arose. Therefore, samples taken from other runs were graded against the 42 original specimens by assigning the average value of the original specimen which matched that of the new specimen or interpolating between the average values of the specimens which bracketed the new samples. These values are shown in parentheses in Table II. Solids from the 42 original prints were also rated by pair comparison by the same two judges, but in this case, each judge ranked the prints once in green light so the recorded values are the average of two ratings. The degree of agreement can be judged from Fig. 2.

There has been no attempt to rate the other tones in the print because differences in evenness are less evident than in the solids and 90% tones. There are two streaks through the print between H and I and between I and J (see letters on print margin). These streaks occur one inking roll circumference

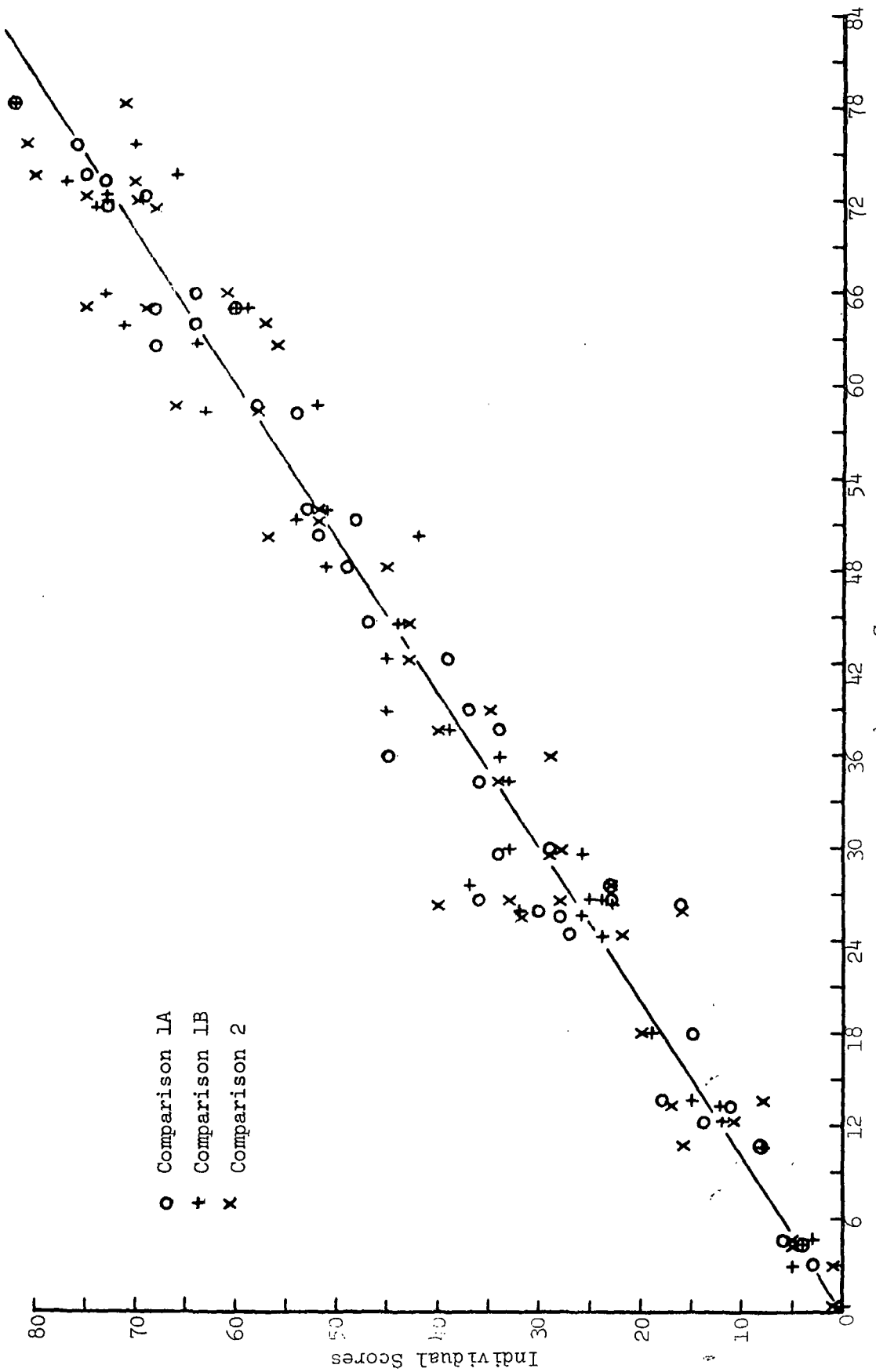

Figure 1. Print Evenness of 90% Printing Area Tone. Individual Comparison Scores vs. Average Scores

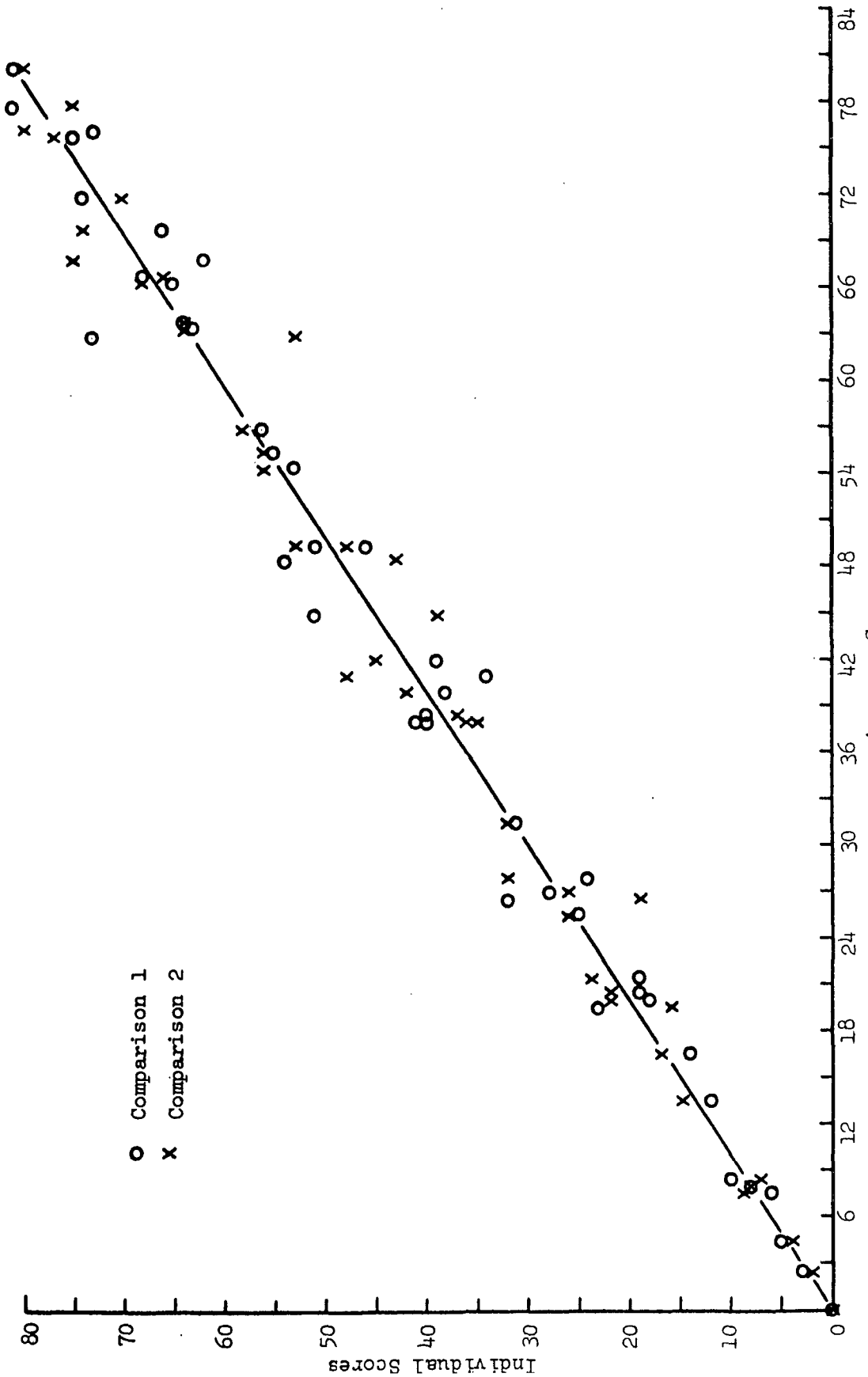

Figure 2. Print Evenness of Solids. Individual Scores vs. Average Score

from the plate cylinder gap and appear as two streaks because the two form rollers are of slightly different size. The intensity of these streaks changes periodically with each excursion of the ink ductor roll. Therefore, this area of the plate has been avoided in making quality judgments.

With one exception among the solid print ratings and two exceptions among the 90% tone ratings the evenness decreases during the run as lint is accumulating on the blanket and in the ink train. It is, of course, possible that decreasing evenness is due to unknown changes which occur systematically during the runs rather than lint accumulation. However, the appearance of the prints, particularly the solid printed areas, indicates paper debris as an important cause of print unevenness.

No relationships between the amount of lint accumulated and the evenness or change in evenness during the run are evident. This is perhaps not surprising in view of the following considerations. First, there are possible causes of unevenness differences between papers other than linting such as smoothness differences or differences in the uniformity of ink absorption. Second, the evenness scales developed cannot be expected to be linear. Equal differences in different parts of the scales probably do not represent the same number of just detectable differences in smoothness. Third, it is probable that the effect of a small amount of lint will be more easily detectable in a run starting with good evenness than a run starting with poor evenness. Nevertheless, the lack of a definite tendency suggests the hypothesis that the nature of the lint may be much more important to printing quality than the amount of lint.

It is believed that the two northern newsprints are prepared from essentially the same furnish. If this is true, the four sides of these four

papers may retain differing amounts of essentially the same lint-producing fibers. For runs made on these four surfaces the evenness of both 90% and solid tones at the end of the run decreases with increasing amount of lint accumulated. Similarly, the change in evenness within the run also correlates with the amount of lint. Therefore, for these limited samples there is evidence that print quality is impaired in proportion to the amount of lint accumulated.

It should be noted that the felt side of the northern conventional paper showed the greatest linting tendency of all surfaces tested. However, print quality remained higher than on some of the other surfaces which deposited much less lint. Even the locally heavy deposits of lint which are so evident in the blanket wax print of Run 69 do not seem to have had any great effect upon the final print. In fact, the solid line at image Position 4 where the blanket was almost completely covered with lint appears to be better covered in the print than the line at Position 13 where the line deposit on the blanket was much less severe. This suggests again that not all lints are equally objectionable.

It should also be noted that, although the felt side consistently contributes more lint during printing, there is little difference between the felt and wire side of the same paper (excepting the northern paper HC) with regard to print evenness. It may be that some component part of the lint rather than the whole lint which is isolated is principally responsible for impaired print smoothness.

DENSITY MEASUREMENTS

Density measurements were made on each tone using the green filter on a Welch Densichron. Density figures used are averages of five values taken in five prescribed locations using a template as a guide. These values show that,

during a run, density of the halftone areas usually increased and the density of the solids decreased causing an overall decrease in the contrast between light and dark tones. In some cases, the tone scale became reversed with the solid print becoming lighter than 90% tone and, in some cases, the 90% tone like the solid became lighter due to interference of paper debris. In Table II the increase in density of the 20% tones, the decrease in solid density, and the resulting change in contrast between these tones are shown. Although the decrease in contrast usually occurs during running, no tendency for the degree of decrease to parallel the amount of lint has been detected. Again, it appears that the nature of the lint may be more important than the amount of lint.

The increase in halftone density and simultaneous decrease in solid density cannot be explained by change in ink level. The increase in halftone density can be explained as due to the accumulation of lint on the blanket in the halftone areas. In effect, printing continues from the mat of lint but there is slight spreading of the dots to increase the density. The dark tones, particularly the solids, show white specks. The largest of these on close examination frequently are white halos surrounding the inked print of a fiber. Comparison of the end-of-run print with the photographic contact print of the blanket wax usually does not show any blanket deposit which corresponds to these obvious print defects. Actually, the solid areas show little lint accumulation as compared with midtone halftone areas. The cause of the large print defects can usually be found to be debris on the plate. It apparently interferes with transfer of ink from the ink rollers to the plate and/or from the plate to the blanket. It is not known whether the deposit on the plate is different in nature than the blanket deposit. However, debris on the plate occurs preferentially where there is little or no water-bearing area. The solids are affected much more than the

90% tones and those solid lines running in the press direction, which are not in line with any water-bearing area within the image, are much more affected than lines which run in the across-press direction between halftones containing water-bearing areas. Within these lines running in the press direction the least affected portion lies at the leading edge of the image in close proximity to the water-bearing margin.

Further studies should give attention to the isolation and identification of paper debris from the lithographic plate and to the effect of such accumulations on printing quality.

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APPENDIX I

EFFECT OF RANDOMIZED VARIABLES ON THE DEGREE OF LINTING

In Table IV press runs have been segregated by the day of the test, by the order of the test within the day, and by the blanket used. In each case it is indicated whether the result was higher (+), or lower (-), than the average of all determinations made on that particular paper surface. It is apparent that runs with each blanket contained a near equal number of higher than average and lower than average results. There is, therefore, no evidence that the particular blanket selected had any effect upon the result.

The different positions within the day also provided near equal occurrence of higher than average and lower than average results. After the first thirty tests were run there was some evidence that the first run of a day produced slightly higher results. However, the final results with seven higher than average and five lower than average values does not confirm the earlier trend. Even if two lower than average values associated with Roll FR5 are disregarded because of a lower linting tendency of that particular roll the remaining seven higher and three lower values could have easily occurred by chance.

The different testing days show one day (the seventh) in which all five values were below the average values and another day (the ninth) in which all five values were above the average values. The differences in most cases were small and do not contribute significantly to differences found between papers. However, for occurrences which by chance should happen once in 32 cases to occur once in eleven cases may indicate a day-to-day variable which has some effect upon the test result. The practice of randomizing the experiments should reduce the effect of such variables on the average result and this practice should be continued whenever several papers are being compared.

TABLE IV

EFFECT OF RANDOMIZED VARIABLES ON TEST RESULTS

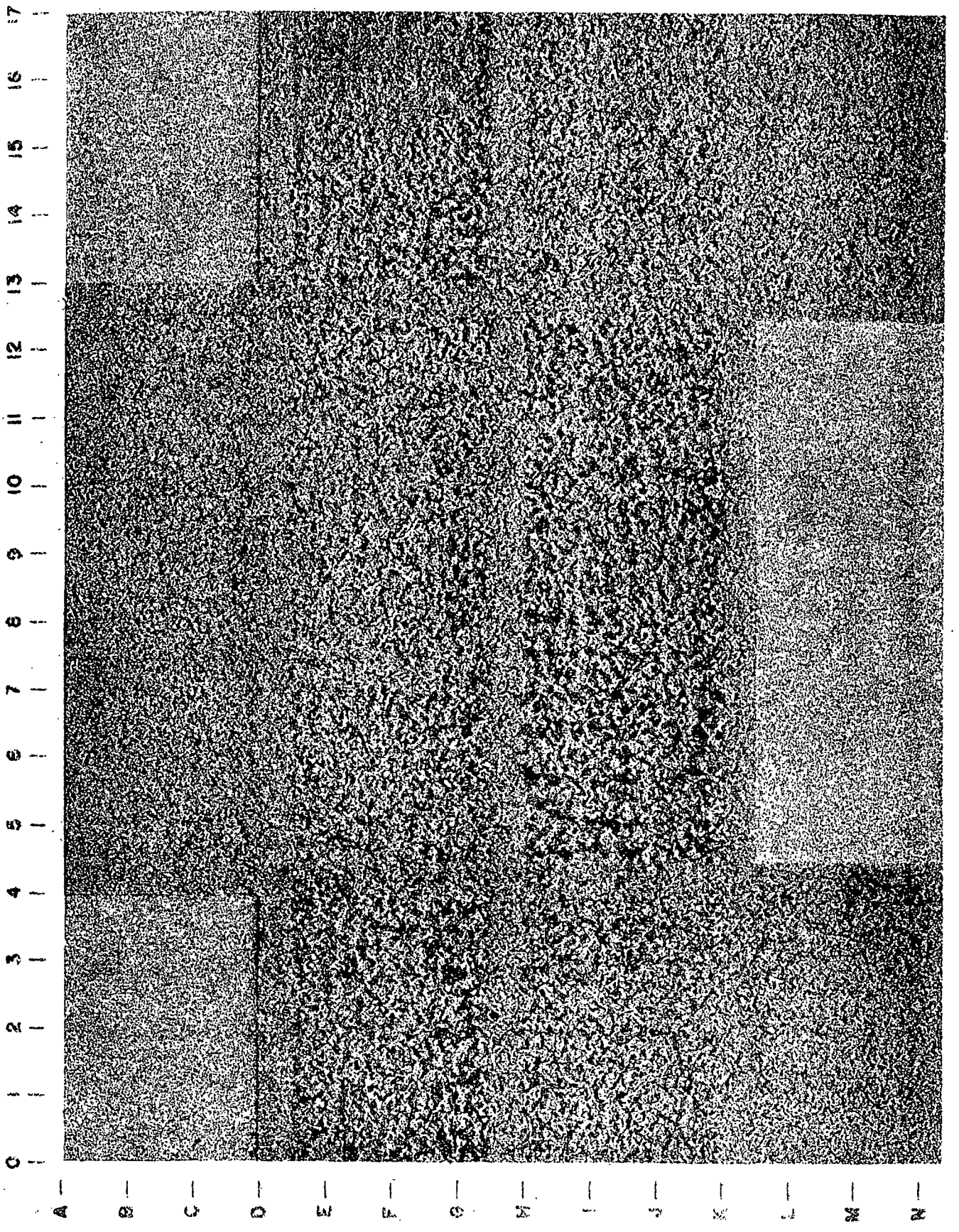
Paper	Side	Day of Test											Order Within the Day						Blanket Used				
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	D	E	F	G	H
AO	F	-	+				-	-							- +		- -				-	+	- -
AO	W			-	+	+							+		+		-		+	-			+
DO	F	+			+	+					-			+ -		+	+			+ -	+ +		
DO	W		+	- -										-	-		+		+			-	-
BR	F	+	-				-	-			+		+ -	-		-	+		+ - +	-			-
BR	W				+		- -						+		-			-			-	+ -	
CO	F			+ -	-						+		+ +			- -			-	-	+ +		
CO	W	-			-		+						+	-		-			+			-	-
FR	F	-	-			-			+		+ +	- + +	- -	+ -	+ + + -	+				-	-	+ +	- +
FR	W		-			+	-						-	+		-			+	-		-	
HC	F							-	-	+			-	+ -					- -			+	
HC	W								- +	+						+	- +		-	+			+
IT	T							-	+	+				+	-	+			+		- +		
IT	B							-		+ +			+		+	-					+	-	+
		2+ 3-	2+ 3-	1+ 4-	3+ 2-	3+ 1-	1+ 5-	5-	3+ 2-	5+	4+ 1-	2+ 1-	7+ 5-	5+ 6-	6+ 5-	4+ 6-	4+ 4-	1-	7+ 5-	3+ 6-	6+ 5-	6+ 5-	4+ 6-

+ Indicates that the result is higher than the average of the values for this particular paper surface.
- Indicates that the result is lower than the average of the values for this particular paper surface.

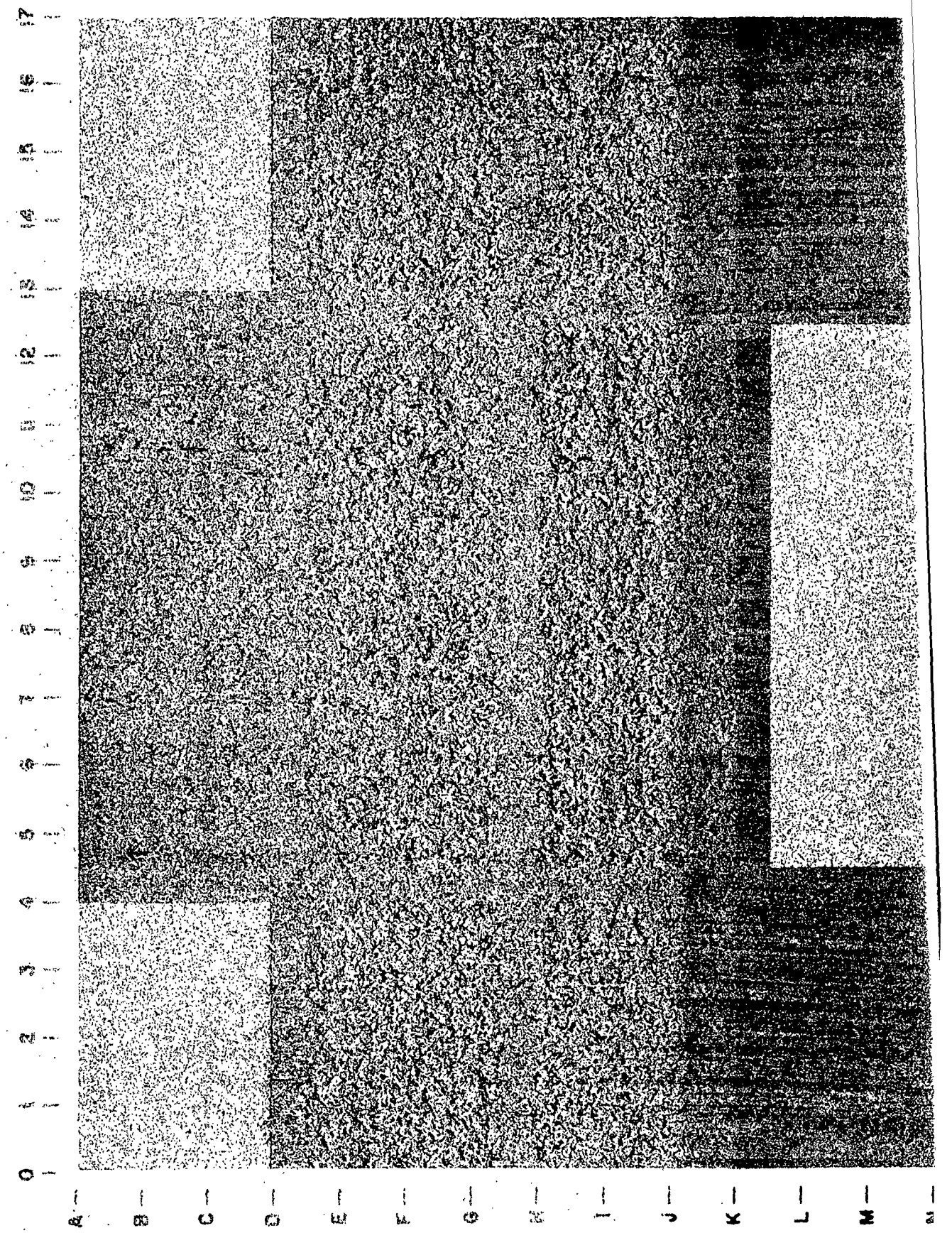
APPENDIX II

CONTACT PRINTS FROM BLANKET WAX

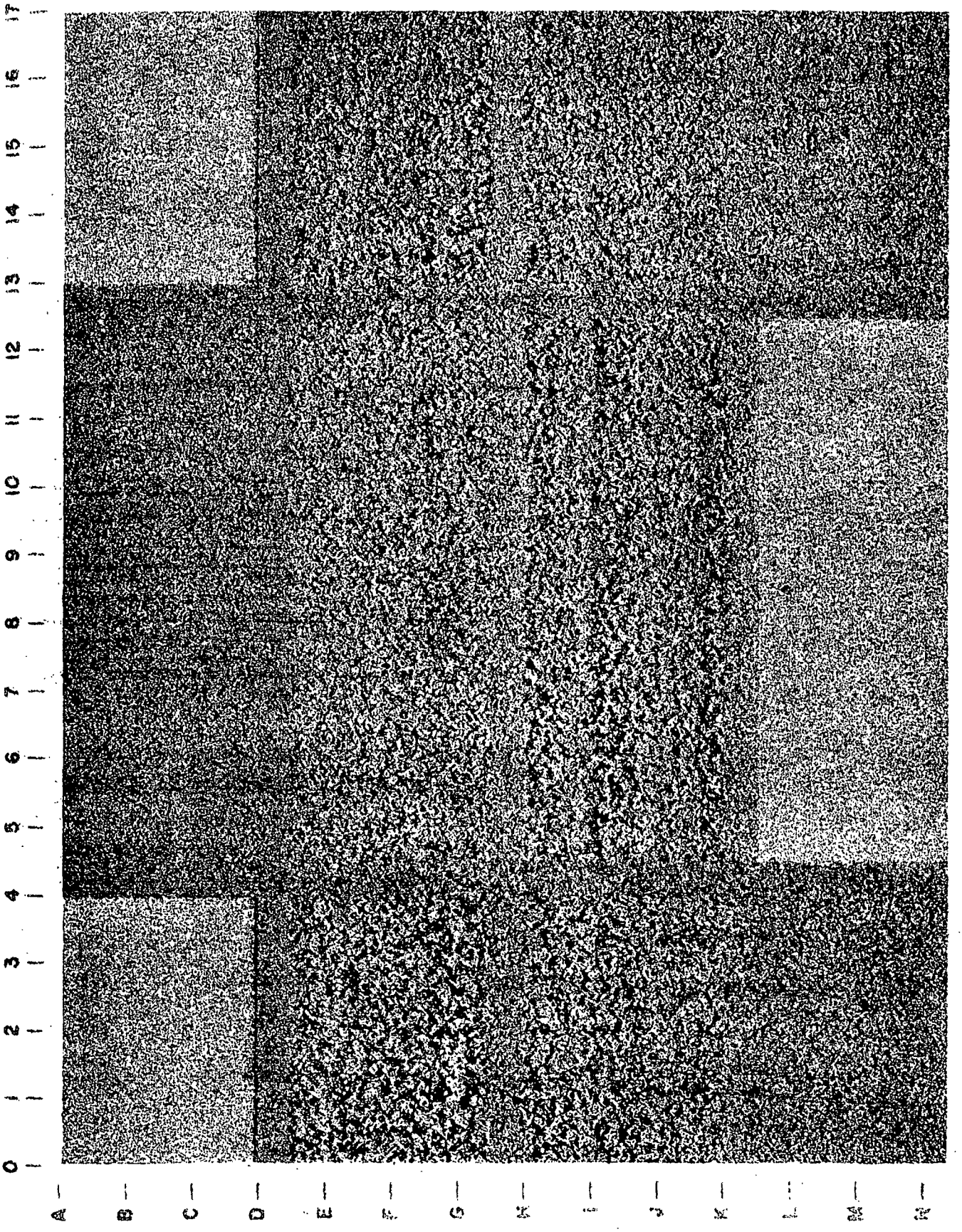
Photographic contact prints were made from the blanket for all press runs to provide a record of the distribution of lint. The prints for fourteen runs — one for each side of each of the seven papers are reproduced in this report. The runs selected for reproduction were those upon which the extensive print quality comparisons were conducted. The prints are arranged in the order of the run numbers.



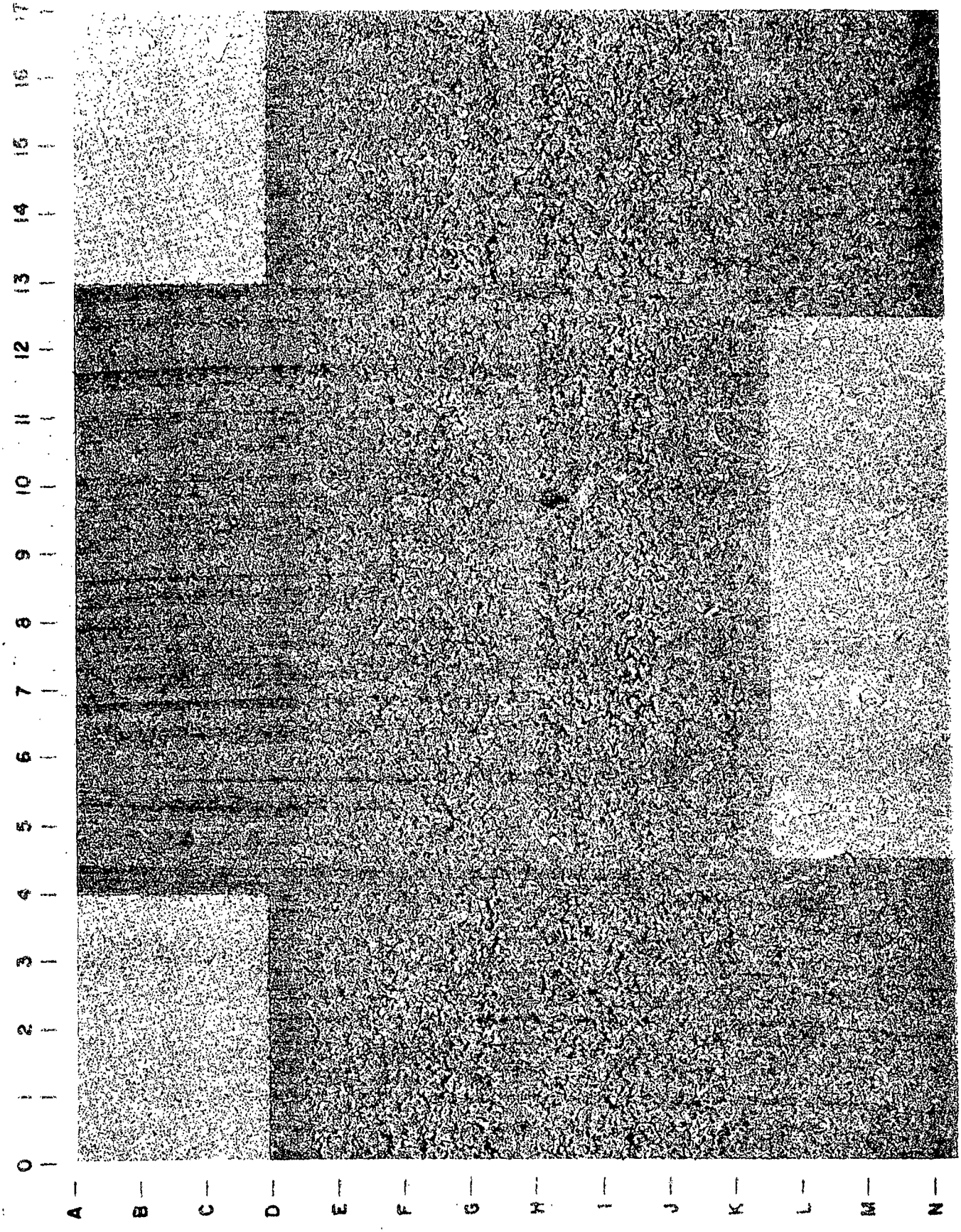
Contact Print from Blanket Wax, Run 28, Paper BR2, Felt Side



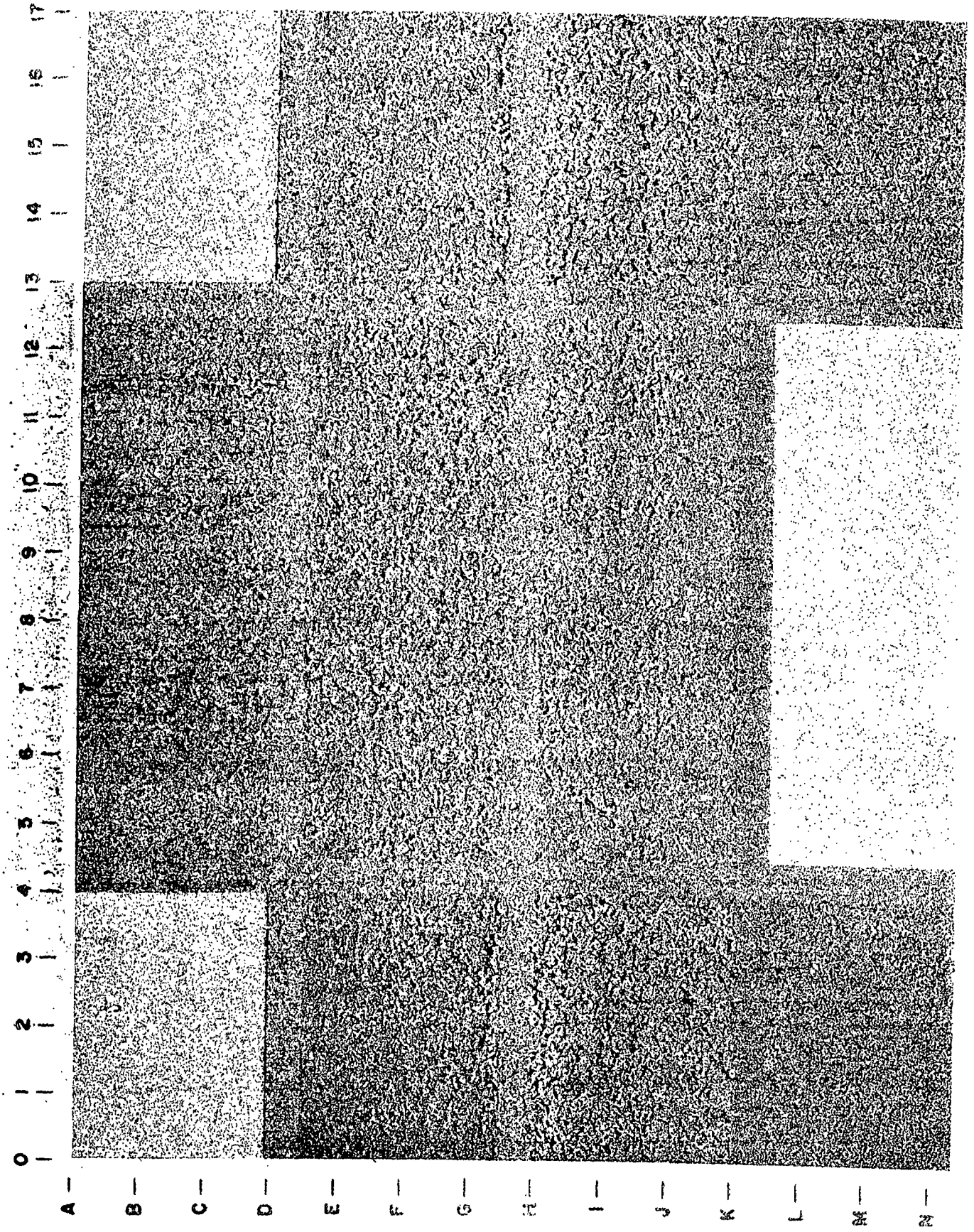
Contact Print from Blanket Wax, Run 37, Paper D04, Wire Side



Contact Print from Blanket Wax, Run 41, Paper C01, Felt Side



Contact Print from Blanket Wax, Run 42, Paper A02, Wire Side


0
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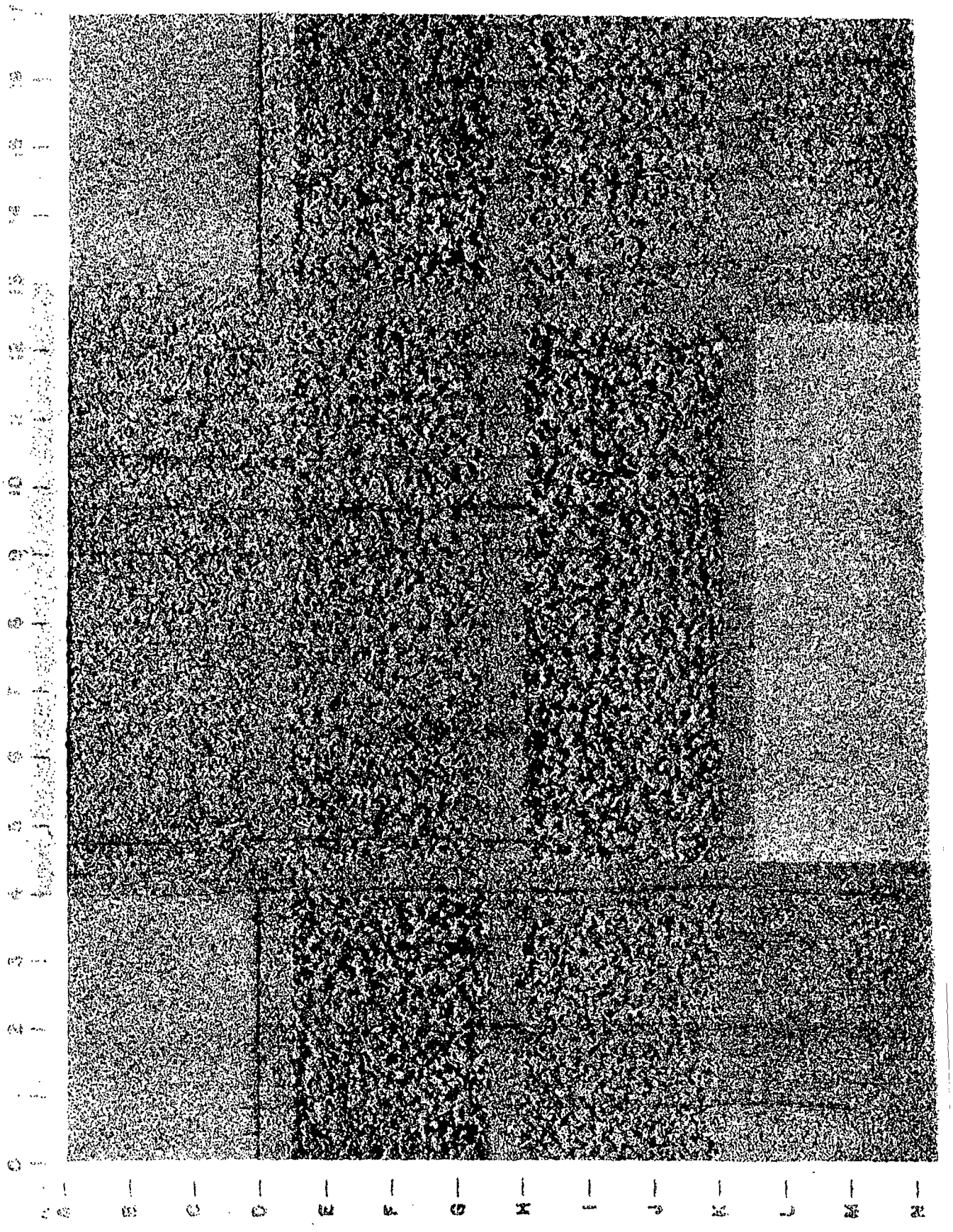
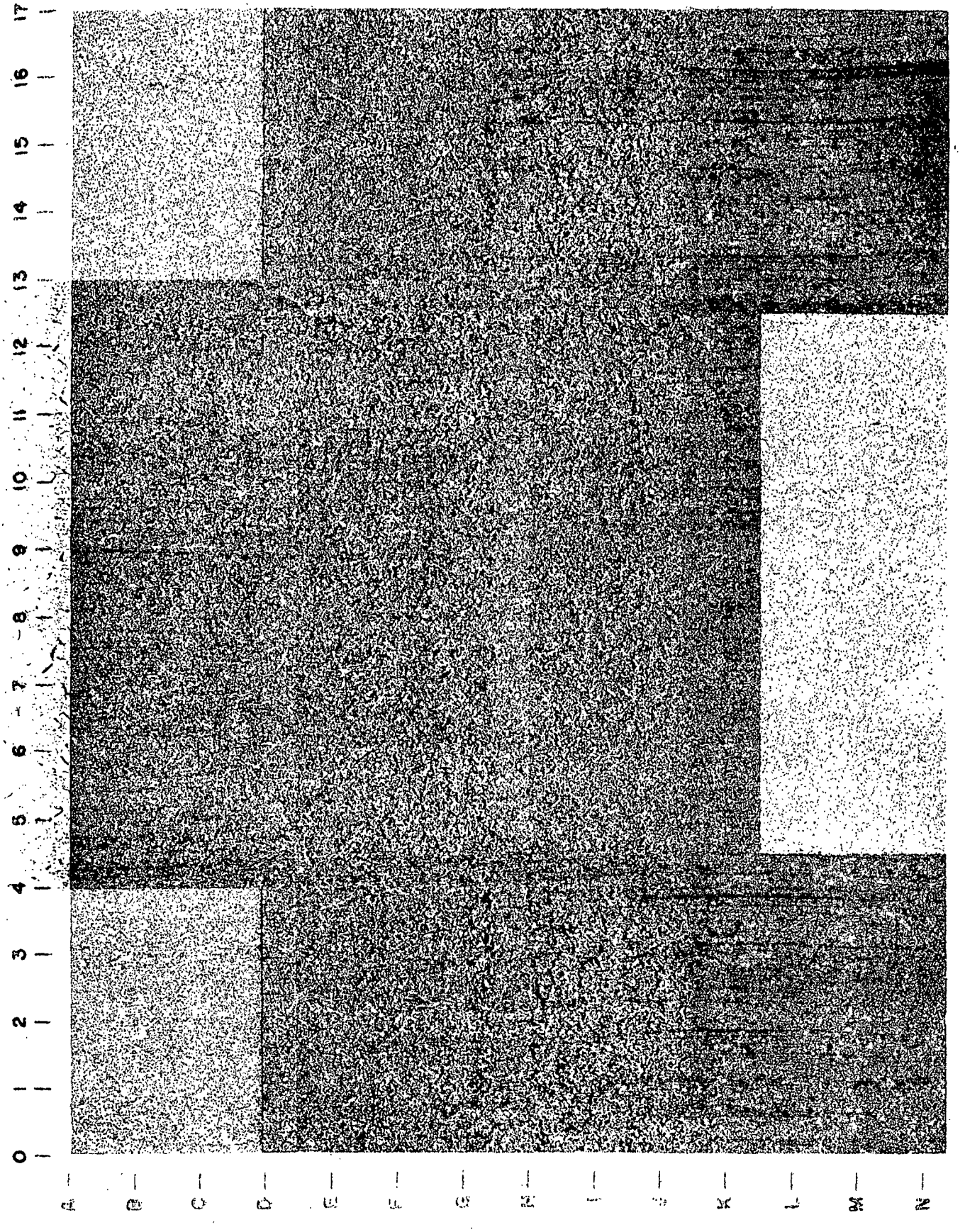
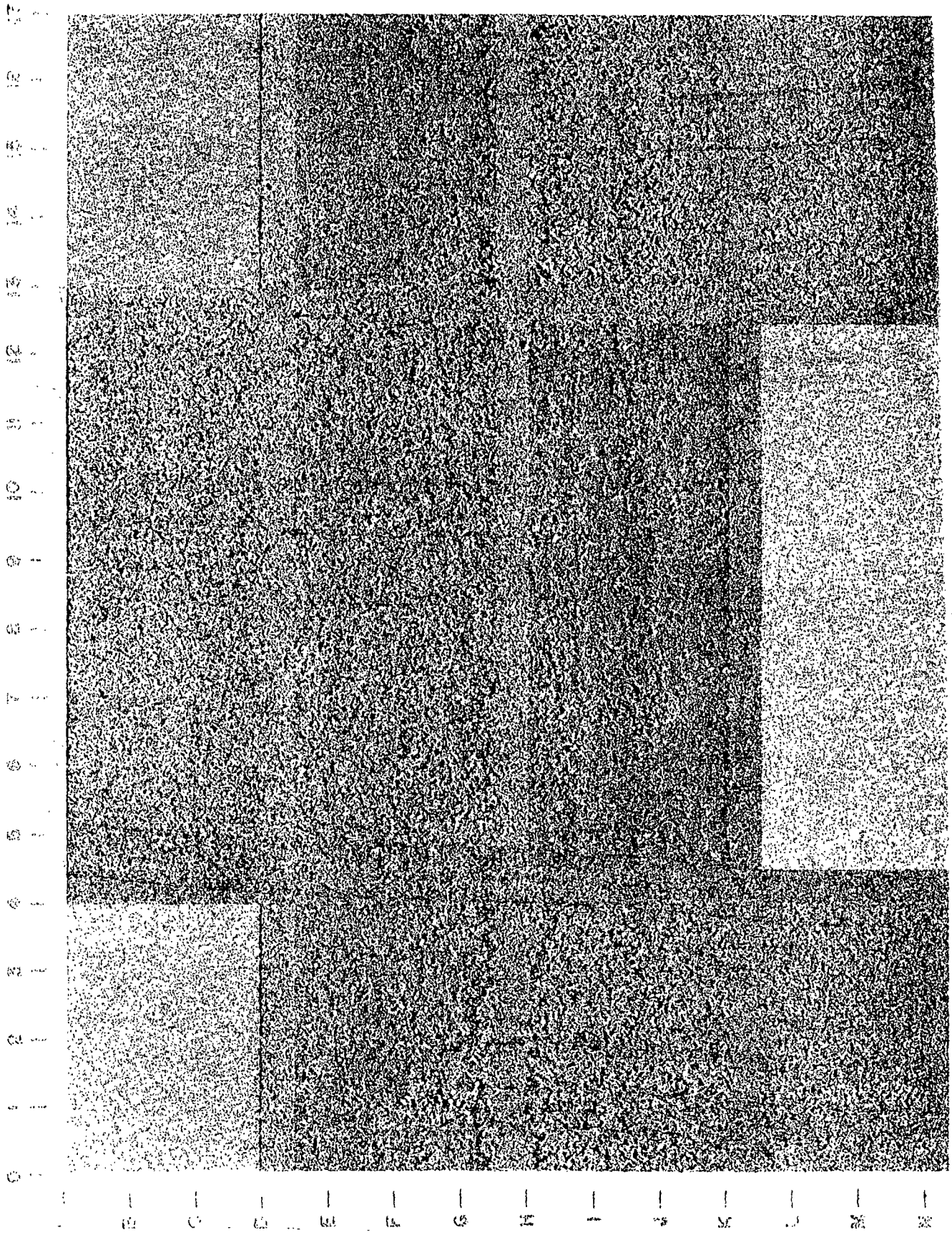
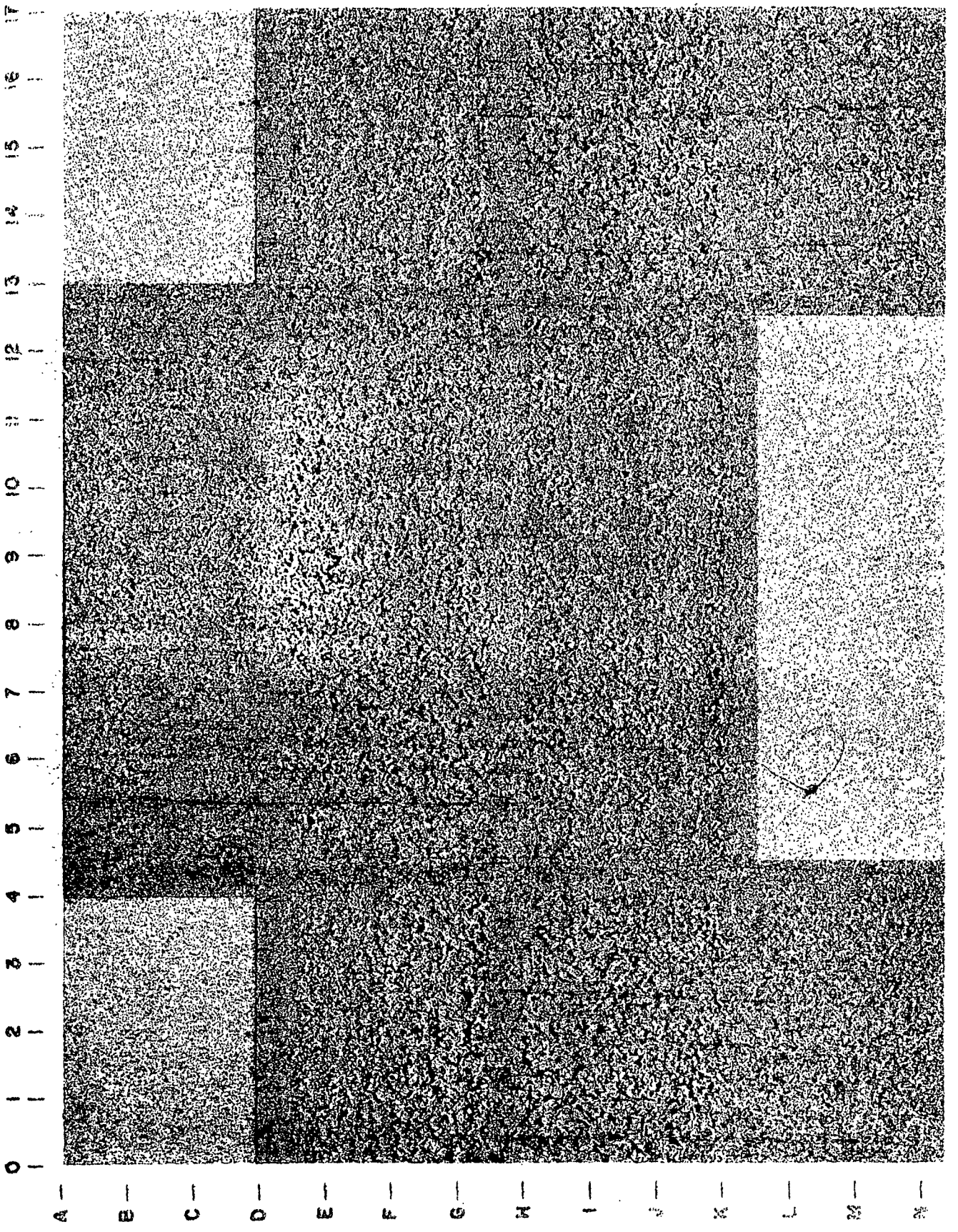


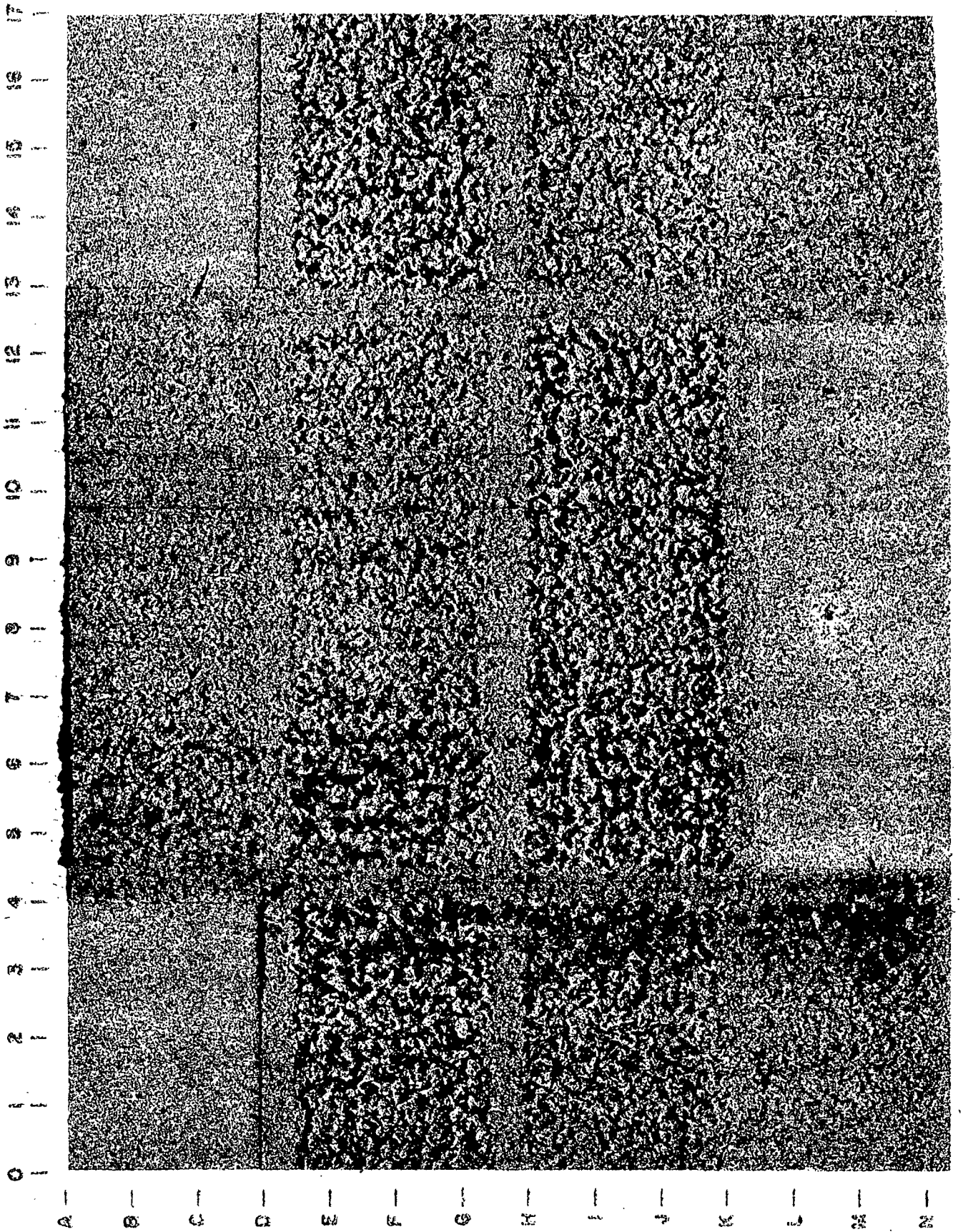
Contact Print from Blanket Wax, Run 47, Paper D01, Felt Side



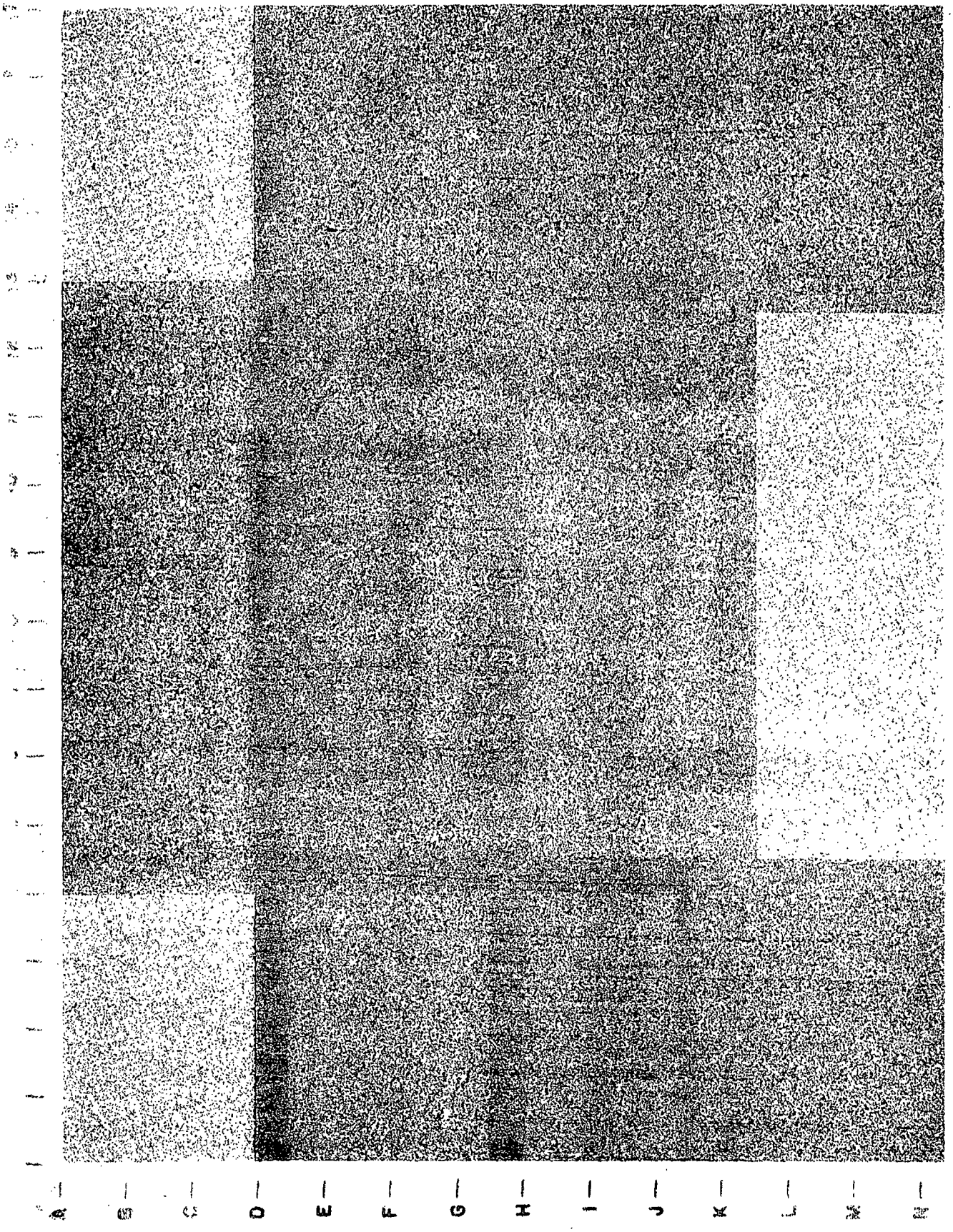




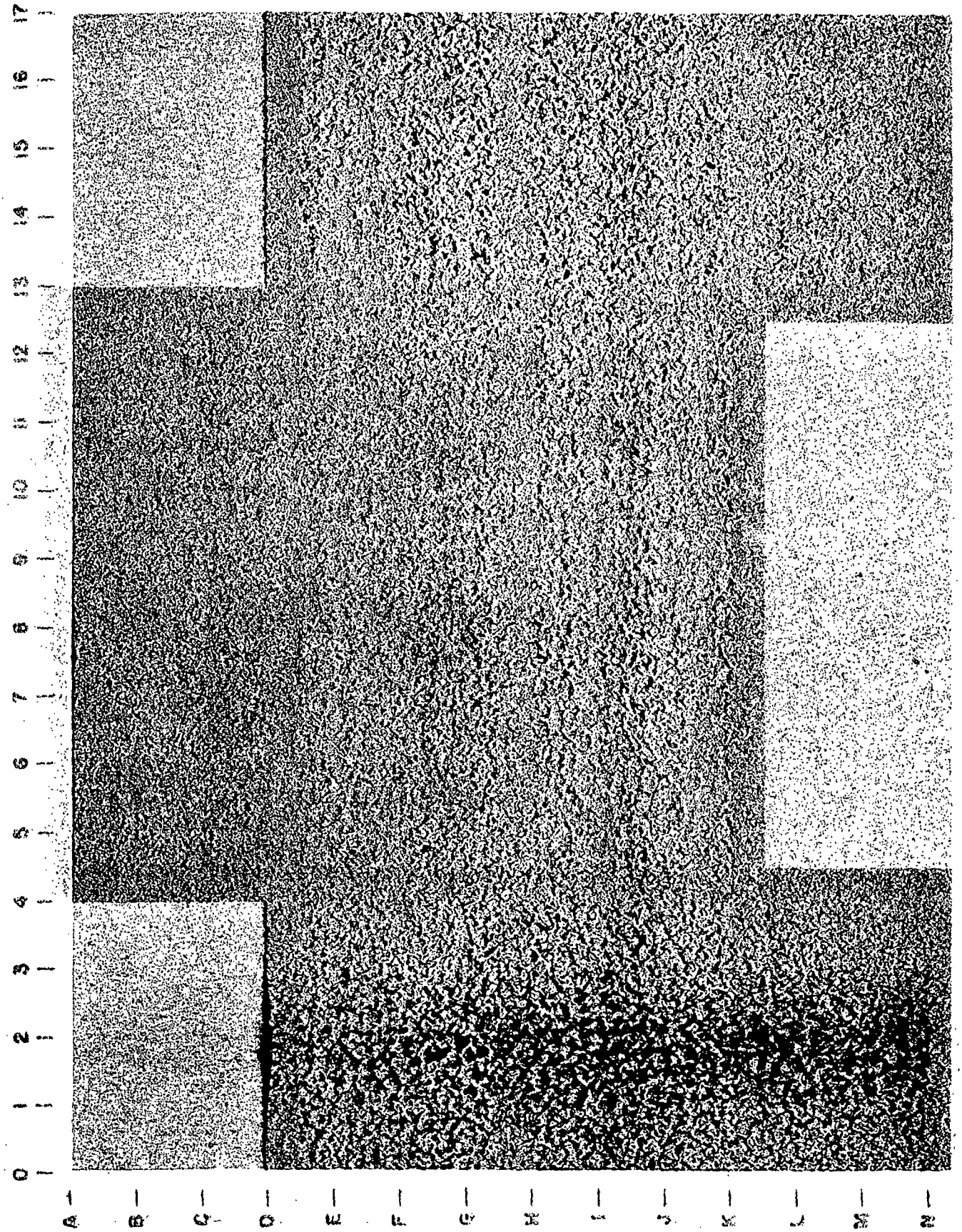
Contact Print from Blanket Wax, Run 53, Paper CO2, Wire Side



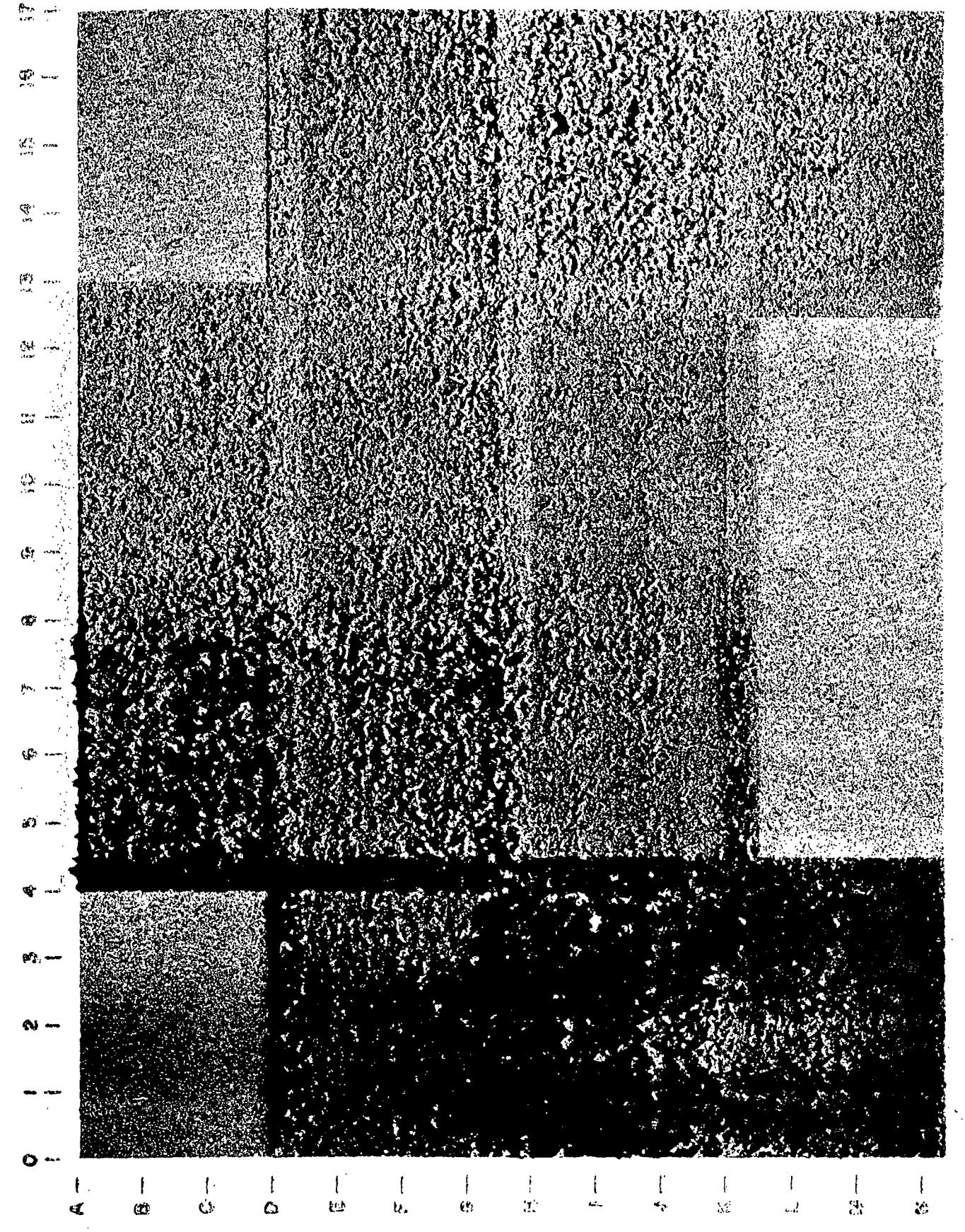
Contact Print from Blanket Wax, Run 57, Paper A01, Felt Side

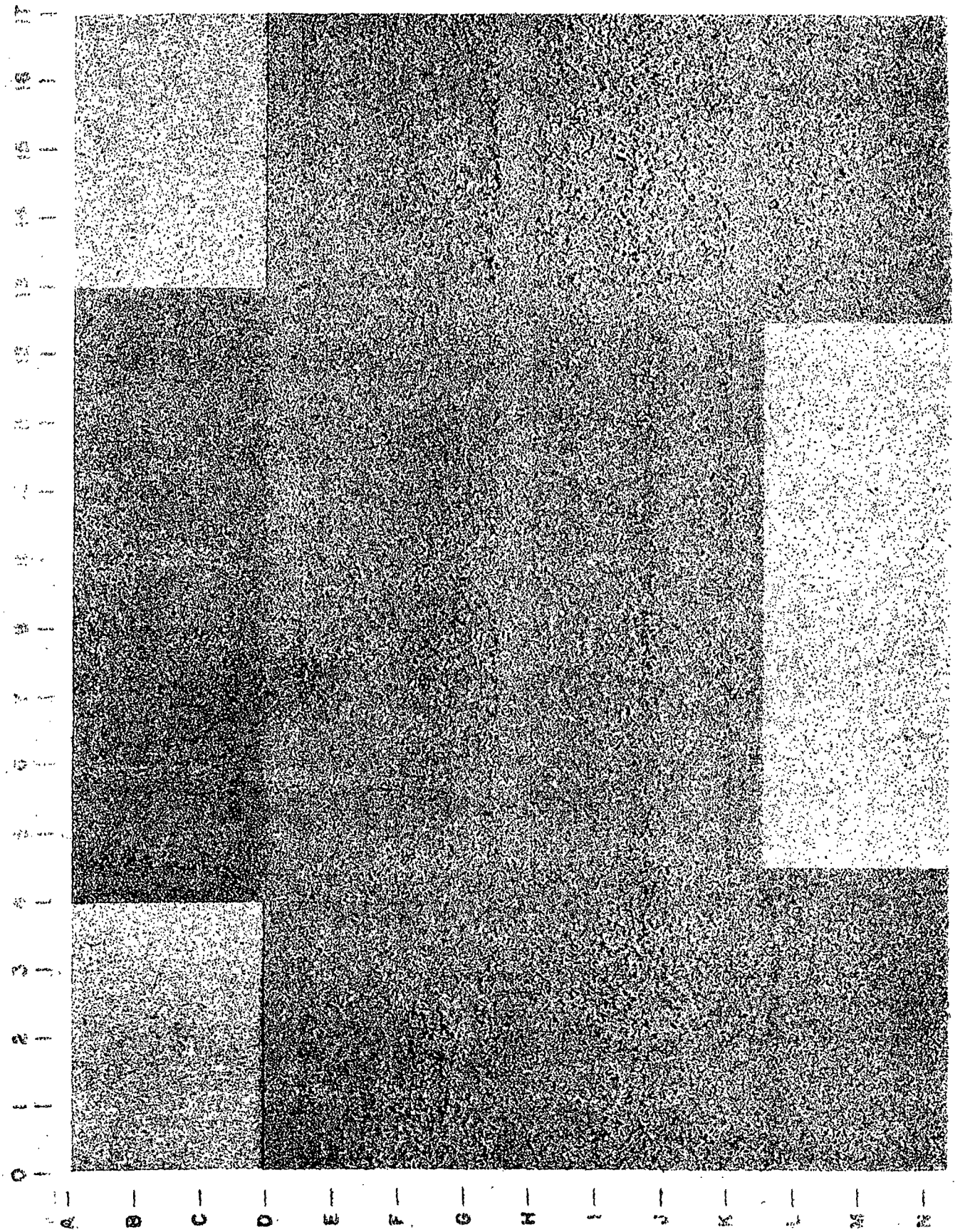


Contact Print from Blanket Wax, Run 67, Paper HC2, Wire Side



Contact Print from Blanket Wax, Run 68, Paper IT1, Bottom Side



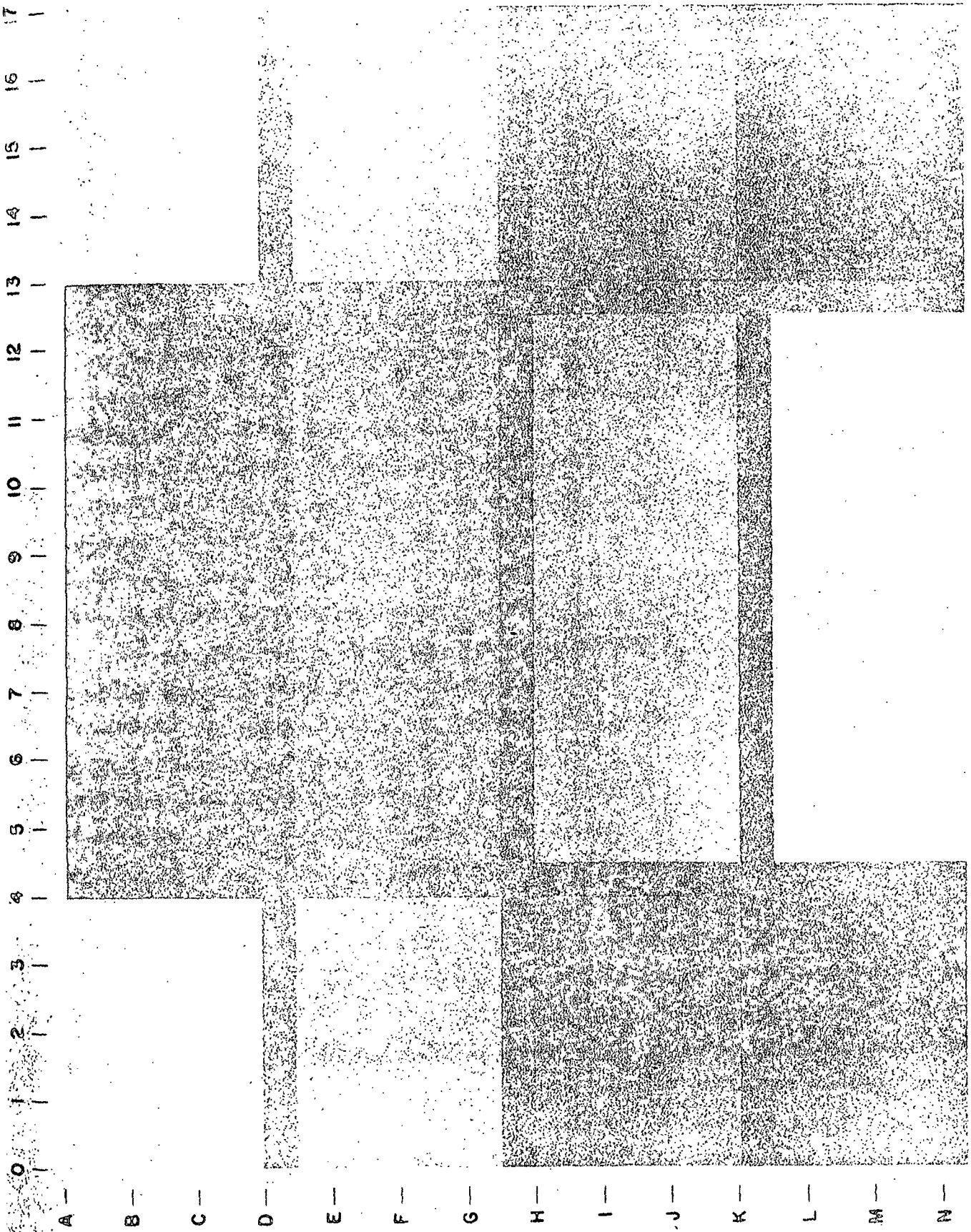


Contact Print from Blanket Wax, Run 71, Paper IT2, Top Side

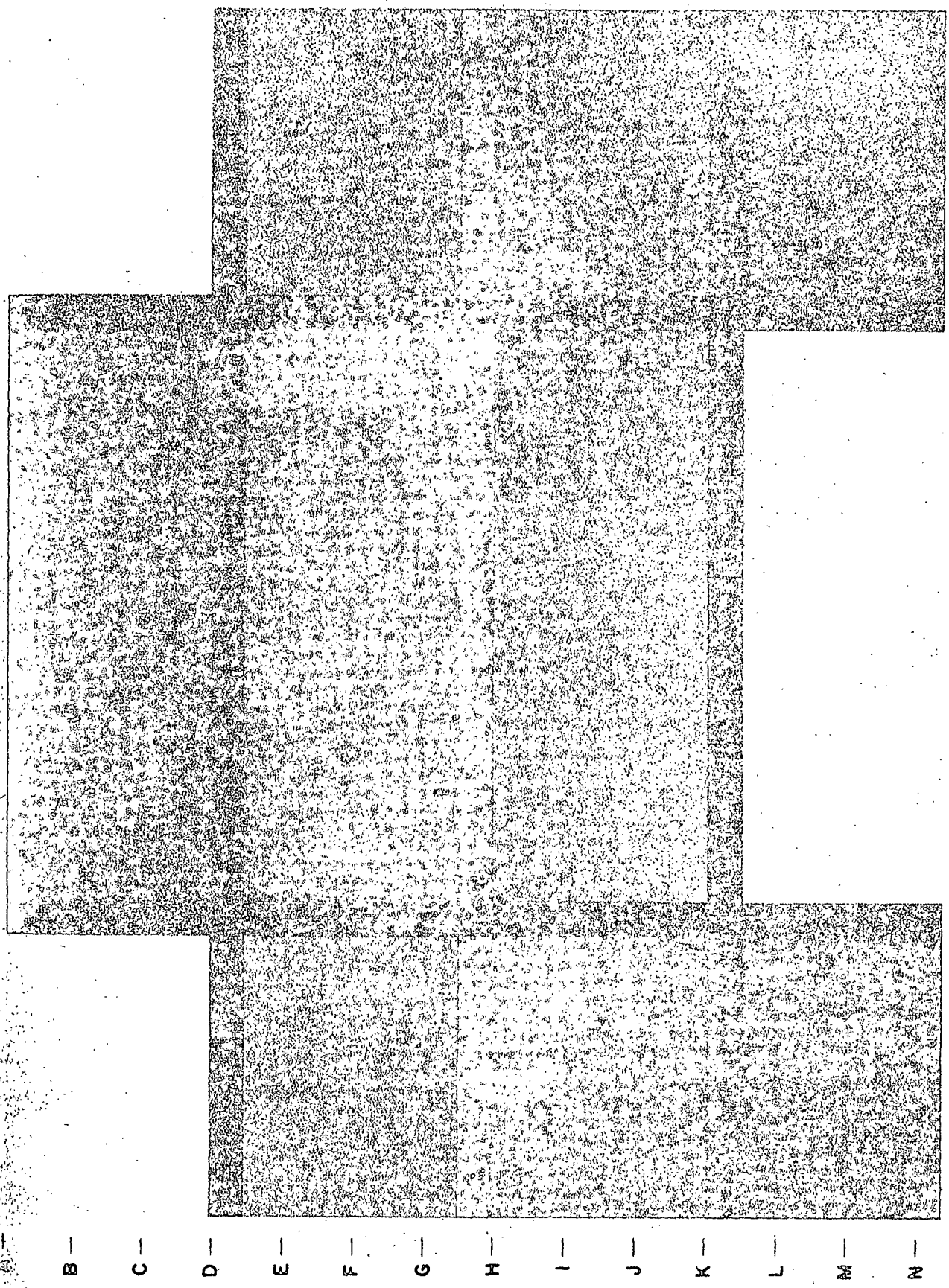
APPENDIX III

PRESS PRINTS

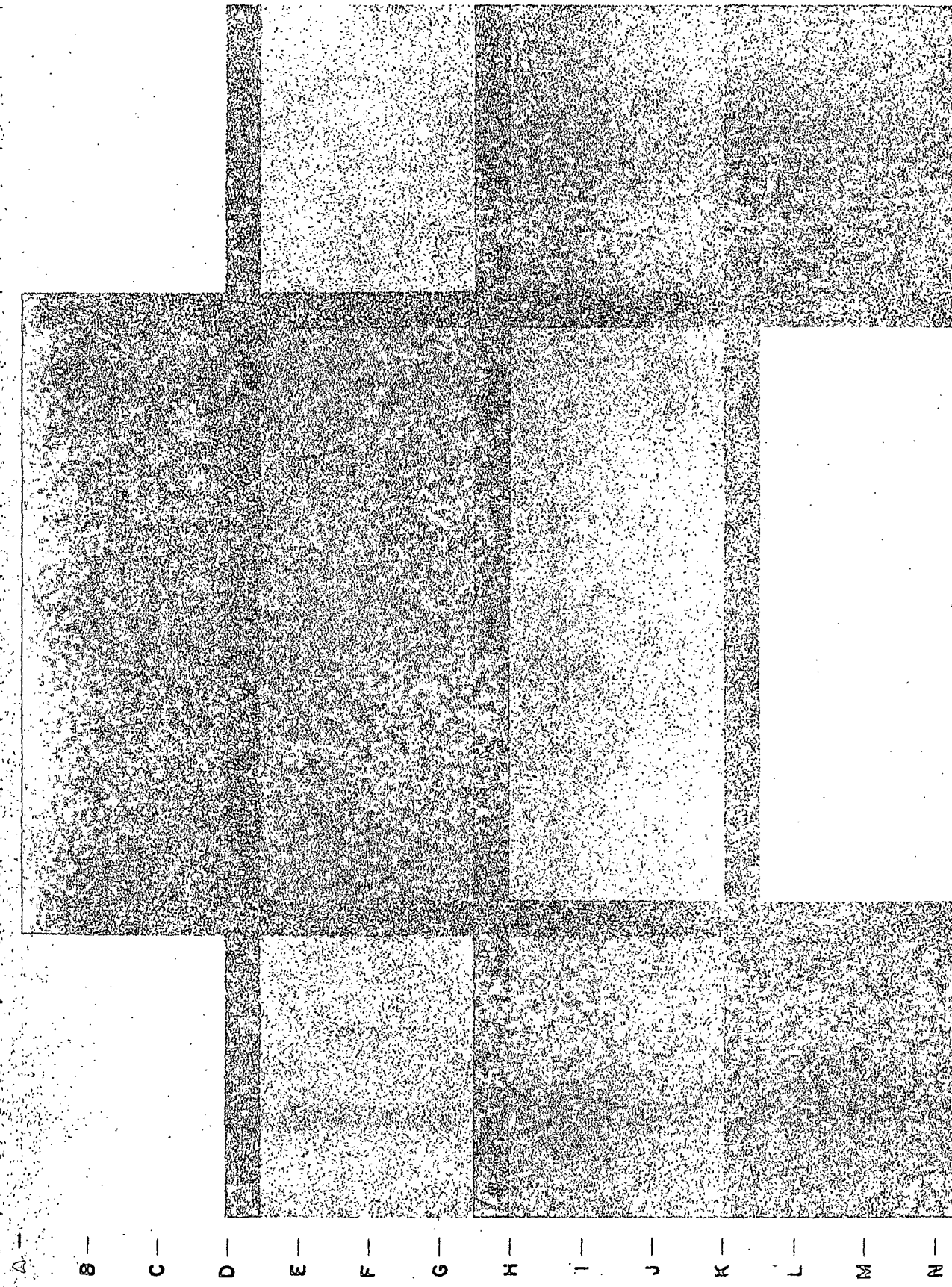
Press prints were taken near the start, near the center, and near the end of the fourteen runs upon which quality comparisons were made. The prints shown should, therefore, be similar to those used in the comparison by pairs. The end of run prints may be compared with the contact prints from blanket wax for evidence of the effect of the blanket deposit upon printing characteristics. The prints are arranged in the order of the run numbers and the letters -S, -C, and -E appended to the run number indicates whether the print is from the start, center, or end of the run.



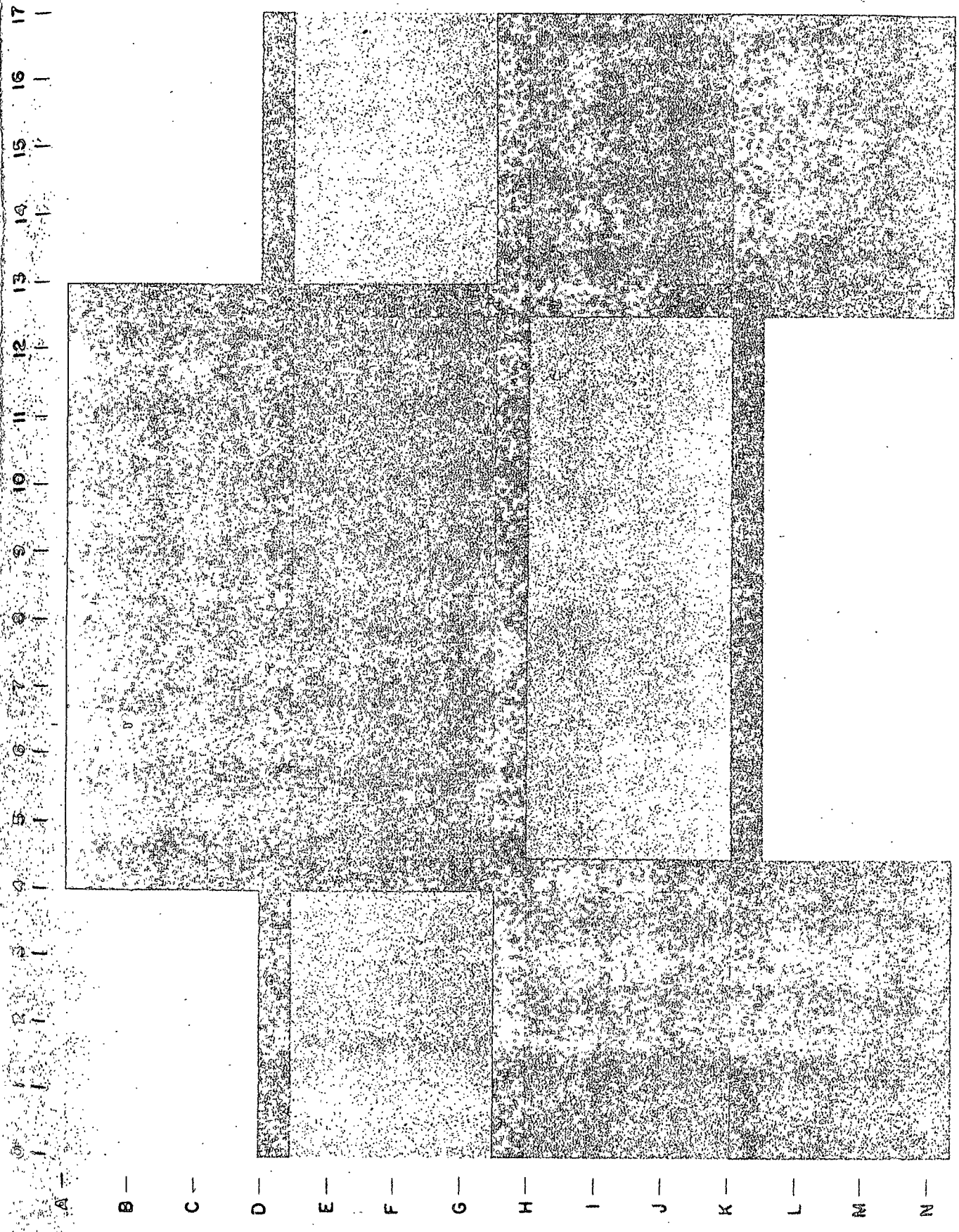
Run 28-S, Paper BR2, Felt Side



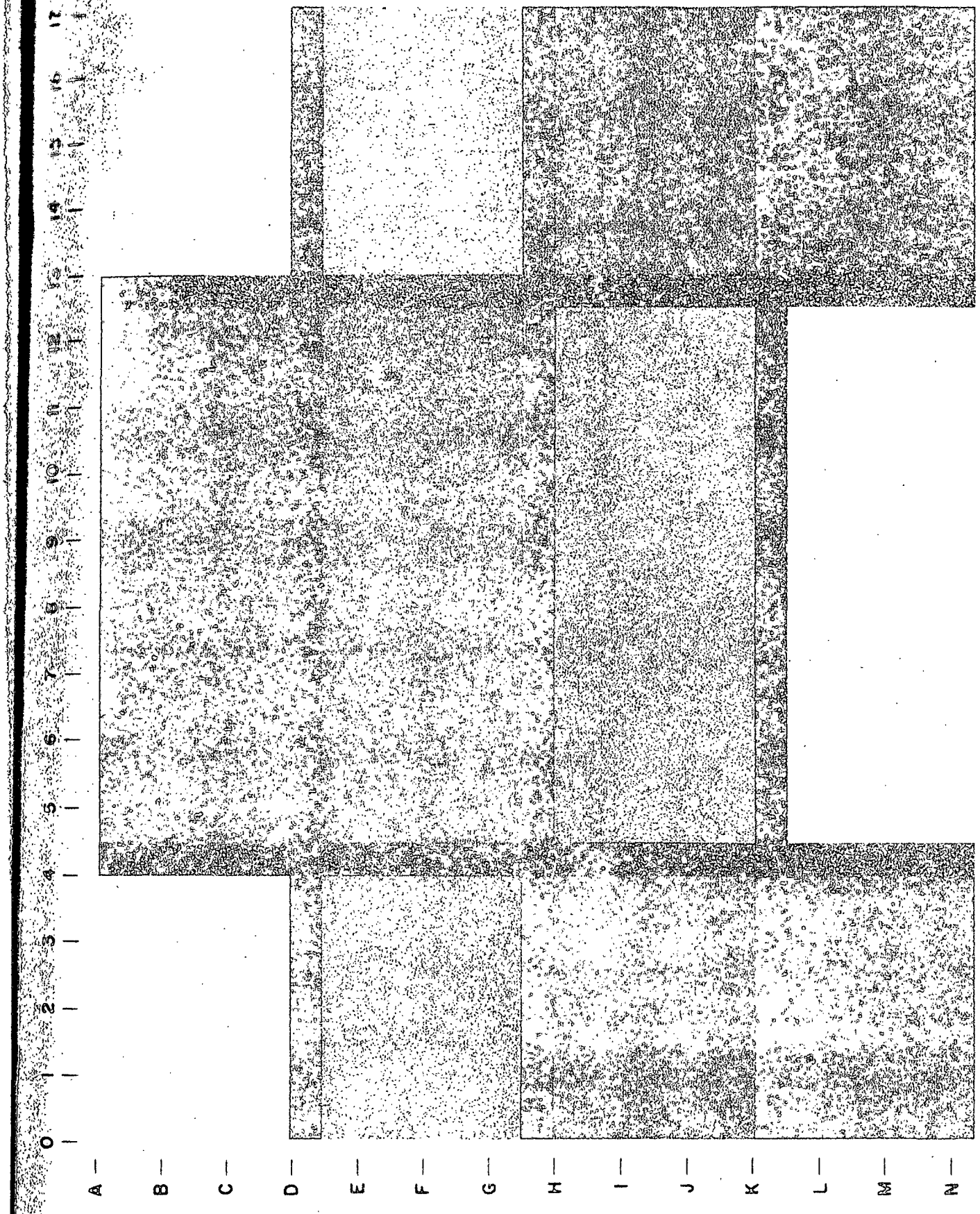
Run 28-C, Paper BR2, Felt Side



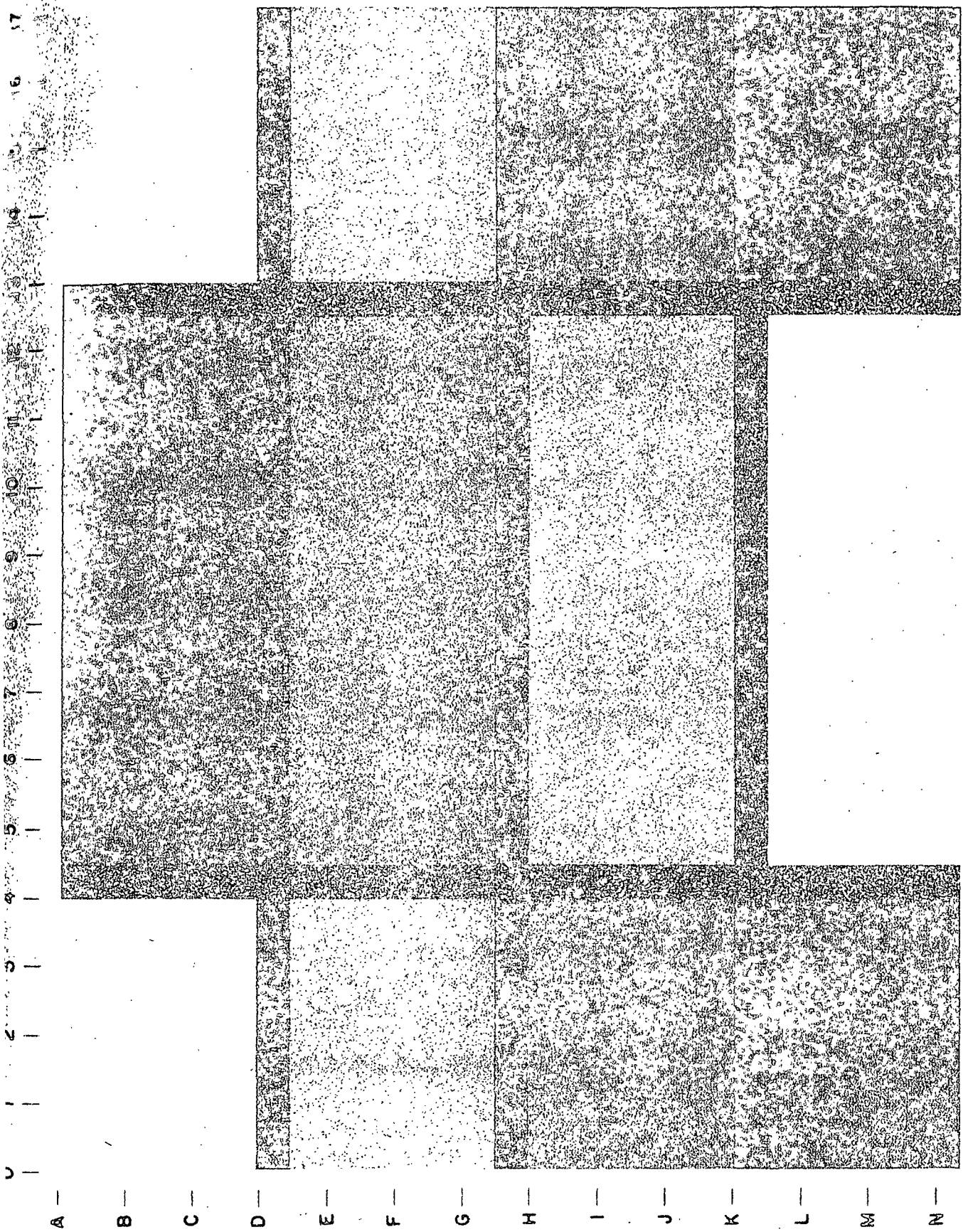
Run 28-E, Paper BR2, Felt Side



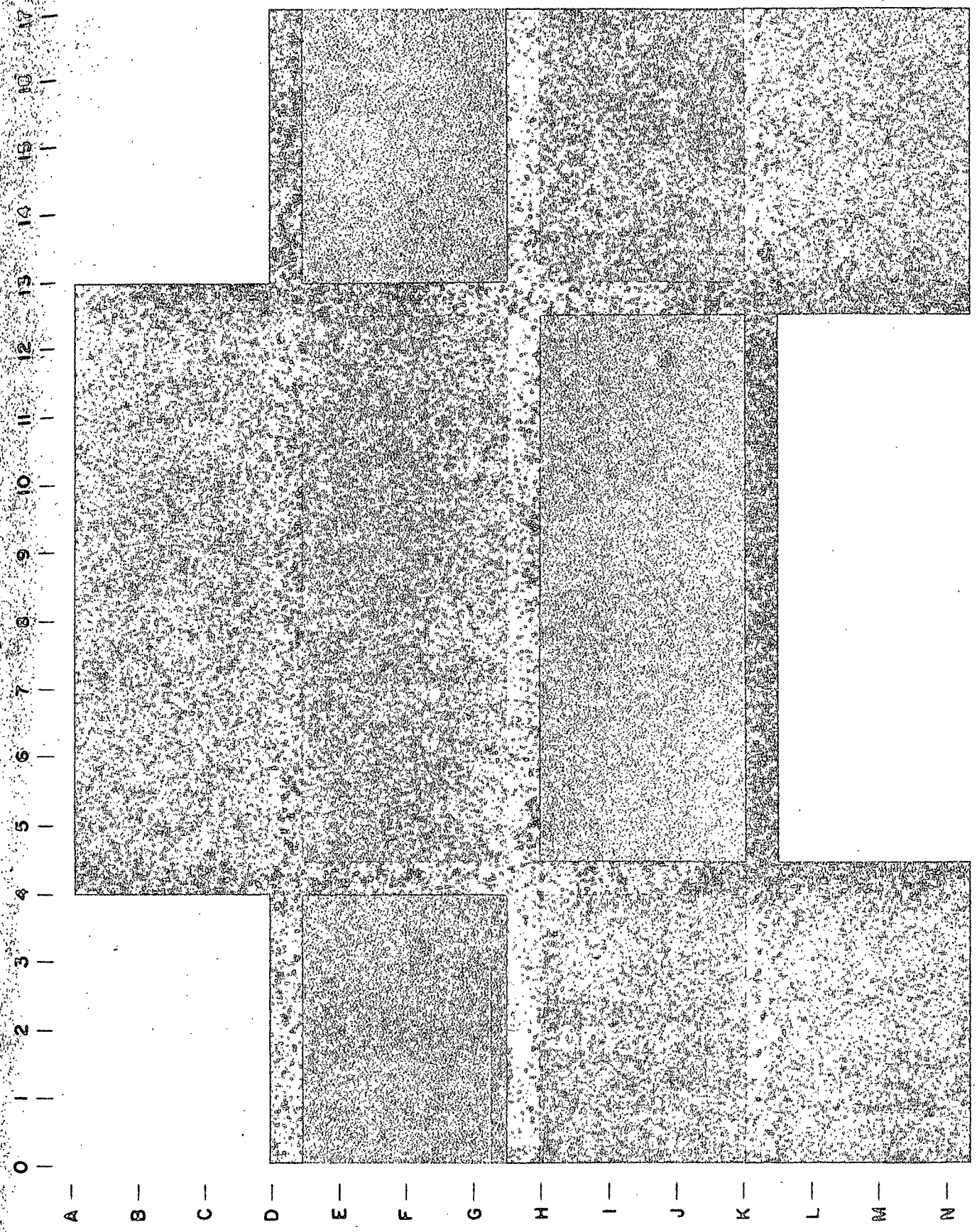
Run 37-S, Paper D04, Wire Side



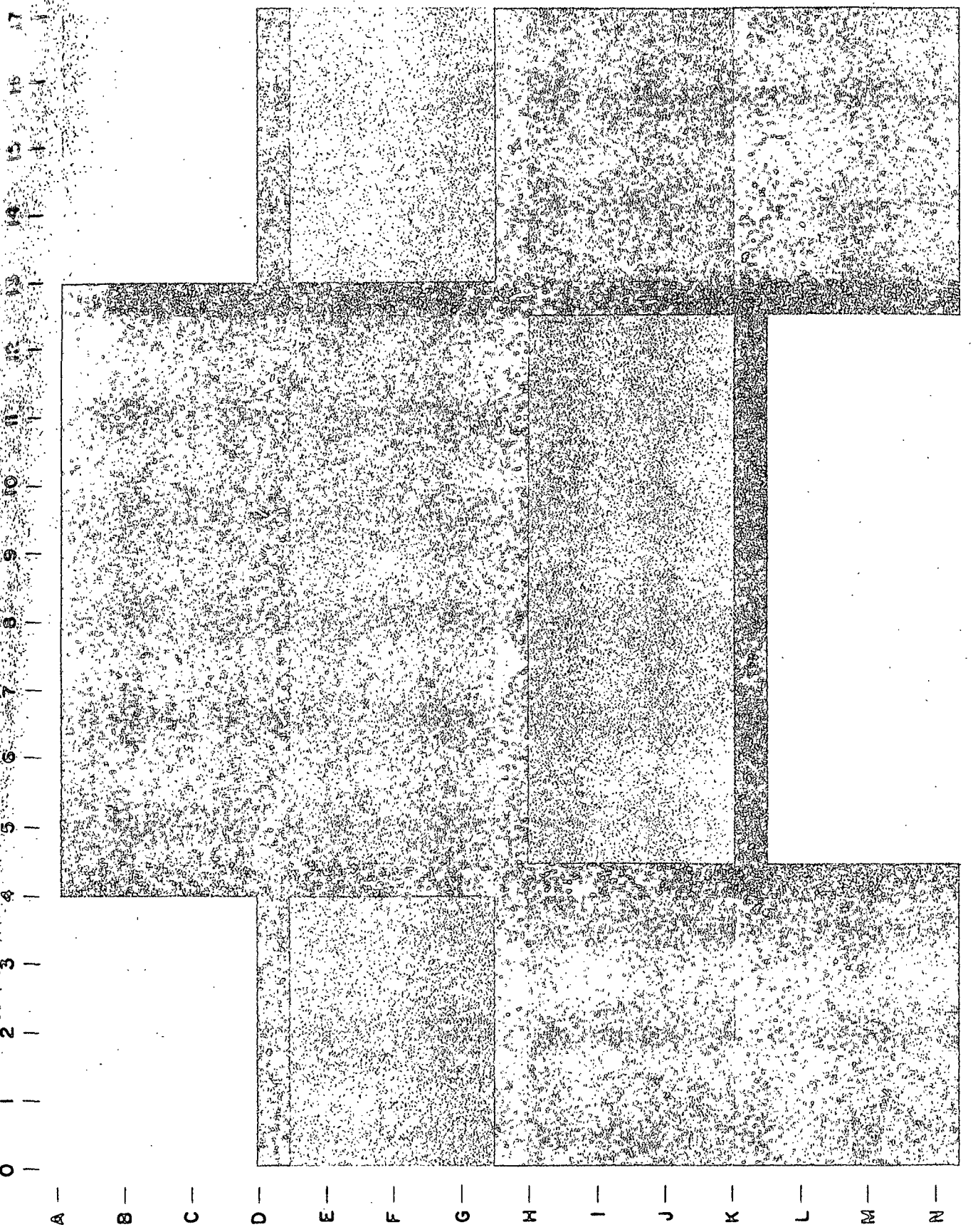
Run 37-C, Paper D04, Wire Side



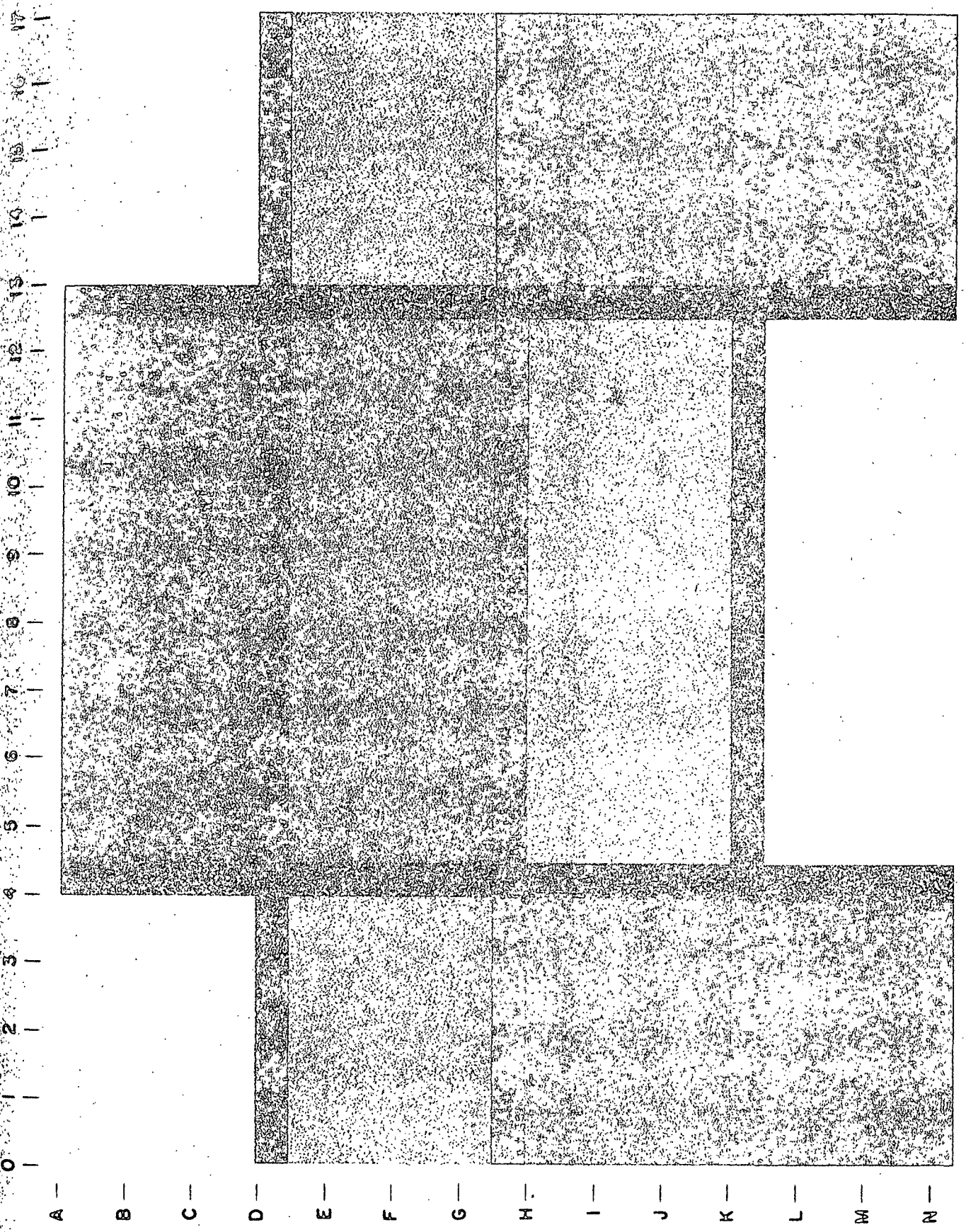
Run 37-E, Paper D04, Wire Side



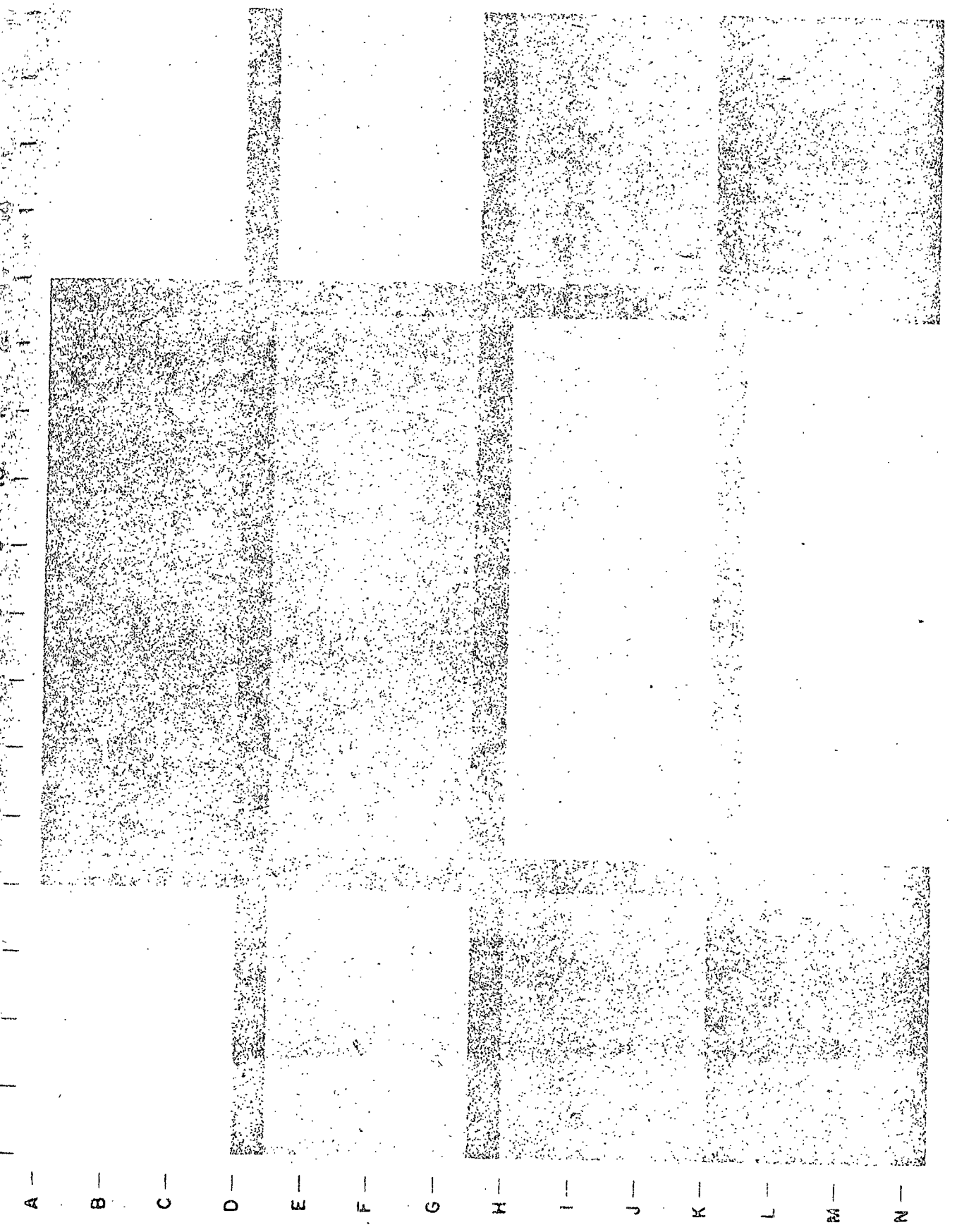
Run 41-S, Paper C01, Felt Side



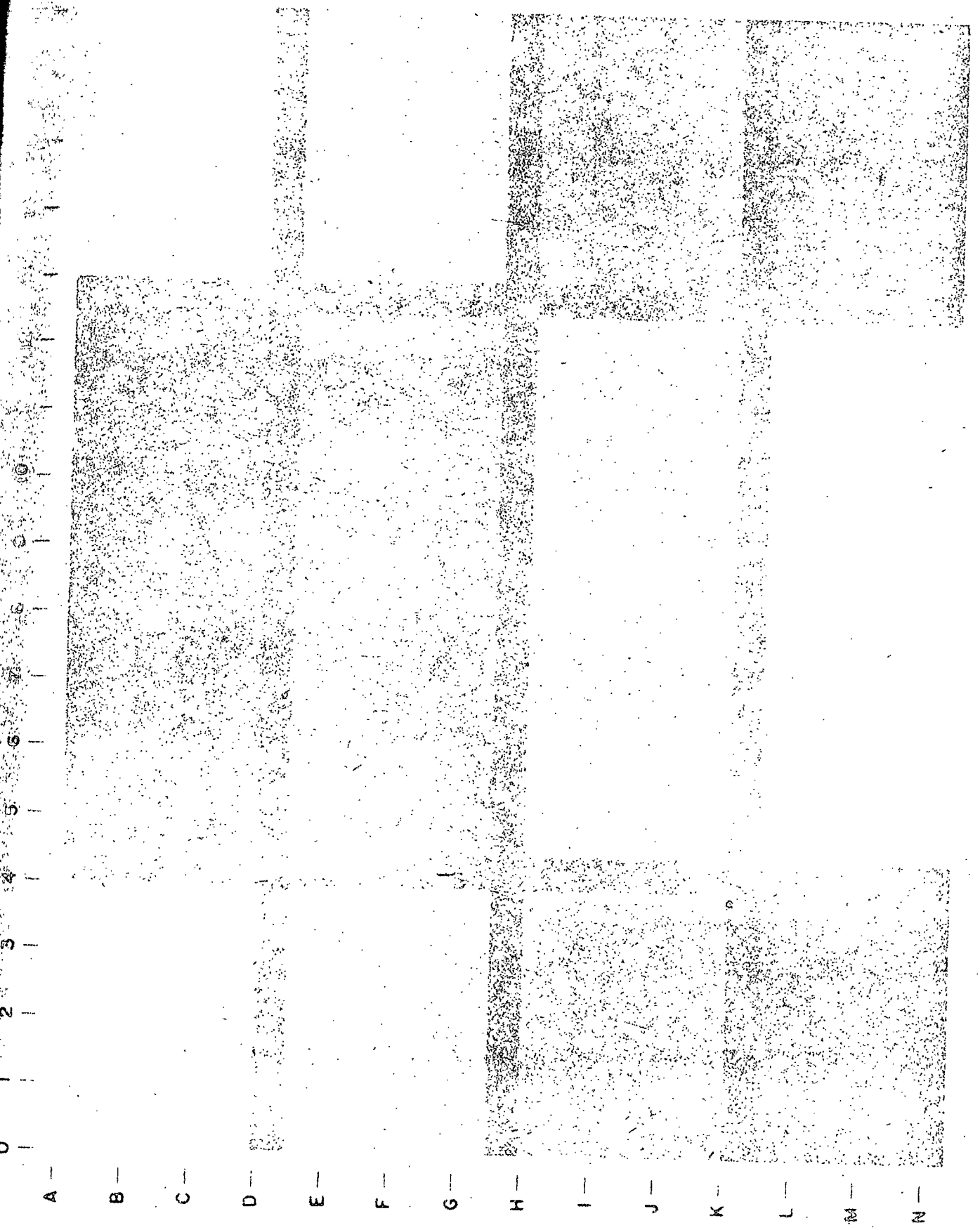
Run 41-C, Paper C01, Felt Side



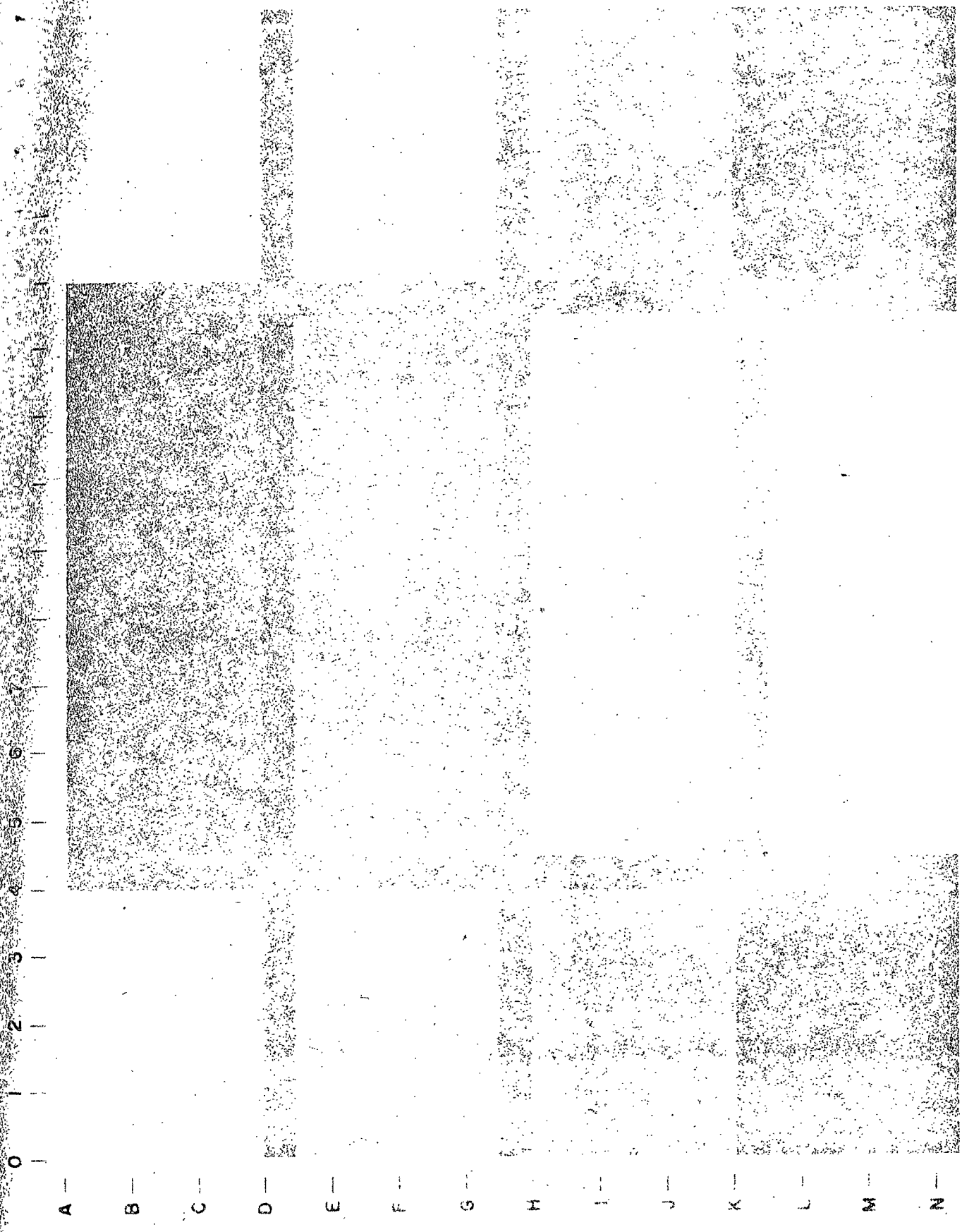
Run 41-E, Paper C01, Felt Side



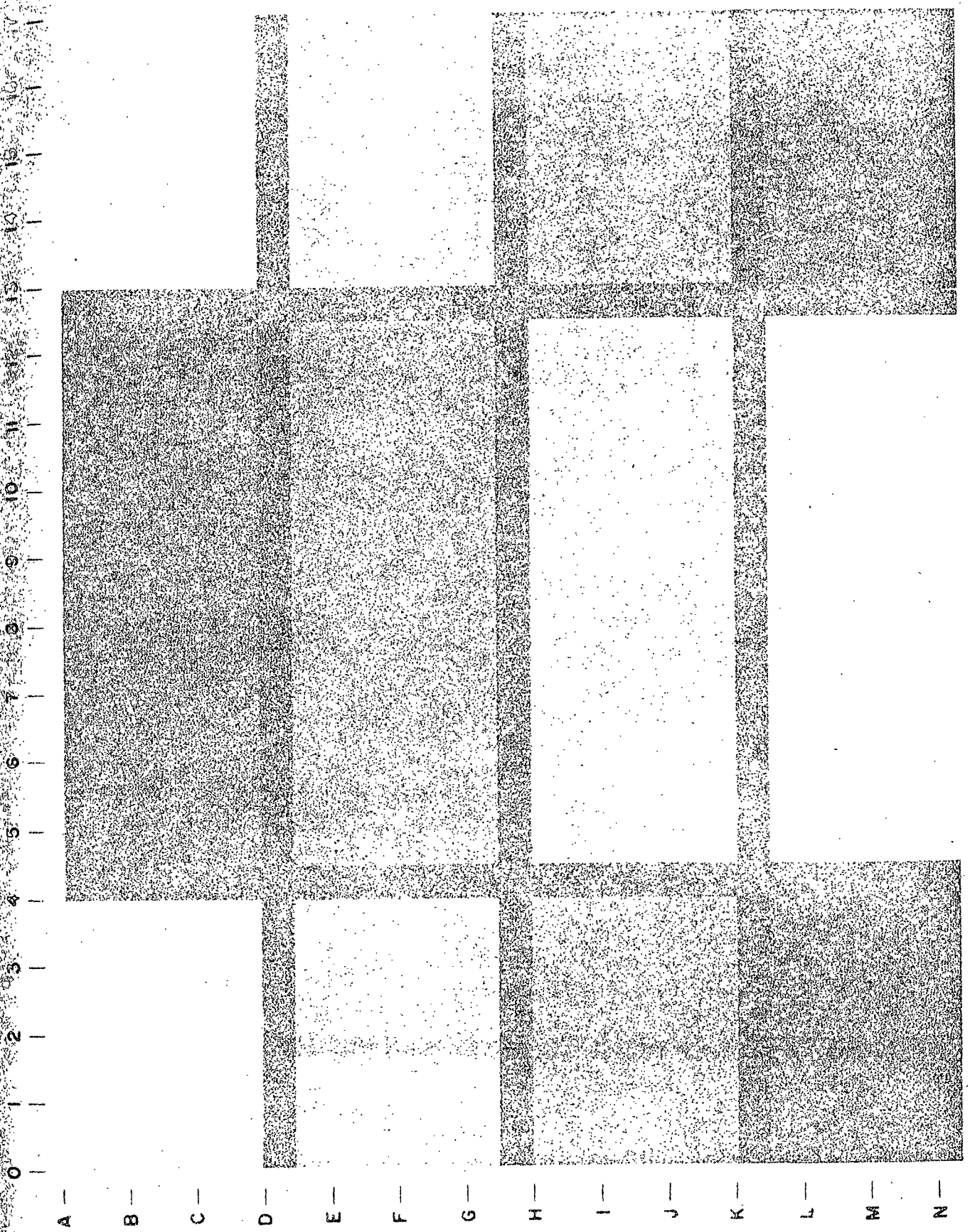
Run 42-S, Paper A02, Wire Side



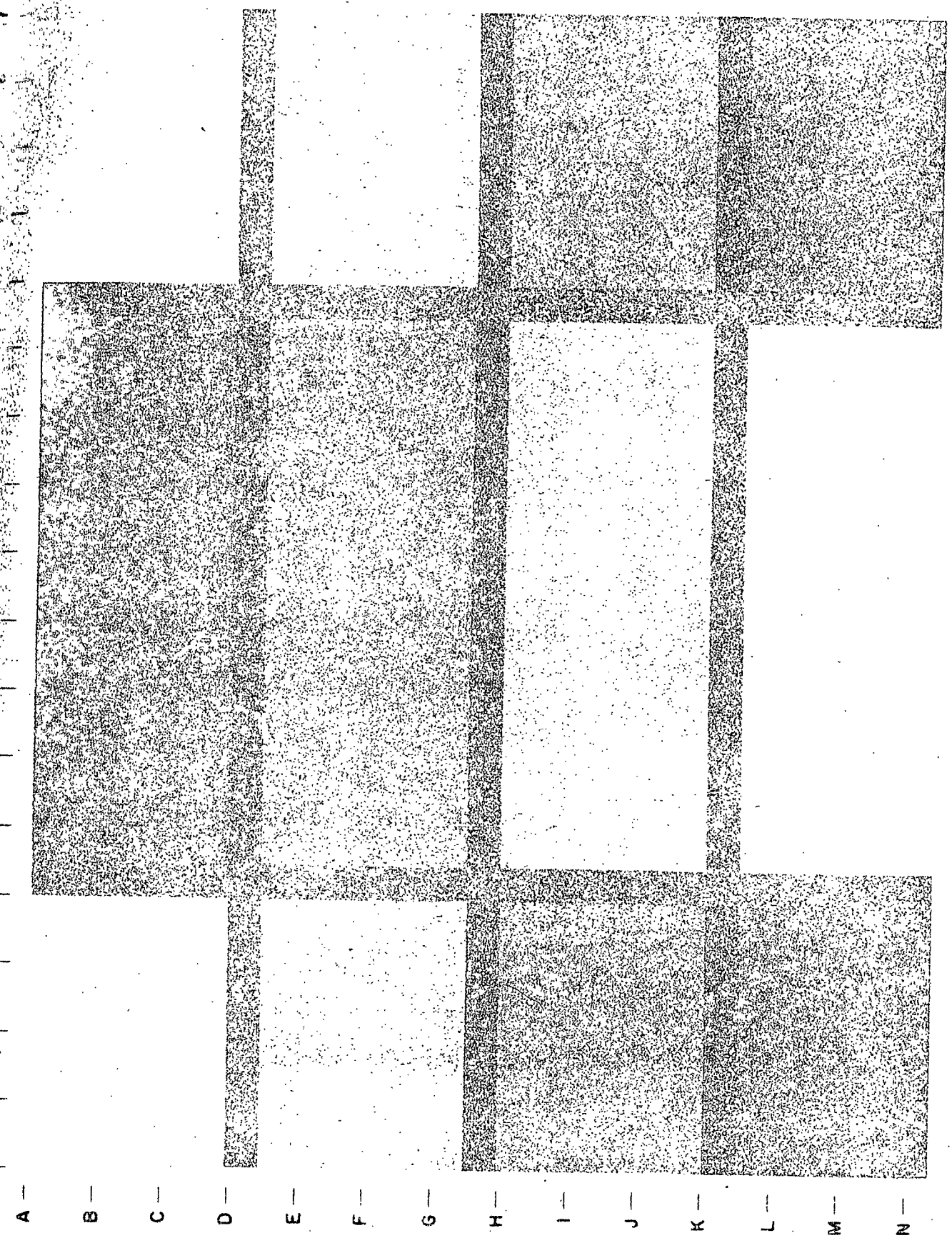
Run 42-C, Paper A02, Wire Side



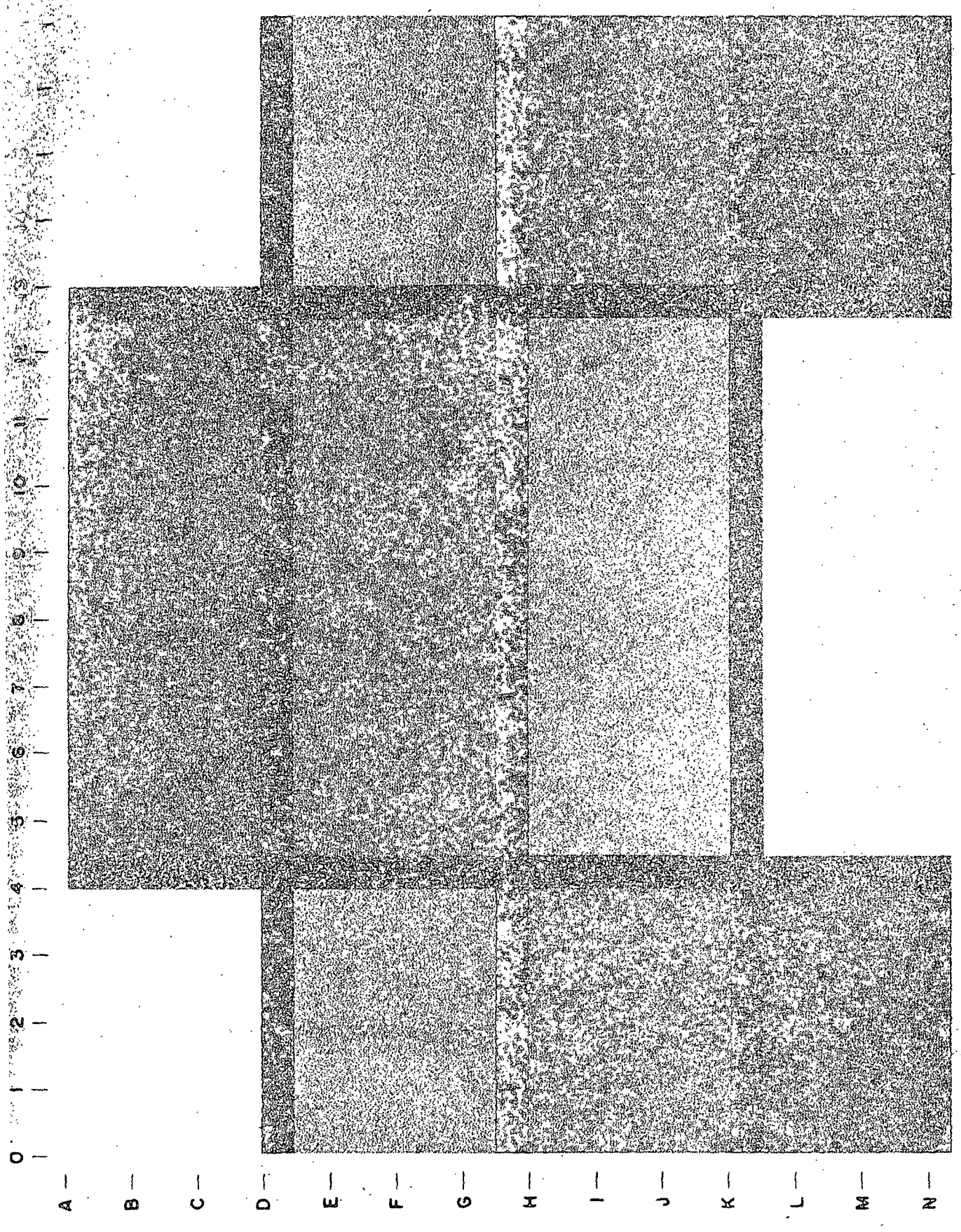
Run 42-E, Paper A02, Wire Side



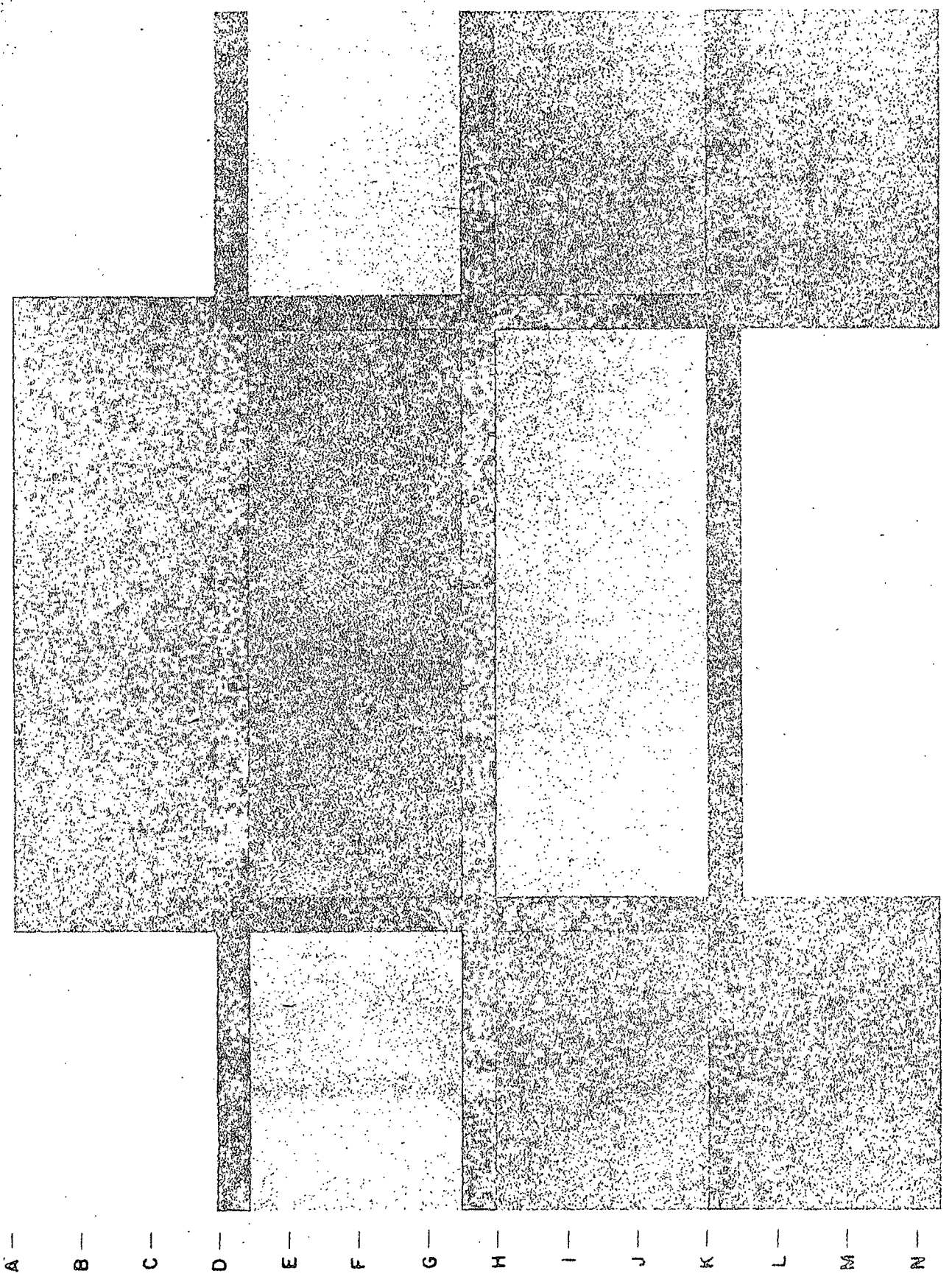
Run 43-S, Paper BR2, Wire Side



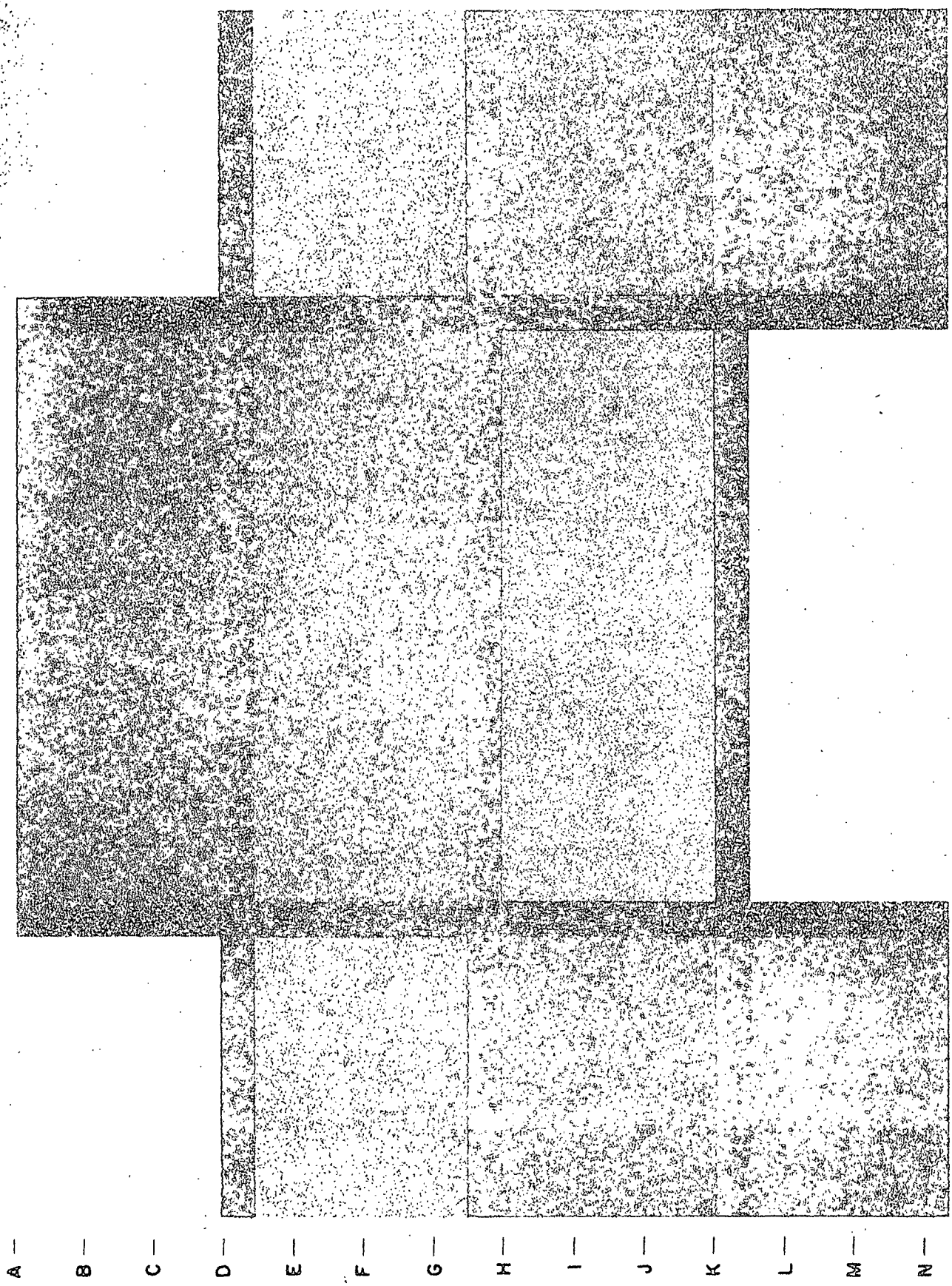
Run 43-C, Paper BR2, Wire Side



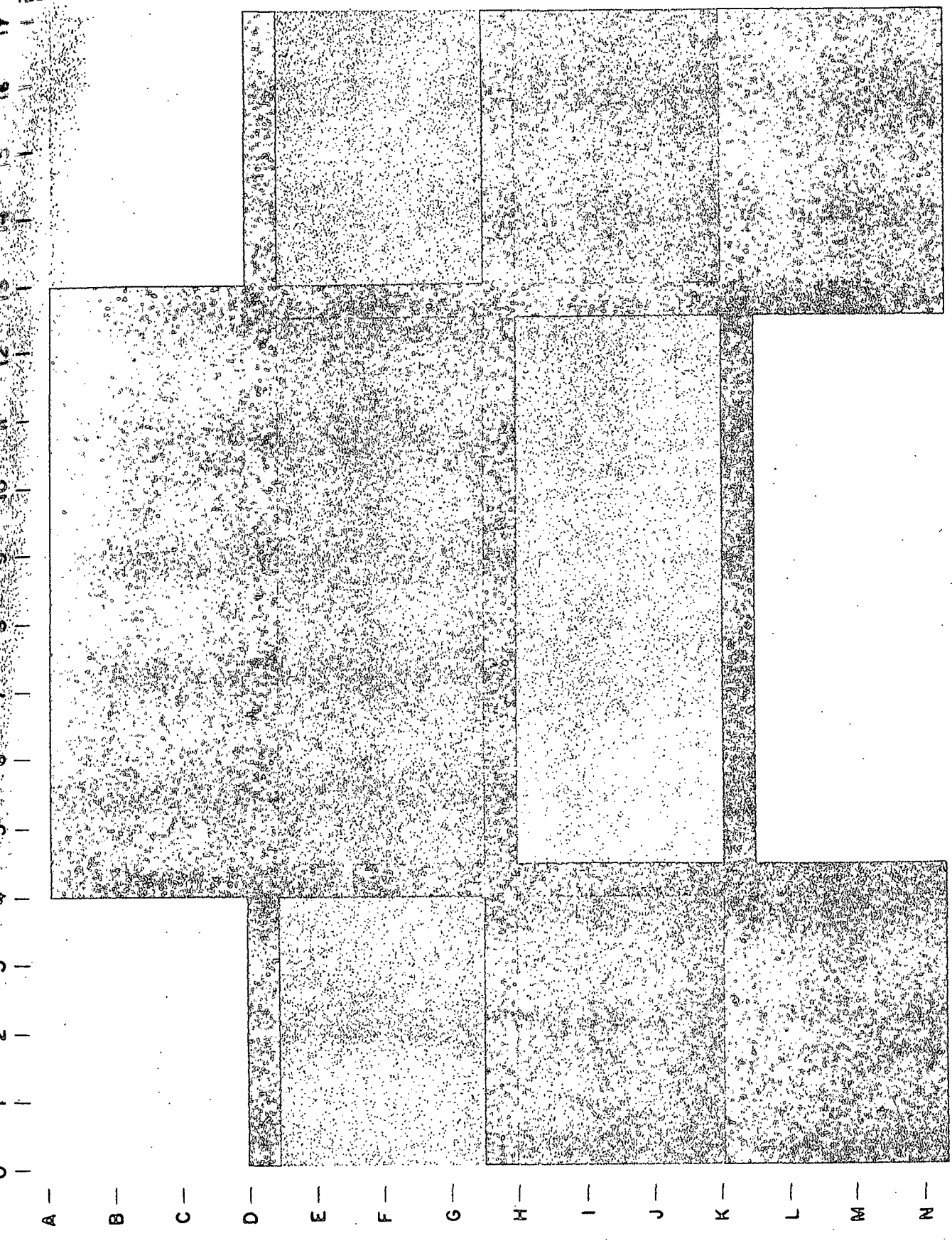
Run 43-E, Paper BR2, Wire Side



Run 47-S, Paper D01, Felt Side

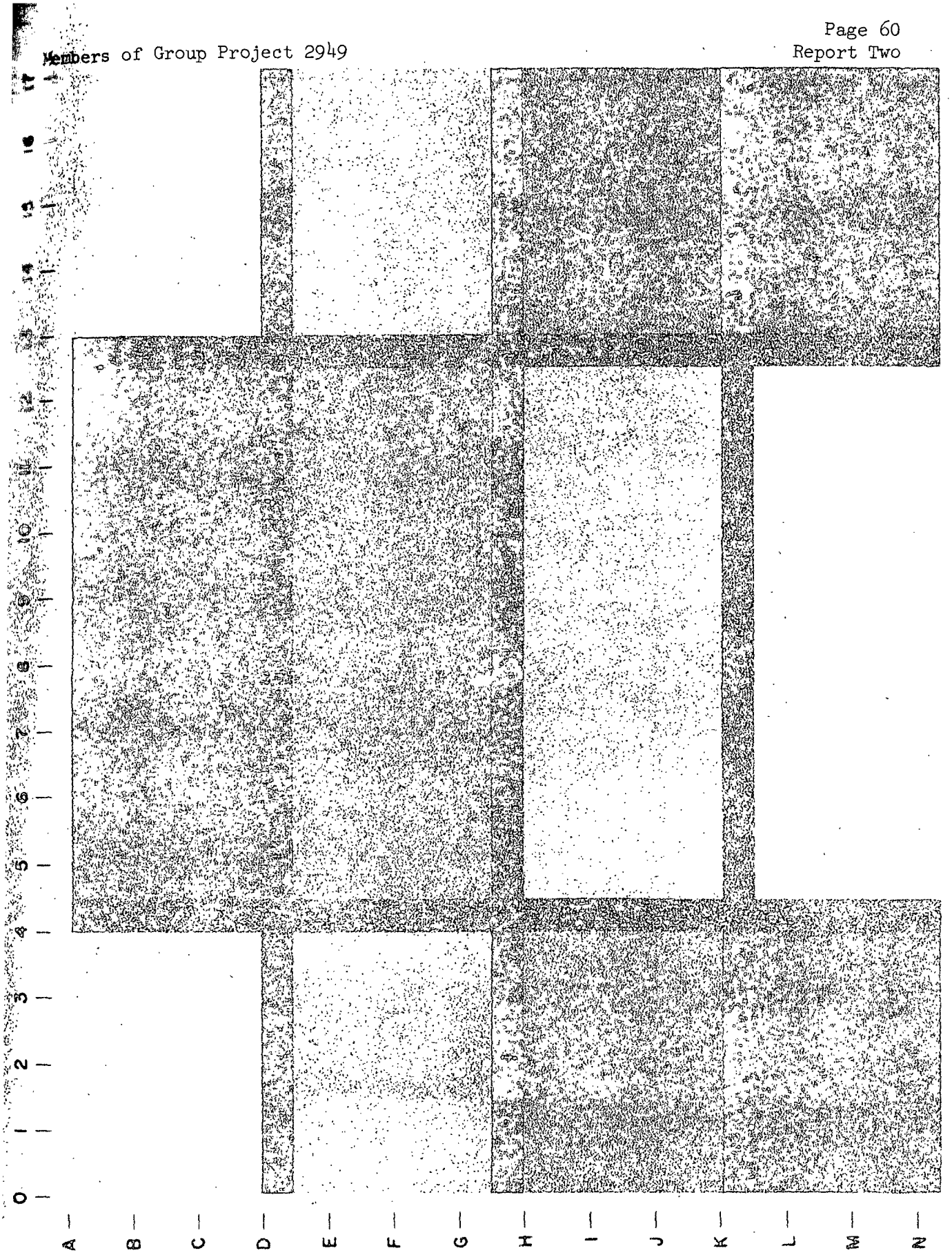


Run 47-C, Paper D01, Felt Side

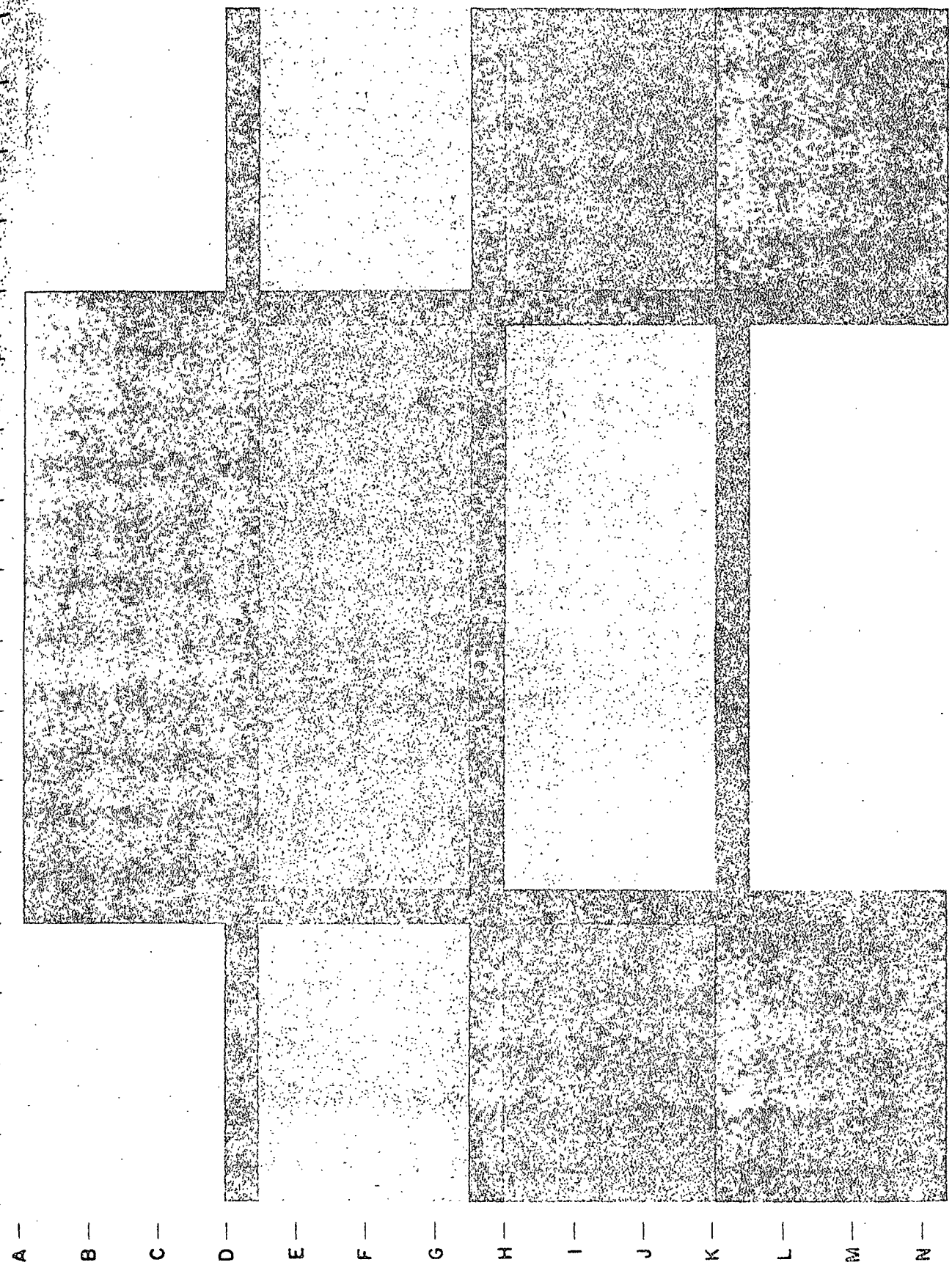


Run 59-S, Paper FR5, Wire Side

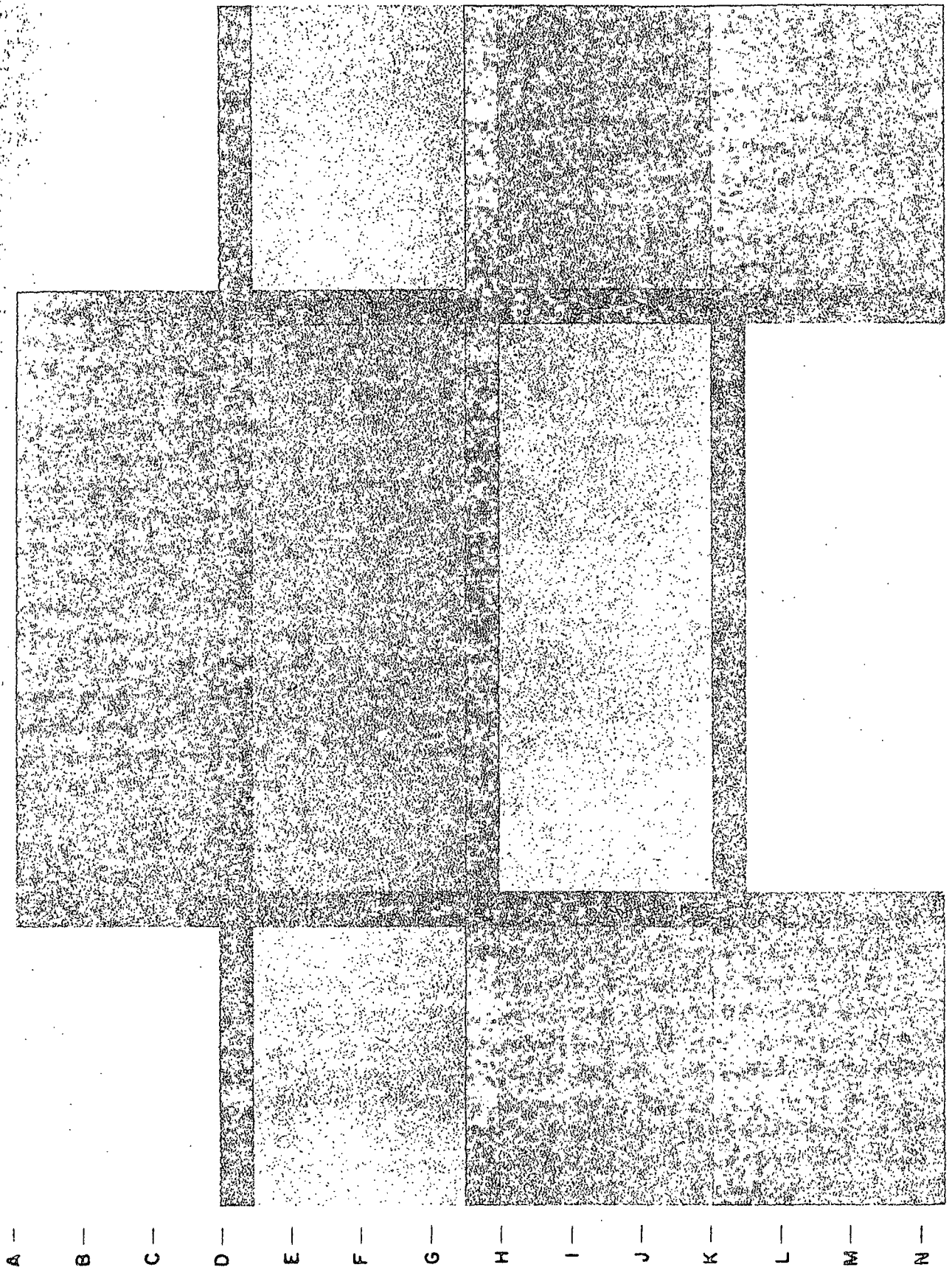
Run 49-C, Paper FR5, Wire Side



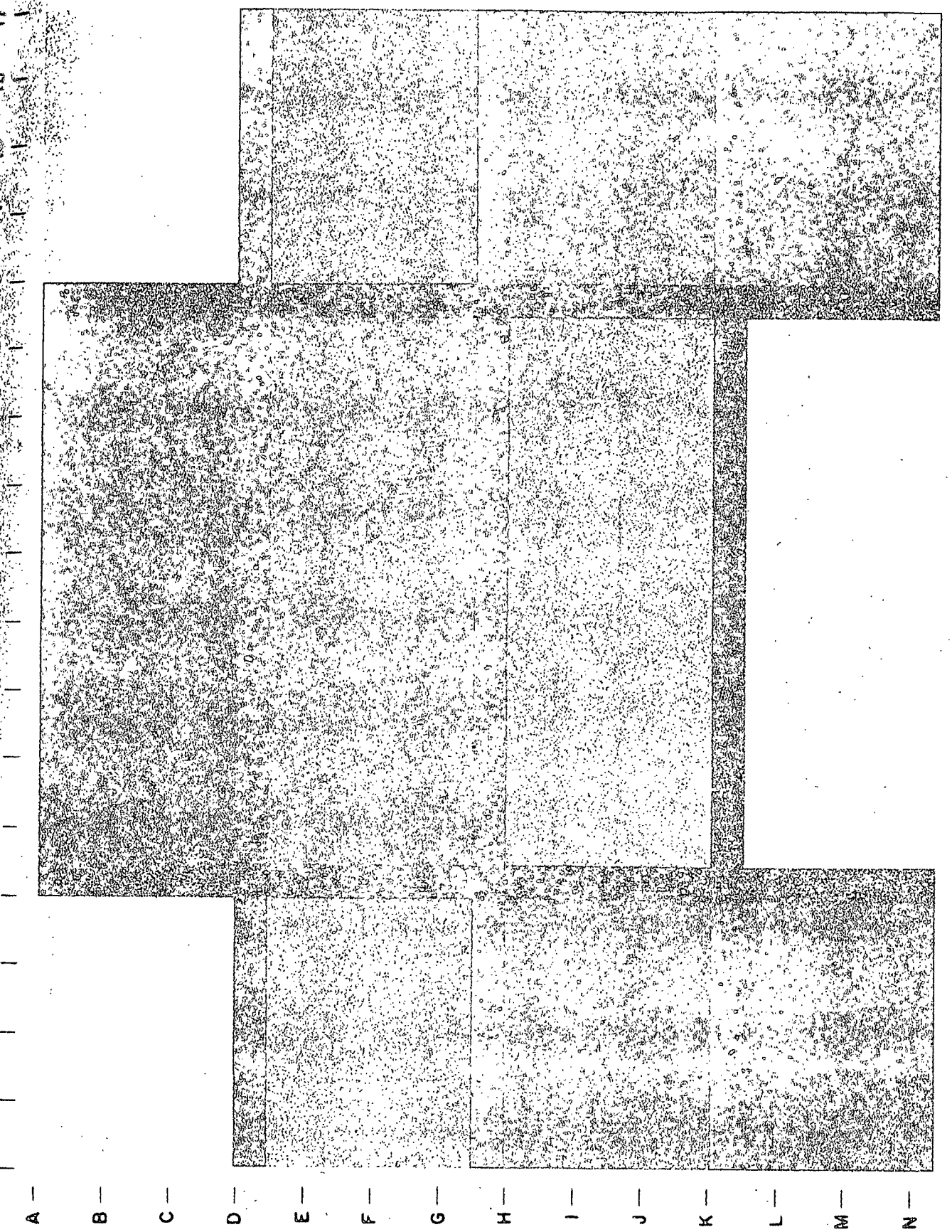
Run 49-E, Paper FR5, Wire Side



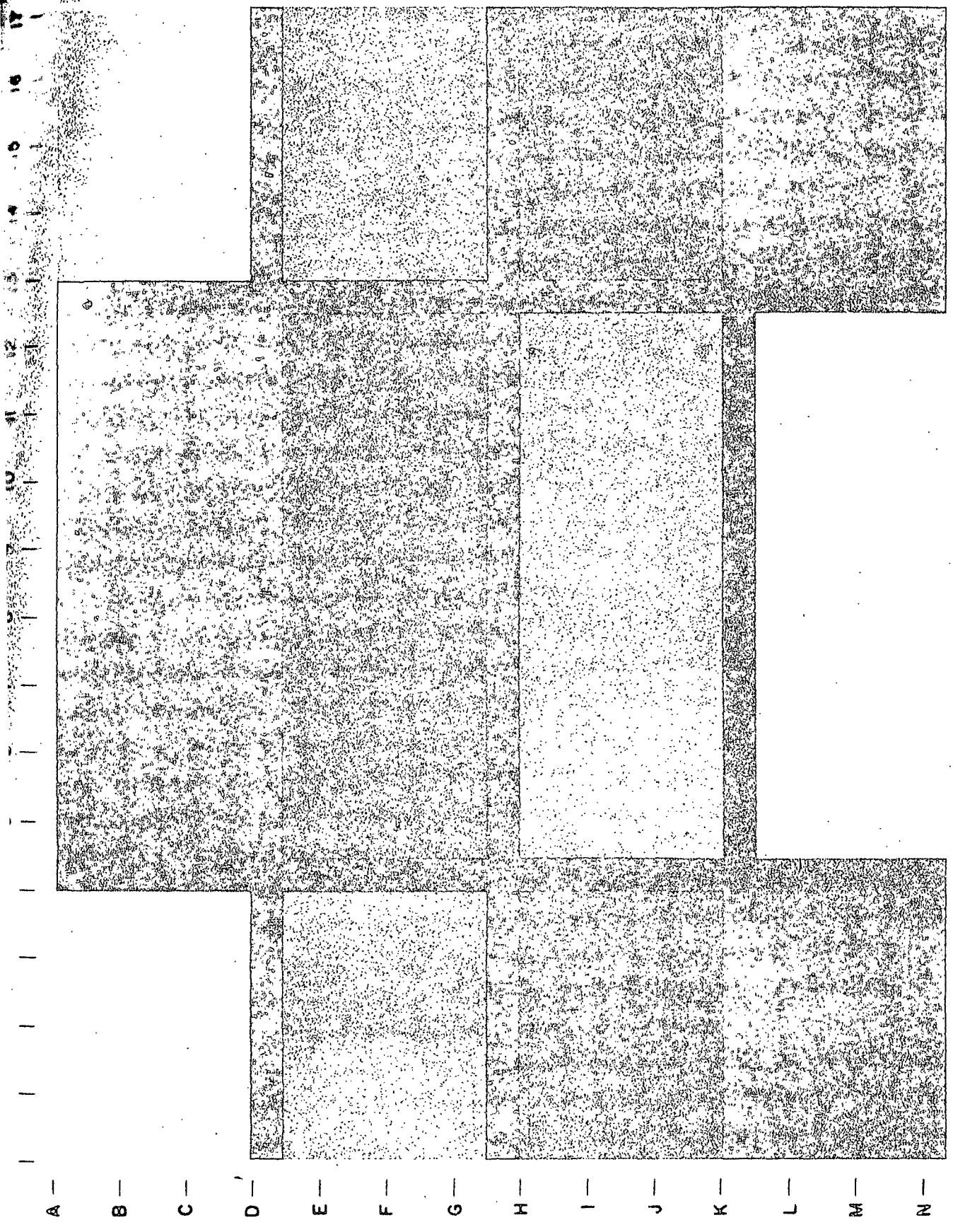
Run 50-S, Paper FR5, Felt Side



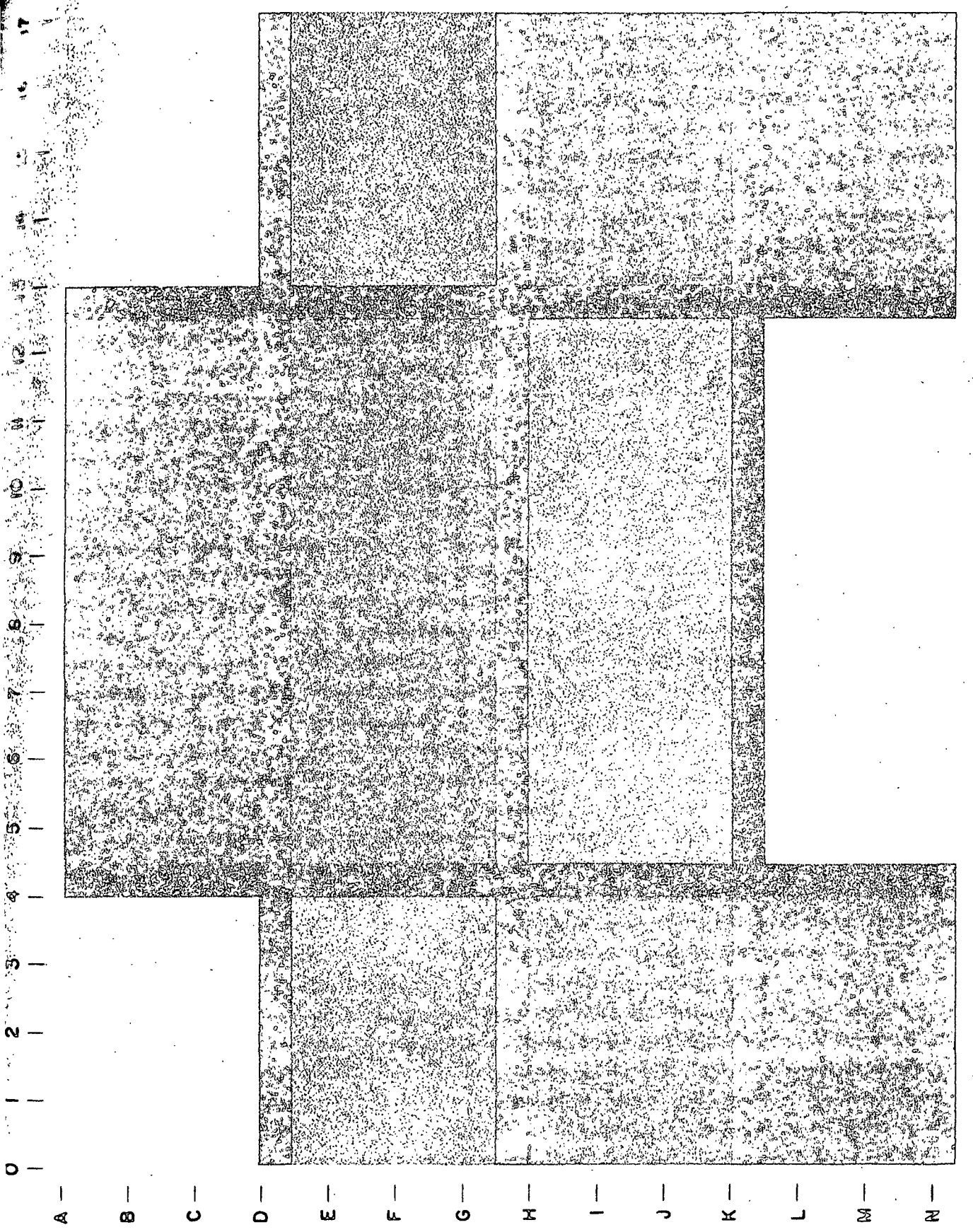
Run 50-C, Paper FR5, Felt Side



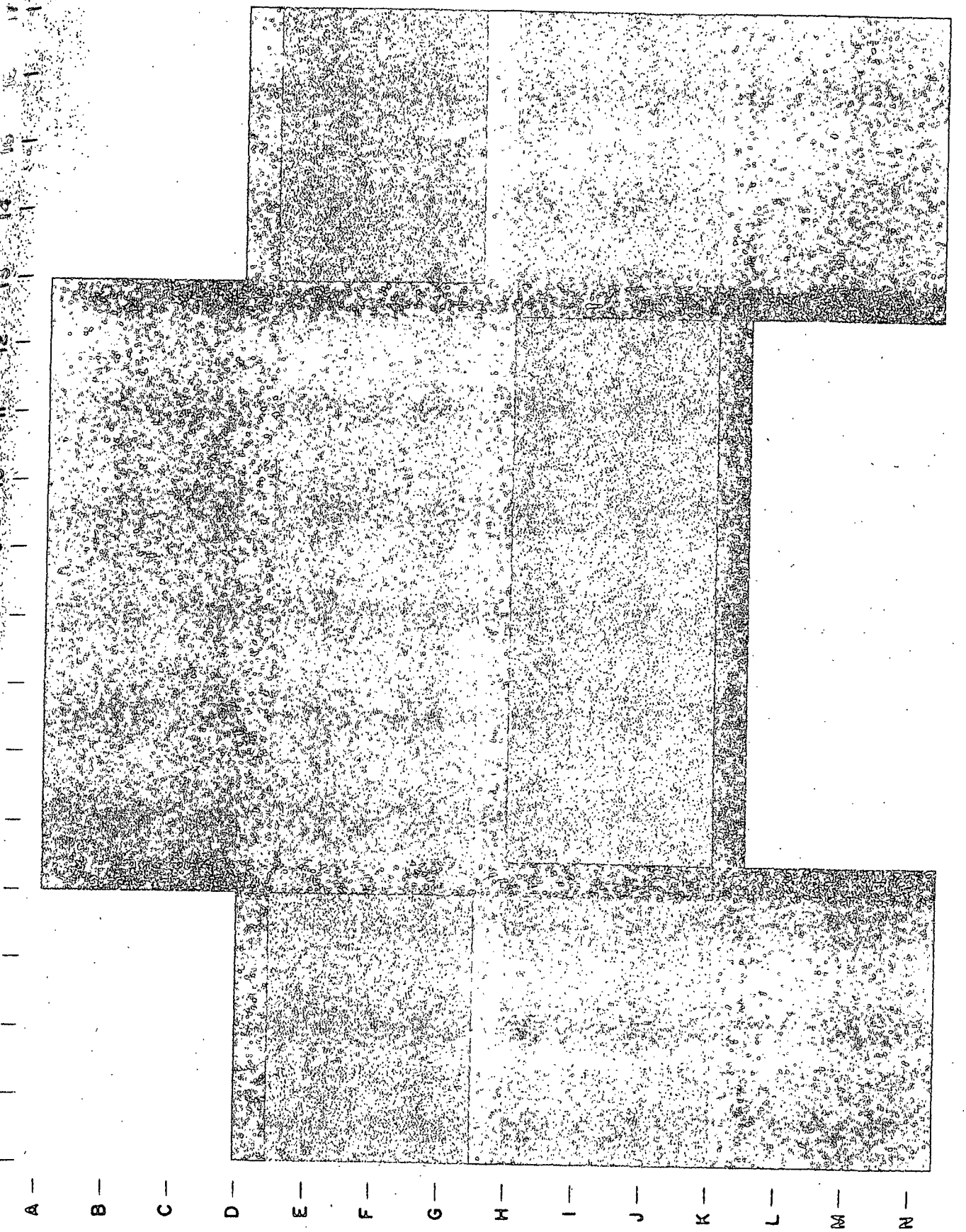
Run 50-E, Paper FR5, Felt Side



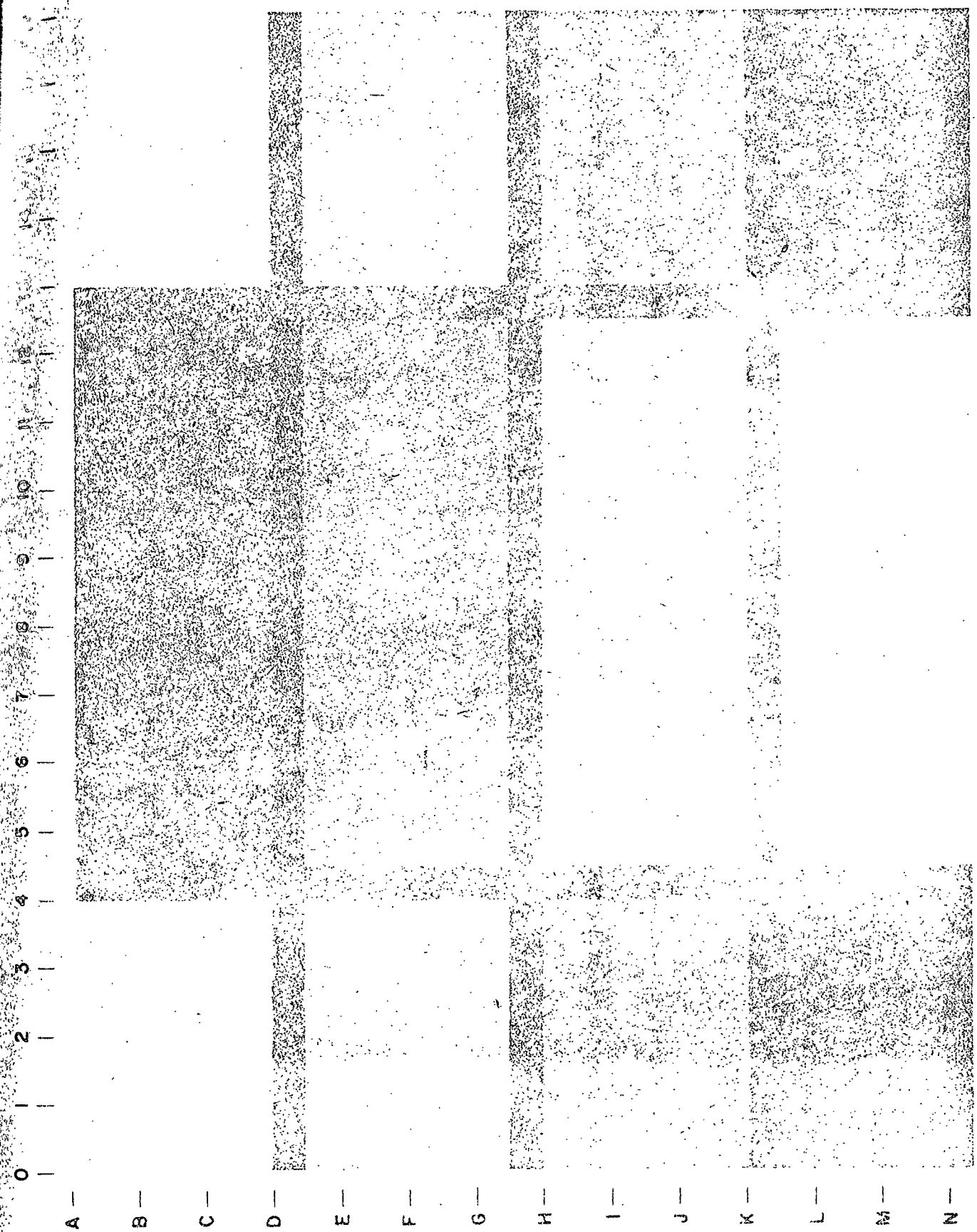
Run 53-S, Paper CO2, Wire Side



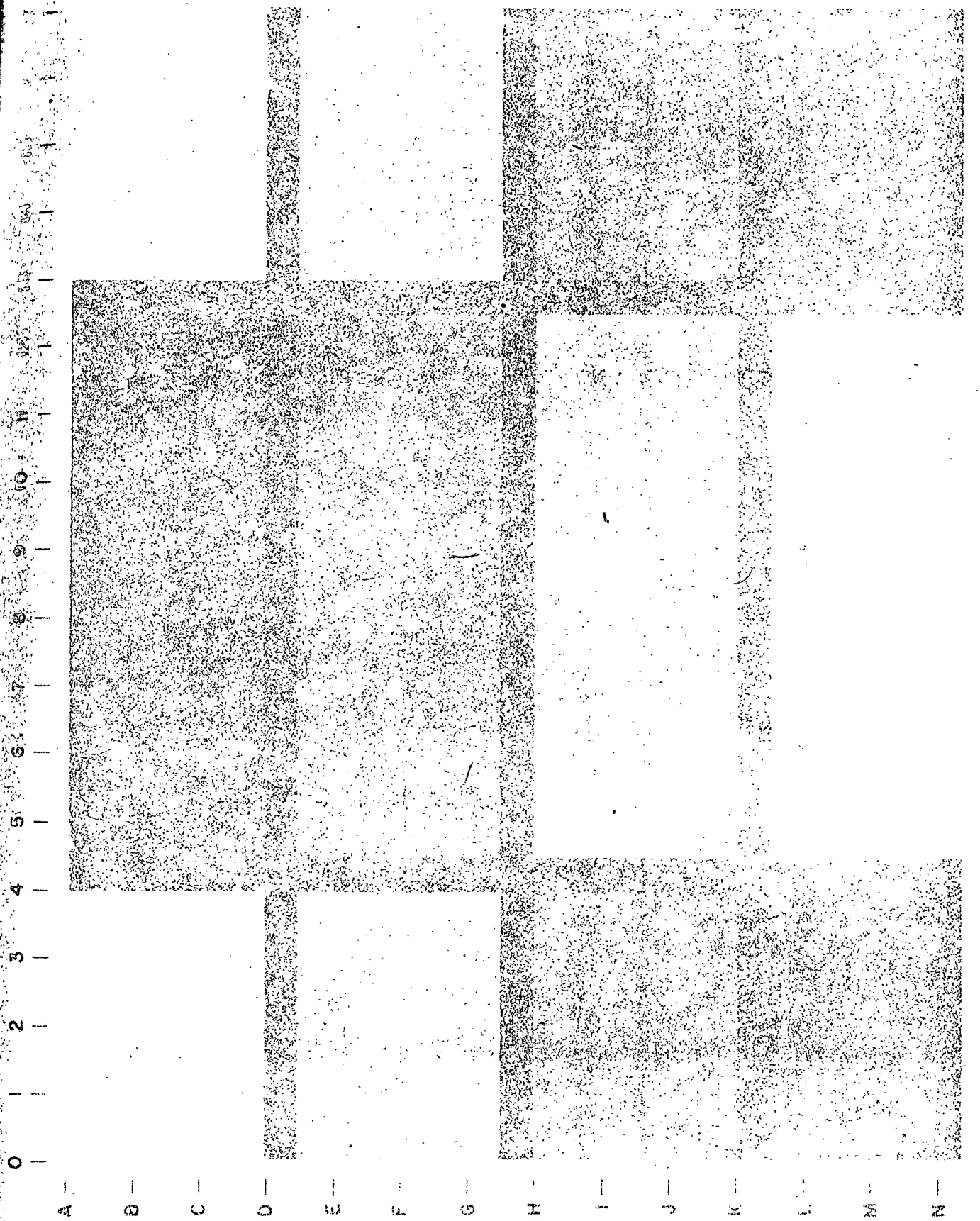
Run 53-C, Paper CO2, Wire Side



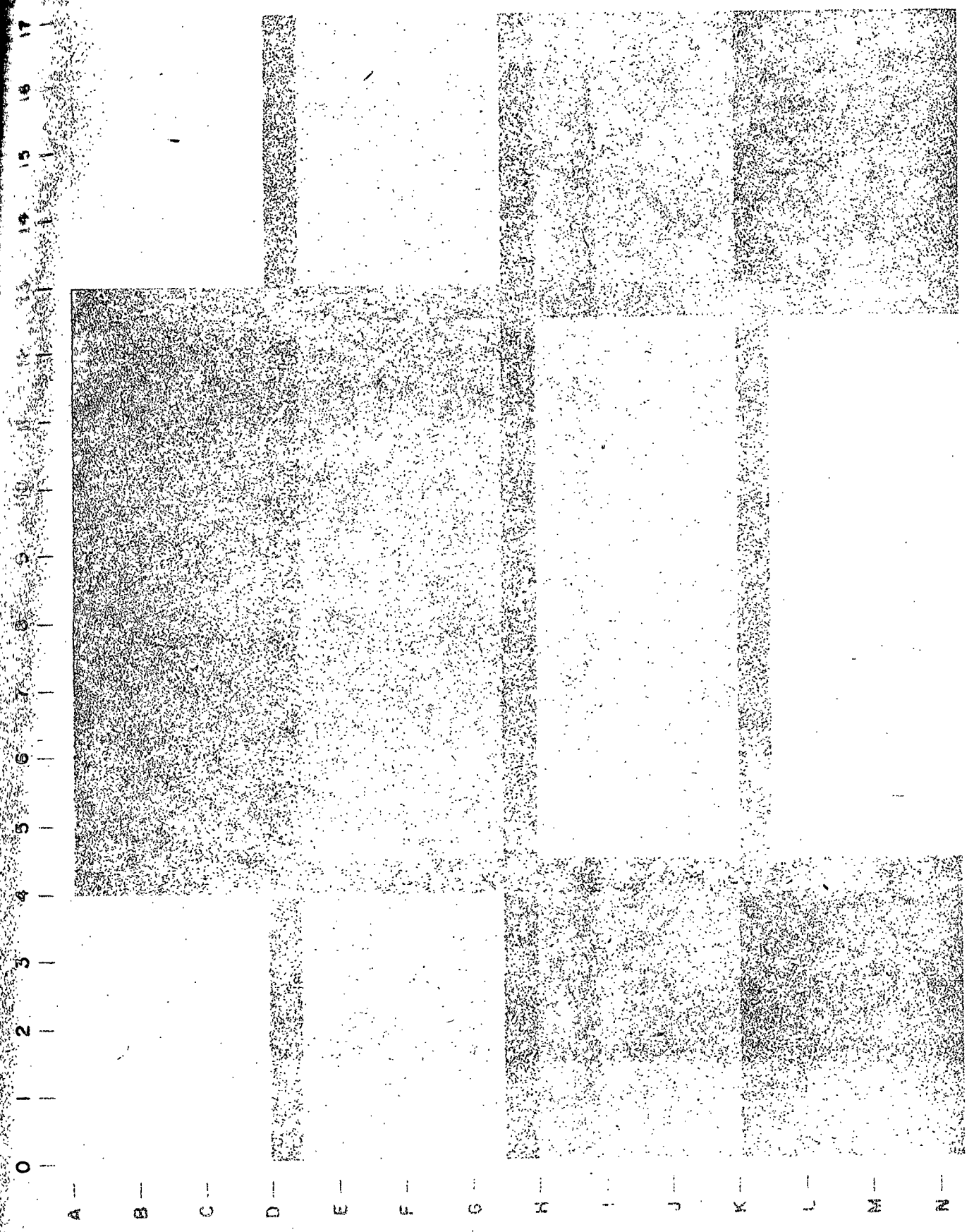
Run 53-E, Paper CO2, Wire Side



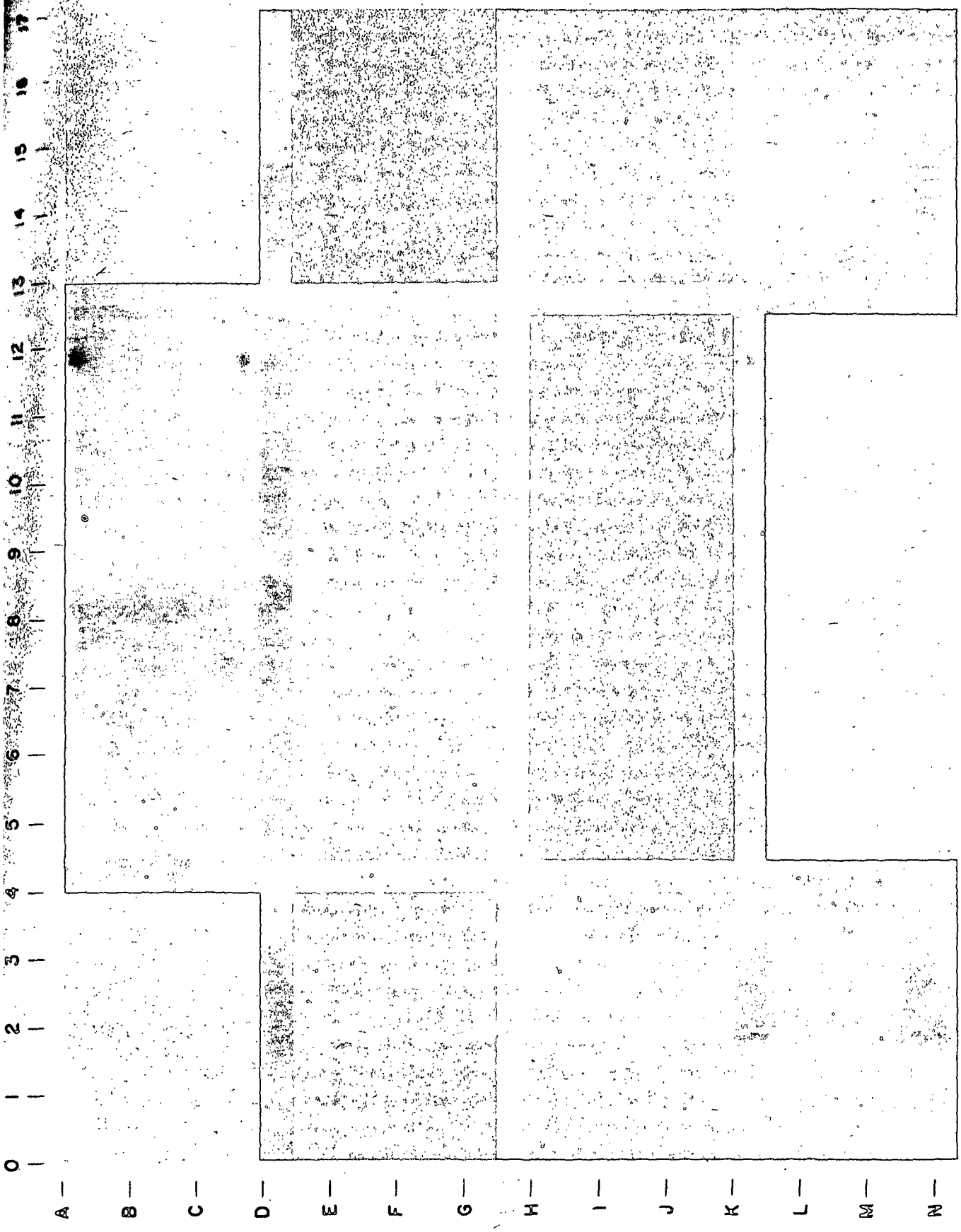
Run 57-S, Paper A01, Felt Side



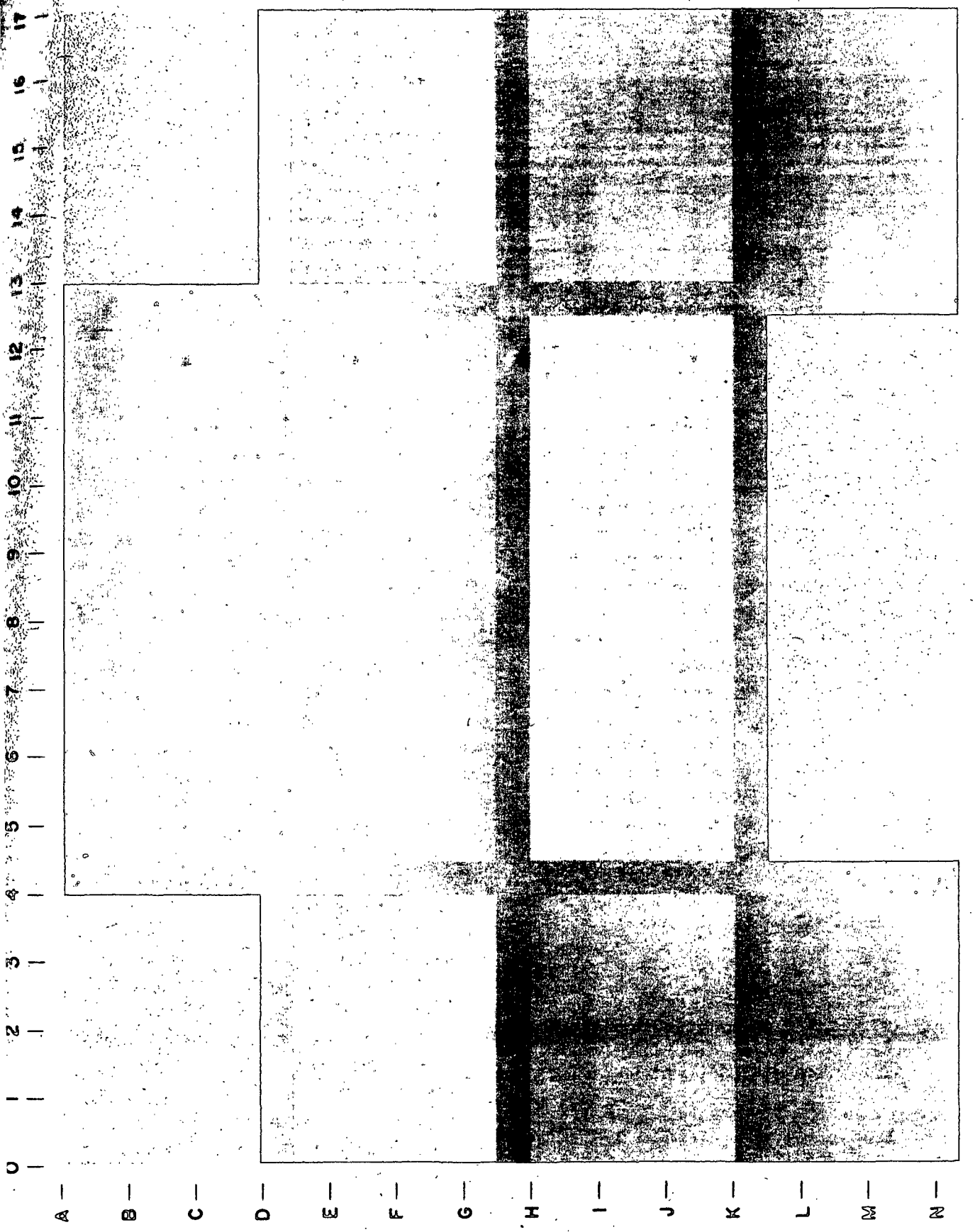
Run 57-C, Paper A01, Felt Side



Run 57-E, Paper A01, Felt Side

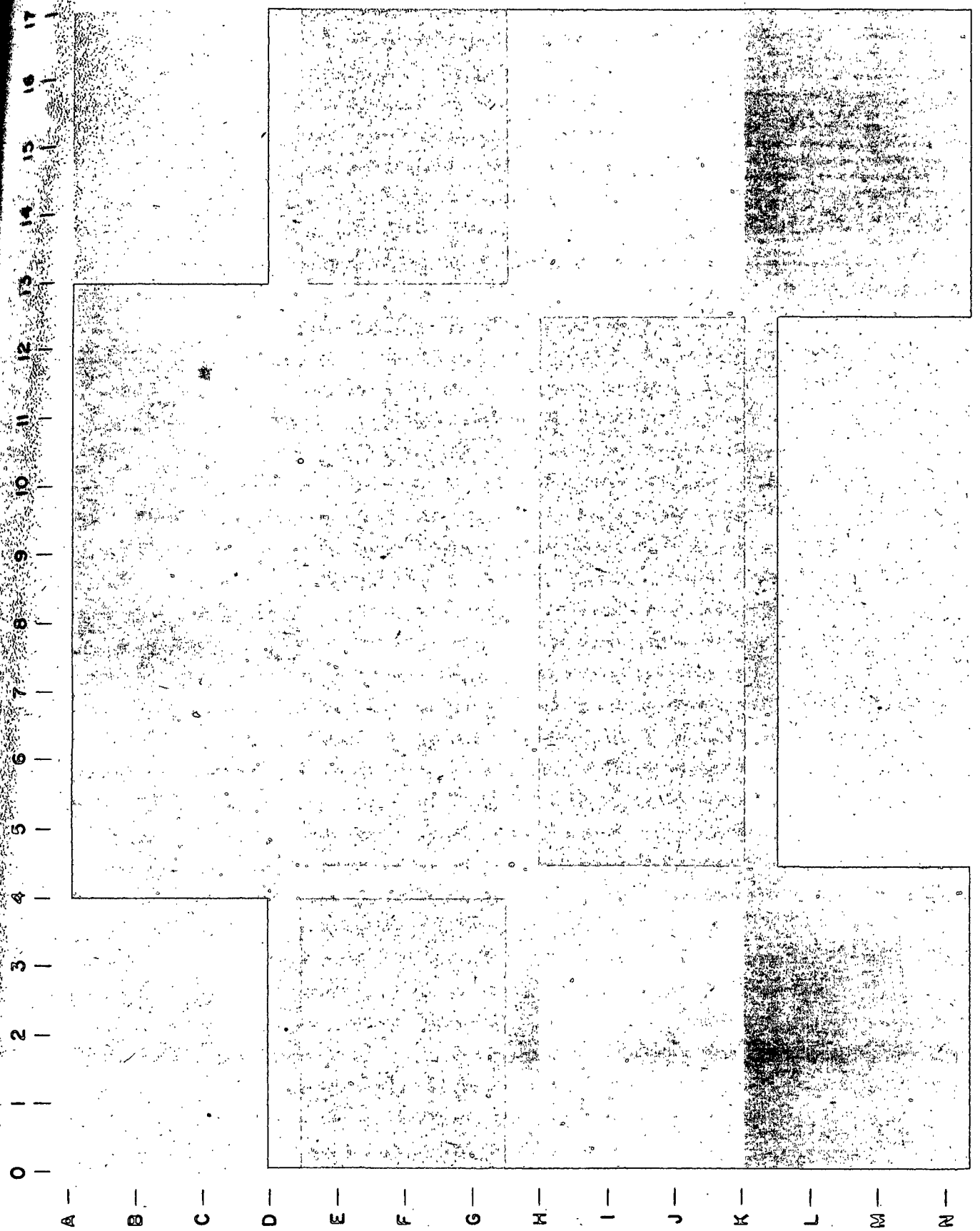


Run 67-S, Paper HC2, Wire Side

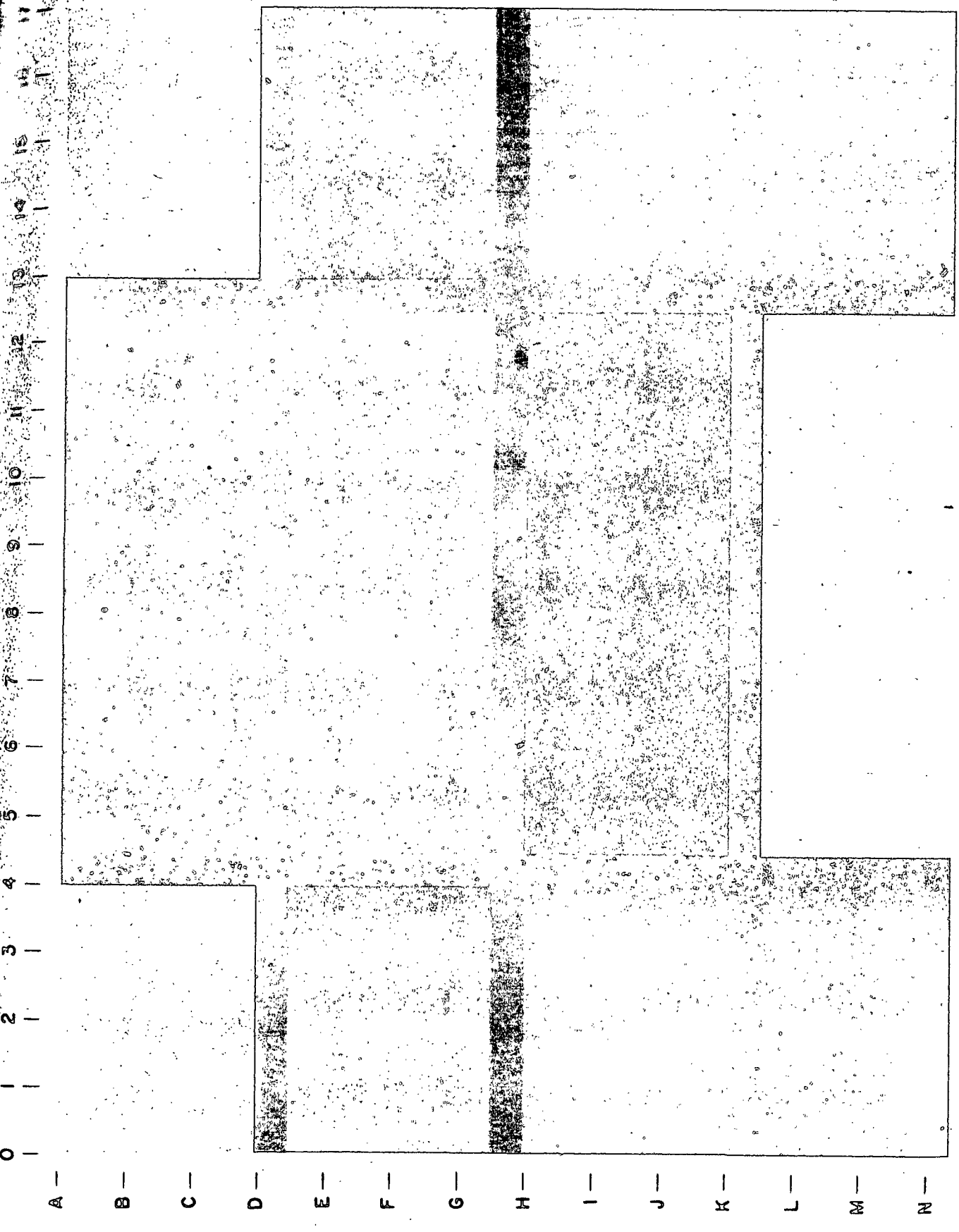


Run 67-C, Paper HC2, Wire Side

Run 67-E, Paper HC2, Wire Side

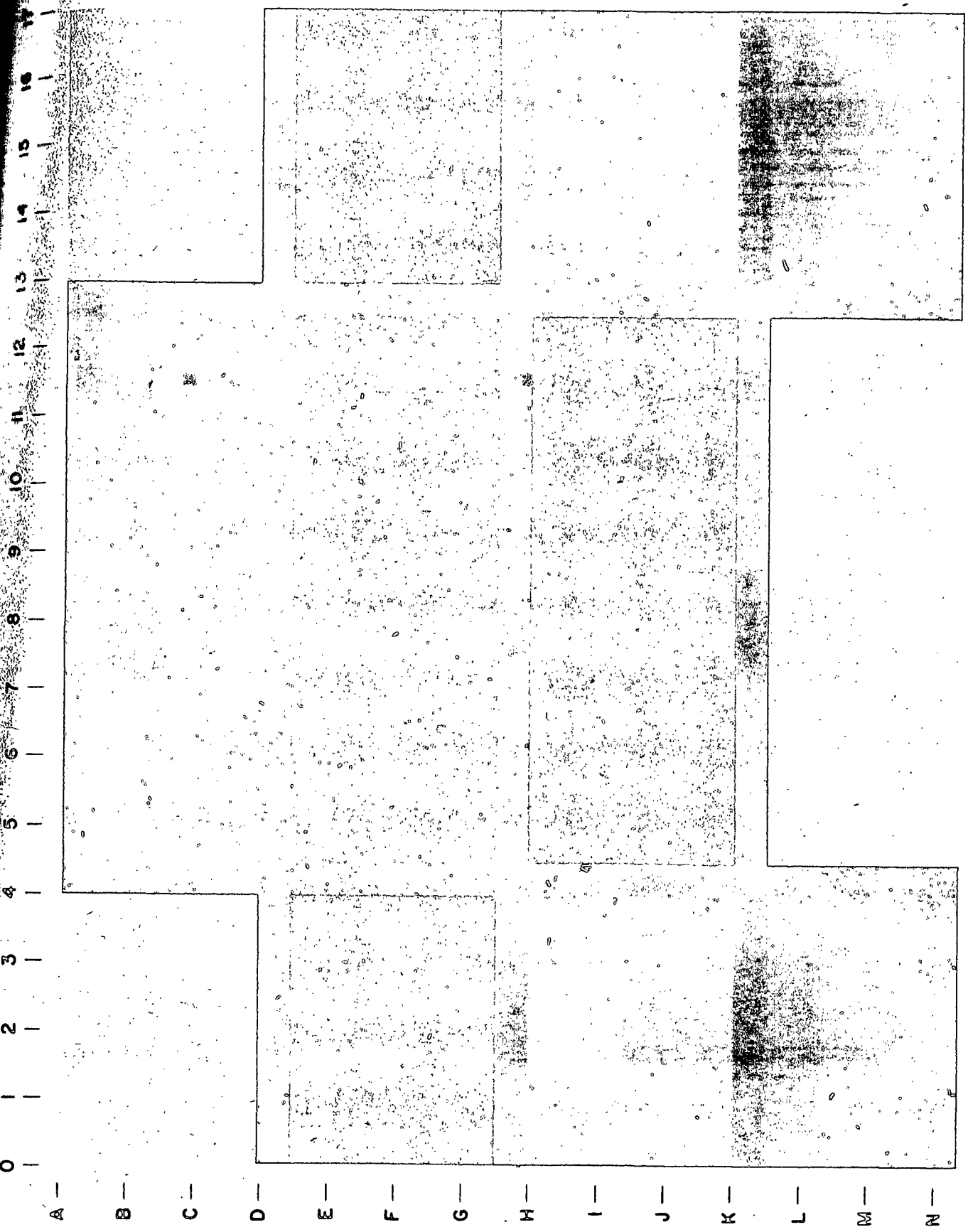


Run 68-S, Paper IT1, Bottom Side

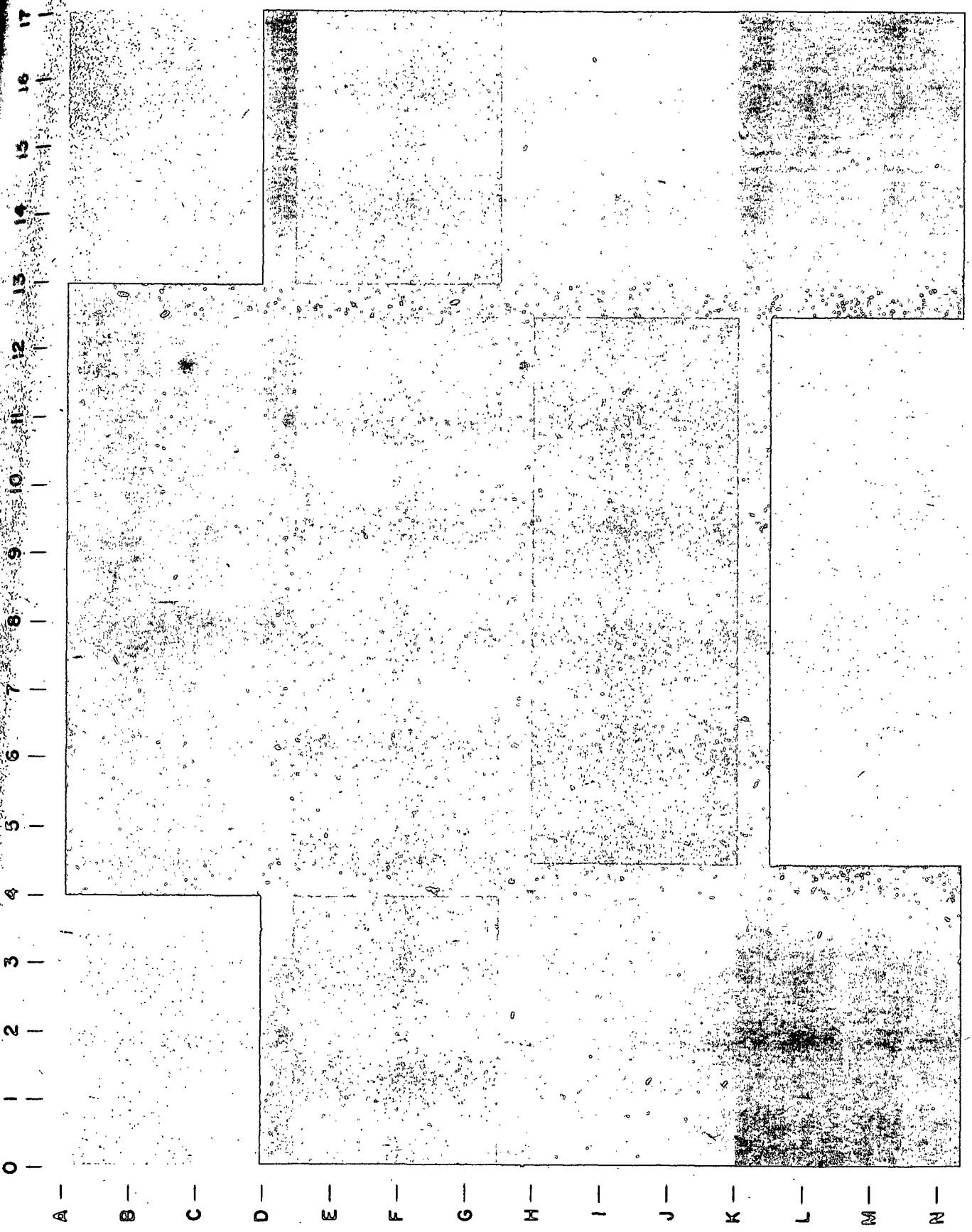


Run 68-C, Paper IT1, Bottom Side

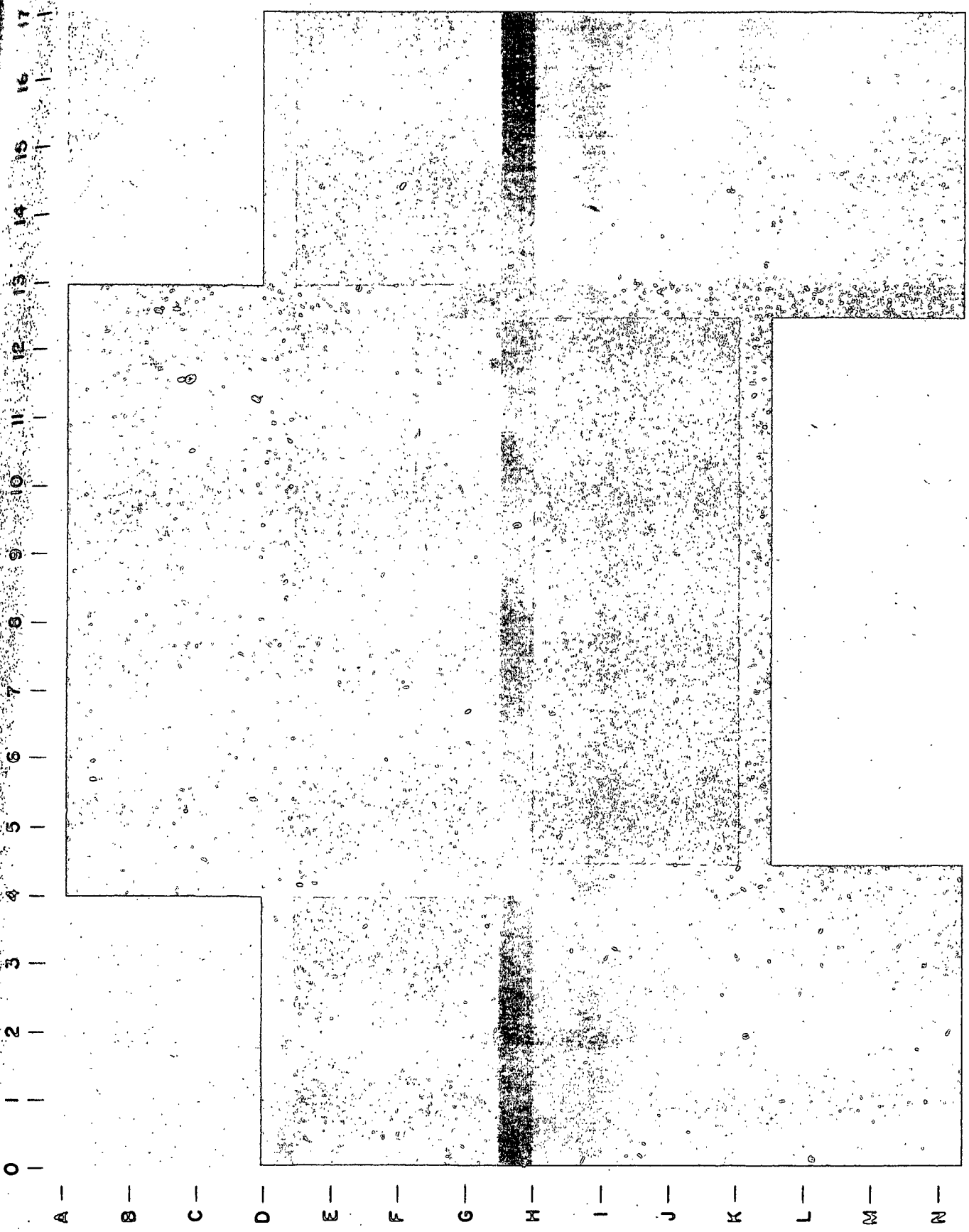
Run 68-E, Paper IT1, Bottom Side



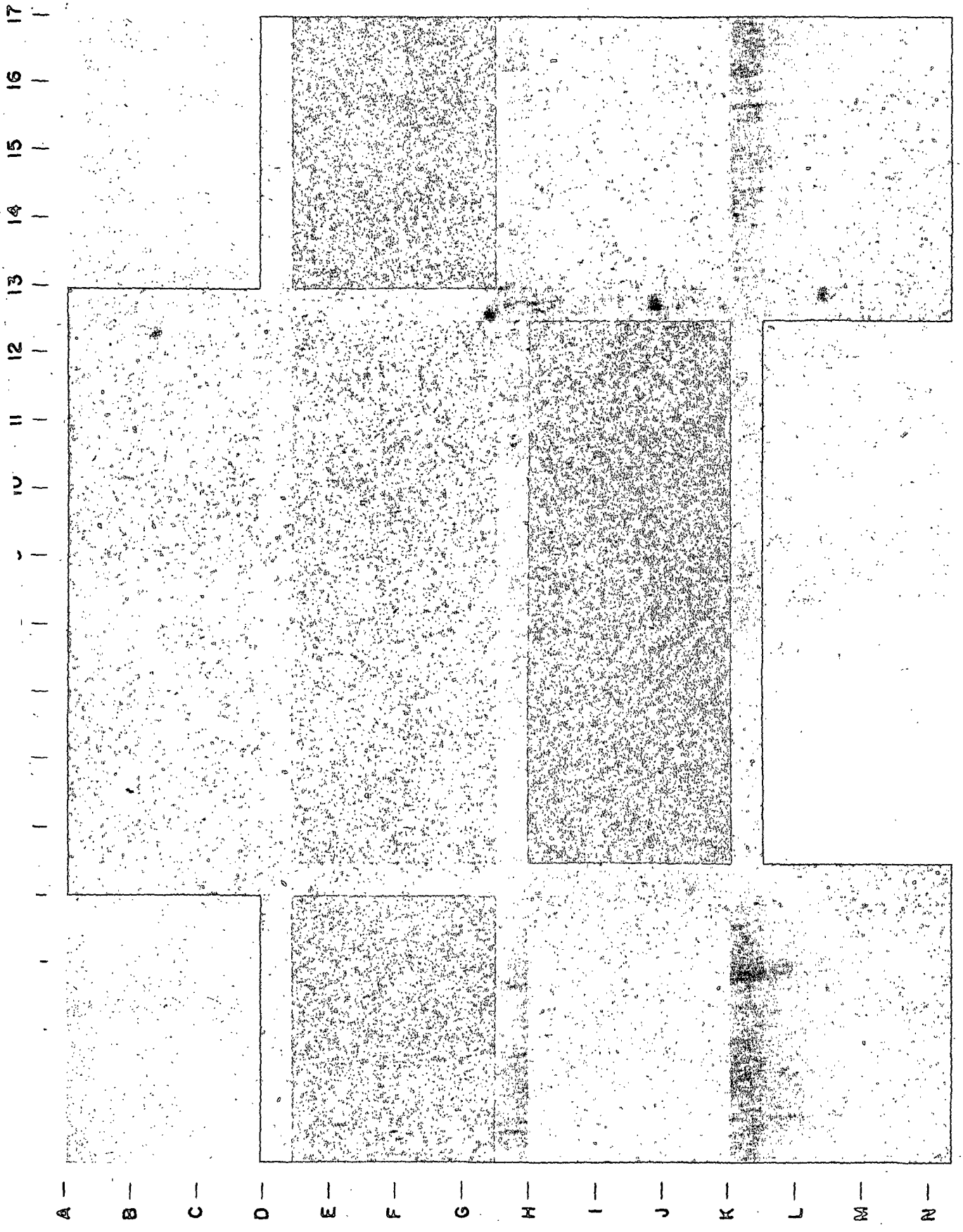
Run 69-S, Paper HCl, Felt Side



Run 69-C, Paper HCl, Felt Side



Run 69-E, Paper HCl, Felt Side



Run 71-S, Paper IT2, Top Side

Members of Group Project 2949