UNIVERSITY OF NEBRASKA - LINCOLN
Lincoln, Nebraska 68508

APPLICATIONS OF REMOTE SENSING IN RESOURCE MANAGEMENT IN NEBRASKA

(NASA-CR-145400) APPLICATIONS OF REMOTE SENSING IN RESOURCE MANAGEMENT IN NEBRASKA Semiannual Report, 1 Jan. - 30 Jun. 1975 (Nebraska Univ.) 79 p HC $4.75 CSCL 08H

N76-10557

Unclas

G3/43 39422

Semiannual Progress Report, January 1, 1975-June 30, 1975

NASA Grant No. 28-004-020

Principal Investigator:
James V. Drew
Dean for Graduate Studies
412 Administration
University of Nebraska - Lincoln
Lincoln, Nebraska 68508

Project Title

Application of Remote Sensing in Land Use Classification and Inventory and in the Delineation of Critical Environmental Areas.

Investigators

Dr. Marvin P. Carlson, Assistant Director and Principal Geologist, Conservation and Survey Division, UNL.

Mr. James Barr, Natural Resource Coordinator, State Office of Planning and Programming.

Dr. Paul M. Seevers, Research Agronomist, Conservation and Survey Division, UNL.

Dr. James V. Drew, Dean for Graduate Studies and Professor of Agronomy, UNL.

Purpose

To test and evaluate ERTS imagery in obtaining Level II land use data and in defining and monitoring critical environmental areas in conjunction with data derived from underflights and ground truth.

Scientific Results Obtained During Reporting Period

Principle scientific result within this project was the development of a computor-generated graphic display of land use data. The level II inventory data for Sarpy County, Nebraska, was placed on magnetic tape. This data could then be displayed in a map format for comparative analysis of amount and distribution of the various categories of land use. The presentation scale can be varied and thus utilized as a direct guide for cartographic purposes during preparation for publication.

An additional result of note is the continuing refinement of the inventory and classification system. Although designed for Nebraska, the technique and definitions can have regional and national utilization. The forms developed and the machine processing capabilities have potential for other types of natural resource data.

Application Results Obtained During Reporting Period

The initial level II inventory (Lancaster County, 1:62,500) was published as a 16-color map. It was very well received by the local audience and was awarded an honorable mention in a national map design competition. Because of this publication, support has been generated from local units for similar land use inventory. The following projects are being accomplished in cooperation with both local user and governmental agency support.

1) The level II map of the Lower Platte South Natural Resource District is in press.
2) The Papio Natural Resources District is inventoried and cartography is nearly complete at level II.
3) All necessary imagery is available, ground truth has been collected and 30% of the inventory is completed for the level II of the Central Platte Natural Resources District.
4) The first flight imagery and ground truth are available for the Upper Republican, Upper Niobrara-White, Lower Niobrara and the Lower Platte North Natural Resources Districts.

   All of these inventories are utilizing a basic ten-acre grid cell and a 27-category classification (form attached).

Numerous local application projects are resulting from the level II land use program. For example, the Papio NRD is utilizing the imagery and the data format to develop the required Conservation Needs Inventory. The Lower Platte South NRD is combining the land use data with soils data to determine necessary land treatment.

COUNTY ______________________ ______ IMAGERY ______________________ DATE ____________

SEC ______ TWN ______ N RNG ______ E/W INTERPRETER ______________________ DATE ____________

	A	B	C	D	E	F	G	H
1								
2								
3								
4								
5								
6								
7								
8								

1. **URBAN**
   - A-Residential
   - B-Commercial
   - C-Industrial
   - D-Transportation
   - E-Institutional
   - F-Recreational
   - G-Strip & Clustered
   - H-Mixed
   - I-Open & Other
2. AGRICULTURAL
   - J-Row Crop
   - K-Small Grain
   - L-Pasture
   - M-Fallow
   - N-Horticultural
   - O-Farmstead
   - P-Feeding Operation
   - Q-Other
3. RANGELAND
   - R-Rangeland
4. FOREST LAND
   - S-Deciduous
   - T-Evergreen
5. WATER
   - U-Streams
   - V-Lakes
   - W-Reservoirs
   - X-Other
6. NONFORESTED WETLAND
   - Y-Nonforested Wetland
7. BARREN LAND
   - Z-Barren Land
   - @-Extractive

______________ Terraced △ House □ Farmstead

All of the Districts are requesting land use data for inclusion in their comprehensive plans.

Computor manipulation of historical land use data is now underway. Data is available for 1949, 1959, 1965 and 1973 within 17 categories. The data is being used locally by planning agencies and as a pilot project for regional trends.

Work Planned for Next Reporting Period

The progress of the level II mapping will continue. As the data becomes available, both in raw data form and map formats, additional application will be explored with the user-audience. As products become available for pilot areas, a greater awareness of the potential of remote sensing is created. It is anticipated that both more specific utilization of large-scale imagery will occur as well as delineation of regional and statewide patterns. The importance of these patterns, whether caused by land use or natural conditions will continue to be assessed.

1. PROJECT TITLE

Application of Remote Sensing to an Inventory of Irrigated Land in Nebraska

2. NAME OF INVESTIGATOR

Donald M. Edwards, Ph.D., Project Leader, Associate Dean, College of Engineering and Technology, University of Nebraska, Lincoln, NE 68588

Richard O. Hoffman, Ph.D., Co-Project Leader, Associate Professor, Department of Industrial and Management Systems Engineering, University of Nebraska, Lincoln, NE 68588

3. PURPOSE OF INVESTIGATION

To evaluate use of aircraft and satellite imagery in detecting and estimating the acreage of irrigated land in Nebraska.

4. SCIENTIFIC RESULTS OBTAINED DURING JUNE 1974 AND DECEMBER 1974.

a. The Phelps County crop inventory map has been printed and distributed to over 400 potential users and agricultural-oriented agencies.

b. The Dawson County crop inventory map has been printed and distributed to over 400 potential users and agricultural-oriented agencies.

c. The location of 6,676 center pivot irrigation systems for all 93 Nebraska counties has been mapped at a scale of 1:250,000 using 1972, 1973 and 1974 ERTS-1 imagery.

d. An 8½ x 11 map of the 6,676 center pivot irrigation systems has been prepared and distributed to appropriate agricultural and water resource agencies and interested persons

e. A list of the number of center pivots in each county for each year, 1972, 1973, and 1974, has been compiled (Table 1) and distributed.

f. An estimate of land irrigated by the center pivot irrigation systems has been calculated and distributed (Table 1).

g. The number of acres irrigated in Nebraska in 1973 has been estimated at 5.1 million, using LANDSAT imagery.

h. Due to the difficulty and cost of obtaining irrigated acreage estimates, the above estimates are becoming the standard.

5. APPLICATION OF RESULTS OBTAINED

a. Direct Applications Already Achieved

In the area of fuel allocation, the remote sensing data from the Irrigation Project is being used to assist in fuel allocation decisions.

Valmont Industries, Inc., Valley, Nebraska, is now building an addition to their plant. They manufacture center pivot sprinkler systems. The data from the Irrigation Project assisted in the deicision for the size and design of the plant addition.

Valmont Industries has used over $6,000 worth of LANDSAT images to assist in determining the location of a new industrial plant.

b. Potential Applications to Local Programs

The Nebraska Unicameral, in 1974, passed an environmental critical area bill. Already, one Natural Resource District has requested action under this law. The data from LANDSAT imagery and the irrigation project will assist in meeting the requirements of the law.

The University of Nebraska Board of Regents sponsors a continuous program called the Irrigation Development Program. Members of this program have used the raw data from the Irrigation Project as a basis for selecting projects and recommendations for action.

The Nebraska Unicameral is currently discussing a water usage and well drilling bill. It probably will not come out of committee this year because of the lack of data available on irrigation and a lack of understanding of the effect of the bill on irrigation. Next year the irrigation project will be complete and the data will assist in the writing of the Water Usage Bill.

c. Potential Application to Federal Programs

If the federal land use bill passes, the states will have a large responsibility in implementing it. The Irrigation Project will provide data so that decisions are based on quantitative information rather than qualitative.

6. WORK PLANNED FOR THE NEXT REPORTING PERIOD

The research work on the Irrigation Project and the Center Pivot Irrigation Project will be completed during FY 1976. A program of updating the maps will be continued.

Irrigation Project

Last year work on the Irrigation Project of identifying land by other than center pivot systems included the successful development and refinement of the procedures for identifying surface irrigated land. These procedures included the use of more sophisticated electronic equipment and photographic procedures. The FY 1976 will include completing an inventory of the irrigated land in the 93 counties and the publication of a Nebraska state map which shows all the surface irrigated land in 1972, 1973, 1974 and 1975.

It is planned that the Surface Irrigation Project will be completed during the FY 1976, with the final publication of an irrigation map and appropriate reports to the interested state agencies.

Center Pivot Irrigation Project:

From the ground truth and the ERTS-1 imagery gathered during the summer of 1973, it has been shown that center pivot irrigation systems can be identified, and the growth rate calculated. This has been accomplished for all 93 Nebraska counties for 1972, 1973, and 1974. During FY 1976 it is planned to update this with the 1975 imagery information. This will increase the accuracy of the map and give a four-year comparison for growth. A Nebraska state map showing the location of land irrigated by center pivot systems, the amount of land irrigated, and the growth rate of center pivots will be published this year. This information has been requested by the Nebraska State Natural Resource Commission, the Nebraska State Office of Planning and Programming, several Natural Resource districts, and the Nebraska Irrigation Program, and several electrical power districts.

TABLE 1 CENTER PIVOTS OBSERVED USING SATELLITE IMAGERY 1974

ENGINEERING RESEARCH CENTER
W181 NEBRASKA HALL
UNIVERSITY OF NEBRASKA
LINCOLN, NE. 68503
402-472-3181

DONALD M. EDWARDS
RICHARD C. HOFFMAN
DAVID D. RAPE
AUGUST 2[illegible], 1975
402-472-[illegible]95

COUNTY NUMBER	COUNTY NAME	NUMBER IN YEAR 1972	1973	1974	PERCENT INCREASES 72/3	74/3
14	ADAMS	19	19	45	0	137
26	ANTELOPE	171	222	334	30	50
91	ARTHUR	1	15	15	1400	0
85	BANNER	13	44	65	238	48
86	BLAINE	3	24	37	700	54
23	BOONE	27	32	43	19	34
65	BOX BUTTE	29	105	178	262	70
63	BOYD	2	2	3	0	50
75	BROWN	108	125	175	16	40
9	BUFFALO	36	42	120	17	186
31	BURT	3	3	4	0	33
25	BUTLER	4	9	30	125	233
20	CASS	0	0	0	N/A	N/A
13	CEDAR	7	7	11	0	57
72	CHASE	113	372	542	229	46
66	CHERRY	45	88	186	96	111
39	CHEYENNE	11	32	49	191	53
30	CLAY	35	45	88	29	96
43	COLFAX	14	19	28	36	47
24	CUMING	12	12	19	0	58
4	CUSTER	65	121	172	86	42
70	DAKOTA	2	2	4	0	100
69	DAWES	0	5	11	N/A	120
15	DAWSON	26	48	82	85	71
78	DEUEL	2	15	30	700	88
35	DIXON	2	2	2	0	0
5	DODGE	3	10	20	233	100
1	DOUGLAS	5	6	11	20	83
76	DUNDY	58	156	229	169	47
34	FILLMORE	25	34	69	36	103
50	FRANKLIN	4	4	6	0	50
60	FRONTIER	26	30	45	15	50
38	FURNAS	17	18	21	6	17
3	GAGE	2	2	23	0	1050
77	GARDEN	8	38	85	375	124
83	GARFIELD	4	5	9	25	80
73	GOSPHER	9	10	15	11	50
92	GRANT	1	2	3	100	50
62	GREELEY	13	21	38	62	81
8	HALL	6	7	41	17	486
28	HAMILTON	31	35	144	13	311
51	HARLAN	8	8	10	0	25
79	HAYES	17	39	55	129	41
67	HITCHCOCK	7	8	14	14	75
36	HOLT	708	847	1024	20	21
93	HOOKER	0	3	13	N/A	333
49	HOWARD	11	12	39	9	225
33	JEFFERSON	2	2	28	0	1300
57	JOHNSON	0	0	3	N/A	N/A
52	KEARNEY	80	80	104	0	30
68	KEITH	27	53	75	96	42
82	KEYA PAHA	28	33	66	18	100

TABLE 1 CENTER PIVOTS OBSERVED USING SATELLITE IMAGERY (CONT.)

COUNTY NUMBER	COUNTY NAME	NUMBER IN YEAR 1972	1973	1974	PERCENT INCREASES 72/3	74/3
71	KIMBALL	12	31	43	158	39
12	KNOX	38	43	63	13	47
2	LANCASTER	2	2	4	0	100
15	LINCOLN	103	129	226	25	75
87	LOGAN	4	21	26	425	24
88	LOUP	8	16	22	100	38
90	MC PHERSON	3	14	23	367	64
7	MADISON	35	43	79	23	84
46	MERRICK	68	88	134	29	52
64	MORRILL	12	95	135	692	42
58	NANCE	12	15	23	25	53
44	NEMAHA	0	0	0	N/A	N/A
42	NUCKOLLS	2	2	10	0	400
11	OTOE	2	2	5	0	150
54	PAWNEE	0	0	1	N/A	N/A
74	PERKINS	94	130	297	91	65
37	PHELPS	55	71	83	29	17
40	PIERCE	80	88	133	10	51
10	PLATTE	40	45	73	13	62
41	POLK	5	5	17	0	240
48	RED WILLOW	16	23	37	44	61
19	RICHARDSON	0	0	3	N/A	N/A
81	ROCK	131	165	205	26	24
22	SALINE	2	2	19	0	850
59	SARPY	0	0	4	N/A	N/A
6	SAUNDERS	6	6	15	0	150
21	SCOTTS BLUFF	0	3	5	N/A	67
16	SEWARD	17	17	57	0	235
61	SHERIDAN	14	51	97	264	90
56	SHERMAN	14	17	40	21	135
80	SIOUX	0	17	34	N/A	100
53	STANTON	3	4	8	33	100
32	THAYER	14	14	73	0	421
89	THOMAS	0	6	11	N/A	83
55	THURSTON	1	1	2	0	100
47	VALLEY	11	24	41	118	71
29	WASHINGTON	0	0	0	N/A	N/A
27	WAYNE	6	6	7	0	17
45	WEBSTER	9	9	21	0	133
84	WHEELER	54	79	102	46	29
17	YORK	10	10	35	0	250
	NEBRASKA	2733	4218	6676	54	58
	ESTIMATED ACRES IRRIGATED BY CENTER PIVOT IRRIGATION SYSTEMS, THOUSANDS	383	591	935	54	58

TABLE 2: IRRIGATED LAND OBSERVED USING SATELLITE IMAGERY 1973

ENGINEERING RESEARCH CENTER — DONALD M. EDWARDS 402-472-3181
W181 NEBRASKA HALL — RICHARD O. HOFFMAN 402-472-3495
UNIVERSITY OF NEBRASKA — DAVID D. PAPE
LINCOLN, NE. 68503 — AUGUST 29, 1975

COUNTY NUMBER	COUNTY NAME	AREA OF COUNTY: SQUARE MILES	ACRES	PERCENT OF NEBR.	IRRIGATED LAND: ACRES	PERCENT OF COUNTY	PERCENT OF NEBR.
14	ADAMS	562	359680	0.73	124089	34.5	0.25
26	ANTELOPE	853	545920	1.11	127743	23.4	0.25
91	ARTHUR	704	450560	0.92	13066	2.9	0.03
85	BANNER	733	472320	0.96	16058	3.4	0.03
85	BLAINE	711	455040	0.93	26847	5.9	0.05
23	BOONE	683	437120	0.89	114962	26.3	0.23
65	BOX BUTTE	1065	681600	1.39	29308	4.3	0.06
63	BOYD	538	344320	0.70	46138	13.4	0.09
75	BROWN	1216	778240	1.59	42024	5.4	0.09
9	BUFFALO	949	607360	1.24	142122	23.4	0.29
31	BURT	483	309120	0.63	N/A	N/A	N/A
25	BUTLER	582	372480	0.76	N/A	N/A	N/A
20	CASS	555	355200	0.72	N/A	N/A	N/A
13	CEDAR	742	474880	0.97	8547	1.8	0.02
72	CHASE	890	569600	1.16	78604	13.8	0.16
66	CHERRY	5966	3818240	7.79	210[illegible]03	5.5	0.43
39	CHEYENNE	1186	759040	1.55	31879	4.2	0.07
30	CLAY	570	364800	0.74	136435	37.4	0.28
43	COLFAX	406	359840	0.73	N/A	N/A	N/A
24	CUMING	571	365440	0.75	N/A	N/A	N/A
4	CUSTER	2558	1637120	3.34	184994	11.3	0.38
70	DAKOTA	255	163200	0.33	N/A	N/A	N/A
69	DAWES	1386	887040	1.81	6870	1.0	0.02
18	DAWSON	975	624000	1.27	184704	29.6	0.38
78	DEUEL	436	279040	0.57	N/A	N/A	N/A
35	DIXON	475	304000	0.62	N/A	N/A	N/A
5	DODGE	528	337920	0.69	N/A	N/A	N/A
1	DOUGLAS	335	214400	0.44	N/A	N/A	N/A
76	DUNDY	921	589440	1.20	61891	10.5	0.13
34	FILLMORE	577	369280	0.75	112999	30.6	0.23
50	FRANKLIN	578	369920	0.75	52898	14.3	0.11
60	FRONTIER	962	615680	1.26	39403	6.4	0.08
38	FURNAS	722	462080	0.94	36966	8.0	0.08
3	GAGE	858	549120	1.12	18670	3.4	0.04
77	GARDEN	1678	1073920	2.19	88061	8.2	0.18
83	GARFIELD	569	364160	0.74	15294	4.2	0.03
73	GOSPER	464	296960	0.61	47216	15.9	0.10
92	GRANT	764	488960	1.00	16135	3.3	0.03
62	GREELEY	570	364800	0.74	31009	8.5	0.06
8	HALL	537	343680	0.70	122350	35.6	0.25
28	HAMILTON	537	343680	0.70	187649	54.6	0.38
51	HARLAN	555	355840	0.73	48038	13.5	0.10
79	HAYES	711	455040	0.93	28212	6.2	0.06
67	HITCHCOCK	712	455680	0.93	43289	9.5	0.09
36	HOLT	2405	1539200	3.14	81577	5.3	0.17
93	HOOKER	722	462080	0.94	6469	1.4	0.01
49	HOWARD	564	360960	0.74	62807	17.4	0.13
33	JEFFERSON	577	369280	0.75	37666	10.2	0.08
57	JOHNSON	377	241280	0.49	8696	3.6	0.02
52	KEARNEY	512	327680	0.67	14090	4.3	0.03
68	KEITH	1032	660480	1.35	N/A	N/A	N/A
82	KEYA PAHA	768	491480	1.00	18676	3.8	0.04
71	KIMBALL	953	609920	1.24	20127	3.3	0.04

TABLE 2: IRRIGATED LAND OBSERVED USING SATELLITE IMAGERY 1973 (CONT.)

COUNTY NUMBER	COUNTY NAME	AREA OF COUNTY: SQUARE MILES	ACRES	PERCENT OF NEBR.	IRRIGATED LAND: ACRES	PERCENT OF COUNTY	PERCENT OF NEBR.
12	KNOX	1107	708480	1.45	81475	11.5	0.17
2	LANCASTER	845	540800	1.10	25950	4.8	0.05
15	LINCOLN	2522	1614080	3.29	171042	10.6	0.35
37	LOGAN	570	364800	0.74	20064	5.5	0.04
88	LOUP	574	367360	0.75	28286	7.7	0.06
90	MC PHERSON	856	547840	1.12	8217	1.5	0.02
7	MADISON	572	366080	0.75	N/A	N/A	N/A
46	MERRICK	480	307200	0.63	N/A	N/A	N/A
64	MORRILL	1402	897280	1.83	41274	4.6	0.08
58	NANCE	439	280960	0.57	N/A	N/A	N/A
44	NEMAHA	400	256000	0.52	15360	6.0	0.03
42	NUCKOLLS	579	370560	0.76	61142	16.5	0.12
11	OTOE	619	369160	0.75	18827	5.1	0.04
54	PAWNEE	433	277120	0.57	9422	3.4	0.02
74	PERKINS	885	566400	1.16	N/A	N/A	N/A
37	PHELPS	544	348160	0.71	155279	44.5	0.32
40	PIERCE	573	366720	0.75	N/A	N/A	N/A
10	PLATTE	667	426880	0.87	N/A	N/A	N/A
41	POLK	432	276480	0.56	N/A	N/A	N/A
48	RED WILLOW	686	439040	0.90	46977	10.7	0.10
19	RICHARDSON	550	352000	0.72	7040	2.0	0.01
81	ROCK	1009	645760	1.32	76345	11.9	0.16
22	SALINE	575	368000	0.75	72128	19.6	0.15
59	SARPY	239	152960	0.31	N/A	N/A	N/A
6	SAUNDERS	759	485760	0.99	N/A	N/A	N/A
21	SCOTTS BLUFF	725	464000	0.95	91534	19.7	0.19
16	SEWARD	571	365440	0.75	92821	25.4	0.19
61	SHERIDAN	2462	1575680	3.21	67754	4.3	0.14
56	SHERMAN	567	362880	0.74	30119	8.3	0.06
80	SIOUX	2063	1320320	2.69	48851	3.7	0.10
53	STANTON	431	275840	0.56	N/A	N/A	N/A
32	THAYER	577	369280	0.75	77548	21.0	0.15
89	THOMAS	716	458240	0.93	17413	3.8	0.04
55	THURSTON	388	248320	0.51	N/A	N/A	N/A
47	VALLEY	569	364160	0.74	44063	12.1	0.09
29	WASHINGTON	386	247040	0.50	N/A	N/A	N/A
27	WAYNE	443	283520	0.58	N/A	N/A	N/A
45	WEBSTER	575	368000	0.75	35696	9.7	0.07
84	WHEELER	576	368640	0.75	21749	5.9	0.04
17	YORK	577	369280	0.75	177992	48.2	0.36
TOTAL/AVG. NEBR.		76488	49025232	100.00	4271506	10.4	8.71

SUMMARY ***

ACRES IN NEBRASKA	49025232.00
ACRES AVAILABLE FOR MEASURMENT	41019934.00
ACRES CLASSIFIED AS IRRIGATED	4271506.00
PERCENT OF NEBRASKA MEASURED	83.67
PERCENT MEASURED ACRES IRRIGATED	10.41

Project Title

Application of Remote Sensing Technology to Accelerate Data Utilization and Graphic Product Distribution for the User Audience.

Investigators

Dr. Rex M. Peterson, Remote Sensing Coordinator, Conservation and Survey Division, UNL.

Dr. Paul M. Seevers, Research Agronomist, Conservation and Survey Division, UNL.

Mr. Duane Eversoll, Geologist, Conservation and Survey Division, UNL.

Mr. Donald Buckwalter, Remote Sensing Analyst, Conservation and Survey Division, UNL.

Purpose of Investigation

To centralize the expertise, equipment and documentation becoming available through remote sensing investigations. This Remote Sensing Center will interface the research, academic, and management agencies and will also serve as a data source for the general public.

Scientific Results Obtained During Reporting Period

Principal scientific results include the development of the polygon method for deriving geologic information form images, a wetland inventory of Nebraska, a cooperative project with the U. S. Geological Survey, and new techniques in microscopic examination of Landsat imagery.

The polygon method for deriving structural geologic data from Landsat and other images is described in Appendix A. Significant features of this development are: (1) it facilitates the location of geologic lineaments and, for the first time, permits ranking the lineaments in importance; (2) the technique can be used at different scales with various types of imagery; (3) it is fast and relatively simple. This means that interpretation of images is much quicker and more precise.

The wetland inventory of Nebraska, done in cooperation with the Nebraska Game and Parks Commission, was completed on schedule at the end of the one-year contract. This project showed that Landsat could be used to inventory wetlands at a scale of 1;250,000 and to categorize the wetlands as open water, marsh, seasonally flooded, or subirrigated.

A cooperative project with the U.S. Geological Survey tested the utility of Skylab imagery for the identification of soil-vegetation-geomorphic units in the one by two degree Fremont, Nebraska Quadrangle. Part of this project involved correlation of features seen on Skylab imagery with features visible on Landsat imagery. The close agreement of polygons and lineaments on the different types of imagery is considered especially significant.

A Wild-Heerbrugg Swiss microscope has been added to the equipment in the Remote Sensing Center. As far as we know, this is the first use of this type of microscope for viewing Landsat imagery. With the light and dark-field illumination, double iris adjustment of light, color filters and polarization, light can be controlled so as to maximize the detail in Landsat images. Experimentation shows that more detail can be seen with this optical system than with systems such as the Spectral Data additive color viewer or the Bausch and Lomb Zoom Transfer Scope. By using the camera lucida attachment on the scope, images can be superposed on maps for fairly detailed mapping.

Application Results Obtained During Reporting Period

The service function of the Remote Sensing Center has continued to increase in response to individual and group requests for information, imagery, presentations, and interpretations. Typical projects utilizing the Center and its staff are as follows:

(1) An interdisciplinary classroom course in remote sensing was taught during the spring, 1975 semester. Forty students took the course for credit in engineering, geology, or geography. Twenty of the students were employed full time in various state and federal agencies. In addition to the formal course, numerous students have received assistance on theses or class projects that involved remote sensing.

(2) Several workshops have been conducted for units within the University and for state agencies. In addition numerous classes and other groups have been given tours and briefings in the Remote Sensing Center.

(3) Several remote sensing displays have been on exhibit, such as one at the University of Kansas symposium on remote sensing for geology, a display at the Nebraska Rock and Gem Show, a permanent display in the head offices of the CENGAS Corp., and coverage on a local television station.

(4) In cooperation with the CENGAS Corp., the Remote Sensing Center has been involved in the first inventory of heat loss from buildings by airborne thermal scanner. Sixteen inch by 20" prints (6X enlargements of the original 70 mm. imagery) were produced in the Center, at cost, for CENGAS. Four-hundred of these prints were needed to cover the City of Lincoln and another 400 were required to cover Beatrice, Norfolk, Columbus, and Sioux Falls. Over 17,000 gas

customers have visited the CENGAS offices to view these prints to see if their homes were losing excessive heat last winter. Detailed studies of each of the 50 public school buildings in Lincoln have been made by the Center, using electronic density slicing equipment. Detail in both color and black and white photos of each building is sufficient to compare with blueprints to ascertain where heat is being lost in each building.

(5) Siting studies have been conducted for electrical generating plants under consideration by the Nebraska Public Power District and the Omaha Public Power District. These are described in more detail in another section of this report.

(6) Assistance has been given to tax appraisers. Ms. Dee Meek, a Senior Appraiser for the Nebraska Department of Revenue, developed a method for equalization of land valuations across county lines with the use of high altitude aircraft photography available in the Center. Ms. Meek is publishing a paper on the method.

Mr. Herbert Kollmorgen, a private tax consultant, has been spending several days per month in the Center using high altitude aircraft imagery to appraise all of Cass and Lancaster Counties. He estimates that he can appraise 10 to 12 times as much land in a day, with greater accuracy, than by using conventional methods.

(7) Comprehensive Planning Advisory Team (CPAT). Assistance has been given to planners affiliated with the Nebraska State Office of Planning and Programming in developing comprehensive development plans for Platte, Antelope, Box Butte, and Sheridan Counties.

(8) High altitude photography in the Center has been used to inventory pits and quarries in Nebraska. Sizes, locations, and activity in hundreds of pits and quarries has been quickly and accurately

inventoried with photography flown by NASA RB-57's, U-2's, and Nebraska Air Guard RF-4C's.

(9) A pilot study is being conducted for the basin Electric Cooperative to select transmission line routes with Landsat and high altitude imagery. The working premise is that Landsat imagery can be used for mapping land use and selecting 15 mile-wide corridors which would be imaged by high altitude aerial cameras. Detailed analysis of the aerial photography would yield sufficient information for routing the power line. This technique could result in a uniform data base over the entire length of the transmission line and considerably lower costs in selection of routes.

(10) Sarpy County Pilot Project. A pilot project is underway for Sarpy County (Omaha area) for the establishment of a data bank. Included in the data bank are several derivitive soil maps and land use maps. These maps have been plotted by computer at various scales.

Work Planned for the Future

Plans for the future include the expansion and continuation of most projects listed above. The remote sensing course will be offered again in the spring semester with an expansion of areas in which academic credit can be earned. As people become more aware of remote sensing the requirement for workshops, briefings and presentations increases, so plans call for an expansion of these activities. There are already several requests per week for assistance in locating water wells by the fracture-trace method and this activity is expected to expand. Research in the location of petroleum deposits will continue as will mapping structural lineaments in Nebraska. Plans are being formulated to map the flood plans in the state. The cooperative venture with CENGAS is expected to continue to expand to an inventory of heat loss in other cities.

Project Title

Application of Remote Sensing in the Delineation of Major Tectonic Lineaments.

Investigators

Dr. Rex M. Peterson, Remote Sensing Coordinator, Conservation & Survey Division, UNL.

Dr. M. P. Carlson, Assistant Director and Principal Geologist, Conservation & Survey Division, UNL.

Mr. David Maroney, Remote Sensing Analyst, Conservation & Survey Division, UNL.

Purpose

To test and evaluate ERTS imagery in the delineation of major tectonic lineaments within the State of Nebraska and to predict the extent of their economic and environmental significance.

Scientific Results Obtained During Reporting Period

(1) The techniques developed during the last reporting period have been refined and extended. Multiple tracings from multispectral and multitemporal images are overlain and registered as before. Significant advances have been made in the enhancement of images with a combination of fresnel lenses, reducing lenses, Ronchi rulings, and colored filters. This new combination of lenses permits an interpreter to map numerous polygons and lineaments and rank the lineaments in importance. The significance of the new lens and filter combinations is that they reveal sufficient polygons and lineaments to permit geologic interpretation; making interpretations without sufficient detail is like trying to assemble a jigsaw puzzle without all the pieces.

With the new combinations of lenses and filters for viewing multi-seasonal, multispectral Landsat imagery, the trained eye can delineate sufficient detail to literally fill a landscape with straight and curved lines. With the detail now available it would appear that the earth is composed of a series of polygons which in turn are subdivided into other polygons in a descending hierarchical order which contains at least ten sizes of polygons. Straight, or gently curved lineaments extend between the margins of polygons and across polygons in certain repetitive ways. It is postulated that strain, from whatever internal and external forces that produce the polygons, is localized at the borders of polygons. Therefore, the probability of faulting and extensive fracturing of rocks should be greatest at the borders of the largest polygons and least at the borders of the smallest polygons. This relationship makes it possible to associate a lineament with a certain size polygon and to assign levels of importance to various lineaments.

Previous work with drawing lineaments on Landsat imagery, or other imagery, has shown that numerous lineaments can be located, but there has been no way of determining which lineaments are likely to represent faults and major fracture zones and which lineaments are unimportant. The new capability of ranking lineaments in order of importance is a major breakthrough that will have implications over a broad range of geologic applications. More detail on the methods used to derive geologic information from LANDSAT imagery and the results are presented in Appendix A.

(2) Polygons as complex as those shown in Figure 17 of Appendix A were drawn from multiseasonal, multispectral Landsat scenes for the one by two degree Fremont, Nebraska Quadrangle. Skylab photographs of the same area were used to draw polygons to compare with those

from Landsat. Even though different interpreters were involved, the pattern of polygons and the lineaments derived from them was the same.

(3) It has been demonstrated that polygons observed on Landsat imagery and Skylab imagery can also be identified on aerial photographs of various scales. Furthermore, lineaments derived from polygons can be recognized from aircraft with altitudes of 10,000 above ground level being best for recognition of major lineaments. In several applications we have started with small-scale Landsat imagery to locate major lineaments, then worked up in scale to locate the same features on conventional aerial photographs.

(4) Lineaments derived from polygons visible on Landsat (by the technique described in Appendix A) show very good correlation with aeromagnetic patterns. Figure 18, Appendix A, shows lineaments derived from Landsat polygons suposed on an aeromagnetic map of southeastern Nebraska (E. R. King and I. Zietz, Geol. Soc. Amer. Bull. v. 82, no. 8, p. 2187-2208). It can be seen that the lineaments from Landsat correspond rather well with abrupt changes in contours and with magnetic highs and lows. Arrangements have been made with S. Parker Gay, consulting geophysicist and president of the American Stero Map Co., to compare our polygon-derived lineaments with the lineaments he interprets from three-dimensional aeromagnetic maps.

(5) In order to check details on Landsat images, the Nebraska Remote Sensing Center has purchased a Swiss Wild-Heerbrugg microscope. With dark and light field illumination and double iris control of light, a surprising amount of detail can be seen on 70 mm. and 9" x 9" Landsat imagery. With the aid of a camera lucida, a portion of a 70 mm. Landsat image can be registered on a 1:250,000 topographic map

and details from the image can be transferred directly to the map. The excellent optics in this microscope and the precise control of illumination, plus the camera lucida attachment, permit fairly precise location of lineaments on maps. Not only is this a new use of this type microscope for viewing imagery, but more importantly, it is a method for adding detail to geologic lineaments mapped from Landsat imagery.

Applications Results Obtained During Reporting Period

A. Direct Applications Already Achieved

With the new capability of ranking lineaments in order of importance, it has been possible to achieve direct applications in the following two areas.

(1) Location of sites for drilling water wells. It has been known for several years, largely as a result of work done at Pennsylvania State University by Lattman and Parizek, that in carbonate aquifers, wells drilled at intersections of fracture traces yielded much more water than wells not on intersections, the reason being that in a tight, carbonate rock formation, such as a limestone, groundwater is concentrated along fractures and the intersection of two or more fractures yields more water than a single fracture. However, a single air photo shows dozens of fracture traces, which vary in importance; some may have considerably more water than others. By associating fracture traces with different size polygons the fracture traces, i.e., lineaments, can be ranked in importance and drilling can be concentrated on the largest fractures. On one farm in southeastern Nebraska the three wells located by this new technique were successful, while four others located by the landowner were failures. In south-central Nebraska where only one out of ten wells is successful, the two wells located by this technique yielded approximately 300 gallons per minute.

B. Siting Studies for Electrical Generating Plants

The Nebraska Remote Sensing Center has cooperated with the Nebraska Public Power District and the Omaha Public Power District in the evaluation of geologic lineaments within 50 mile radii of proposed nuclear power plants. The previous state of the art of lineaments was that shown on Figure 1 (Appendix 1) which consisted of mapping numerous lineaments without any ranking. What geologic-engineers need for site evaluation is a ranking system for lineaments, so they know which lineaments are likely to represent faults and which might represent harmless, small fractures. Such an evaluation is shown in Figure 2 (Appendix A) which is part of a 50-mile radius map centered on the Decatur, Nebraska proposed nuclear site. Line symbols show lineaments in ranks one through five; lineaments of ranks below five were considered unimportant and were eliminated from the map.

This map was used by consulting geologists with the firm of Shannon and Wilson in their evaluation of the Decatur site for the Nebraska Public Power District (NPPD). Similar information was provided for NPPD for the Dunning site in central Nebraska and the Omaha Public Power District for one of their sites.

(2) Potential Applications Obtained During Reporting Period

It is very possible that new deposits of petroleum can be found by using lineaments mapped by the Landsat-polygon method. Figure 19 (Appendix A) shows the location of oil fields in southwestern Nebraska and northern Kansas in an area of one Landsat scene. The major lineaments in the area (as interpreted from sizes of polygons) are shown in heavy lines. It can be seen that oil fields (shown by X's) tend to occur at the intersections of major lineaments. Hundreds of wells have been drilled in areas away from the lineament intersections, but no oil has been found there. Areas blacked-out on Figure 19 which appear as highly fractured zones on Landsat imagery, also had many dry holes drilled in them; similar areas should be given low priority in future searches for oil. The significant feature of this map is the many intersections of lineaments where there has been no drilling; therefore, this may represent potential oil fields. Some leasing is taking place now on these intersections and test drilling will follow.

It should be emphasized that the lineaments shown in Figure 19 cannot be mapped directly from Landsat or other images; Figure 19 is a second generation map derived from polygons similar to those shown in Figure 17. However, once the lineaments are mapped and locations are known, they can be located on the ground or seen from an aircraft.

(3) Potential Application to Federal Programs

The polygon method, as outlined in Appendix A, not only shows the location of lineaments and ranks lineaments, it shows the location of intensely fractured zones. The location of highly fractured zones is of great value in economic geology because many deposits of metals and radioactive minerals depend on the plumbing or fracturing in rock. Location of fractured zones is of value to engineers seeking stable sites for dams, tunnels, power plants, bridges, and airfields. Location of highly fractured areas is also a factor in subsidence from collapse of caverns (which develop on fractures) and in the collapse of roofs of underground mines.

The polygon method can be applied not only to Landsat imagery, but to any images of any scale. The resulting data on geologic structure can be applied to geologic problems over a broad range, including petroleum exploration, ground water, engineering geology, and mining geology.

Work Planned for the Future

Work planned for the future includes the following:

1. Continue to compare all available ground truth with interpretations made from Landsat polygons.

2. Continue to compare polygons and lineaments mapped from Landsat imagery with those from other types of imagery.

3. Map lineaments in the Paradox Basin, Utah, so that S. Parker Gay can compare them with his aeromagnetic lineaments.

4. Map geologic structure in the California Central Valley and Coast Ranges for checking by Mr. Ira Becktold, a consulting geologist in La Habra, California.

5. Continue to locate water wells to improve the technique.

6. Assist in the selection of sites for drilling oil wells.

7. Continue plotting of lineaments of Nebraska so that a map can be prepared showing major lineaments, with a ranking of lineaments.

PROJECT TITLE:

Application of Remote Sensing in Estimating Evapotranspiration in the Platte River Basin.

INVESTIGATORS:

Blaine L. Blad, Assistant Professor of Agricultural Meteorology, Department of Horticulture, University of Nebraska.

PURPOSE OF INVESTIGATION:

Primary objectives of this study are; (1) to develop and test evapotranspiration (ET) models based on crop temperature and (2) to determine the feasibility of using remotely sensed thermal imagery to supply data on crop temperature for use with these models.

SCIENTIFIC RESULTS DURING REPORTING PERIOD;

Analysis of the data taken during 1972 and 1973 has been completed and is reported in Agricultural Meteorology Progress Report 75-1. (Attached) From these data two articles have been prepared for submission to scientific journals for publication (Preprints are enclosed with this report).

Analysis has begun of thermal imagery and meteorological data collected in 1974 as part of a research grant funded by the Office of Water Resources Research. Methods are being developed to account for the atmospheric attenuation of thermal radiation in the layer between the surface and the airborne sensor. Crop temperature data obtained with a thermal scanner, with IR thermometers located near the surface and with leaf thermocouples have been applied in the following resistance model of latent heat flux (LE):

$$-LE = Rn + S + C_p\rho \, \frac{(T_a - T_c)}{r_a}$$

Rn is net radiation, S is soil heat flux, C_p is the specific heat of air, ρ is the density of moist air, T_a is air temperature, T_c is crop temperature and r_a is the boundary layer resistance to the diffusion of heat. Estimates of LE made with this model will be compared to direct measurements made with precision weighing lysimeters.

The thermal imagery obtained in 1974 is of superior quality to that obtained in 1972-1973. It is possible to obtain quantitative estimates of crop temperature from this imagery if adjustments are made to account for atmospheric attenuation of the thermal radiation and for crop emissivity effects.

APPLICATIONS RESULTS OBTAINED DURING REPORTING PERIOD:

The thermal imagery obtained in this study has been used to verify our earlier findings which show that alfalfa behaves as a potential evaporator and, as such, generally consumes more water than does pasture,corn, and many other crops. This information is needed by Agricultural Engineers and others who are currently devising methods for scheduling irrigations.

It may, one day, be possible, with improved satellite technology to supply needed data to utilize the methods developed in this study for estimating evapotranspiration for large regions. Such estimates will aid in irrigation scheduling, and in application of hydrologic models to watershed water balance. The prediction of floods, for example, by such models depends on knowledge of antecedent soil moisture conditions - knowledge which can eventually be gained through satellite supplied data.

Techniques developed in this study for interpretation of the thermal imagery will be useful in other applications. Techniques for survellience of crop moisture stress conditions can be improved by remote sensing. Knowledge of the moisture conditions of crops is vital to the accurate prediction of crop yields and these predictions, in turn, are extremely valuable to numerous government agencies.

As the production of food and fiber and the management of water resources becomes increasingly critical, the application of techniques and methods developed in this study will likewise become increasingly valuable. Their application to local and federal programs will depend on the information desired and the scope of the investigation.

WORK PLANNED FOR NEXT REPORTING PERIOD:

Analysis of the 1974 imagery and meteorological data will be continued. Techniques for adjusting the thermal imagery data to account for atmospheric attenuation and crop emissivity effects will be further refined. Crop temperature data will be utilized in the model to estimate ET and these estimations will be compared to ET measured directly by weighing lysimeters.

No additional field work is planned as part of this study. Efforts over the next several months will be directed towards completion of the analysis of our data and preparation of a final report for completion by July 1, 1976.

Project Title

Application of Remote Sensing in the Determination of Water Quality in Nebraska Reservoirs.

Investigators

Dr. Gary L. Hergenrader, Associate Professor, School of Life Sciences UN-L.
Mr. Kelly White, Graduate Assistant, School of Life Sciences, UN-L.

Purpose of Investigation

The purpose of this research is to determine the feasibility of detecting and quantifying selected water quality parameters in Nebraska reservoirs by remote sensing. Specifically to what extent can the parameters chlorophyll, suspended solids, Secchi depth and turbidity be detected and accurately measured? If it is possible to accurately determine water quality by remote sensing, then the characterization of the trophic state of these reservoirs should also be possible.

Work Accomplished to Date

Since the last reporting period a Masters thesis entitled "The Remote Sensing of Water Quality Parameters of the Salt Valley Reservoirs" has been completed by Mr. Kelly White. The detailed findings included in that thesis will not be repeated here. Copies of the thesis are being included as an addendum to this report. The major conclusions of the thesis follow:
1) of the four formats used in the study, a) imagery obtained from paired 35mm cameras flown at low altitude in a small airplane; b) multispectral imagery obtained by flights made by the University of Kansas Remote Sensing Center; c) color infrared imagery from the Nebraska Air National Guard; d) imagery obtained from Landsat-1, the University of Kansas' black and white multispectral and the Landsat-1 CCT's proved to have the smallest confidence intervals for the

various parameters. The 35mm color imagery obtained on low altitude flights was a disappointment and not very useful for quantifying the parameters under investigation.

2) Secchi depth, turbidity, and suspended solids are the parameters which can be most accurately quantified. These can be determined with an accuracy of ± 25% of the mean with the appropriate imagery and with the equations developed.

3) Chlorophyll can be detected and measured but the confidence limits are broad. With either the University of Kansas imagery or the Landsat CCT's water masses containing 20 μg/l, 60 μg/l, 125 μg/l, and 250 μg/l of chlorophyll could be distinguished; however, water masses containing 30 μg/l and 50 μg/l of chlorophyll could not. While this precision is sufficient to distinguish lakes at opposite ends of the trophic spectrum, it is insufficient to delimit lakes relatively close together in their trophic status but which on the basis of ground sampling are clearly different.

4) It would be possible with the models derived to classify Nebraska reservoirs into broad classes based upon their differences in Secchi depth, suspended solids, and turbidity by the use of remote sensing.

The correlations derived from the CCT of Landsat-1 were quite strong. However, because ground truth was available for only one date, the correlations must be viewed with some caution. During this past June, July, and August ground truth was collected from Lake McConaughy, a 35,000 acre reservoir in western Nebraska coincident with the overflights of Landsat-1. Water samples were collected on six different dates and analyzed for Secchi depth, turbidity, suspended solids, and chlorophyll in order to provide ground truth data which will be used to verify the correlations observed with the use of the CCT.

Applications Results Obtained During Reporting Period

This work has shown that Secchi depth, suspended solids, and turbidity can be measured with reasonable accuracy by remote sensing. Consequently, it should be possible to construct water quality maps of Nebraska reservoirs on a temporal basis which should be of use to the Nebraska Department of Environmental Control, the Nebraska Game and Parks Commission, the Nebraska Natural Resources Commission and other state and federal agencies concerned with water quality. Seasonal changes in chlorophyll concentrations, which can indicate the trophic status, can also be detected and measured by remote means, provided a high level of accuracy is not required.

Work Planned In Next Reporting Period

The water samples collected in June, July, and August are now being analyzed. In addition, the CCT's from the overflights corresponding to our ground truth are being ordered from Goddard. When the tapes are received the radiance values from our sampling sites will be compared with ground truth to determine the correlations. The data will be subjected to the same statistical treatment given our earlier information. This will allow us to determine whether the strong correlations we obtained earlier from the CCT were due to chance or whether the CCT's are the best format for use in determination of water quality.

APPENDIX A

NEW METHODS OF EXTRACTING STRUCTURAL GEOLOGIC INFORMATION FROM LANDSAT IMAGERY

Rex Peterson
Remote Sensing Coordinator
Conservation & Survey Division
University of Nebraska - Lincoln, NE 68588

Although this interpretive technique was developed with LANDSAT satellite imagery (formerly ERTS), it works with other images, including high-altitude aircraft photos, conventional aerial photos, and radar images. The key to the technique is to use many-sided polygons as clues to find lineaments and to rank them in importance. To delineate sufficient polygons for this technique it is necessary to view imagery with combinations of Fresnel lenses, reducing lenses, Ronchi rulings (diffraction gratings), magnification, and color filters. Recommended combinations are two reducing lenses used together, a reducing lens and a Fresnel lens together, a reducing lens and a Ronchi ruling together, and a reducing lens and a reading glass together. Gray, blue, and red diazachrome filters should be used with all of these lenses. Lenses and filters should be rotated every few minutes while examining imagery. A light table to back-light images, even prints, is recommended; and a mask should cover all light from the table except that passing through the image. It is also advisable to darken the room while examining images. Recognition of polygons on imagery is often a matter of graytone thresholds, so the intensity of light should be varied.

The study of lineaments on aerial photos, space images, and radar imagery has been handicapped by the lack of a means of ranking lineaments in order of importance. Figure 1 shows lineaments drawn from several Landsat images of one LANDSAT frame, 110 miles on a side. Although trends and numbers of lineaments are shown, the information is of little value because there is no way of telling, from the diagram, which lineaments represent major faults and which insignificant joints.

By contrast, in Figure 2 lineaments are ranked in order of importance and lineaments considered insignificant have been eliminated from the map. This map, which was prepared by the author for a siting study shows lineaments in a 50 mile radius of a proposed nuclear generating plant. The map was compiled from LANDSAT images, but an analysis of Skylab imagery, by techniques described in this paper, gave the same results. After plotting the lineaments by the polygon method described in this paper, they were located on small scale aerial photo mosaics. It was also possible to locate and follow them in an aircraft at 10,000 feet.

The basis for the technique of locating lineaments and ranking them is a series of polygons. Although the origins of these polygons are unexplained and beyond the scope of this paper, it can be stated that the earth appears to be composed of a series of polygons which can be used to interpret geologic structure.

In the polygon hypothesis, advanced in this paper, it is assumed that circles (or many-sided polygons) are natural features of the earth's crust and that they appear in a heirarchical range of sizes. When viewed through reducing lenses, the LANDSAT mosaic of the United States shows many circles 400 miles or more in diameter. An excellent example is the polygon that includes the Great Basin with the east edge of the polygon bounding the Wasatch Front and the west side bounding the Sierra Nevadas. This polygon can be divided into several smaller polygons and each of those polygons into smaller polygons. The division can be continued using individual LANDSAT images and then aerial photographs.

It is postulated that each polygon can act as a structural unit in response to internal and external stresses. Strain appears to be localized along the edges of polygons; and the larger the polygon, the greater the strain at its edges. Strain at the edges of polygons results in weaknesses in rock, which may be exhibited on the landscape as stream courses, differential erosion, breaks in topography, vegetation differences, soil differences, or some other tonal anomaly. It is the evidence of strain at the edges of polygons, expressed in the landscape, that we call lineaments. It is the relationship between the size of a polygon and the lineament that bounds it that makes possible a ranking of lineaments.

Figure 3 shows a grid with several circles of various sizes. If more straight lines, including diagonals, were added, an approximation of a circle could be formed by using only straight line segments. At small scales the eye generalizes many-sided polygons to circles. For example, a laccolithic dome in northeastern Wyoming appears as a multi-sided polygon (Figure 4) at a scale of 1:6,000, but as a circle at smaller scales. In this paper many-sided polygons are generalized to circles in figures and, in some cases, terminology.

Examination of Figure 3 shows that circles can be drawn in one square, four squares, or eight squares. More squares could be added to increase the size of circles and the number of circles in the hierarchy. Furthermore, the spacing of circles can be altered so that circles overlap while the size of circles remains the same. The result may seem to be a very complex arrangement of circles, but there is order in the arrangement because the circles are arranged in a grid pattern and there is a hierarchy of sizes. The same order appears to be present in the circles that fill the earth's surface.

Some rules for interpretation of structure can be illustrated with Figure 3, although to avoid a diagram that is too complex the full range of sizes and the overlapping of circles encountered in the real world is not shown. Lines passing between large circles should be considered more important than lines passing between small circles. Straight lines (lineaments) may bound circles in any of the cardinal directions, as shown in Figure 3. In the real world the orthogonal grid can be oriented differently than along cardinal directions, but one should always look for an orthoganal grid as an aid to interpretation. Lineaments may bisect a circle or transect it half way between the center and the outside. Which lineaments are major in an area depends on the local geology, but the arrangement shown in Figure 5 is common. This is a combination of lines bounding circles, a bisecting line, and a line passing half way between the center and the outside of a circle. In rank the last-mentioned line would be least important compared with the other types of lines. Where different sizes of polygons are present, lineaments bounding the largest polygons are the most important. Lineaments that bisect polygons rank next. In many cases the bounding polygon is so large that it does not all appear on one image, even on LANDSAT, so the lineament that bisects the largest polygon on the frame should be considered dominant.

The following illustrations depict the application of the polygon method. Several illustrations are taken from U.S. Geological Survey Professional Paper 373 to illustrate applications on stereopairs that are readily available. When mapping polygons with stereopairs, it should be remembered that some polygons are more visible on one photo than on its mate, so even though tracing is done on only one side of the model, both sides should be examined with Fresnel lenses, reducing lenses, etc. besides the stereoscope. Figs. 6 & 7 show faulted, horizontal sedimentary rocks in Utah with known faults shown in heavy lines. Note the grid-like pattern of circles and the method by which faults bisect and bound circles. (Pages 156, 157, USGS Prof. Paper 373)

Figure 8 shows known faults in Alaska where a dam is built along a fault. Note the two concentric circles truncated by the fault. The fault followed by the stream below the dam bounds circles and bisects a large circle whose right edge extends through the center of the photo. (From page 218, USGS Prof. Paper 373)

Figures 9 and 10 were drawn from high altitude aircraft images published by Johnson, Miller, and Englund (Application of Remote Sensing to Structural Interpretations in the Southern Appalachians) in the USGS Journal of Research for May-June, 1975. Circles drawn from their aerial photos show the Canebrake fault (Figure 9) bisecting several circles of various sizes and bounding a large circle. The Canebrake fault has been traced for about 20 miles in southwestern Virginia and southern West Virginia. Figure 10 shows the Coeburn fault which has also been traced on the ground (for almost 24 kilometers) in Virginia. In this case the lineament bisects several concentric circles and bounds several smaller circles.

Figure 11 shows the Wasatch Front, Great Salt Lake, and Utah Lake in heavy lines. This tracing is from LANDSAT prints at 1:1,000,000 scale. The east edge of the Great Basin polygon, visible on the LANDSAT mosaic of the western United States, extends along the Wasatch Front. Local deviations in the Front follow smaller circles and bisect circles. Faults controlling local geology are related to polygons visible on this frame. Polygons shown here are only a few of the many visible on LANDSAT images of this area.

Figure 12 was drawn from the LANDSAT mosaic of California. The San Andreas fault is shown by a heavy line which bisects several circles. Very small circles shown along part of the fault occur on entire length but are shown here in only one portion. These small circles are most abundant along the fault and decrease rapidly away from the fault. Since they are visible along many faults, they can be used to delineate unknown faults with the preparation of polygon diagrams. (Fig. 12 was printed in reverse by mistake.)

Figure 13 (from page 154 of USGS Prof. Paper 373) illustrates a ring dike in New Hampshire. The ring dike is shown in heavy lines, although there is nothing strikingly perculiar in the pattern of circles to distinguish the ring dike from many other circles in the area. Note that the landscape is covered with circles of various sizes, which is a common pattern.

Figure 14 is a tracing from the LANDSAT mosaic of the Meteor Crater area in Arizona. Note the Circles of various sizes and the grid-like arrangement of the circles, which is again the common pattern. The black dot near the center of the figure is Meteor Crater. Some small circles have been delineated in that area for size comparison, but these circles appear throughout the area. There does not appear to be anything distinctive in the basic, overall circular geometry of this area. The impact crater appears as a superficial addition tothe landscape, which does not alter the basic geometry of circular patterns. Glacial landforms and eolian features have similar relationships to basic circular geometry; they form a superficial covering that does not change, or really obscure the basic circular geometry.

Figure 15 illustrates some of the circles visible on a stereo-pair of an area in Alaska. Note the typical grid-like arrangement of circles. A small area of patterned ground, common in floodplains in the area, is shown as a concentration of polygons which are different in size, shape, and pattern from the basic circular features.

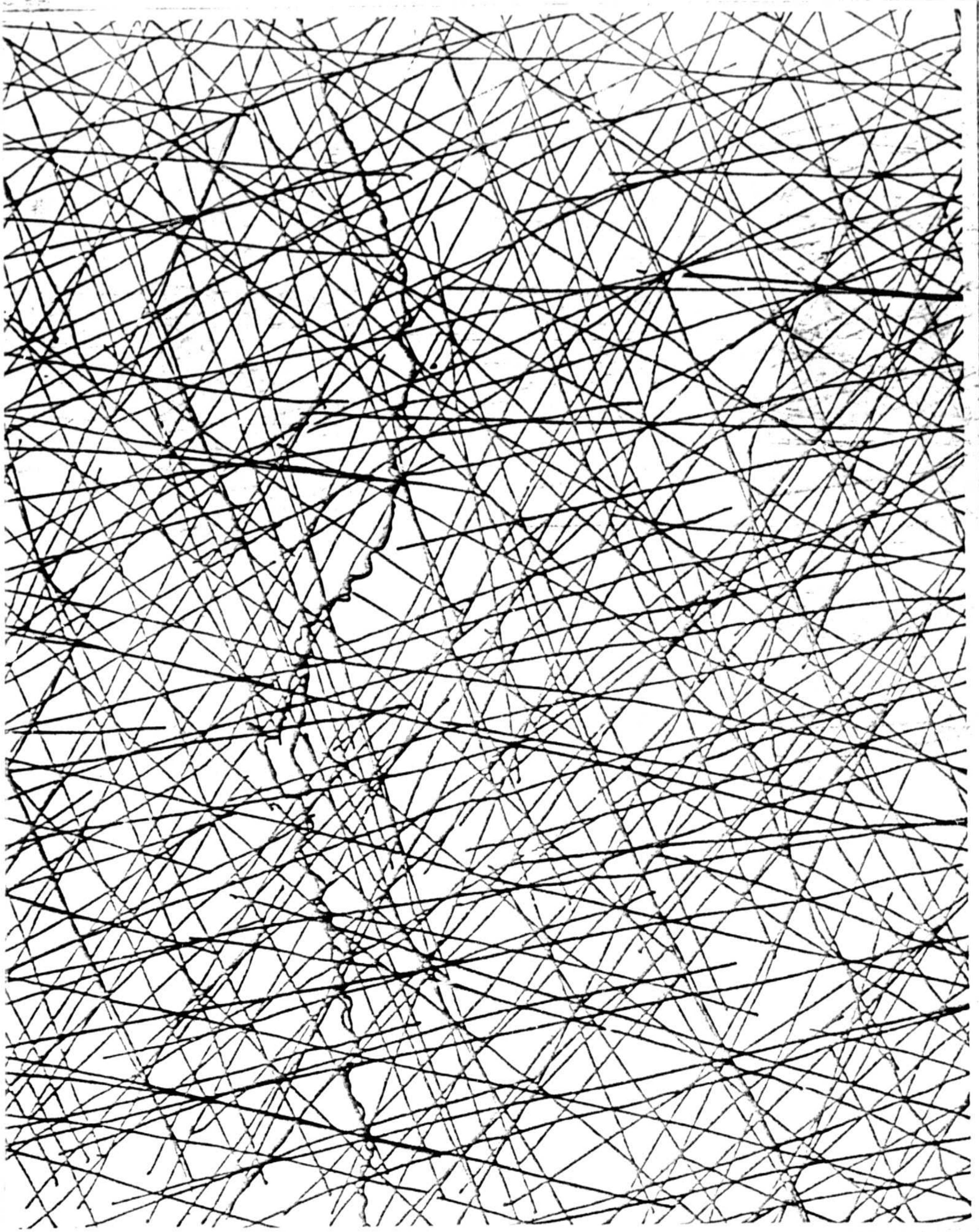
Figure 16 illustrates lines drawn on a 1:1,000,000 scale LANDSAT image of Nebraska with the aid of lenses and filters previously described. This figure depicts one stage in the compilation of several overlays of the same area.

Figure 17 is the same area as Figure 16 but more overlays have been added. For interpretation the overlays are projected onto a map at 1:250,000 scale and lines are plotted on the map. A reducing lens is helpful in sorting out the main patterns in this diagram.

Figure 18 is an aeromagnetic map of southwestern Nebraska (see E. R. King and I. Zietz, Geol. Soc. Amer. Bull. v. 82, no. 8, p. 2187-2208). The heavy lines added to the map represent major lineaments interpreted from diagrams (similar to Figure 17) derived from LANDSAT imagery. The correspondence of lineaments derived from LANDSAT by the polygon method with aeromagnetic patterns is rather striking.

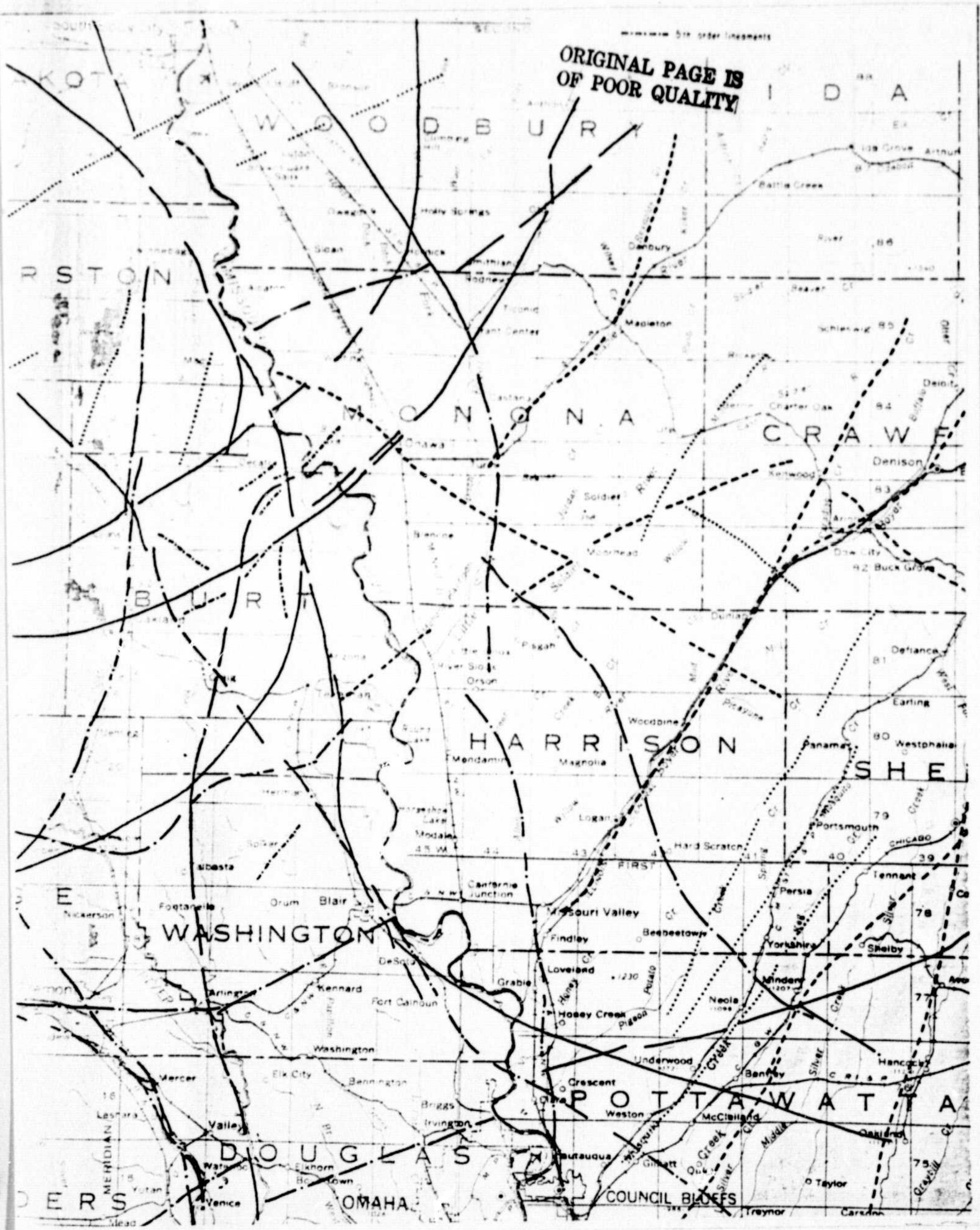
Figure 19 is a map of an oil-producing area in southwestern Nebraska and adjacent parts of Kansas. The area shown is one LANDSAT frame, 110 miles on a side. Hundreds of oil wells have been drilled in this area, so it is possible to compare location of producing wells with structures interpreted from LANDSAT. The heavy lines represent major lineaments, bounded by the largest polygons on the LANDSAT frame. Existing oil <u>fields</u>, indicated by X's, tend to lie at intersections of major lineaments or along the lineaments. Many dozens of wells drilled away from the intersections were dry holes. Areas that are blanked out on the map are distinct on LANDSAT. Extensive drilling in these areas yielded no oil, so such areas, recognizible on LANDSAT, could be given low priority in searches for new oil fields. The map shows a number of intersections, similar to those that are oil-bearing, where there has been no drilling. On the author's advice leasing and drilling will soon take place on one of these. It should be noted that the lineaments shown on this map were not mapped previously by other means; they are derived from LANDSAT by the polygon method. As a check on the lineaments, a structural contour map, prepared from subsurface data in Red Willow County, Nebraska, was compared with the LANDSAT lineaments. Three LANDSAT lineaments that separated oil fields lined up very well with the V's in structural contour lows.

SUMMARY. -- The polygon method for interpreting images of various types is based on a hierarchical order of polygons. These polygons, usually generalized to circles, range in size from hundreds of miles across to tens of yards across. Each polygon can be considered as a semi-autonomous block in the earth's crust. Strain is maximized at the borders of each block. The larger the block, the greater the liklihood of strain and rupture at its edges. Large polygons, such as the Great Basin polygon, are bounded by major faults. By associating lineaments and polygons, lineaments can be ranked in importance. The assocation of polygons and lineaments also facilitates the mapping of lineaments where they are not visible, because polygons can often be mapped more readily than lineaments. For interpretation by the polygon method it is necessary to first map polygons with a combination of colored filters and Fresnel lenses, reducing lenses, Ronchi rulings, and magnification. Interpretation of multiple overlays of LANDSAT images can be complex, but no more complex than many other techniques used by geoscientists.



PRECEDING PAGE BLANK NOT FILMED

Fig 1



5th order lineaments
WOODBURY
IDA
MONONA
CRAWF
HARRISON
SHE
POTTAWATTA
BURT
WASHINGTON
DOUGLAS
RSTON
DERS
Battle Creek
Danbury
Mapleton
Castana
Charter Oak
Denison
Soldier
Moorhead
Dow City
Buck Grove
Dunlap
Defiance
Earling
Woodbine
Westphalia
Panama
Mondamin
Magnolia
Logan
Portsmouth
Modale
Hard Scratch
California Junction
Missouri Valley
Persia
Tennant
Blair
Fontanelle
Nickerson
Beebetown
Yorkshire
Shelby
Findley
Loveland
DeSoto
Kennard
Fort Calhoun
Honey Creek
Neola
Minden
Arlington
Washington
Underwood
Hancock
Mercer
Elk City
Bennington
Crescent
Weston
McClelland
Oakland
Valley
Irvington
Briggs
Elkhorn
Gilliatt
Taylor
Venice
Yutan
OMAHA
COUNCIL BLUFFS
Treynor
Carson
MERIDIAN

Fig 2

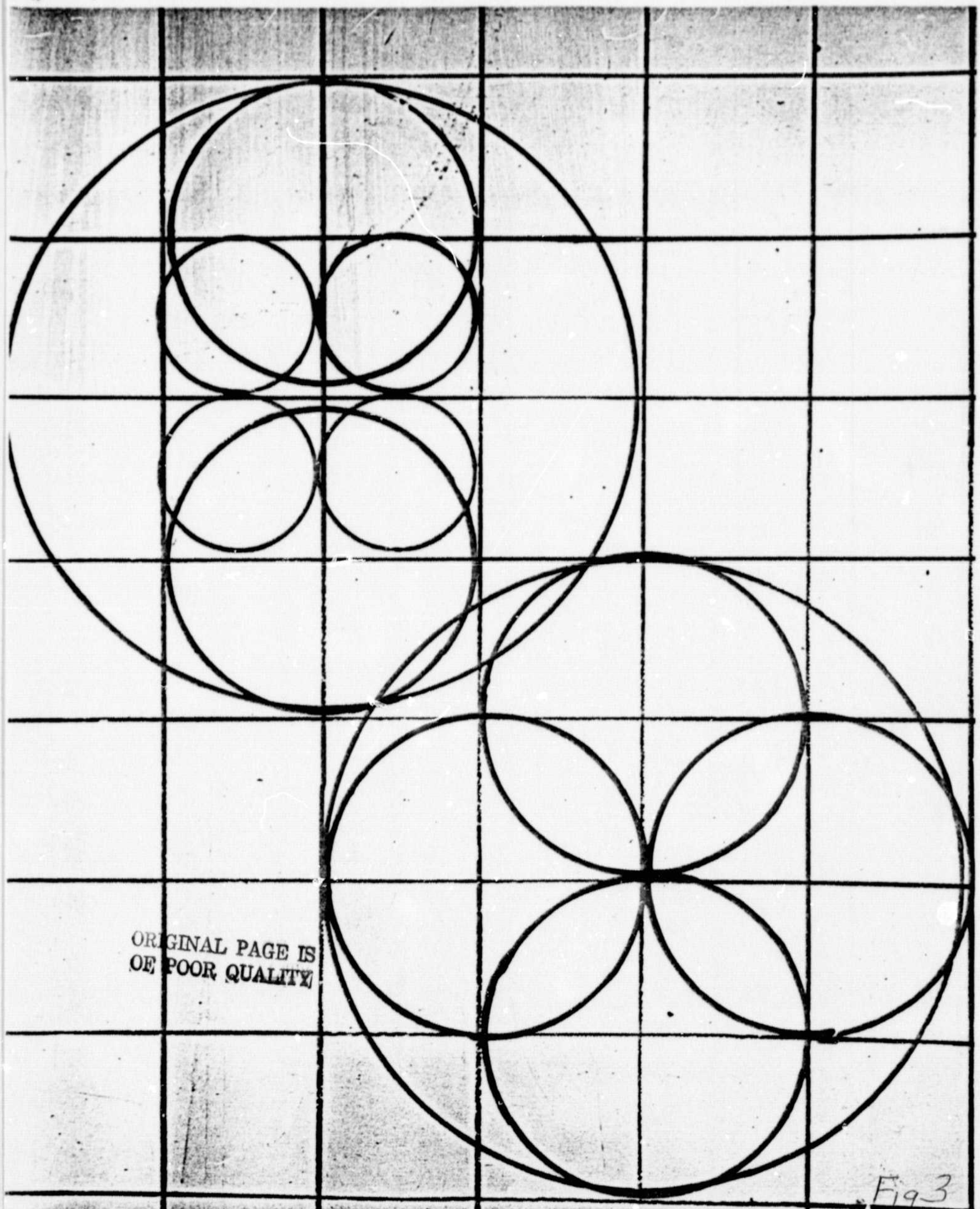


Fig 3

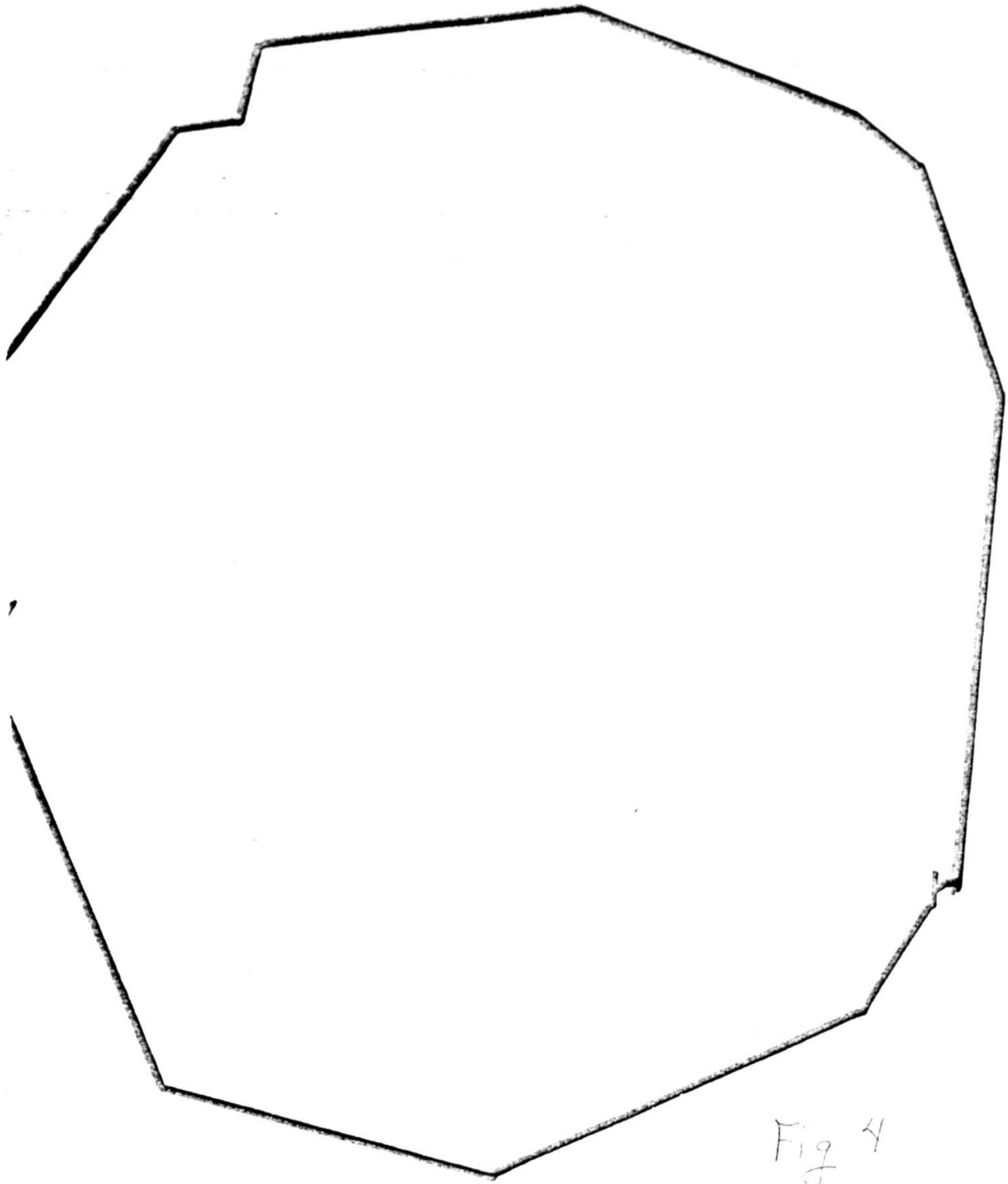


Fig 4

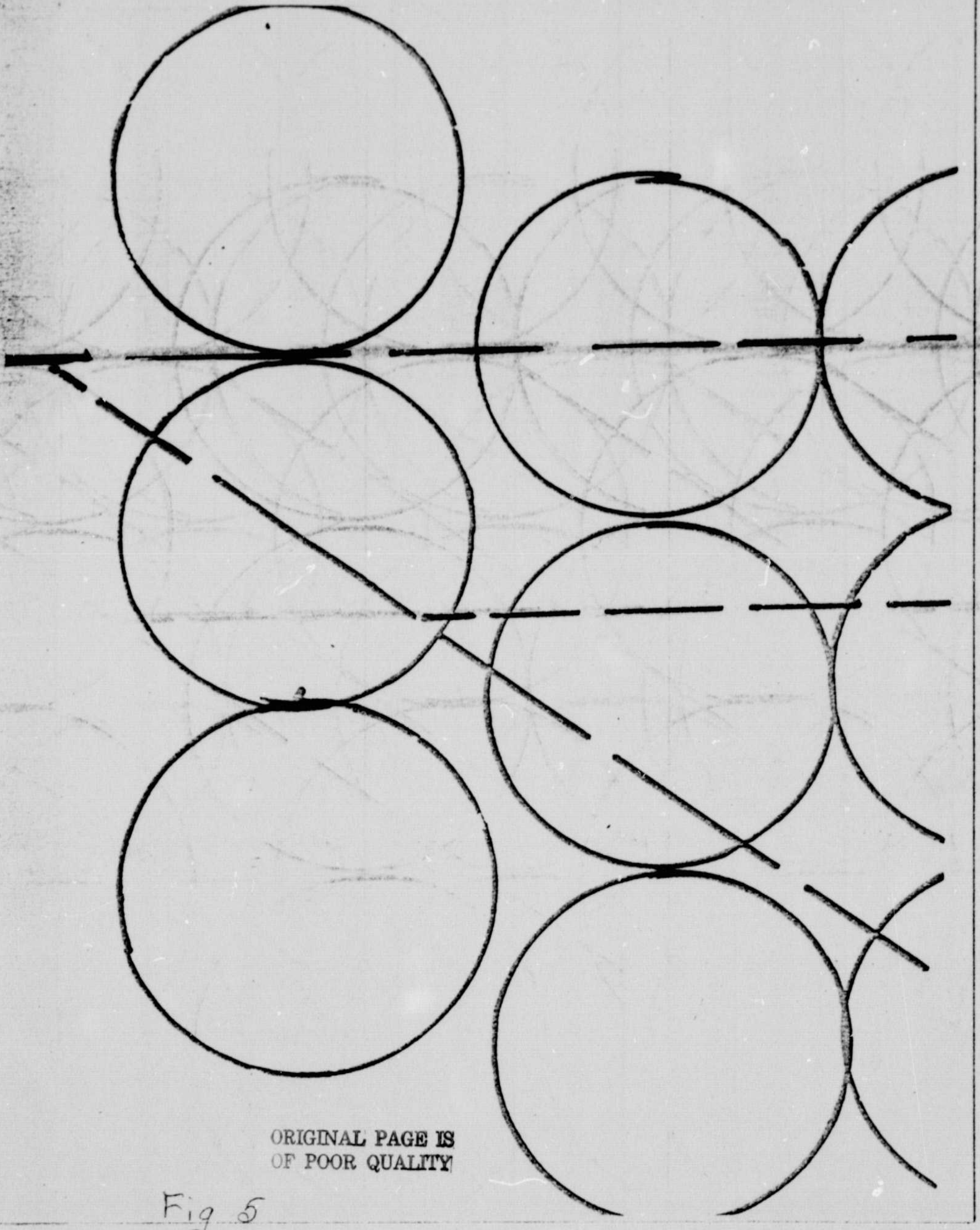


Fig 5

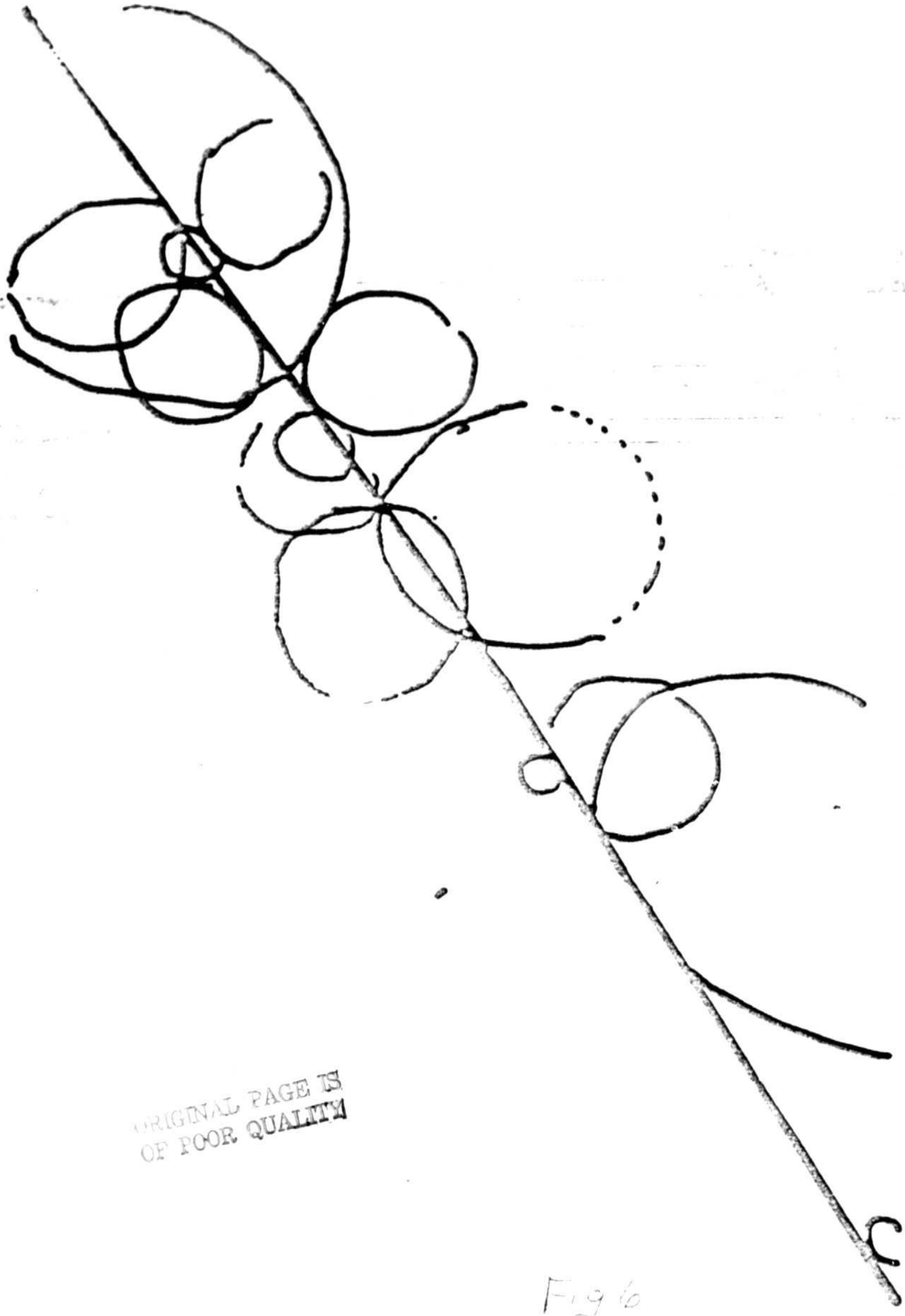


Fig 6

Fig 7

Illustration printed in reverse. Sorry.

Figure 8

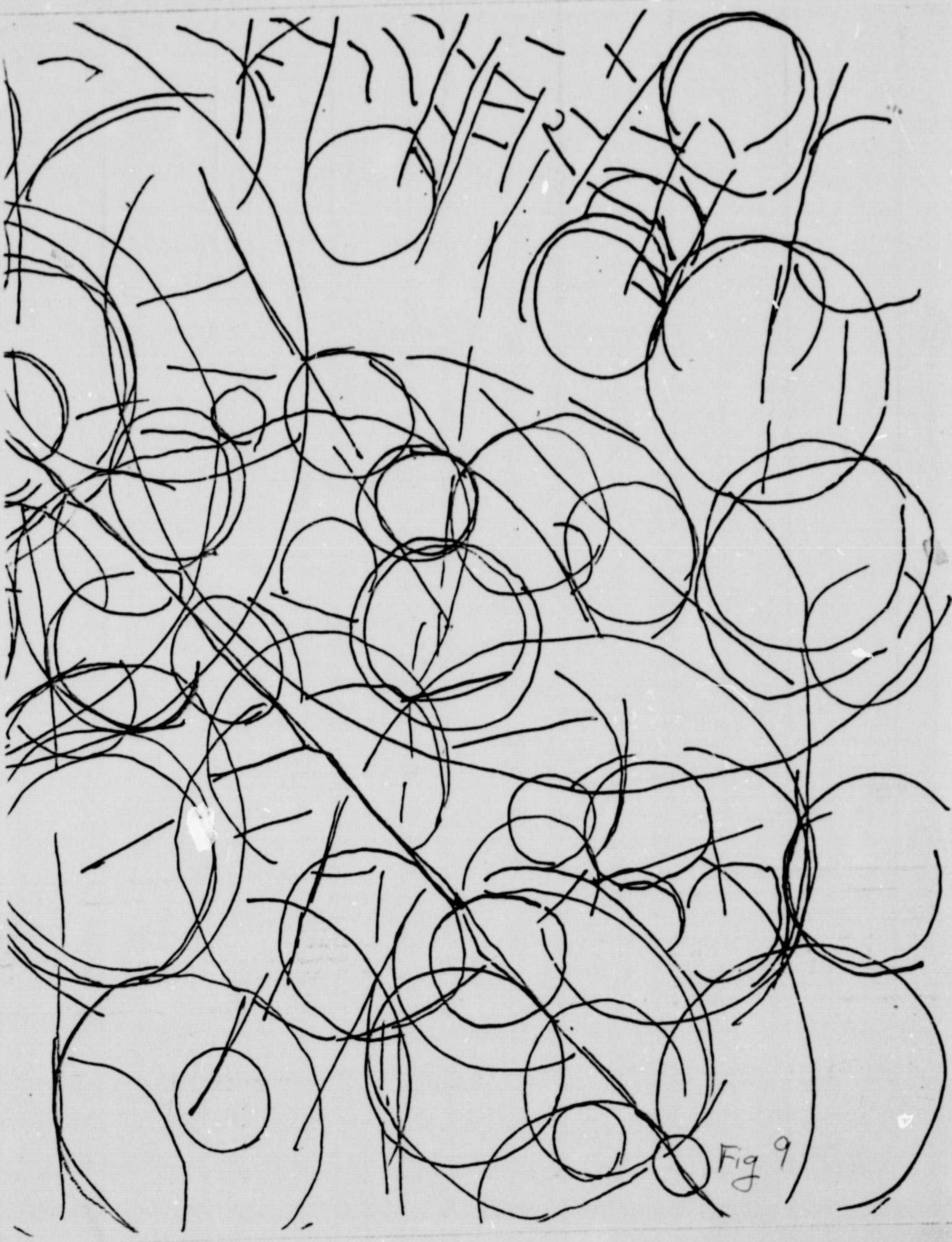


Fig 9

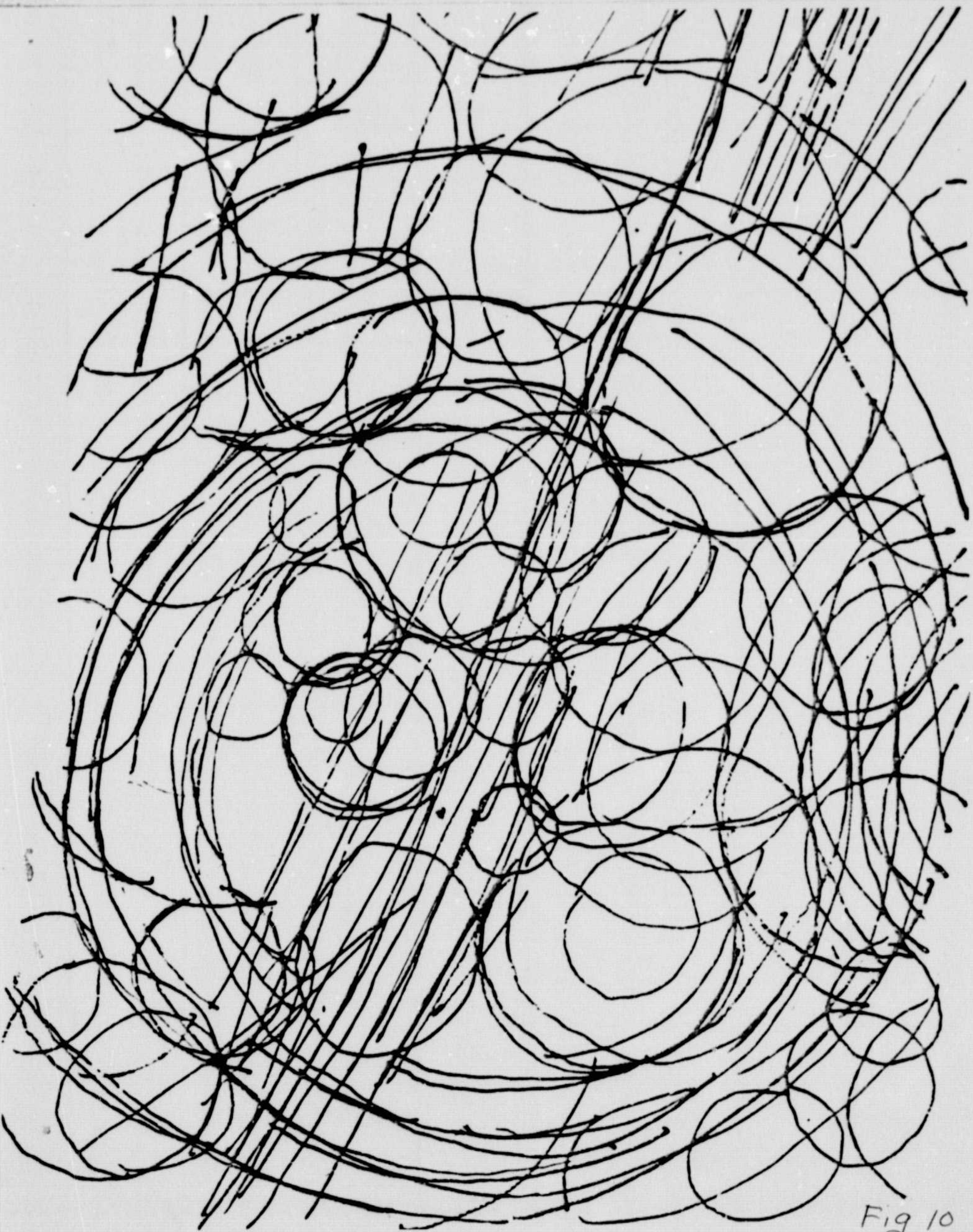
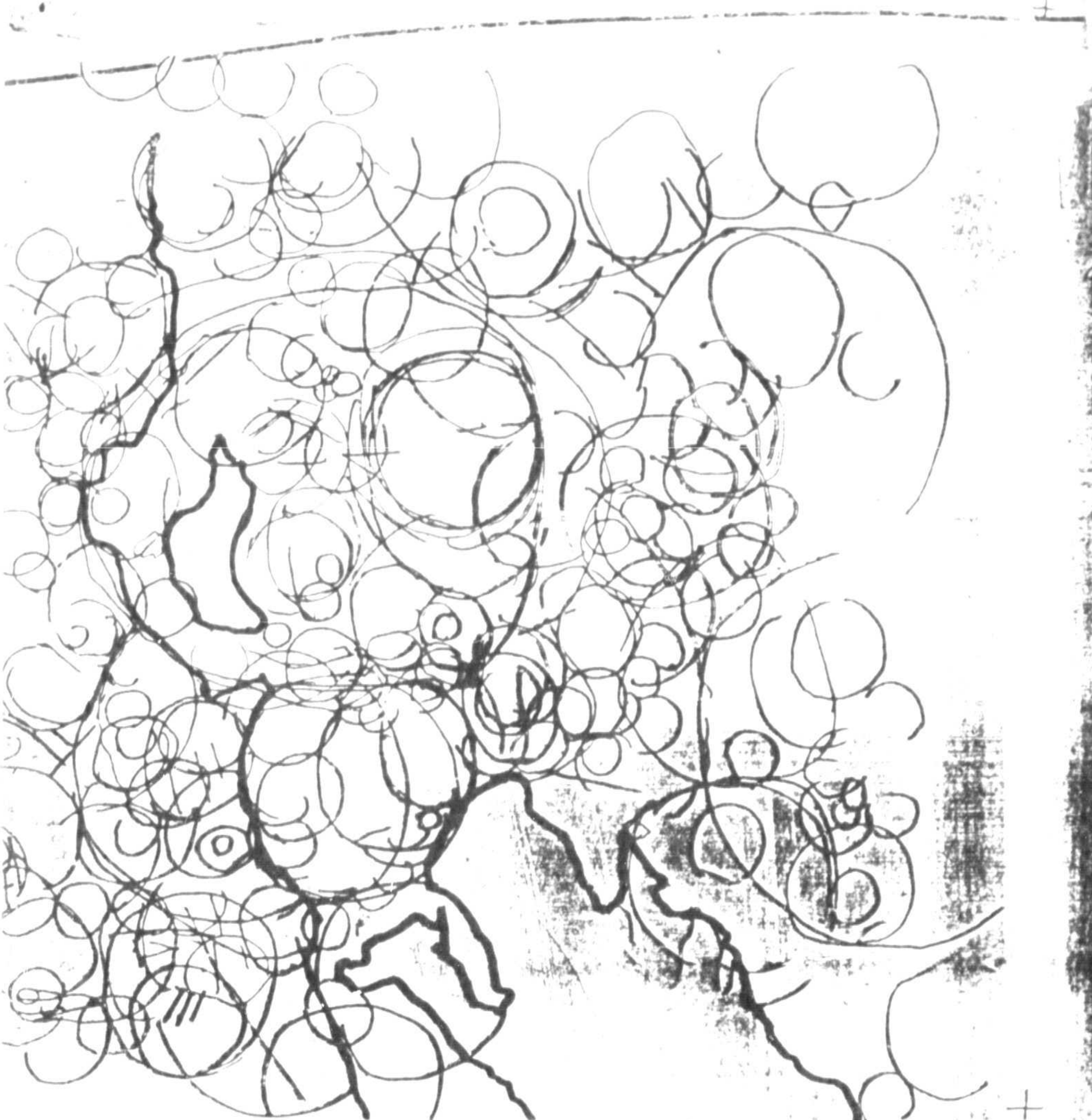
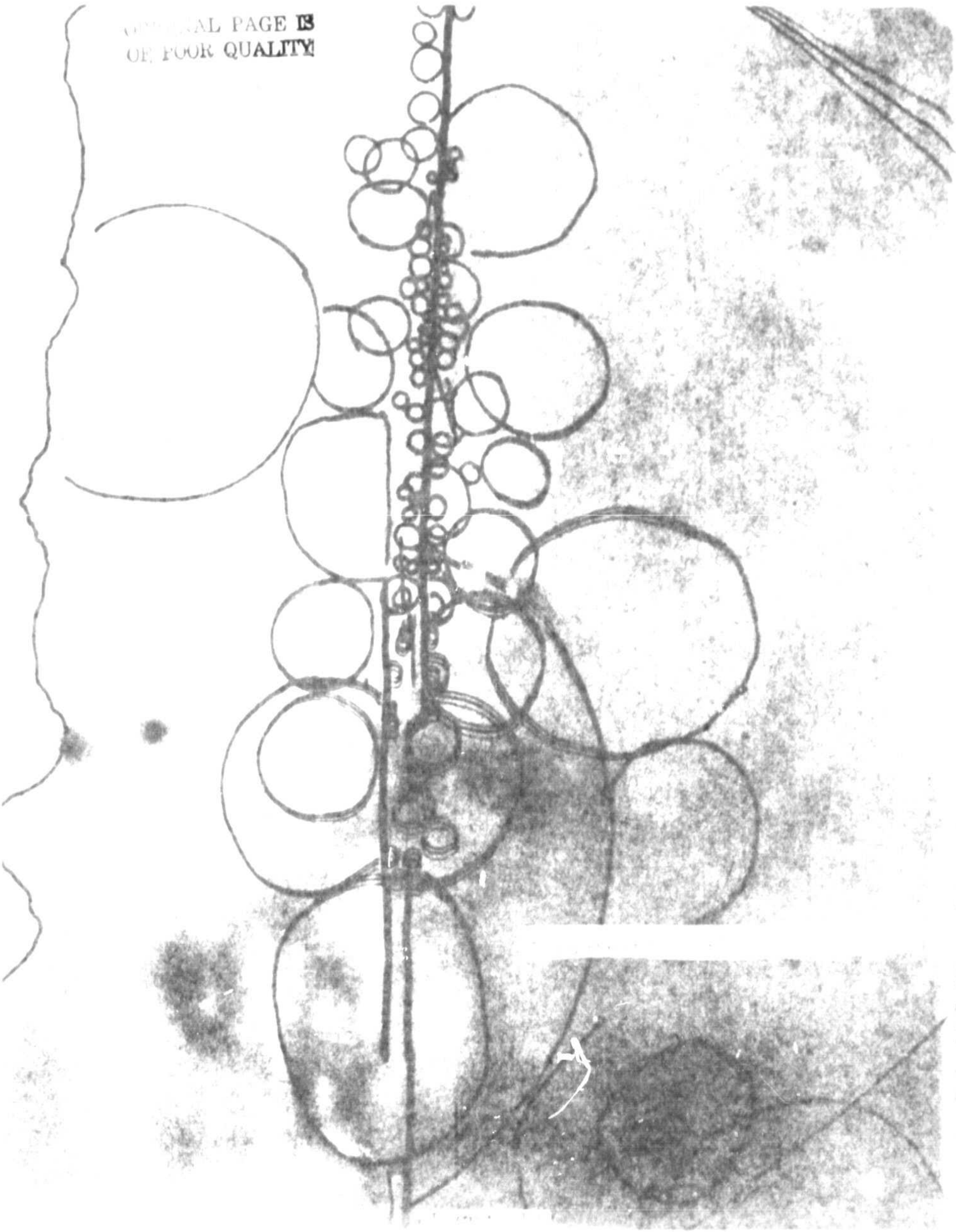


Fig 10





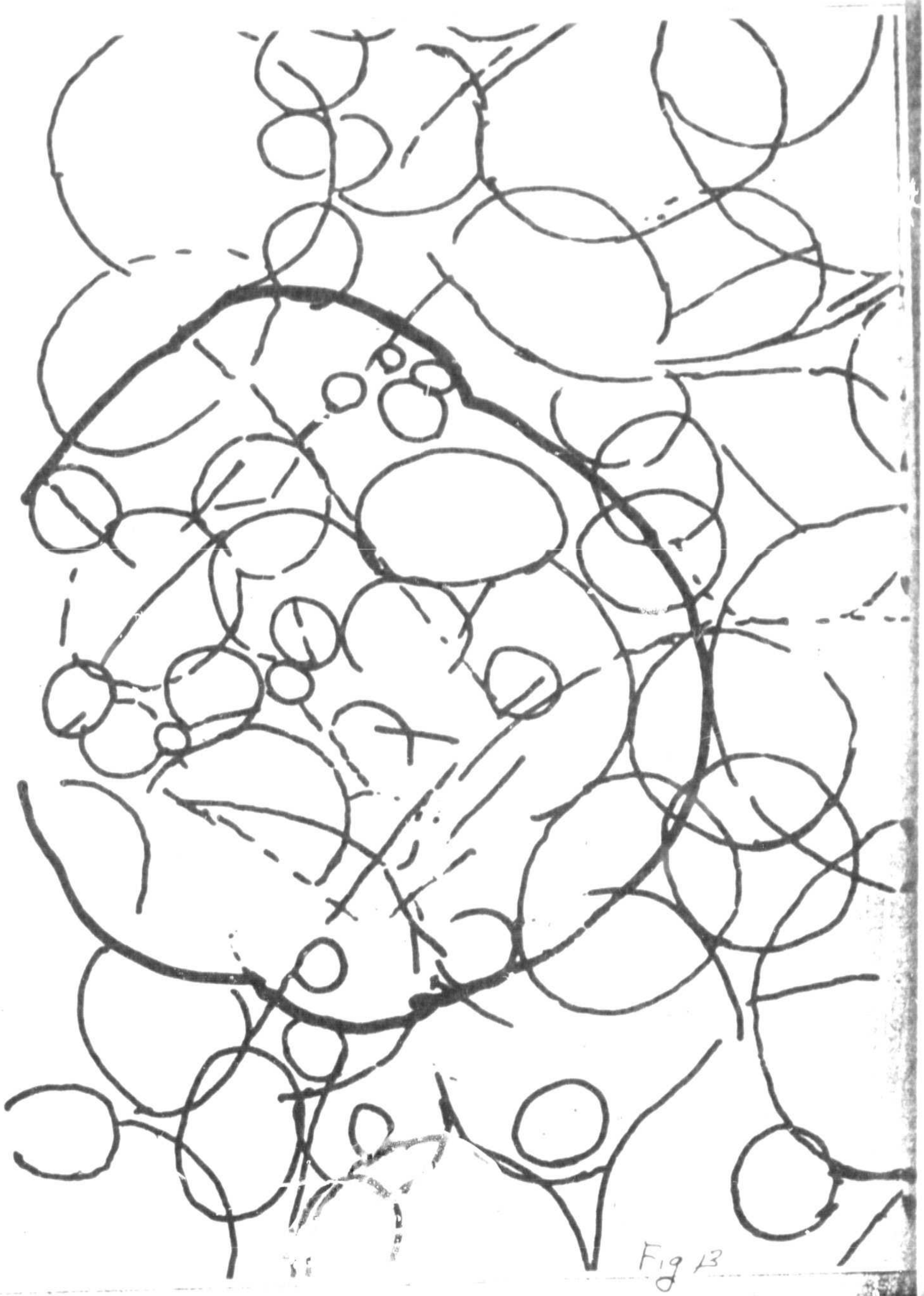


Fig 13

Fig 14

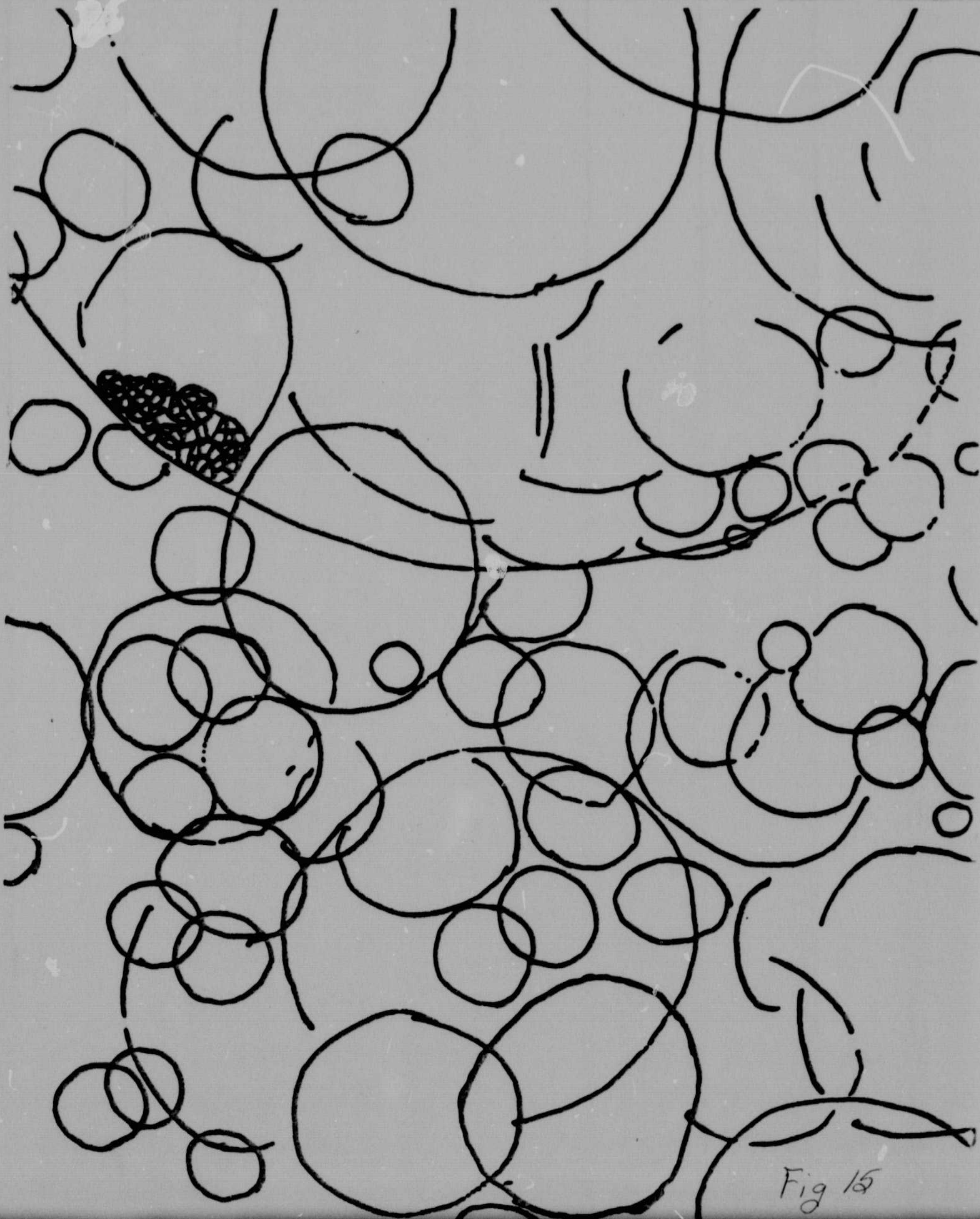


Fig 15

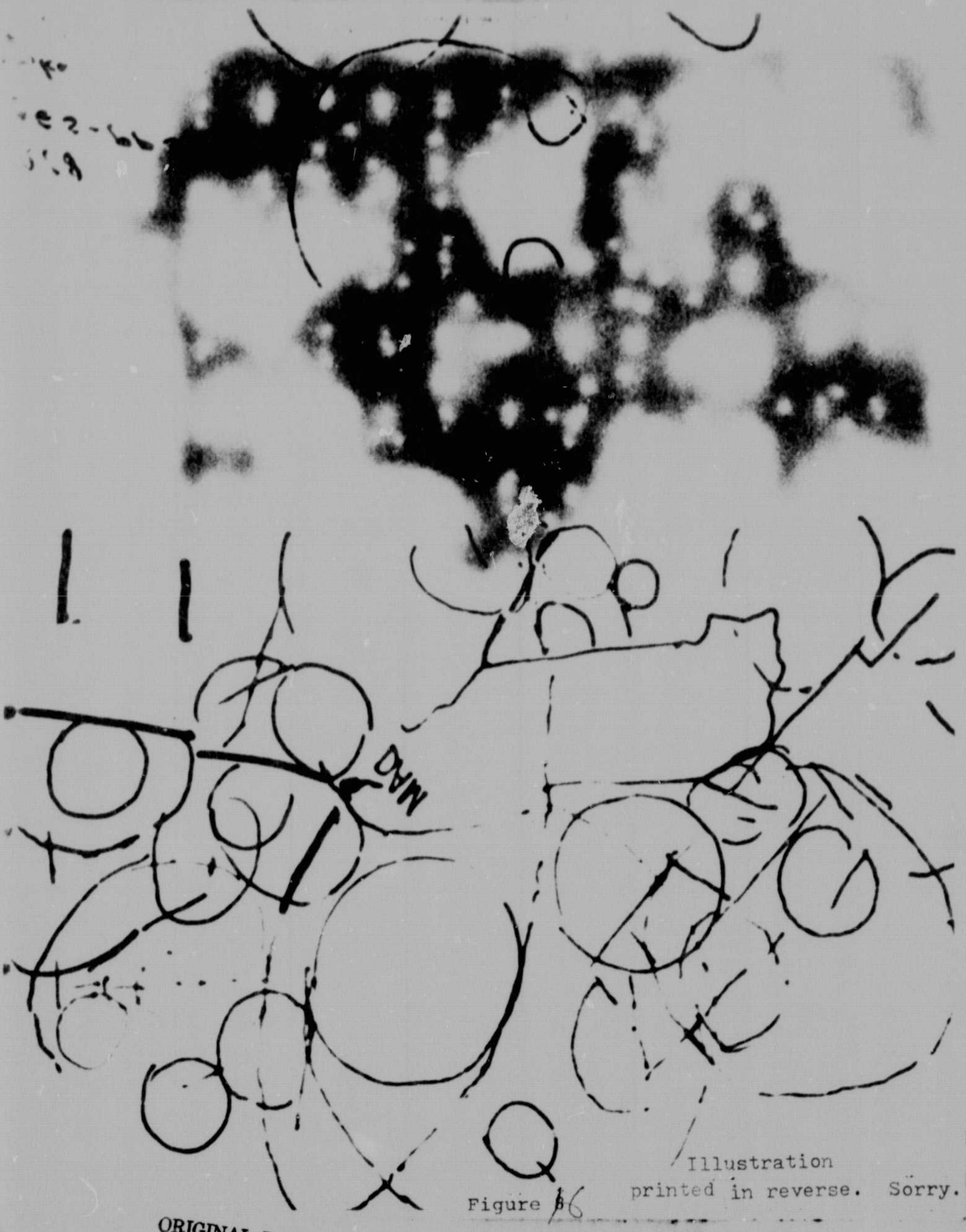


Illustration printed in reverse. Sorry.

Figure 16

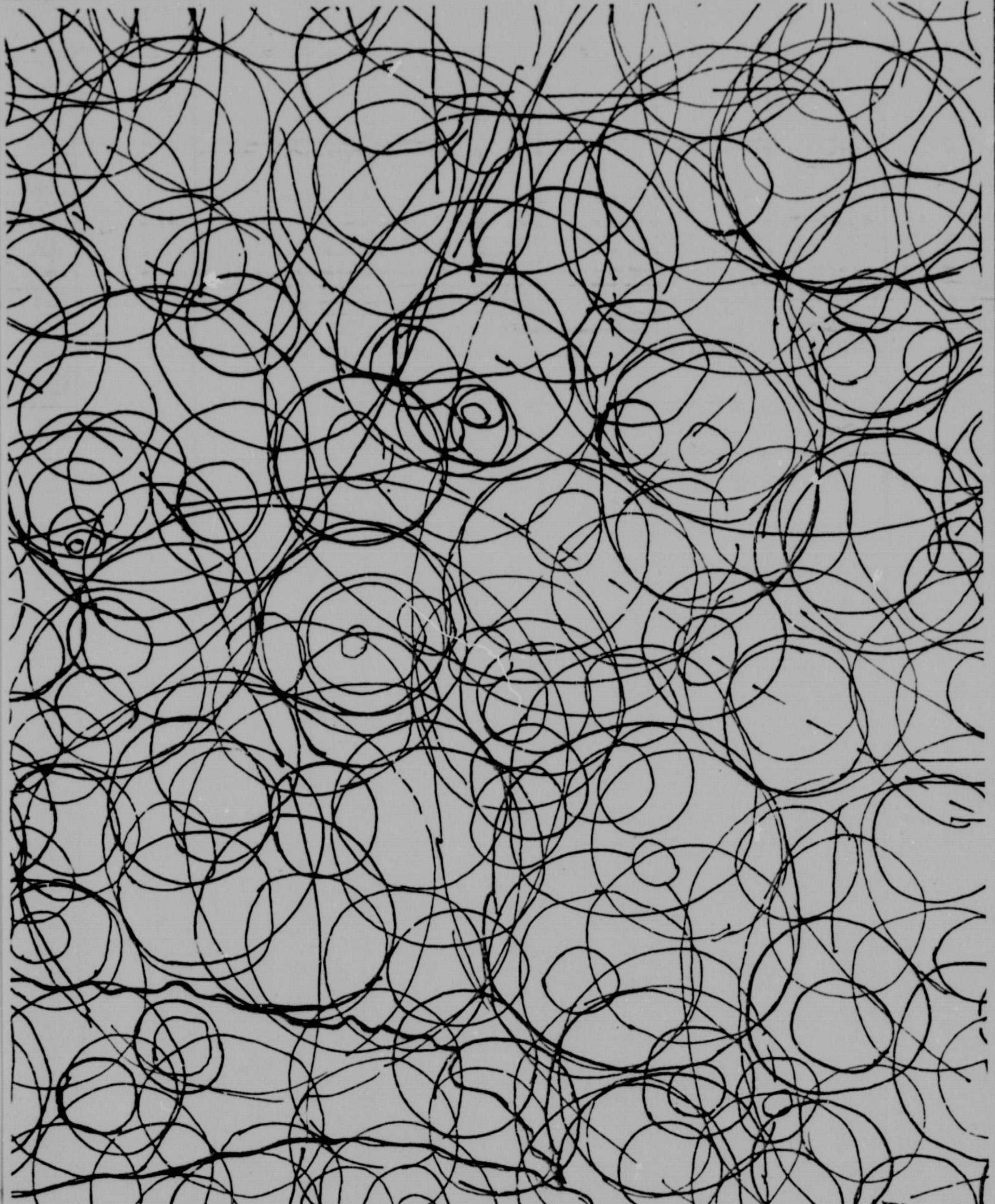


Fig 17

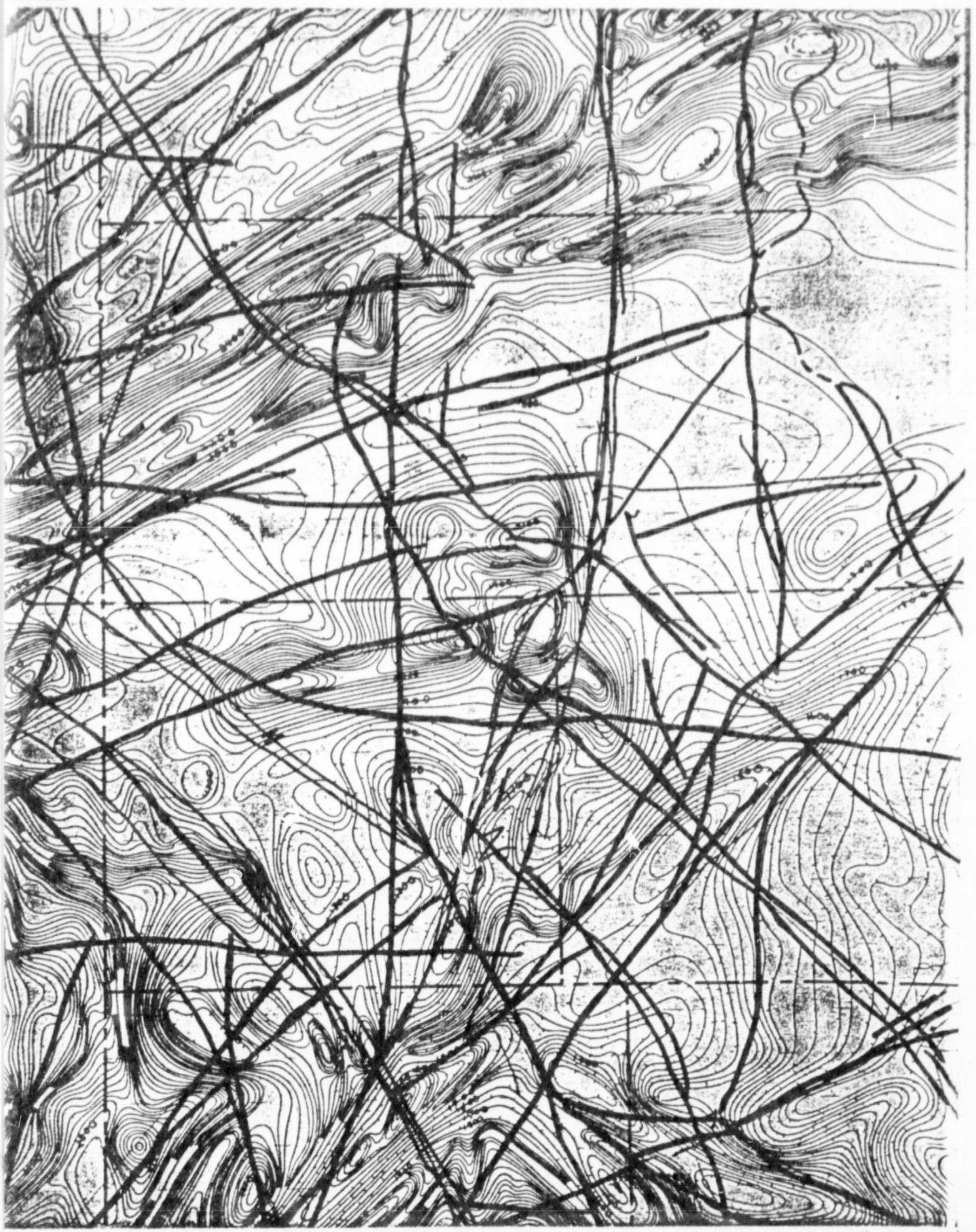


Fig 18

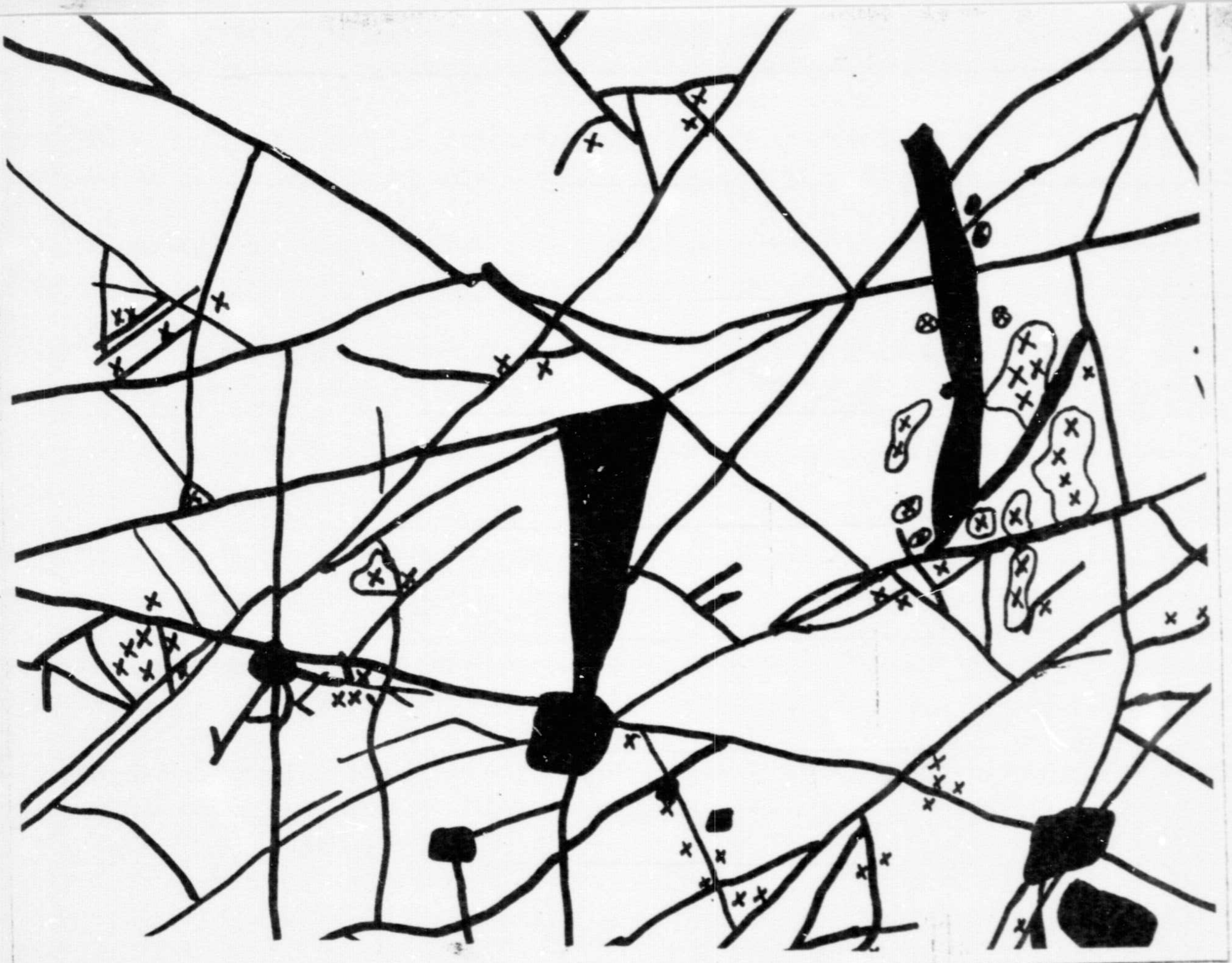


Fig 19

Nebraska Farmer

VOL. 117, NO. 6 MARCH 15, 1975

Photo 1 . . . farmland southwest of Grand Island.

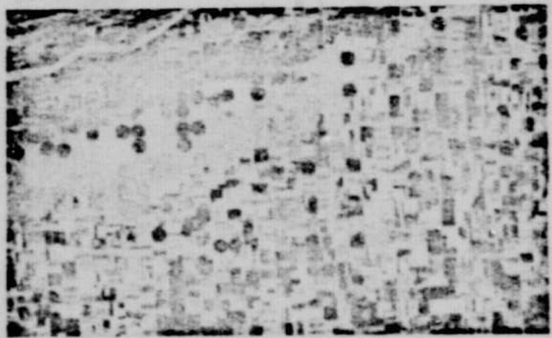


Photo 2 . . . contrast between irrigated and non-irrigated land.

Photo 3 . . . effects of the low water level in the Platte.

Irrigation inventory taken by satellite

By Dr. PAUL SEEVERS
Department of Agronomy
University of Nebraska

LAST summer's drouth gave researchers an opportunity to accurately inventory irrigated land in Nebraska.

Pictures taken by the Earth Resources Technology Satellite (ERTS) differentiate irrigated from non-irrigated land by shades of grey. The dark tones of irrigated lands are prominent because lack of moisture in non-irrigated areas resulted in little or no plant growth.

Photo 1 shows an area southwest of Grand Island where there is a mixture of gravity and center pivot irrigation along with non-irrigated farming. For most fields it's fairly apparent which are irrigated and which aren't.

Photo 2 is an area just west of Grand Island. The Platte valley is almost solid irrigation where the uplands are almost all non-irrigated.

Photo 3 shows Grand Island and the Ordnance Depot. Note that the river channels of the Platte River are less dark in tone, indicating less than adequate water for the grasses in that area because of the drop in water table during high water use.

The greater contrast between irrigated and non-irrigated farms shown in 1974 enabled investigators to identify irrigated land with greater accuracy than in non-drouth years. The geometric form of the center pivots became more noticeable, especially where corners weren't watered. Boundaries between irrigated and non-irrigated fields were more obvious also.

A comparison was made between visual interpretation of satellite pictures for irrigated fields and Soil Conservation Service listing of irrigated fields for a portion of the Blue River Basin. Interpretation error was less than 2%.

This inventory reflects both the water consumption and energy requirements for the area. It used to take years to get a similar inventory, resulting in inaccurate figures because of rapid irrigation expansion. ■

Nebraska Farmer

Lincoln Journal May 21, 1975

NU Gets $200,000 Grant Renewal

Satellites Aid Resource Care

Remote sensing with earth resources satellites was characterized Wednesday as a refined scientific tool that will prove increasingly valuable to Nebraska citizens in the management and discovery of natural resources.

Dr. Rex M. Peterson, remote sensing coordinator for the University of Nebraska NU Conservation and Survey Division, said remote sensing has proved exceptionally valuable during the three-year lifetime of Landsat-1, the first such satellite, and should be even more useful with the recent launch of Landsat-2.

Other speakers at a workshop pointed out that remote sensing has many direct uses in Nebraska, such as inventoring center pivot irrigation units, forage yields, irrigated land, land use and wetlands.

Other uses include measuring the impact of irrigation on the state's farmland, locating underground water supplies, increasing the efficiency of land appraisal and equalization of tax appraisals across county lines, urban planning and management of Natural Resources Districts (NRDs).

James B. Swinehart, NU research geologist, said remote sensing imagery is being used to identify fracture traces. These, in turn, are proving useful in locating high-yield water wells in Nebraska.

Dr. Richard O. Hoffman, of NU's College of Engineering and Technology, said use of remote sensing to inventory center pivot irrigation systems has disproved one common belief.

While it has been generally assumed that a sizeable number of center pivot wells are not registered, he said, remote sensing has shown that almost all installed systems have operated out of registered wells.

Dr. James V. Drew, NU dean of graduate studies and principal investigator of the National Aeronautics and Space Administration (NASA) remote sensing grant, told the workshop that NU's grant for remote sensing has been continued at $200,000 for June 1, 1975 to May 21, 1977.

Nebraska Farmer

VOL. 117, NO. 6 MARCH 15, 1975

Photo 1 . . . farmland southwest of Grand Island.

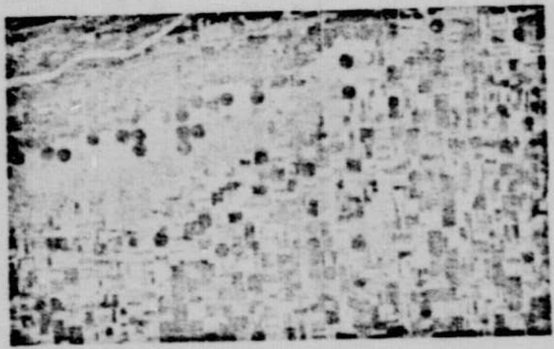


Photo 2 . . . contrast between irrigated and non-irrigated land.

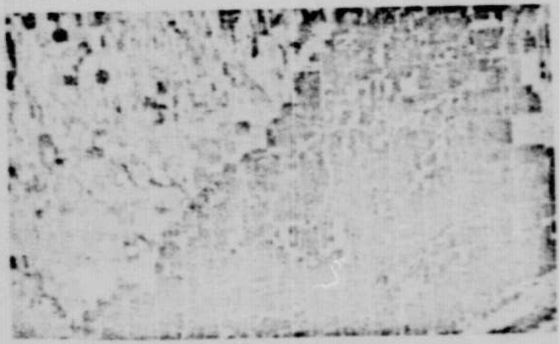


Photo 3 . . . effects of the low water level in the Platte.

Irrigation inventory taken by satellite

By Dr. PAUL SEEVERS
Department of Agronomy
University of Nebraska

LAST summer's drouth gave researchers an opportunity to accurately inventory irrigated land in Nebraska.

Pictures taken by the Earth Resources Technology Satellite (ERTS) differentiate irrigated from non-irrigated land by shades of grey. The dark tones of irrigated lands are prominent because lack of moisture in non-irrigated areas resulted in little or no plant growth.

Photo 1 shows an area southwest of Grand Island where there is a mixture of gravity and center pivot irrigation along with non-irrigated farming. For most fields it's fairly apparent which are irrigated and which aren't.

Photo 2 is an area just west of Grand Island. The Platte valley is almost solid irrigation where the uplands are almost all non-irrigated.

Photo 3 shows Grand Island and the Ordnance Depot. Note that the river channels of the Platte River are less dark in tone, indicating less than adequate water for the grasses in that area because of the drop in water table during high water use.

The greater contrast between irrigated and non-irrigated farms shown in 1974 enabled investigators to identify irrigated land with greater accuracy than in non-drouth years. The geometric form of the center pivots became more noticeable, especially where corners weren't watered. Boundaries between irrigated and non-irrigated fields were more obvious also.

A comparison was made between visual interpretation of satellite pictures for irrigated fields and Soil Conservation Service listing of irrigated fields for a portion of the Blue River Basin. Interpretation error was less than 2%.

This inventory reflects both the water consumption and energy requirements for the area. It used to take years to get a similar inventory, resulting in inaccurate figures because of rapid irrigation expansion. ■

Nebraska Farmer

 Omaha World-Herald, Thursday, May 22, 1975

Lofty View Shows Down-to-Earth Methods

WORLD-HERALD BUREAU.

Lincoln — Remote sensing was described here Wednesday as a refined scientific tool that will prove increasingly valuable in the management of Nebraska's natural resources and in the discovery of new resources.

Dr. Rex M Peterson, remote sensing coordinator for the University of Nebraska's Conservation and Survey Division, made this assessment during a workshop at Nebraska Center.

Remote sensing, he said, has already proved exceptionally valuable over the three-year lifetime of Landsat-1, the first earth resources technology satellite, and should prove more useful in the follow-on investigations that will be made possible by the recent launch of Landsat-2.

Grant Extended

WORLD-HERALD BUREAU.

Lincoln — The National Aeronautics and Space Administration (NASA) has extended a grant to the University of Nebraska-Lincoln to develop applications of remote sensing from both aircraft and spacecraft, it was announced here Wednesday.

The grant extension will provide $200,000 from June 1, 1975, to May 21, 1977, according to Dr. James V. Drew, principal investigator of the NASA University Affairs grant and NU dean of graduate studies.

supplies in the future. The project is scheduled to reach 95,000 families in Lincoln, Columbus, Beatrice, Norfolk and Sioux Falls, S D.

Dr. Paul M. Seevers, research agronomist with the Conservation and Survey Division, reported success in a three-year project aimed at relating vegetative biomass to satellite data.

Forage Yardstick

This refined scientific measurement of forage yield and density is expected to give an accurate and speedy method of evaluating actual forage in the field, he added, and prove useful in range management decisions by ranchers.

Dr. Leslie F. Sheffield, assistant to the vice chancellor of the Institute of Agriculture and Natural Resources, revealed how remote sensing is being used for measuring and forecasting the economic impact of irrigation in Nebraska.

Ms. Dee Meek, appraiser to the Nebraska Department of Revenue, said remote sensing is proving to be a great boon in the equalization of property appraisal across county lines.

Nebraska earlier operated on a 10-year cycle of updating tax values employing different values for land on two sides of a county boundary even though the land was being put to similar use.

Rapid Inventory

Now that appraisal values must be updated annually according to legislative statute, remote sensing fills a special need by offering rapid and accurate inventory of land use, she said.

This together with other factors, Ms. Meek said, will permit an annual review of appraisal values and equalization of tax appraisal across county lines.

A research geologist with the Conservation and Survey Division reported progress in using remote sensing to locate underground conditions that are conducive to high-yield water wells.

Wetlands Measured

James B. Swinehart said this method of locating wells had generated considerable interest throughout the state.

A project near completion, according to Kenneth Johnson of the Nebraska Game and Parks Commission, is an inventory of the state's wetlands. By early June, he said, the project would be in its drafting phase with the final result a detailed map showing all wetlands.

Satellite imagery is being used successfully to inventory center pivot irrigation systems and irrigated land, according to Dr. Richard O. Hoffman of the NU College of Engineering and Technology.

Two NASA officials from Washington, D.C., Frank Hansing and Joseph Vitale, attended the workshop.

Goal: Less Waste

One of the more imaginative uses of remote sensing was outlined by Clancy Woolman, marketing manager for Cengas. It involves the use of thermal scanning equipment on aerial flights made in winter to measure rooftop temperatures of homes as a check on heat loss through the ceilings.

The goal of the project, he said, is reduction of wasted energy and conservation of fuel

ORIGINAL PAGE IS OF POOR QUALITY

Natural Resources Use Aided by Space Flight

By JAY FUSSELL, University of Nebraska-Lincoln

LINCOLN — At a workshop here recently Dr. Rex M. Peterson characterized remote sensing as a refined scientific tool that will prove increasingly valuable to the citizens of the state in the management of Nebraska's natural resources and in the discovery of new resources.

Dr. Peterson, who is remote sensing coordinator for NU's conservation and survey division, told his hearers at the Nebraska Center for Continuing Education that remote sensing has already proved exceptionally valuable over the three-year lifetime of Landsat-1, the first earth resources technology satellite, and should be even more useful in the follow-on investigations that will be made possible by the recent launch of Landsat-2.

Other speakers on the one-day workshop program underscored this contention by highlighting applications of remote sensing for inventorying Nebraska's center pivots, forage yields, irrigated land, land use and wetlands. Other reported uses of remote sensing included the measuring of the economic impact of irrigation on the state's economy; the locating of groundwater supplies; increasing the efficiency of land appraisal and the equalization of tax appraisal across county lines, urban planning, and the management of a Natural Resources District (NRD).

One of the more imaginative uses of remote sensing with wide practical consequences for Nebraskans was outlined by Clancy Woolman, marketing manager for Cengas. He reported an innovative approach to energy conservation being undertaken in cooperation with UNL's Remote Sensing Center.

Thermal Scanners

The project, he explained, depends on the use of thermal scanning equipment on aerial flights made in winter when it is possible to measure rooftop temperatures of residential homes and to check on heat loss through the ceilings. The project is scheduled to reach 65,000 families in Lincoln, Columbus, Beatrice, Norfolk and in Sioux Falls, S.D.

The information aquired by remote sensing imagery in February and March will soon be made available to Lincoln customers who will be invited to come in to Cengas offices to check their own rooftop temperatures on large 16 x 20 inch photographs.

"To our knowledge," said Woolman, "this project is the first of its kind to be directed primarily to residential consumers." The goal of the project is the reduction of wasted energy and the conservation of fuel supplies for the years ahead.

Dr. Paul M. Seevers, research agronomist with UNL's Conservation and Survey Division, reported success in a three-year project aimed at relating vegetative biomass to satellite data. This refined scientific measurement of forage yield and forage density is expected to give an accurate and speedy method of evaluating actual forage in the field. This information in turn will prove useful in range management decisions by Nebraska ranchers.

Dr. Leslie F. Sheffield, assistant to the vice chancellor of the Institute of Agriculture and Natural Resources, explained how remote sensing is being used for measuring and forecasting the economic impact of irrigation in Nebraska.

Benefits

The latest statistics show, he said, that the current impact of irrigation on the total Nebraska economy results in an added value of $493.77 per acre.

Another way of assessing the beneficial effect of irrigation on the Nebraska economy is to multiply each dollar of added output at the farm level due to irrigation by $7.95. That is a concrete way of understanding the far-reaching economic impact of irrigation on the state, he explained.

Remote sensing is proving a great boon in the equalization of property appraisal across county boundaries, reported Dee Meek, appraiser to the Nebraska Department of Revenue.

Nebraska earlier operated on a 10-year cycle of updating tax values, employing different appraisal firms. At times this resulted in different appraisal values for land on two sides of a county boundary, even though the land was being put to similar use.

Now that appraisal values must be updated annually according to legislative statute, remote sensing fills a special need by offering rapid and accurate inventory of land use.

This together with other factors, said Mrs. Meek, will permit an annual review of appraisal values and the equalization of tax appraisal across county boundaries. This represents a significant step in the right direction, said Mrs. Meek, because "equalization is our goal."

James B. Swinehart, research geologist with NU's conservation and survey division, reported progress in using remote sensing imagery to identify fracture traces, which in turn are proving useful in locating high-yield wells in Nebraska. He mentioned that this revolutionary method of locating irrigation wells has generated considerable interest throughout the state, producing telepone calls and letters from many interested persons.

Remote sensing imagery is being used to inventory the state's wetlands and that project is nearing completion, according to Kenneth Johnson of the Nebraska Game and Parks Commission. By early June this project will enter the drafting phase and soon afterward will be sent to the printer. The finished product, a detailed map showing all the wetlands of Nebraska, will then be made available for public distribution.

Center Pivots

Dr. Richard O. Hoffman of NU's College of Engineering and Technology, reported that satellite imagery has been used successfully to inventory the center pivot systems and the irrigated land of the state. There is a positive correlation, he concluded, between the growth of center pivots in various counties and increased fuel allocations for those counties.

Registered

"But the biggest surprise so far in the counties we've checked," he said, "is that almost all installed center pivots inventoried have operated out of registered wells."

It has been a persistent belief that a sizable number of wells are not being registered, he said, but data on center pivots in the state indicate otherwise.

Dr. James V. Drew, NU dean of graduate studies as well as principal investigator of the NASA university affairs grant, who presided at the workshop, announced that word has been received that NASA has extended UNL's grant for remote sensing to provide $200,000 from June 1, 1975, to May 21, 1977. The grant is for developing applications of remote sensing from both aircraft and spacecraft in managing Nebraska's natural resources, he said.

Visitors from Washington, D.C., attending the workshop included Dr. Frank Hansing of the Office of University Affairs, NASA, and Joseph Vitale, also of NASA.

Other speakers on the workshop program included Hal Schroeder, manager of the Lower Platte South NRD; William H. Harrison, environmental planner from Omaha; Herbert Kollmorgen, soil science consultant from the Lancaster County Tax Assessor's Office, and Joseph Vitale, chief of the Engineering Systems Design Branch, Office of University Affairs, NASA.

Unique Home Insulation

Wednesday, June 4, 1975 Lincoln Neb. Journal

Check to Be Offered Free

By Harold Simmons

If you're interested in saving energy and at the same time holding down your monthly bills for heating and air conditioning, you'll do well to accept an unique invitation from Cengas.

Lincoln homeowners, businessmen and government officials will be receiving invitations in the next few weeks to visit the Cengas office at 12th and N Sts. and inspect a thermogram of their buildings.

The first 2,800 invitations go out Thursday with natural gas bills. All Lincolnites will receive such invitations in the next two months.

The thermograms offer owners an opportunity to see a photographic picture of their buildings such as they've probably never seen before.

The pictures were taken for Cengas with infrared film in an airplane that photographed all of Lincoln, Columbus, Beatrice, Norfolk and Sioux Falls, S.D., last winter.

The photographic images were taken by the Remote Sensing Institute of South Dakota State University and converted to the equivalent of aerial photographs by the University of Nebraska-Lincoln Remote Sensing Center.

What building owners will be shown by Cengas officials is an image of their buildings that can range from nearly coal black to nearly pure white.

And the particular degree of shading tells exactly how well insulated are the buildings.

A home or building that shows up as black on the thermograms is well insulated with little heat loss in winter and a minimum need to air condition in summer.

One that shows up as near white has a high heat loss in winter and a greater-than-necessary need for operating an air conditioner during summer.

Clancy Woolman, marketing manager for Cengas, a division of Central Telephone and Utilities, said the three major points of heat loss in winter and heat entry in summer are ceilings, walls and windows.

Ceilings alone can account for as much as 40% of heat loss or entry, he said, and that is the focal point of the thermograms.

The data developed by Cengas does not show a particular pattern as to sections of town or types of buildings with good or poor insulation according to Woolman and C. W. Wilcox, Lincoln division manager.

The thermograms show many older homes in Lincoln need more insulation. But some are well insulated. And the same holds true for newer homes and apartment complexes and public buildings.

Some buildings show a newer addition is well insulated while the older part is poorly insulated.

Woolman pointed out that homeowners are not the only ones who can benefit by using the thermograms. They can also be used by businessmen and for public buildings such as schools, churches and government buildings.

One Lincoln school building showed up on the thermograms as nearly pure white, indicating a high winter heat loss that helps account for the high heating bills paid by the Lincoln School District.

A preliminary survey of the thermograms has led insulation contractors to estimate that perhaps as many as 20,000 of the 54,000 Cengas customers in Lincoln may have excessive heat loss in their buildings.

When Cengas customers view thermograms of their buildings, they will also have an opportunity to talk with Cengas officials about different types of insulation and view displays of insulation.

Wilcox said Cengas is particularly interested in how many Lincolnites visit the Cengas office to view the thermograms.

Cengas launched the program — apparently the first of its kind in the nation by a private utility — as a means of helping building owners conserve energy, he said.

And the project has attracted the attention and interest of the Federal Energy Administration, U.S. Commerce Dept. and state energy officials.

ORIGINAL PAGE IS OF POOR QUALITY

Lincoln Evening Journal
October 2, 1975

Nebraska Irrigating More

Satellite Notes Changing Pattern in U.S. Land Use

The scanning of the Nebraska countryside by a resources satellite (from 565 miles high) has dramatically revealed a changing pattern in U.S. land use that could have quite an impact on national energy priorities.

But Dr. James V. Drew says he wants to make sure that federal agencies such as the Federal Energy Administration are aware "when they're establishing fuel use allocations," that Nebraska appears to have "more than 10,000 center-pivot irrigation systems in operation," using perhaps 55 million more gallons of diesel fuel than was needed in 1972.

Drew, dean for graduate studies on the University of Nebraska-Lincoln campus, is the principal investigator for the NASA-funded Remote Sensing Center in the Conservation and Survey Division.

10,000 Systems?

Speaking to the annual meeting of the Lincoln Board of Realtors, he said that a count of center-pivot systems, using satellite cameras, shows this Nebraska growth: 2,700 in use in 1972, some 4,200 in 1973, and about 6,700 during 1974. He expects the 1975 count to exceed 10,000 systems. About a tenth of the state's landscape was irrigated last year — some five million acres.

The center-pivot inventory was directed by Dean Donald Edwards and Dr. Richard Hoffman of the UNL College of Engineering, Drew noted.

Although these figures help to explain why Nebraska had the greatest increase of any state in irrigated acres between 1969 and 1974, Drew says it's the fuel projections which relate to irrigation pumps that he wants to underline.

"A center pivot system will use 7,200 gallons of diesel fuel to put 15 inches of water on a quarter section."

Farm, Ranch and Home

QUARTERLY

Fall 1975

Institute of Agriculture and Natural Resources, University of Nebraska—Lincoln

Farm, Ranch and Home
QUARTERLY
Fall 1975 Vol. 22, No. 3

In this issue:

On the cover:

Screen image from a density slicer, showing aerial photo of Nebraska cropland. The density slicer, part of an electronic image enhancement system, is used by remote sensing specialists of the Conservation and Survey Division to inventory the natural resources of the state. See story this page; photo by Jay Fussell.

The *Quarterly* is published by the Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, Neb., 68583, and distributed free to persons interested in Institute activities that affect agriculture, natural resources and family life.

REMOTE SENSING

By Rex Peterson

Remote sensing is a method of getting information from a distance. For remote sensing of the earth's surface, with photographs or images, that distance can be several thousand feet or hundreds of miles.

Aerial photographs are not new; in fact, during the American Civil War, Union forces sent photographers up in balloons to photograph Confederate positions. The first aerial photos of large areas of the United States date back to the 1930's when the U.S. Department of Agriculture began a large-scale project of photographing farmland from airplanes.

Today's remote sensing differs from aerial photography prior to the 1950's in that (1) pictures are taken from much higher altitudes and thus include more area than previously, (2) pictures are taken not only with light visible to the human eye but with energy not visible to humans, (3) pictures are taken much more frequently, (4) pictures cost less since the advent of satellites equipped with optical scanning systems, and (5) pictures now are available of most of the earth's surface.

Although remotely sensed data can be in many forms, most of the work being done in Nebraska is with pictures. The Remote Sensing Center (part of the Conservation and Survey Division of the Institute of Agriculture and Natural Resources) has color infrared photographs of more than a third of Nebraska, some from altitudes of 40,000 and 60,000 feet.

The Remote Sensing Cener has pictures taken by astronauts from 270 miles on the skylab missions

(Continued on page 4)

REX PETERSON is coordinator of Remote Sensing for the Conservation and Survey Division.

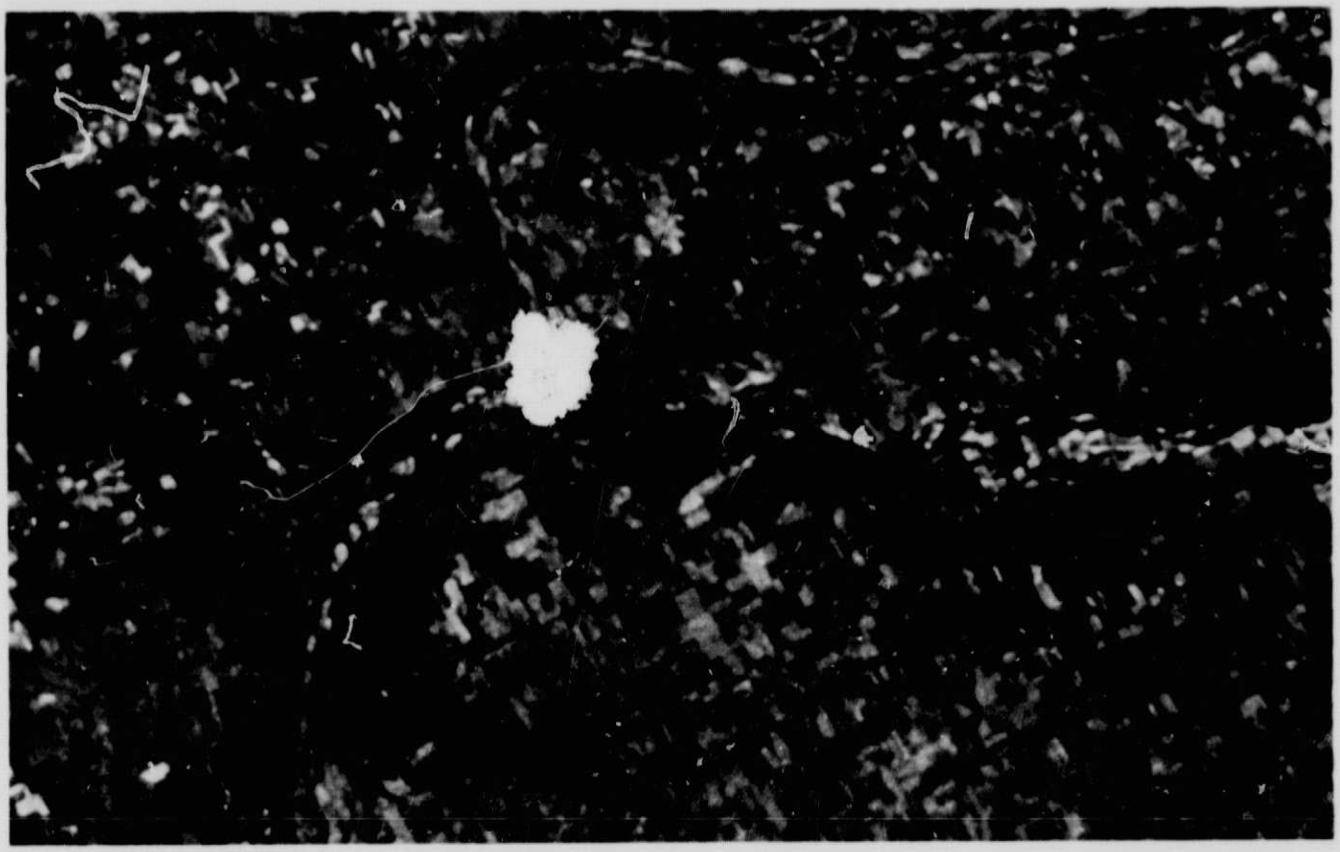
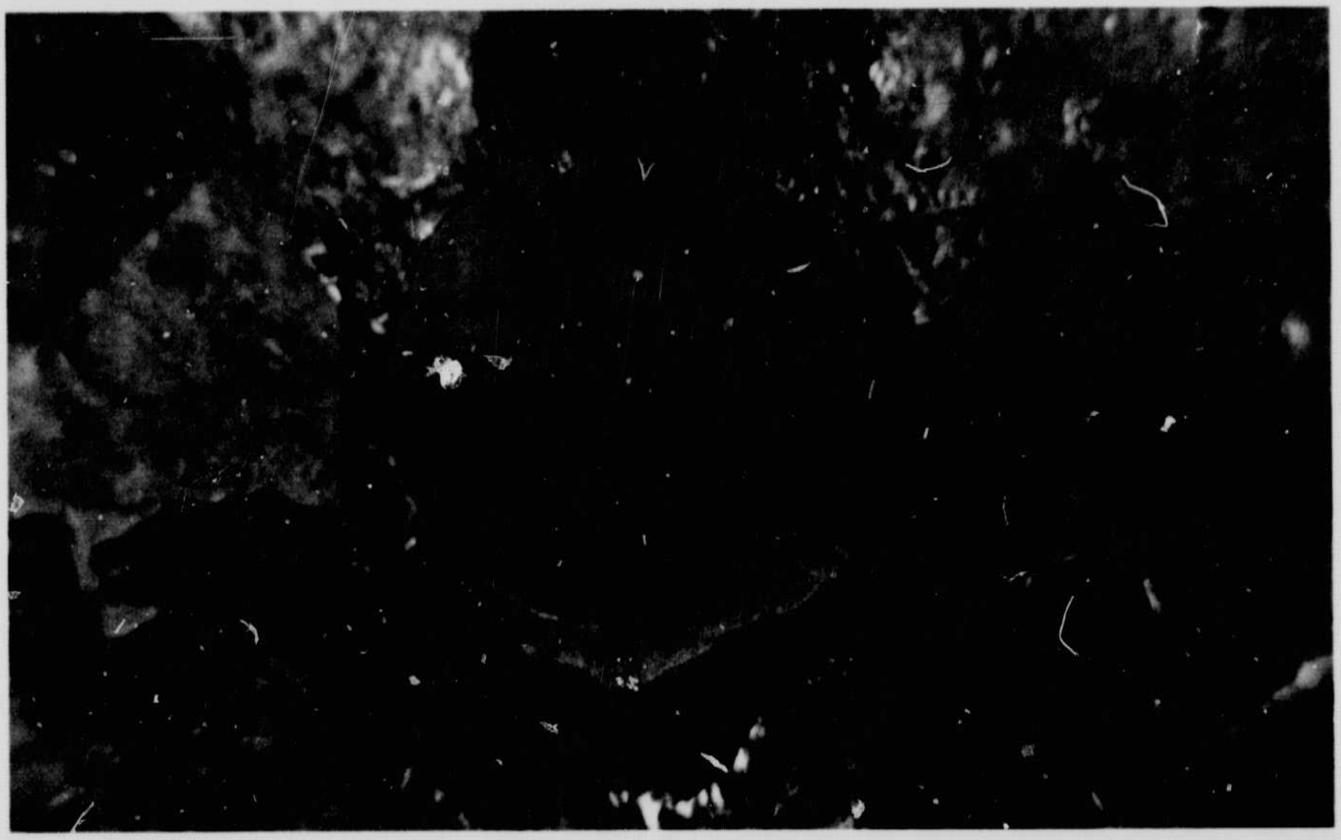


Fig. 1. Above, photo taken by Skylab astronauts from 270 miles above Nebraska showing the Niobrara and Missouri Rivers and Lewis and Clark Reservoir. Fig. 2. Below, a center pivot irrigation system photographed from 60,000 feet. Lush vegetation is red on the false-color infrared film.



Remote Sensing . . .

(Fig. 1 is an example). Figure 2 is a color infrared photo taken by a RB-57 airplane from 60,000 feet. Thousands of pictures are transmitted back to earth by the unmanned LANDSAT satellite (Fig. 3).

The LANDSAT 1 satellite (formerly called ERTS 1) was launched 3 years ago and is still transmitting images back to earth via radio. LANDSAT 2, launched in January 1975, has the same capabilities as LANDSAT 1 and is used mostly for areas outside the United States. Both of these satellites are 565 miles above the earth in orbits that take them directly over the north and south poles.

The LANDSAT satellites do not take photographs with film in a camera. Instead, images are received electronically in the fashion of a TV picture. A rotating mirror on the spacecraft scans a track 110 miles wide, looking at "cells" 300 feet square. The brightness of each cell is converted to a numeric value and is broadcast by radio beam to receiving stations.

Approximately 6 million separate radio signals are required to build one LANDSAT image, but that image covers 12,000 square miles of the earth's surface. Part of a LANDSAT image of the Omaha area is shown in Figure 3.

Actually, LANDSAT detects four different wavelengths simultaneously. One is made only with green light, one with red light, and two with infrared light. These four wavelengths produce pictures that can be viewed separately as black and white images, or they can be combined to make color images as shown in Figure 4.

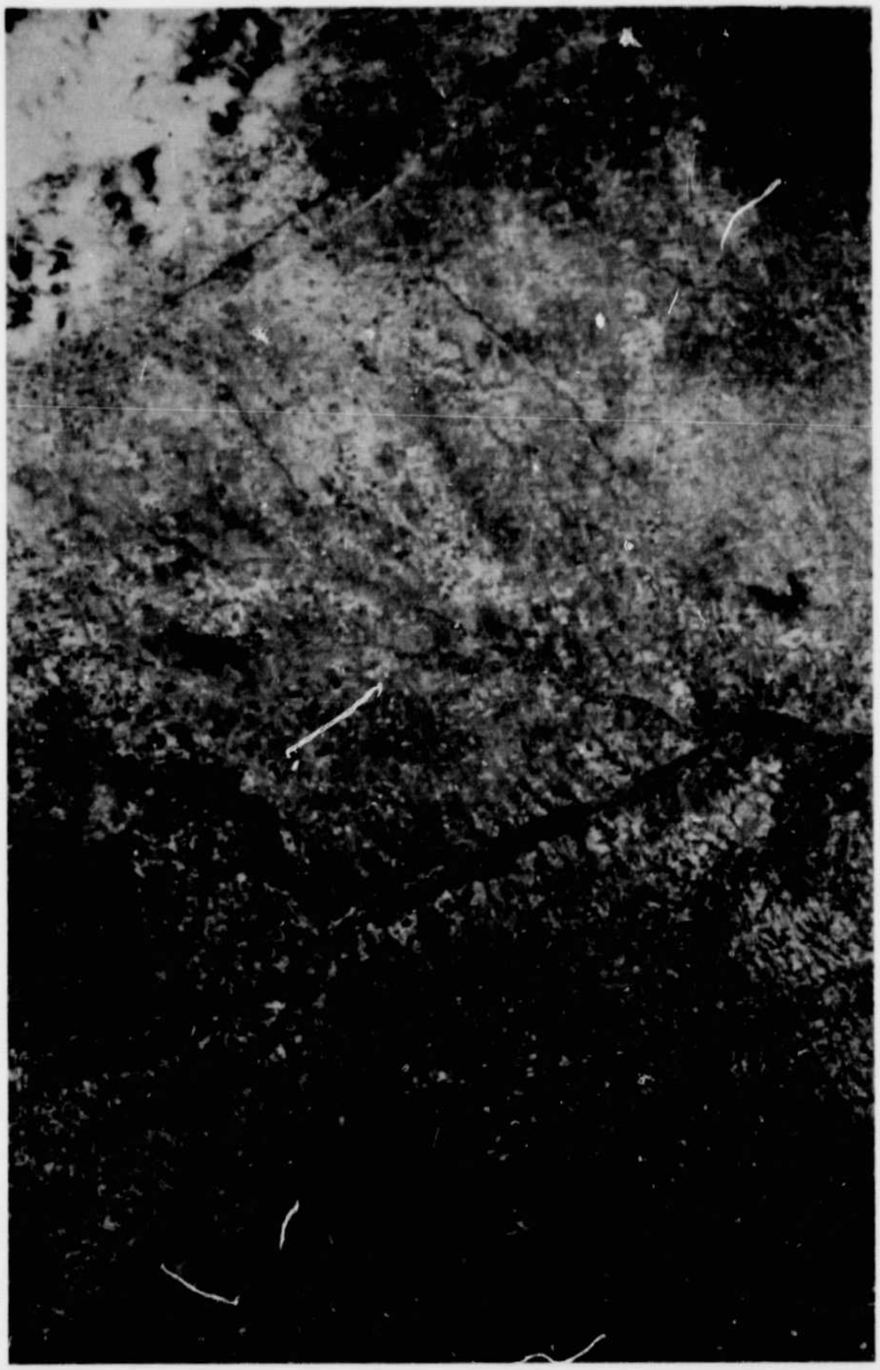
Many features of the earth's surface appear differently in different colors, so the amount of information available is greatly multiplied by having separate images made from different colors of light. Another advantage of LANDSAT imagery is repetitive coverage; each LANDSAT passes over the same spot every 18 days. Because the two LANDSAT satellites are in different orbits it is possible to obtain new sets of pictures every 9 days. Repetitive coverage detects changes and takes advantage of different appearances of the earth at different seasons.

Nebraska's Remote Sensing Center has achieved national recognition for its application of remote sensing. Over the past 3 years, the National Aeronautics and Space Administration has supported the University of Nebraska in a wide variety of projects

Fig. 3 LANDSAT image of eastern Nebraska. The Missouri River on the right forms the outline of a man's face ("Hungry Omaha)" with the Platte River meeting it at the chin.

for research and applications of remote sensing. Cooperative projects have been supported by other agencies. Among the applications has been an inventory, by means of LANDSAT imagery, of Nebraska's wetlands (made for the Game and Parks Commission). This inventory is complete. Maps showing the distribution of open water, marshes, seasonally flooded areas, and subirrigated areas throughout the state are being prepared.

Fig. 4 Color composite image of southwestern Nebraska made from three separate LANDSAT images in July 1973.



Satellite images of Nebraska show thousands of center pivot irrigation systems. In fact, a landmark for the Skylab astronauts was the cluster of center pivots in Holt County. More than 6,600 center pivots have been counted in Nebraska and the number of pivots in different counties will be used for fuel allocation in case another fuel shortage develops. An inventory of irrigated land, which is much more difficult than counting center pivots, is underway. In a dry summer, such as 1974, irrigated land is quite easily identified on infrared imagery. To test the method, inventories have been made for Phelps and Dawson Counties.

Maps showing the main categories of land use in Nebraska have been prepared from satellite imagery. Much more detailed maps showing dominant land use in each 10-acre parcel of land are in preparation for several Natural Resource Districts. The Remote Sensing Center's land use map of Lancaster County won an international cartographic award.

Agronomists are doing research on range management and forage density in the Sandhills. Using computer data from the LANDSAT satellite they can accurately determine rangeland condition. With some improvements, their technique could be used as a range management tool.

Other applications of remote sensing are in the field of geology. In areas where rock fractures yield much water, locations for several good wells have been determined from high altitude photographs. A new technique is being tried to locate structures where oil and gas deposits might be located.

Remote sensing provides an inexpensive, timely means of getting information for large areas. In addition, the perspective provided from high altitudes, the images taken in wavelengths other than visible light, and the repetitive photos all contribute to a tool that will prove to be increasingly more useful. □

FARMER NEB on the air

By Norman Tooker

Teaching with television is not new, but a group of eastern Nebraska county Extension agents are using television in a new way to reach a farmer-rancher audience.

The agents created and produced a series of live television programs broadcast in prime time last winter over the Nebraska Educational Television Network.[1] Early in 1976 they will have another series of programs on the air.

The series is unique because it is an area effort, the brainchild of Extension agents in a cluster of counties around Omaha. While still in its beginning stages, the series has proved to be an efficient method for these agents to reach a large audience on a relatively limited budget.

Called "Farmer Neb," the series covered a broad range of topics of interest to farmers, ranchers, agribusinessmen, and others involved in agriculture.

More than two years ago, the agents expressed a common concern about their agricultural education programs. The agents had a wealth of information to pass along to farmers, but traditional evening Extension meetings were losing their effectiveness. Often they were poorly attended. This raised the question about justifying the time spent by county agents and state Extension specialists in planning the programs and traveling to meeting sites.

The agents decided to try television teaching as an alternative. The University of Nebraska at Omaha expressed interest in airing a farm-oriented program over KYNE-TV (Channel 26) and suggested 8 to 9 on Thursday evenings during February and March. The station covers Douglas, and parts of Washington, Dodge,

---

Norman Tooker is County Extension Agent Chairman of Douglas County.

[1]Extension Specialists participating included: Paul Guyer (Beef Cattle), Bill Zollinger (Livestock Development District Specialist), Allen Wellman (Marketing), Mike Turner (Marketing), Phil Henderson (Farm Management), Wally Moline (Forage Crops), Alex Martin (Pesticides and Weeds), Ed Penas (Soils), Robert Roselle (Entomology), Doug Duey (Farm Management District Specialist), and Iowa Extension Specialist Errol Peterson.

FARMER NEB logo as seen on screen.

THE UNIVERSITY OF NEBRASKA–LINCOLN
LINCOLN, NEBRASKA 68508

OFFICE OF THE DEAN
FOR GRADUATE STUDIES, UN-L

October 28, 1975

Honorable Carl T. Curtis
United States Senate
Washington, D. C. 20510

Dear Senator Curtis:

Earlier this year I sent to you a copy of the first land use map of Lancaster County, Nebraska that was prepared by the University of Nebraska-Lincoln using remote sensing techniques. Since then we have published a second map for the entire Lower Platte South Natural Resources District. I thought you might be interested in looking at the enclosed copy of the second map.

This map is now in use by the Board of Directors of the Lower Platte South NRD in planning programs related to agriculture and natural resources and, specifically, in developing steps to reduce soil erosion and water pollution from non-point sources. The land use inventory is part of a program supported by NASA Grant NGL 28-004-020, a grant to the University of Nebraska-Lincoln from NASA's Office of University Affairs to permit the development of applications of remote sensing in resource management in Nebraska.

We appreciate very much your interest in our studies of remote sensing.

Sincerely,

James V. Drew

James V. Drew
Dean

JVD:jsw

cc: Chancellor A. C. Breckenridge

THE UNIVERSITY OF NEBRASKA—LINCOLN
LINCOLN, NEBRASKA 68508

OFFICE OF THE DEAN
FOR GRADUATE STUDIES, UN-L

October 28, 1975

Honorable Charles Thone
1531 Longworth Building
Washington, D.C. 20515

Dear Congressman Thone:

Earlier this year I sent to you a copy of the first land use map of Lancaster County, Nebraska that was prepared by the University of Nebraska-Lincoln using remote sensing techniques. Since then we have published a second map for the entire Lower Platte South Natural Resources District. I thought you might be interested in looking at the enclosed copy of the second map.

This map is now in use by the Board of Directors of the Lower Platte South NRD in planning programs related to agriculture and natural resources and, specifically, in developing steps to reduce soil erosion and water pollution from non-point sources. The land use inventory is part of a program supported by NASA Grant NGL 28-004-020 a grant to the University of Nebraska-Lincoln from NASA's Office of University Affairs to permit the development of applications of remote sensing in resource management in Nebraska.

We appreciate very much your interest in our studies of remote sensing.

Sincerely,

James V. Drew

James V. Drew
Dean

JVD:ml
cc: Chancellor A. C. Breckenridge

THE UNIVERSITY OF NEBRASKA—LINCOLN
LINCOLN, NEBRASKA 68508

OFFICE OF THE DEAN
FOR GRADUATE STUDIES, UN-L

October 28, 1975

Honorable John Y. McCollister
217 Cannon Building
Washington, D.C. 20515

Dear Congressman McCollister:

Earlier this year I sent to you a copy of the first land use map of Lancaster County, Nebraska that was prepared by the University of Nebraska-Lincoln using remote sensing techniques. Since then we have published a second map for the entire Lower Platte South Natural Resources District. I thought you might be interested in looking at the enclosed copy of the second map.

This map is now in use by the Board of Directors of the Lower Platte South NRD in planning programs related to agriculture and natural resources and, specifically, in developing steps to reduce soil erosion and water pollution from non-point sources. The land use inventory is part of a program supported by NASA Grant NGL 28-004-020 a grant to the University of Nebraska-Lincoln from NASA's Office of University Affairs to permit the development of applications of remote sensing in resource management in Nebraska.

We appreciate very much your interest in our studies of remote sensing.

Sincerely,

James V. Drew

James V. Drew
Dean

JVD:ml

cc: Chancellor A. C. Breckenridge.

THE UNIVERSITY OF NEBRASKA–LINCOLN
LINCOLN, NEBRASKA 68508

OFFICE OF THE DEAN
FOR GRADUATE STUDIES, UN-L

October 29, 1975

Honorable Virginia Smith
1005 Longworth Building
Washington, D.C. 20515

Dear Congresswoman Smith:

Earlier this year I sent to you a copy of the first land use map of Lancaster County, Nebraska that was prepared by the University of Nebraska-Lincoln using remote sensing techniques. Since then we have published a second map for the entire Lower Platte South Natural Resources District. I thought you might be interested in looking at the enclosed copy of the second map.

This map is now in use by the Board of Directors of the Lower Platte South NRD in planning programs related to agriculture and natural resources and, specifically, in developing steps to reduce soil erosion and water pollution from non-point sources. The land use inventory is part of a program supported by NASA Grant NGL 28-004-020, a grant to the University of Nebraska - Lincoln from NASA's Office of University Affairs to permit the development of applications of remote sensing in resource management in Nebraska.

In addition, I am enclosing land use maps we have prepared for Phelps and Dawson Counties, Nebraska, from imagery obtained by NASA's Landsat satellite. These maps are of interest particularly with respect to the inventory of irrigated land.

We appreciate very much your interest in our studies of remote sensing.

Sincerely,

James V. Drew

James V. Drew
Dean

cc: Chancellor A.C. Breckenridge