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Progress Report

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Atmospheric Tritium Sampling

October 1979—August 1980

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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STRATOSPHERIC TRITIUM SAMPLING

October 1979--August 1980

by

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ABSTRACT

Sampling of tritium gas (HT) and tritiated water vapor (HTO) was conducted as part of Project Airstream. Data were obtained at four altitudes in the upper troposphere and lower stratosphere between the equator and 75 degrees north latitude. The HTO mixing ratios showed an overall decrease, with the normal springtime input from higher altitudes superimposed. The HT mixing ratios were essentially constant.

I. INTRODUCTION

Project Airstream is the aircraft component of the US Department of Energy (DOE) High Altitude Sampling Program. Three deployments are conducted annually, sampling the upper troposphere and lower stratosphere for a number of constituents over altitude and latitude spans of 12 to 19 km and 0 to 75 degrees north. The dominant chemical forms of tritium, that is, tritium gas (HT) and tritiated water vapor (HTO), have been included in this program since 1975. The US DOE and its predecessors sponsored the University of Miami in the development and operation of a catalytic-adsorptive sampler, which was described in a prior publication.[1] Data obtained between April 1975 and July 1979, and between October 1980 and November 1982, have been reported.[2,3] The data in this report are presented to complete the record for that period.

II. EXPERIMENTAL RESULTS

Tables I through III contain the HT and HTO mixing ratios obtained, in addition to the corresponding navigational and meteorological data. The column headings are defined as follows: Flight is the number of the flight as defined by the mission plan. Sample no. is the sequential tritium sample number on each flight. Latitude, longitude, altitude, pressure, temperature, and potential temperature are the means of those parameters over the sampling periods. The mixing ratios are presented in units of picoCuries per standard cubic meter (0°C, 760 mm); this is a conservative unit and may be converted to the usual University of Miami units of tritium atoms per milligram of air by the factor 15.97 or to becquerel per standard cubic meter by the factor 0.037. The one-sigma error estimates are denoted by "σ". Figures 1 through 3 show the isopleths of HTO as calculated by the contouring subroutine of the DISSPLA (Integrated Software Systems Corporation) library. The HT isopleths are not shown, as they are relatively uniform throughout the sampled region. Smoothed tropopause heights for the periods of deployments are depicted by "TRPP".

Airstream missions were flown on the following dates:

Mission 17	October 10 to November 18, 1979
Mission 18	April 9 to May 13, 1980
Mission 19	July 23 to August 12, 1980

Missions 17 and 18 were unusually long. They yielded fewer than normal samples because of aircraft problems during the Alaska portions of both deployments. Mission 19 was essentially normal.

III. CONCLUSIONS

The three missions reported here showed HTO distributions typical of the stratosphere several years following a large atmospheric nuclear test such as the one of November 17, 1976. The qualitative conclusion is that HTO has been injected at altitudes higher than the aircraft's ceiling and that it is transported downwards in the polar region during the winter. Sampling in the spring then shows high mixing ratios in the far north. Subsequent missions

reveal southward and downward transport, with removal through the tropopause as the ultimate fate of the HTO.

The HT data in the stratosphere are essentially uniform, as is expected from the conventional model, which considers that major sources are located at ground level and that destruction is slow at the levels explored here.

ACKNOWLEDGMENTS

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Collection of these data required the collaboration of the Isotope Geochemistry Group, Los Alamos National Laboratory, and the Aircraft Operations Division, Johnson Space Center, National Aeronautics and Space Administration, Houston, Texas. The efforts of P. R. Guthals, C. D. Anderson, and their colleagues were vital to the success of the program.

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1. Allen S. Mason and H. Göte Östlund, "Atmospheric HT and HTO. 3. Vertical Transport of Water in the Stratosphere," J. Geophys. Res. 81, 5349-5352 (1976).

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TABLE I

TRITIUM GAS AND TRITIATED WATER VAPOR

SAMPLED BY AIRSTREAM MISSION 17

Flight	Sample No.	North Lat.	West Long.	Alt. (km)	Pressure (mbar)	Temp. (°C)	θ (K)	Tritium (pCi/scm) HTO	σ	HT	σ
1	1	28.3	95.1	9.1	302	-38.4	330	3.60	0.09		
1	2	28.5	95.3	12.2	188	-56.6	349	0.43	0.04		
1	3	28.5	95.3	13.7	148	-63.8	362	0.43	0.04		
1	4	27.7	95.8	15.2	116	-69.1	377	0.75	0.04		
1	5	28.8	95.1	16.8	92	-69.2	404	0.34	0.04		
1	6	27.5	96.2	19.2	63	-56.6	478	1.93	0.08		
3	1	18.0	84.3	15.2	116	-71.4	373	1.25	0.07	1.85	0.09
5	1	1.0	79.6	15.2	116	-77.9	361	3.34	0.20	2.11	0.06
5	2	1.0	79.6	16.8	92	-77.9	386	1.03	0.05	1.97	0.09
5	3	1.5	79.6	18.3	72	-75.8	418	2.15	0.15	2.40	0.11
5	4	1.5	79.8	19.2	63	-70.9	447	6.22	0.26	2.69	0.16
8	1	39.0	92.9	16.8	92	-61.5	419	1.28	0.06	2.05	0.09
8	2	39.0	92.5	19.2	63	-53.9	484	4.44	0.18	1.97	0.09
9	1	39.1	109.1	15.3	116	-65.4	385	3.94	0.13	1.73	0.06
9	2	49.0	125.9	15.1	118	-56.8	398	5.65	0.11	1.89	0.08
10	1	49.0	126.2	13.7	148	-51.4	383	0.16	0.03	1.92	0.07
11	1	66.1	148.4	12.2	189	-53.3	354	1.43	0.07	1.73	0.08
11	2	74.0	147.1	12.2	188	-52.8	355	1.75	0.08	1.51	0.07
11	3	74.0	148.2	16.9	90	-48.9	446	7.66	0.28	2.05	0.09
11	4	66.0	148.2	16.8	92	-49.0	444	10.47	0.37	1.92	0.09
12	1	66.0	149.8	15.2	116	-48.7	415	4.22	0.18	1.72	0.08
12	2	74.0	149.5	15.2	116	-50.9	411	4.90	0.20	2.03	0.07
12	3	74.0	149.6	18.8	67	-48.3	486	23.78	0.97	2.39	0.11
14	1	49.2	125.9	13.7	148	-65.5	358	6.08	0.23	1.98	0.08
15	1	39.0	107.2	13.7	148	-63.5	362	4.85	0.20	1.92	0.05

TABLE II

TRITIUM GAS AND TRITIATED WATER VAPOR

SAMPLED BY AIRSTREAM MISSION 18

Flight	Sample No.	North Lat.	West Long.	Alt. (km)	Pressure (mbar)	Temp. (°C)	θ (K)	Tritium (pCi/scm) HTO	σ	HT	σ
1	1	28.9	97.5	9.1	302	-35.0	335	4.40	0.16		
1	2	29.0	95.4	12.2	188	-55.3	351	0.75	0.03		
1	3	28.6	94.8	13.7	148	-67.3	355	0.53	0.03		
1	4	28.8	95.3	15.2	116	-65.1	385	0.70	0.03		
1	5	28.9	95.1	16.8	92	-68.3	405	1.56	0.06		
1	6	28.4	95.5	19.2	63	-57.0	477	11.99	0.31		
4	1	18.0	79.2	16.8	92	-78.1	386	1.00	0.09		
4	2	17.9	79.1	19.2	63	-63.8	462	2.37	0.08		
5	1	1.0	79.6	15.2	116	-75.9	365	5.08	0.14		
5	2	1.0	79.7	16.8	92	-83.8	375	1.61	0.09		
5	3	1.0	79.8	18.3	72	-80.1	409	2.68	0.10		
5	4	1.0	79.7	19.2	63	-73.8	440	2.97	0.13		
7	1	17.7	84.0	13.7	148	-64.9	360	4.28	0.18	1.76	0.11
8	1	39.0	93.1	16.8	92	-54.2	433	6.17	0.19	1.90	0.09
8	2	39.0	93.9	19.2	63	-47.6	498	8.51	0.26	1.65	0.08
9	1	39.0	107.4	15.2	116	-55.2	403	2.74	0.09	1.65	0.05
9	2	49.0	125.4	15.2	116	-54.4	404	3.20	0.11	2.68	0.08
10	1	49.0	126.1	13.7	148	-51.1	383	1.46	0.06	2.05	0.07
11	1	66.0	148.8	12.2	188	-46.3	366	0.79	0.04	2.32	0.08
11	2	74.0	148.3	12.2	188	-42.7	372	2.27	0.09		
11	3	74.0	148.0	16.8	92	-42.5	457	7.32	0.26	1.88	0.09
11	4	66.0	148.8	16.8	92	-40.1	461	8.33	0.31	1.84	0.08
12	1	66.0	150.9	15.2	116	-41.5	428	7.86	0.31		
12	2	74.0	148.9	15.2	116	-41.1	429	12.31	0.44	2.17	0.07
12	3	74.0	148.6	18.4	70	-39.6	498	23.63	0.80	2.08	0.09
12	4	66.0	149.1	19.2	63	-39.8	515	21.85	0.74	1.92	0.09
14	1	49.0	135.4	16.8	92	-47.3	447	3.02	0.12	1.77	0.08
14	2	49.0	127.3	19.2	63	-48.2	497	8.46	0.31	2.10	0.08
15	1	39.0	107.6	13.7	148	-50.1	385	25.38	0.83	1.67	0.06

TABLE III

TRITIUM GAS AND TRITIATED WATER VAPOR

SAMPLED BY AIRSTREAM MISSION 19

Flight	Sample No.	North Lat.	West Long.	Alt. (km)	Pressure (mbar)	Temp. (°C)	θ (K)	Tritium (pCi/scm) HTO	σ	HT	σ
2	1	20.9	93.9	16.8	92	-68.9	404	0.76	0.06	1.73	0.08
2	2	21.0	93.8	18.9	66	-58.8	467	1.08	0.06	2.21	0.07
3	1	20.9	85.7	15.2	116	-72.1	372	0.51	0.03		
3	2	11.0	80.7	15.2	116	-76.0	364	0.44	0.03		
4	1	11.1	79.5	16.8	92	-72.6	397	1.81	0.06	1.85	0.06
4	2	10.9	79.4	19.2	63	-59.3	472	10.11	0.32	1.73	0.09
5	1	1.0	79.7	16.8	92	-71.4	399	0.49	0.04	1.69	0.06
5	2	1.0	79.8	18.3	72	-61.6	448	1.75	0.08	1.84	0.10
7	1	11.2	81.2	15.2	116	-72.9	370	0.34	0.04	1.59	0.06
7	2	21.1	85.7	19.2	63	-58.6	474	2.85	0.11	1.63	0.09
8	1	33.0	95.4	16.8	92	-67.0	408	0.46	0.06	1.84	0.09
8	2	41.0	94.9	16.8	92	-63.7	415	2.51	0.11	1.74	0.08
8	3	37.5	95.0	19.2	63	-52.2	488	9.16	0.31		
8	4	31.0	95.0	19.2	63	-54.7	482	16.98	0.55	1.78	0.09
9	1	31.0	98.5	15.2	116	-68.6	378	0.83	0.04		
9	2	41.0	109.9	15.2	116	-64.0	387	1.40	0.06		
10	1	51.1	130.2	13.7	148	-49.3	387	2.21	0.09	1.76	0.05
11	1	63.2	149.8	12.2	188	-44.4	369	3.74	0.13	1.72	0.06
11	2	74.0	148.3	12.2	188	-44.9	368	1.54	0.07	1.77	0.06
11	3	74.0	149.0	16.8	92	-43.1	455	13.03	0.48	1.87	0.06
11	4	62.9	149.9	16.8	92	-45.8	450	5.78	0.23	2.47	0.13
12	1	63.4	149.5	15.2	116	-45.4	421	2.00	0.09	1.83	0.09
12	2	74.0	147.7	15.2	116	-45.9	420	2.92	0.12	2.13	0.09
12	3	73.0	148.6	18.5	69	-39.6	500	7.92	0.28		
12	4	63.0	149.5	19.2	63	-42.1	510	9.85	0.38	2.13	0.09
13	1	49.5	151.9	15.2	116	-46.1	420	2.88	0.13	1.65	0.07
14	1	50.9	136.9	16.8	92	-51.3	439	2.01	0.09	1.85	0.09
14	2	48.6	126.5	19.2	63	-47.5	498	4.81	0.18		
15	1	41.0	109.3	13.7	148	-59.5	369	1.77	0.08	1.71	0.08
15	2	31.0	96.7	13.7	148	-66.3	357	2.40	0.11	1.85	0.08

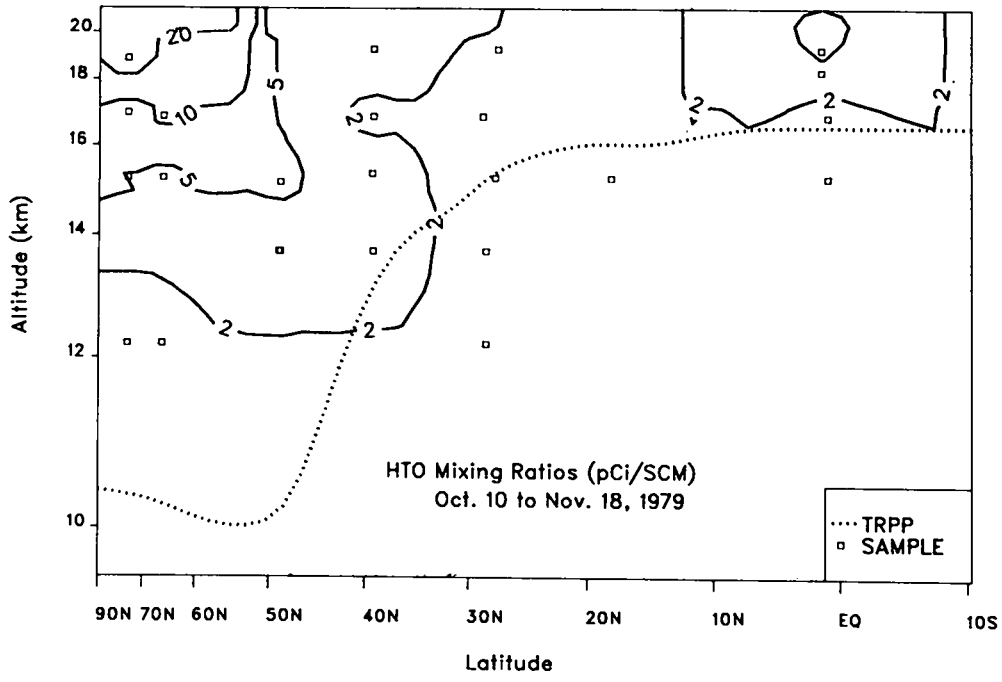

Fig. 1. Airstream 17: HTO contours.

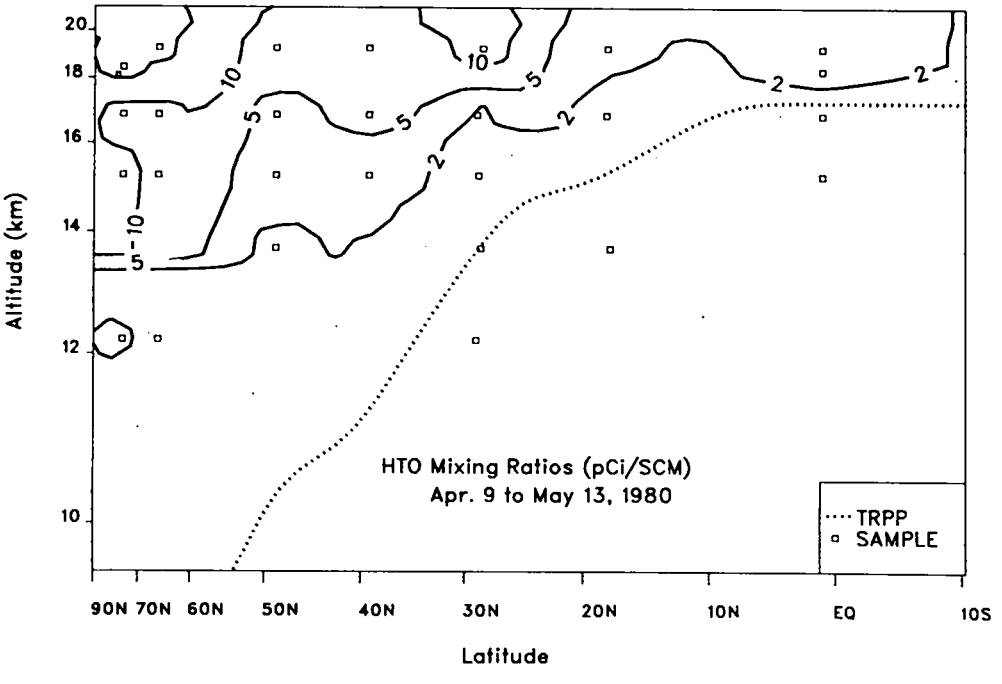

Fig. 2. Airstream 18: HTO contours.

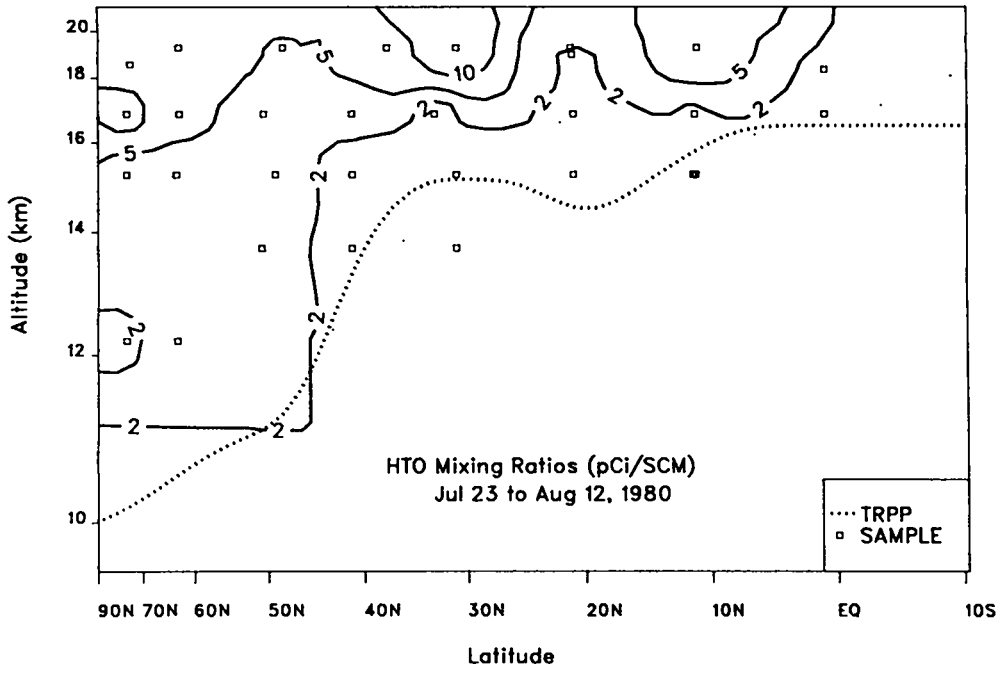

Fig. 3. Airstream 19: HTO contours.

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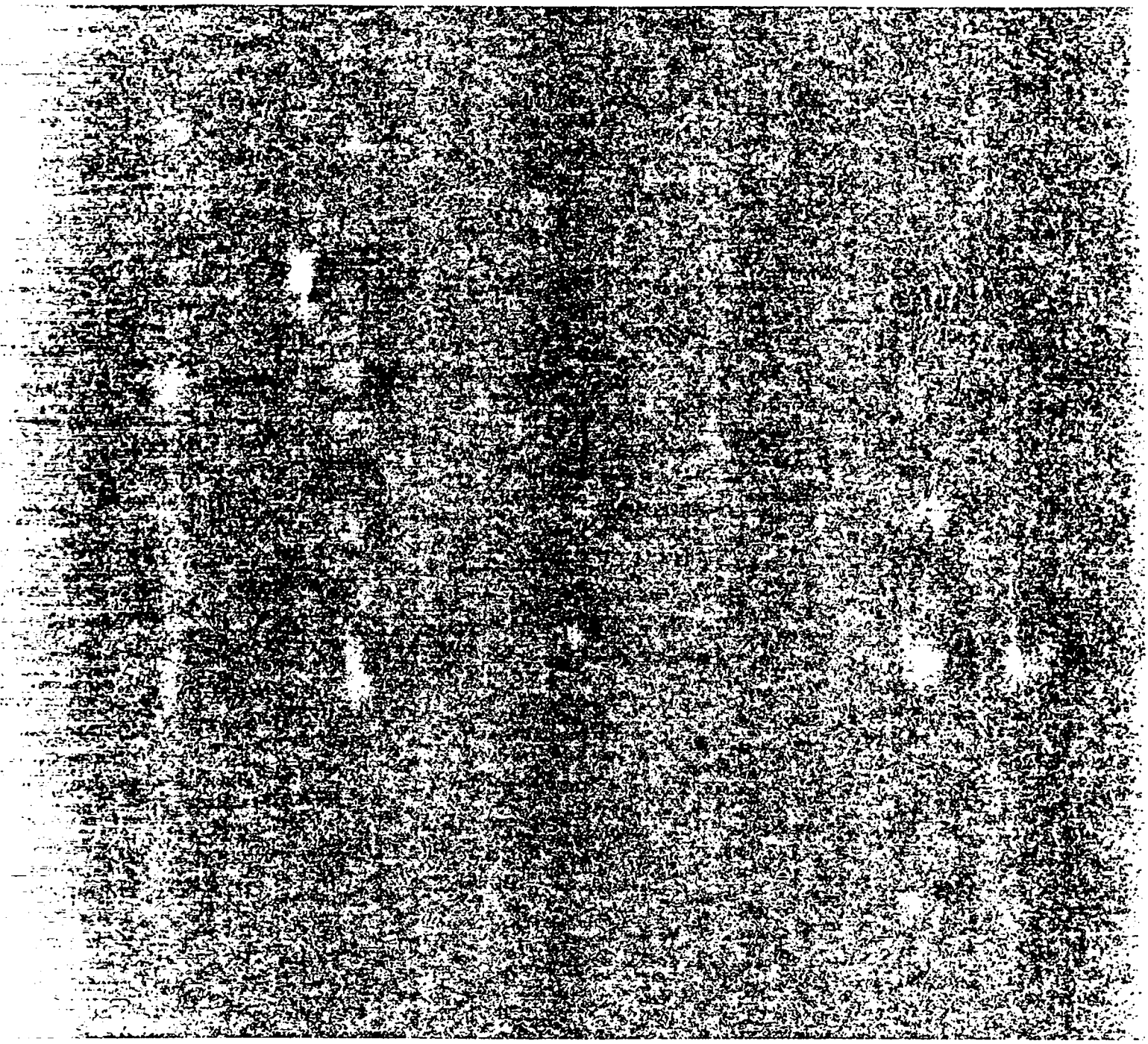

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