

FINAL REPORT  
for  
OTEC RAISER CABLE AT  
PUNTA TUNA, PUERTO RICO

to  
SIMPLEX WIRE AND CABLE COMPANY  
Portsmouth, New Hampshire



CENTER FOR ENERGY AND ENVIRONMENT RESEARCH  
UNIVERSITY OF PUERTO RICO - U.S. DEPARTMENT OF ENERGY

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH  
of the  
University of Puerto Rico  
College Station  
Mayaguez, Puerto Rico 00708

FINAL REPORT

for

OTEC RAISER CABLE AT  
PUNTA TUNA, PUERTO RICO

to

SIMPLEX WIRE AND CABLE COMPANY  
P.O. Box 479  
Portsmouth, New Hampshire 03801

Prepared by:



Date:

25 March, 1981

Mr. Thomas Morgan  
Inspection Investigator

Approved by:



Date:

25 March, 1981

Dr. Donald S. Sasscer  
Director, OTEC Program



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## Background

On December 3, 1979, the Center for Energy and Environmental Research was contracted by Simplex Wire and Cable Company to conduct a site specific, corrosion and biofouling test on eight different marine riser cable coverings. The cable coverings were mounted on racks and suspended from the CEER-OTEC research platform moored at a potential OTEC site two miles off the southeast coast of Puerto Rico (Fig. 1).

Four sets of racks, each containing the eight coverings to be tested, were deployed from two different lines. Each line had one set of racks at a depth of 25 feet and one set of racks at a depth of 200 feet (Fig. 2). The arrangement of the samples on the racks is shown in figure 3.

The racks were deployed on 13 and 14 May 1980. Inspections of the samples and of the lines which supported the racks were made on 25 June, 4 August, 10 September, 31 October 1980, and 20 & 21 January 1981. The racks were not redeployed following the January 1981 inspection since DOE funding for the research platform was terminated. A report on the 25 June inspection was sent to Simplex on 16 July 1980. Since CEER received no funding from Simplex during the summer, no reports on the August and September inspections were submitted. This final report includes inspection forms and photographs from the October, 1980 and January, 1981 inspections.

During inspections, samples were out of the water for 30 to 60 minutes and were regularly wetted to prevent them from drying out. The only exception to this was for the August inspection. Due to the approach of hurricane Allen, the samples were left out of the water from noon on

Figure 1 Map of Puerto Rico showing location  
of the CEER-OTEC research platform.

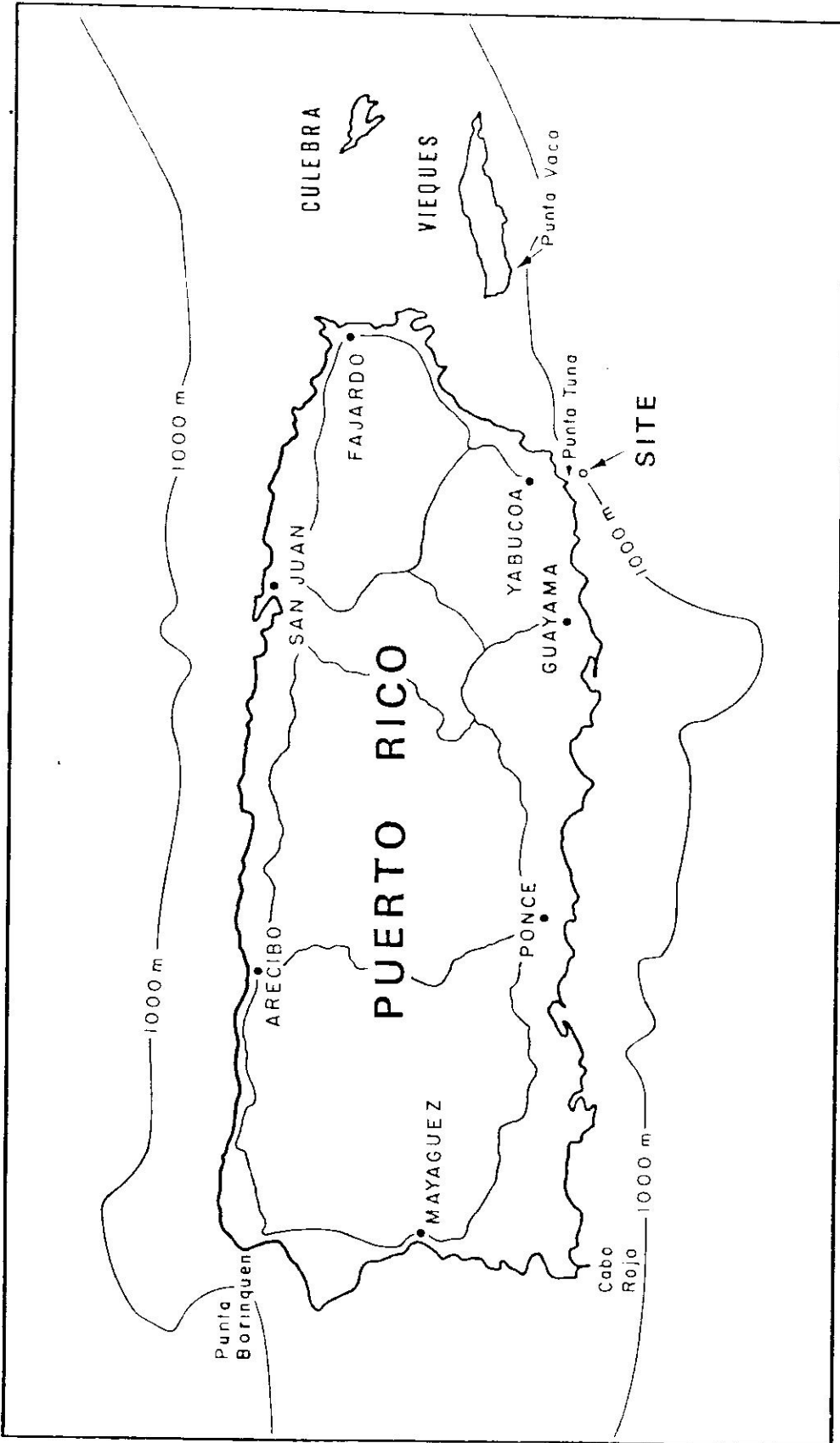


Figure 2 Diagram of experimental  
rack deployment

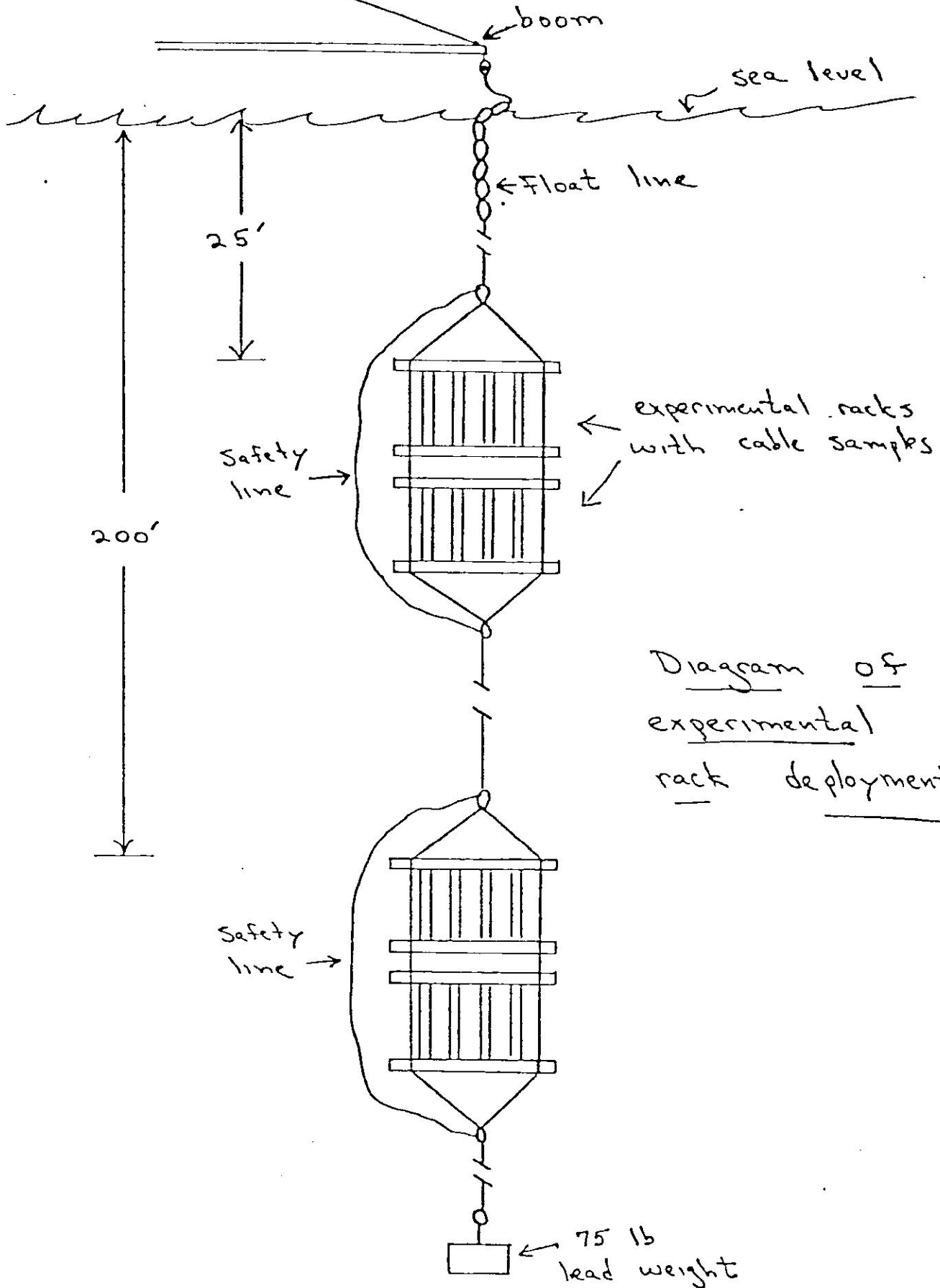


Diagram of experimental rack deployment

47331 58 PRESS 1 SQUARE  
23321 168 PRESS 1 SQUARE  
23326 168 PRESS 1 SQUARE  
MARINE

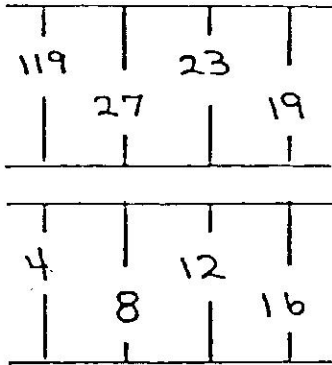
Figure 3 Arrangement of cable samples  
on experimental racks.



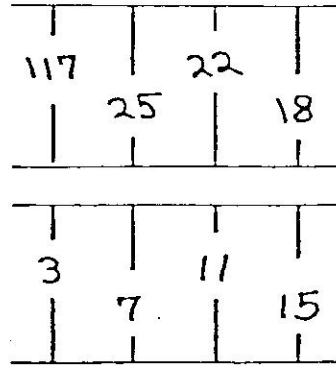
Arrangement of cable samples on  
experimental racks

Line # 1

20'

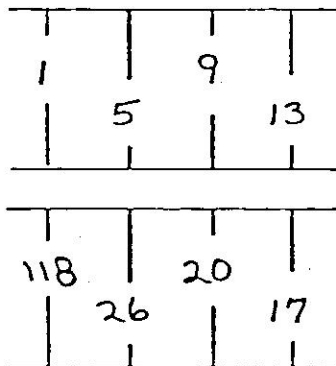


200'

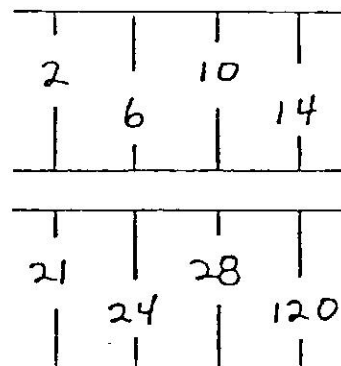


Line # 2

20'



200'



4 August to 1700 on 5 August.

Following the October inspection, an underwater inspection showed that the racks had been redeployed properly. That evening line #1 parted at a depth of 85 feet. The cut was clean and not frayed as it would have been if it had been caused by chafing.

### Conclusions

#### Erosion

The tar on sample #12 appeared to be cracking on the first inspection. However, this condition did not worsen and there was no evidence of erosion on any of the other coverings.

#### Corrosion

With the exception of the copper-nickel coverings, none of the samples showed any evidence of corrosion. In October, some superficial pitting of the surface of the copper-nickel covering was evident. By January, there was considerable pitting of the surface of these samples. Pitting of the copper-nickel samples in deep water appeared to be less severe than that of the samples in shallow water.

#### Macro-Biofouling

As would be expected, there was little biogrowth on the copper-nickel samples. There was some growth on the cloth which covered half of the copper-nickel samples and the hydroid Obelia was able to live in the crevices between the ribbons of metal, but with the exception of amphipods no organisms colonized the metal surface of the copper-nickel.

There was no noticeable difference between biofouling on any of the tar-covered or string-covered samples. For this reason, biofouling organisms for these coverings are lumped together on the inspection

form. What we saw on the shallow samples was the successional development of a biofouling community. Initially, they were colonized by few species - mainly the hydroids Obelia and Halocordyle and the filter feeding amphipod Podocerus. With time, the communities became more complex. Algae became more and more predominant, three more amphipod species appeared, and species of sponges, anemones, polychaetes, molluscs, sipunculids, bryozoans, and ascidians were all part of the diverse community which had developed by the end of the experiment. On the deep samples, species diversity of the fouling community was considerably less.

It is doubtful that any of the organisms encountered could affect the coverings adversely. Some of them adhered to the surface of the coverings while others moved freely along the coverings, but there was no evidence that any of them caused erosion or other damage to the coverings.

## SPECIES IDENTIFICATION

SPECIES IDENTIFICATION

Kingdom Animalia

Phylum Porifera

Scypha sp.

Phylum Cnidaria

Class Hydrozoa

Halocordyle disticha (Goldfuss)

Obelia sp.

Plumularia sp.

Class Anthozoa

Aiptasiogeton sp.

Phylum Annelida

Class Polychaeta

Filograna sp.

Hydroides sp.

Phylum Mollusca

Class Gastropoda

Alaba incerta Orbigny

Cerithium eburneum Bruguiere

Class Pelecypoda

Atrina seminuda Lamarck

Musculus lateralis Say

Pinctada radiata Leach

Phylum Arthropoda

Class Crustacea

Subclass Cirripedia

Conchoderma sp.

Lepas sp.

Subclass Malacostraca

Order Amphipoda

Elasmopus pocillimanus (Bate)

Podocerus braziliensis (Dana)

Stenothoe crenulata Chevreax

unidentified caprellid

Phylum Sipunculida

1 unidentified species

Phylum Bryozoa

2 unidentified species

Phylum Chordata

Subphylum Urochordata

Class Ascideacea

Diplosoma macdonaldi Herdman

Herdmania momus (Savigny)

RESULTS

June 1980



CENTER FOR ENERGY AND ENVIRONMENT RESEARCH  
UNIVERSITY OF PUERTO RICO

16 July 1980

Mr. Jeffrey P. Kurt  
Development Engineer  
Simplex Wire and Cable Company  
P. O. Box 479  
Portsmouth, New Hampshire 03801

Dear Mr. Kurt:

On 25th June, the Simplex cable samples were removed from the water and examined. Inspection forms and photographs of the samples are enclosed. The fouling organisms mentioned were sampled but have not yet been identified beyond a general classification.

Sincerely yours,

Thomas Morgan  
Senior Associate

TM/cc  
Enclosure

cc: Dr. Donald S. Sasscer  
w/encl.



SIMPLEX CABLE EXPERIMENT

MONTHLY INSPECTION FORM

BUOY ( 1 ) 2

DATE 6-25-80

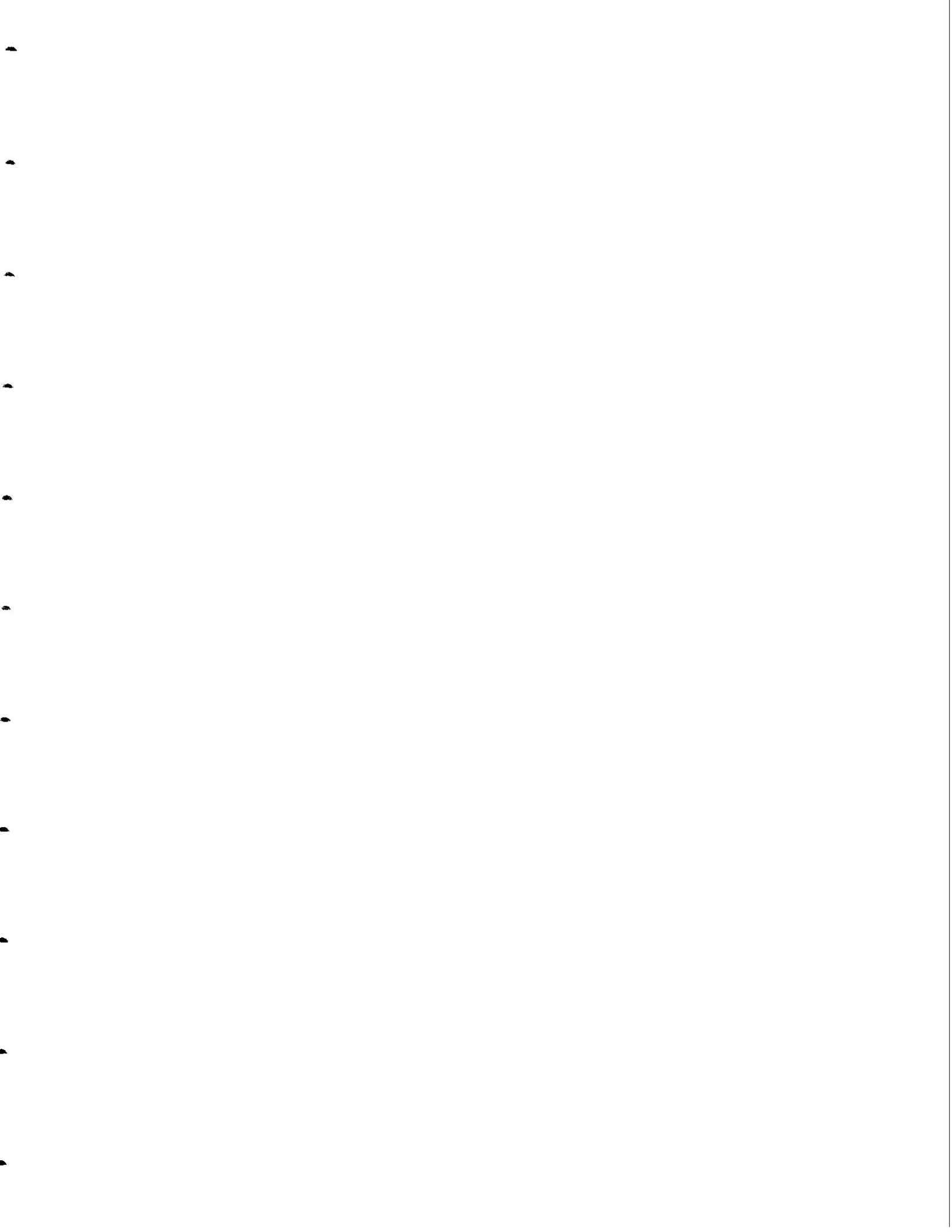
DEPTH 25' ( 200' )

TIME OUT 1320

INSPECTOR Morgan

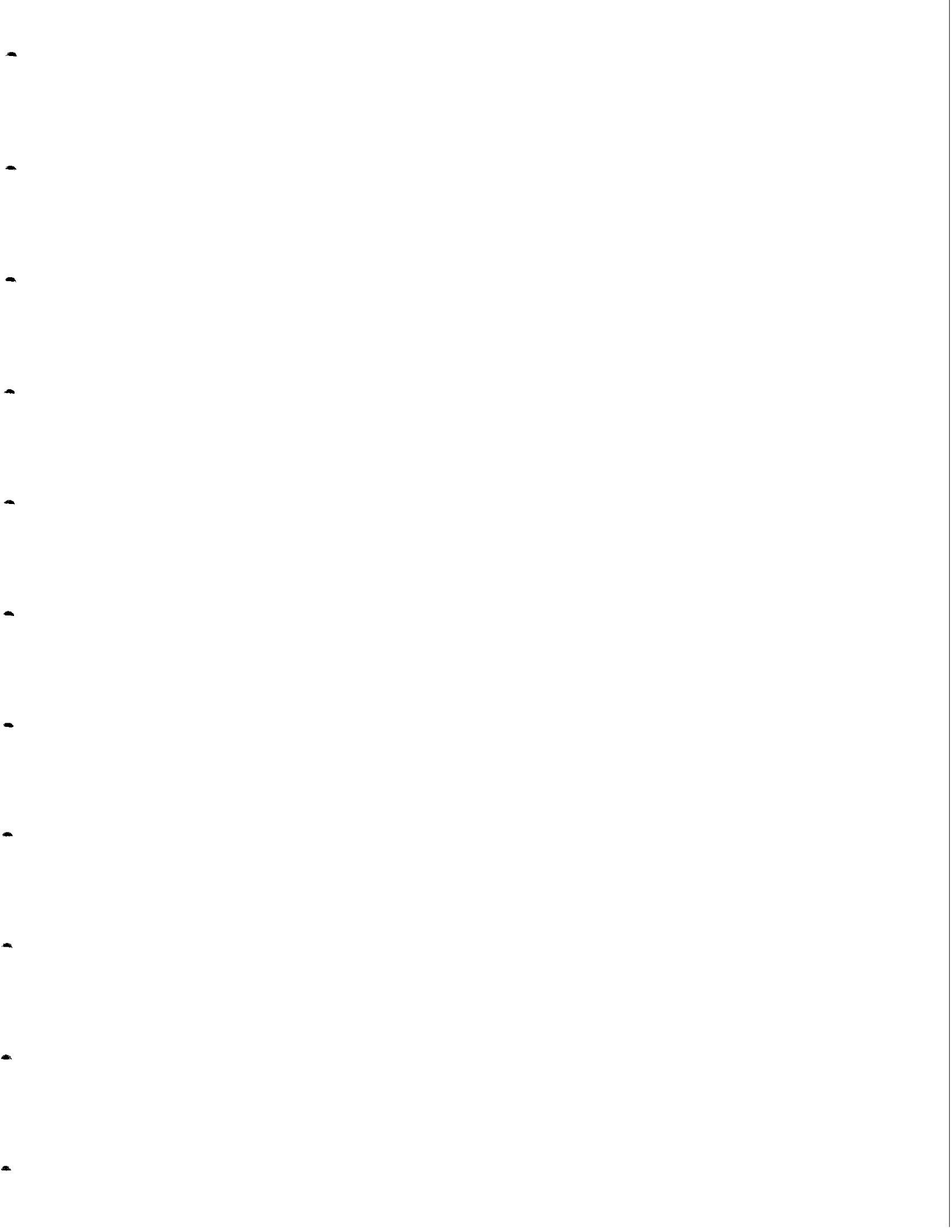
TIME IN 1345

SAMPLE #	EROSION	CORROSION	BIOFOULING
3	NONE	NONE	Hydroids (<5% cover)
7	NONE	NONE	Hydroid (30% cover)
11	NONE	NONE	Hydroid (5-10% cover)
15	NONE	NONE	Hydroid (50% cover)
18	NONE	Superficial Some oxidation	NONE
22	NONE	Slight corrosion at seams	NONE
25	NONE	NONE	Hydroid (50% cover)
117	NONE	NONE	Hydroid (50% cover)





6/25/80

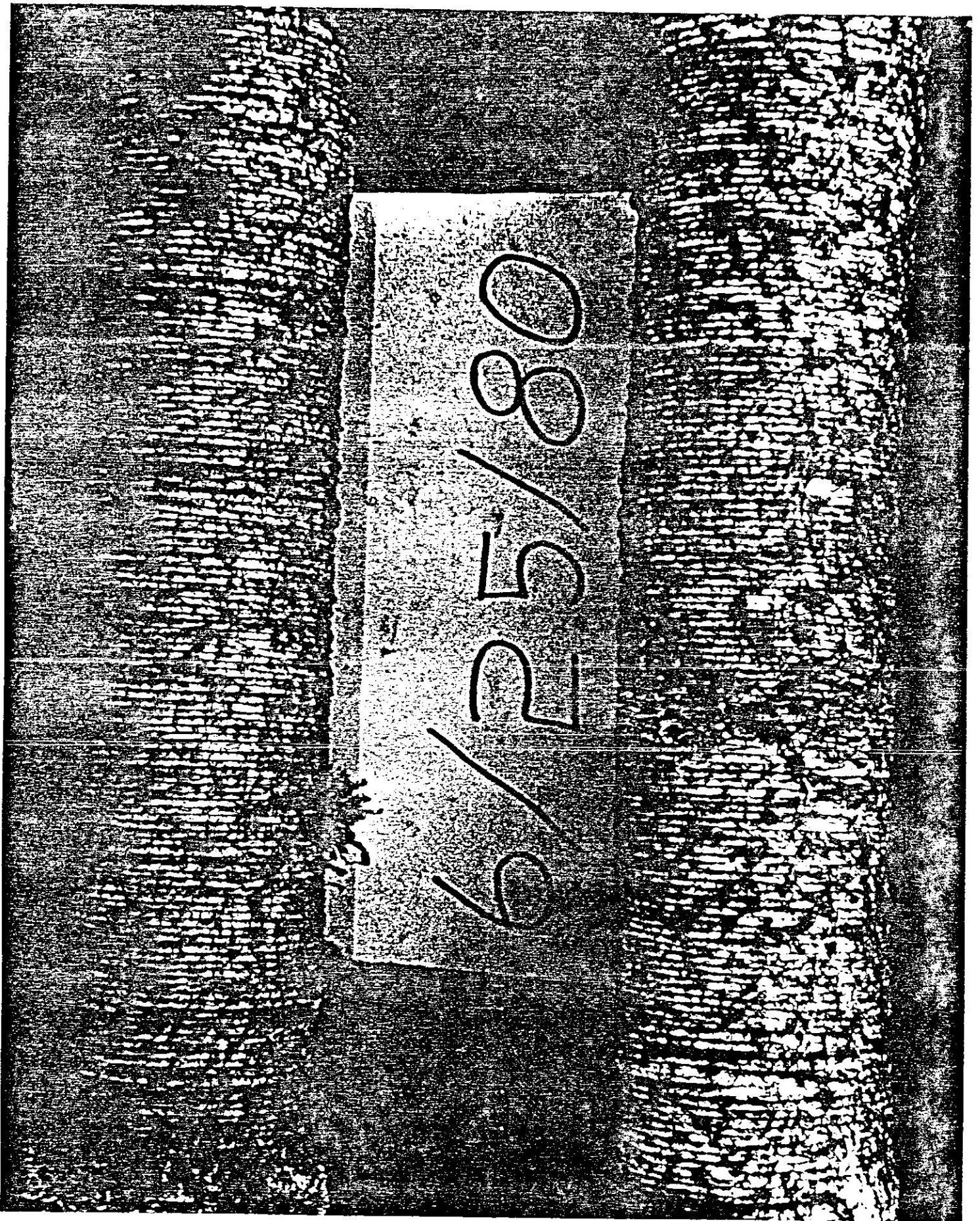




6/25/80







6/25/80

## SIMPLEX CABLE EXPERIMENT

Page 3 of 3

## MONTHLY INSPECTION FORM

BUOY 1 (2)

DATE 6-25-80

DEPTH (25') 200'

TIME OUT 1410

INSPECTOR Morgan

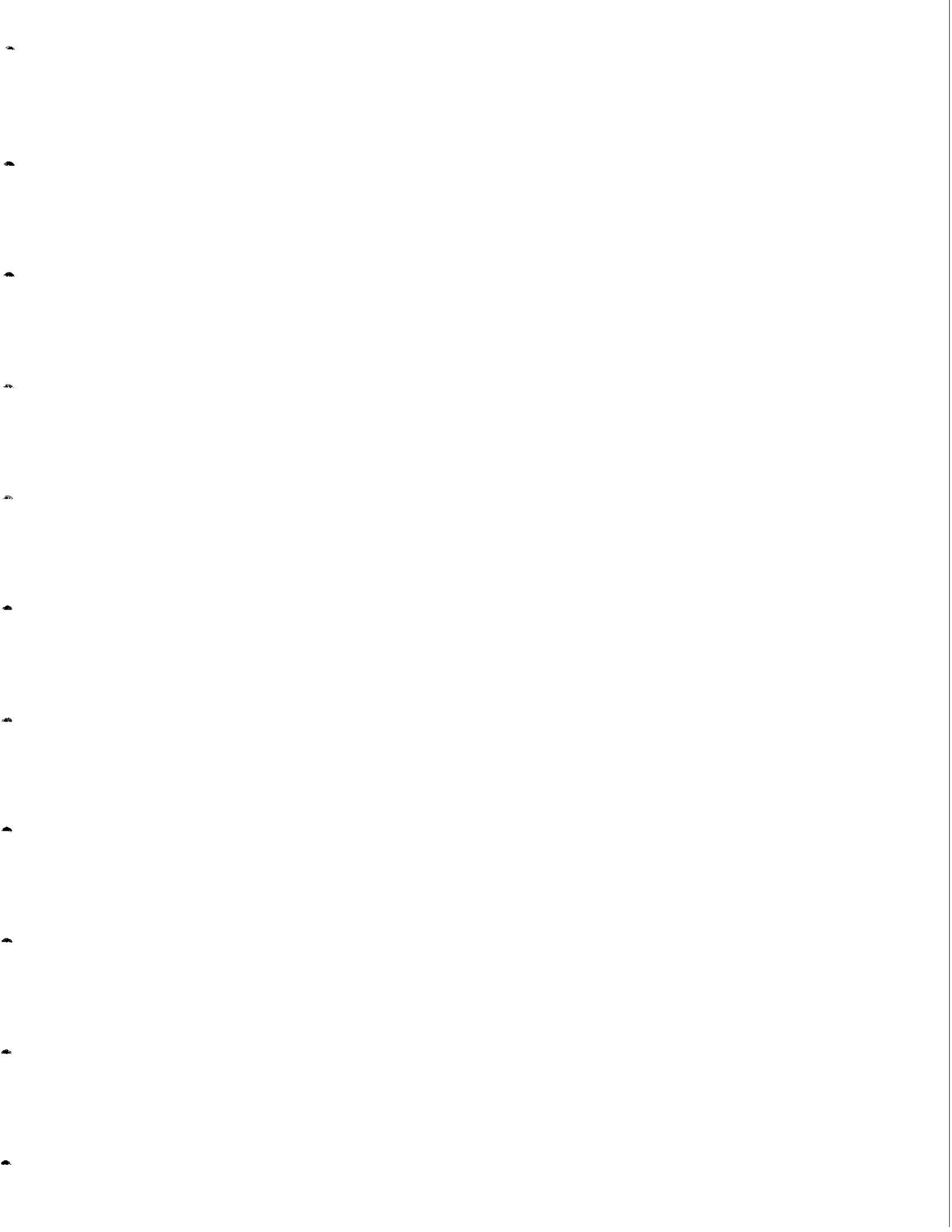
TIME IN 1450

SAMPLE #	EROSION	CORROSION	BIOFOULING
1	NONE	NONE	Hydroids (50% cover) Amphipods (numerous)
5	NONE	NONE	Hydroids (50% cover) Amphipods (numerous)
9	NONE	NONE	Hydroids (70% cover) Amphipods (numerous) Polychaete (13)
13	NONE	NONE	Hydroids (70% cover) Amphipods (numerous) Polychaete (13)
17	NONE	Some superficial oxidation	NONE
20	NONE	Slight corrosion at seams	Hydroids (5-10% cover)
26	NONE	NONE	Hydroids (70% cover) Macro-algae (<1% cover) Amphipods (numerous)
118	NONE	NONE	Hydroids (70% cover) Macro-algae (<1% cover) Amphipods (numerous)

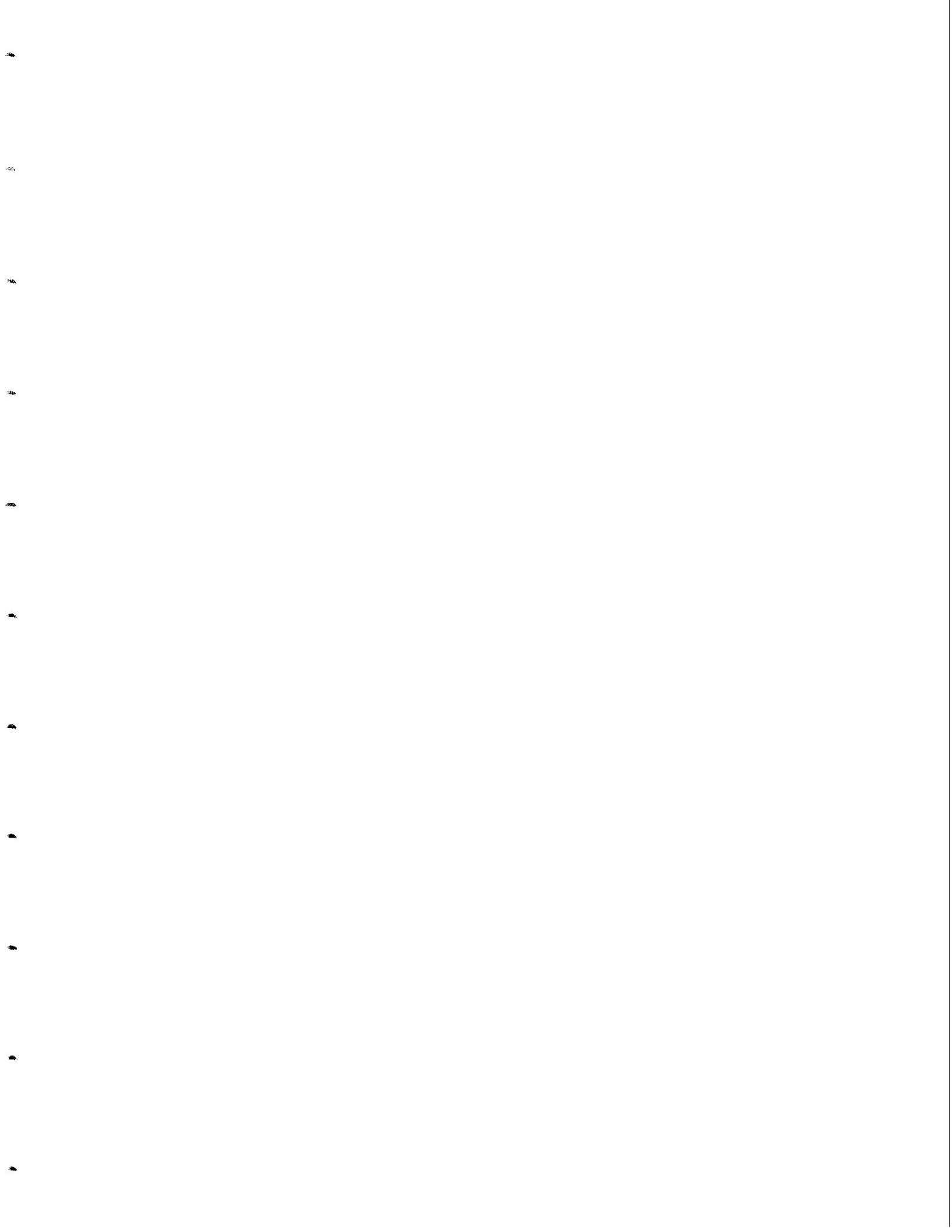




6/25/80



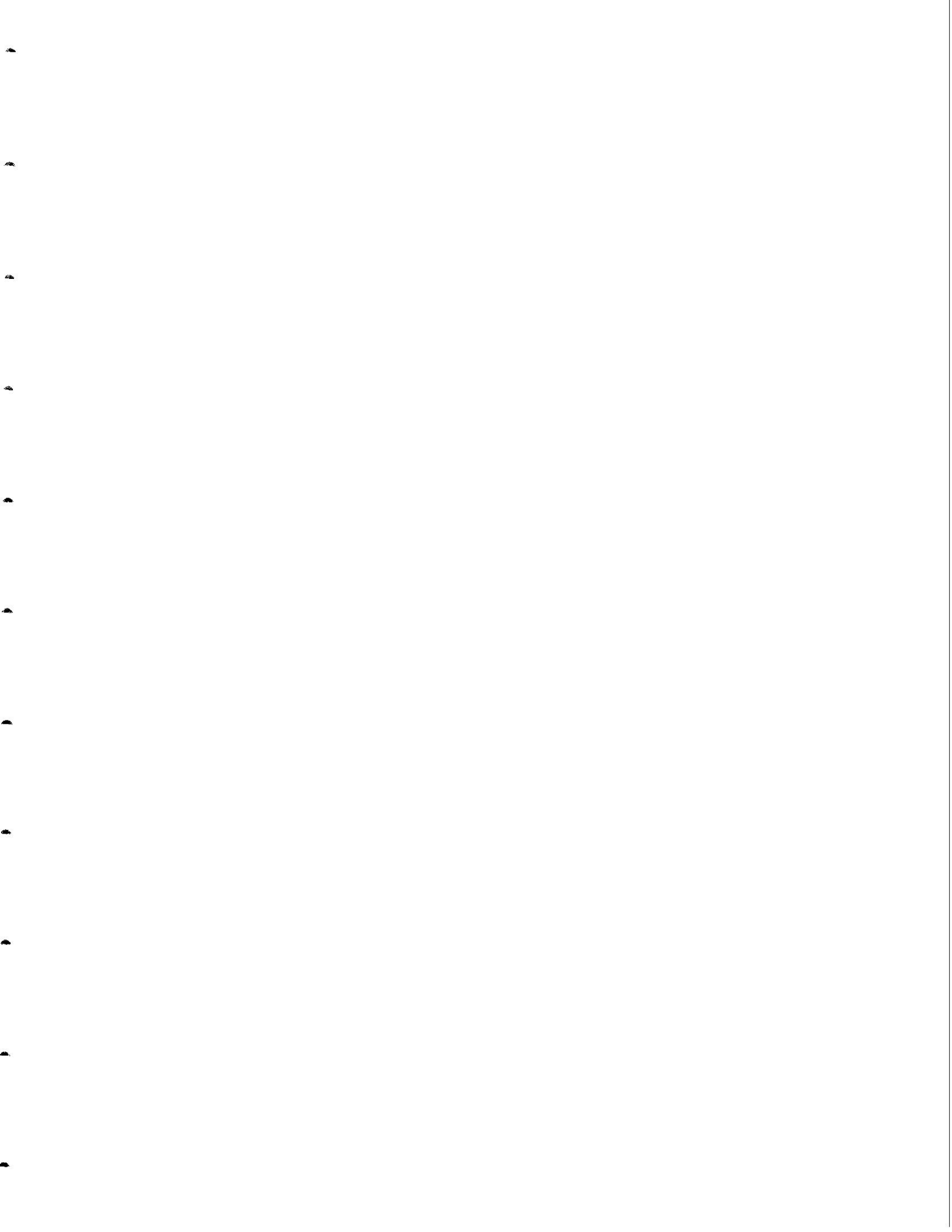
6/25/80







6/25/80



6/25/80



SIMPLEX CABLE EXPERIMENT

MONTHLY INSPECTION FORM

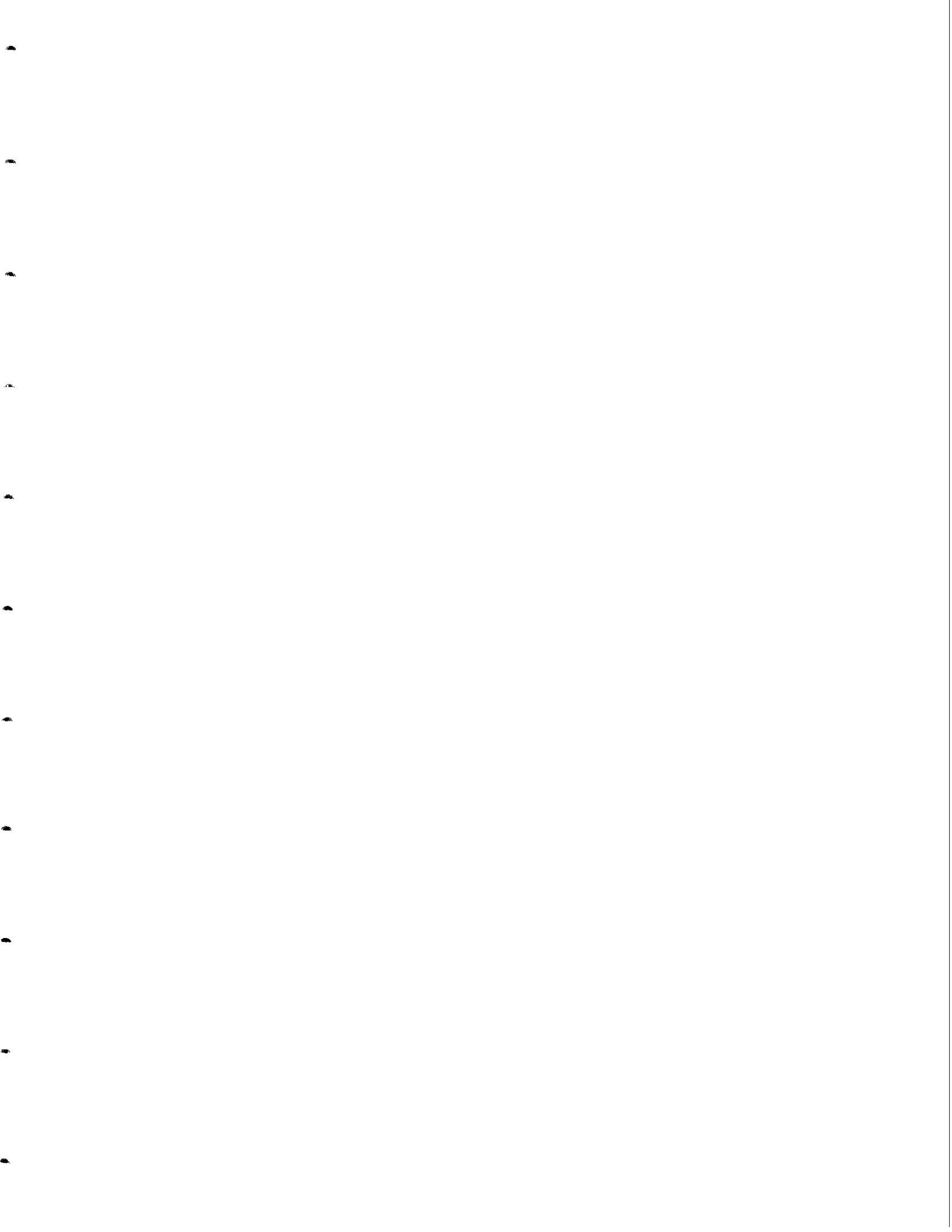
BUOY 1 ( 2 )  
 DEPTH 25' ( 200' )  
 INSPECTOR Morgan

DATE 6-25-80  
 TIME OUT 1440  
 TIME IN 1510

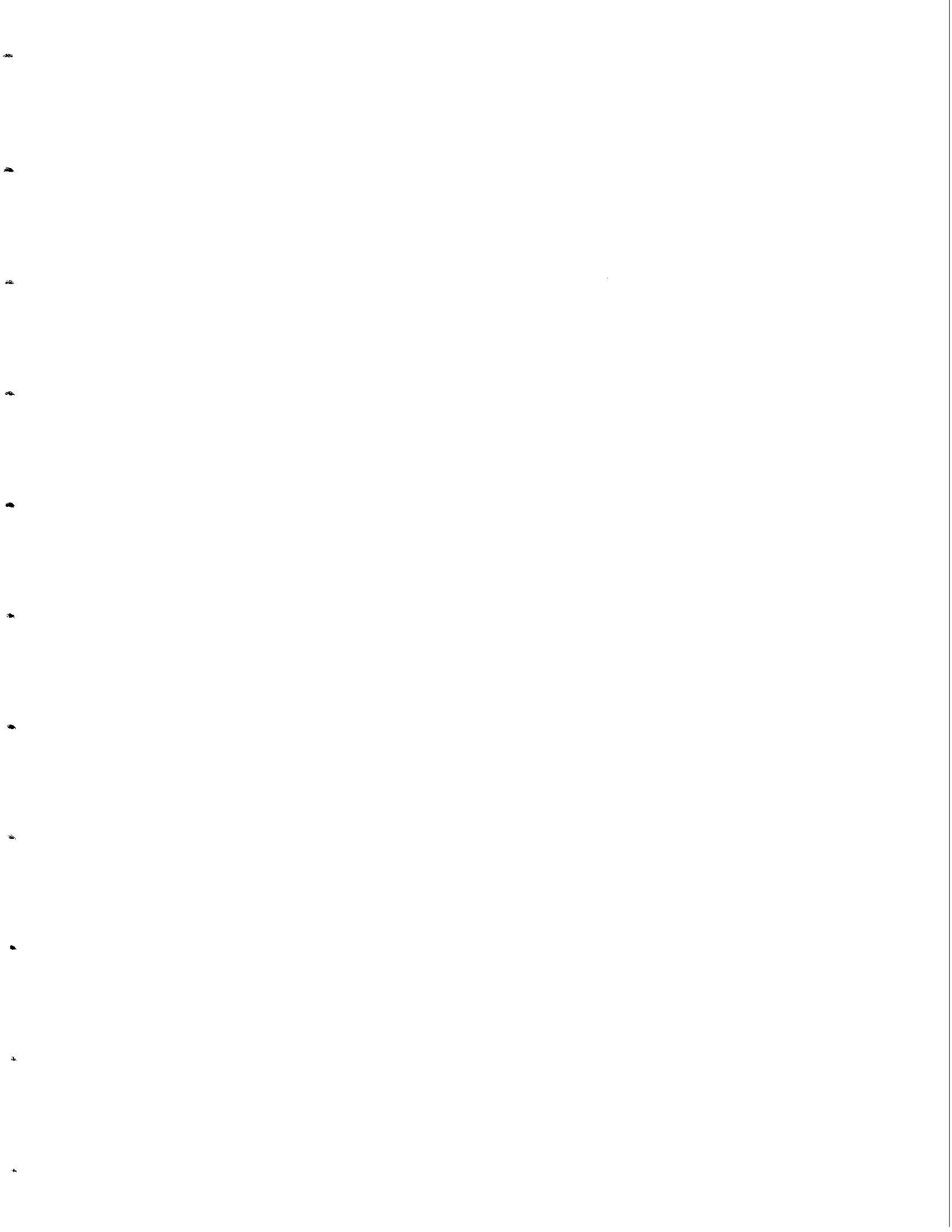
SAMPLE #	EROSION	CORROSION	BIOFOULING
2	NONE	NONE	Hydroids (40% cover)
6	NONE	NONE	Hydroids (40% cover)
10	NONE	NONE	Hydroids (50% cover)
14	NONE	NONE	Hydroids (50% cover)
21	NONE	Some superficial oxidation	NONE
24	NONE	Slight corrosion at seams	Hydroids (5-10% cover)
28	NONE	NONE	Hydroids (50% cover)
120	NONE	NONE	Hydroids (50% cover)



6/25/80

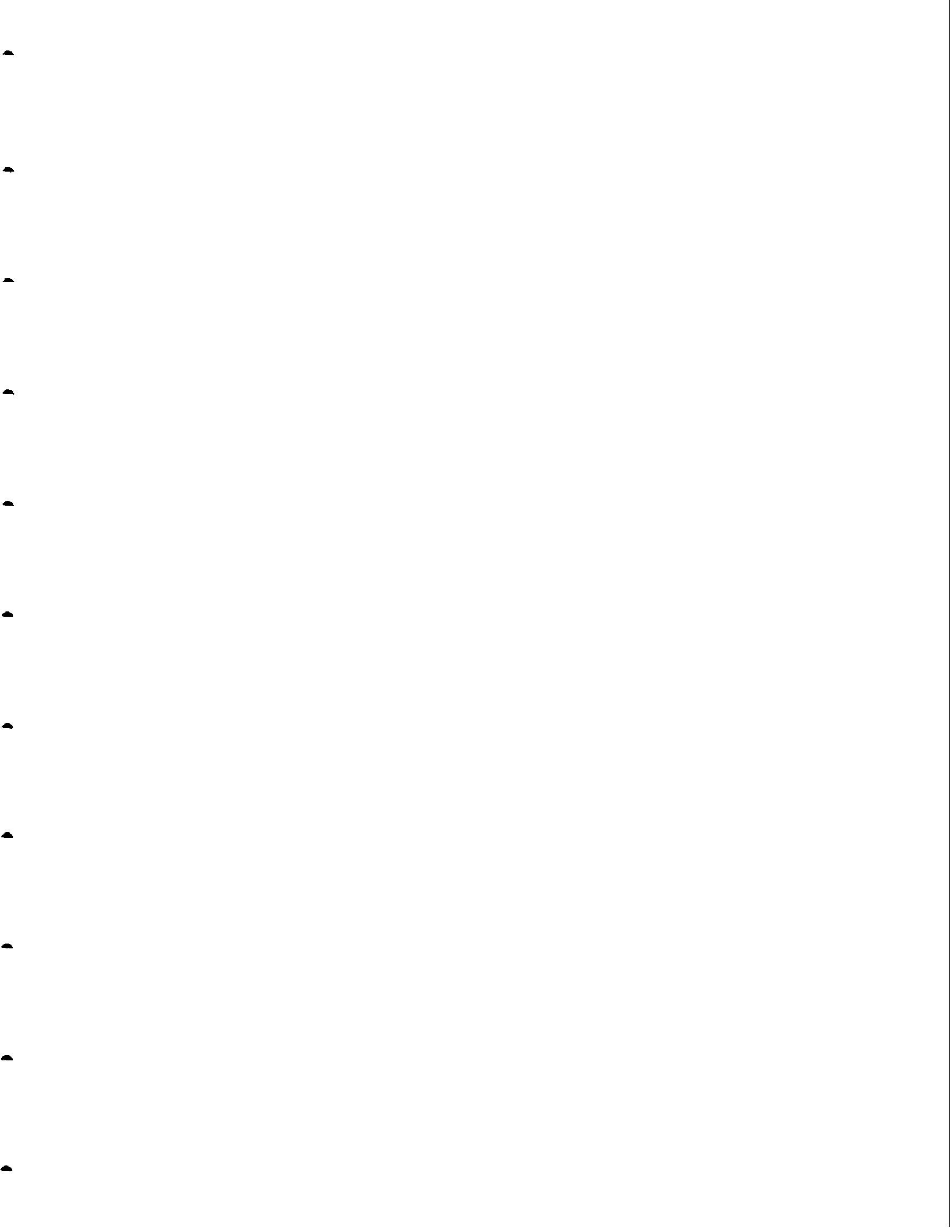


6/25/80





6/25/80





6/25/80

October  
1980

SIMPLEX CABLE EXPERIMENT

Page \_\_\_\_\_

MONTHLY INSPECTION FORM

BUOY 1      2

DATE 31 October 1980

DEPTH 25'      200'

TIME OUT 1230

INSPECTOR Thomas Morgan

TIME IN 1300

SAMPLE #	EROSION	CORROSION	BIOFOULING
4	None	None	See Detailed Analysis
8	None	None	" " "
12	None	None	" " "
16	None	None	" " "
19	None	Shallow pitting	amphipod
23	None	cover turn shallow pitting	some hydroid, algae, amphipod on cover
27	None	None	See Detailed Analysis
119	None	None	" " "

DETAILED ANALYSIS

Buoy:   1  

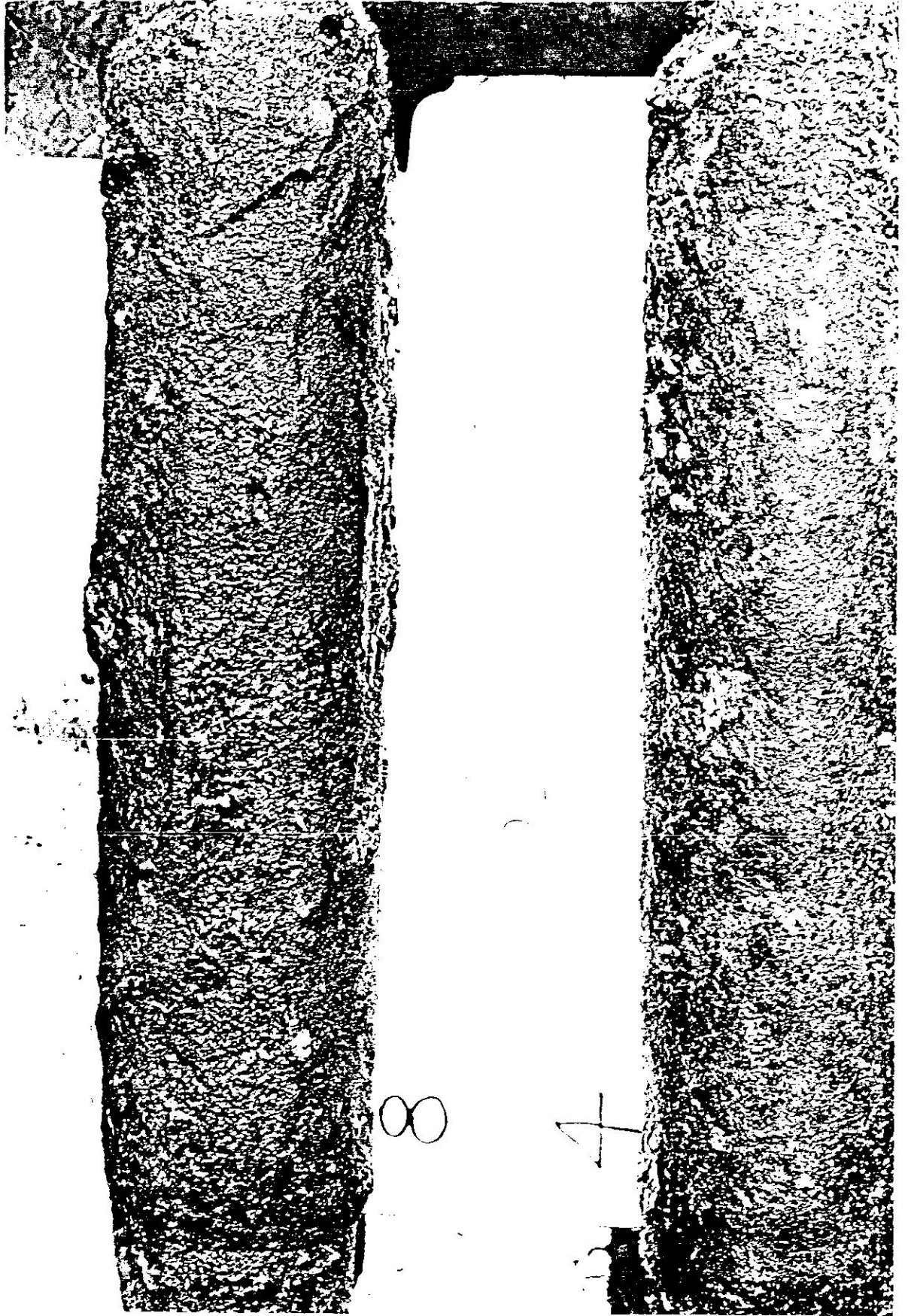
Depth:  25' 

Date:  31 October 1980 

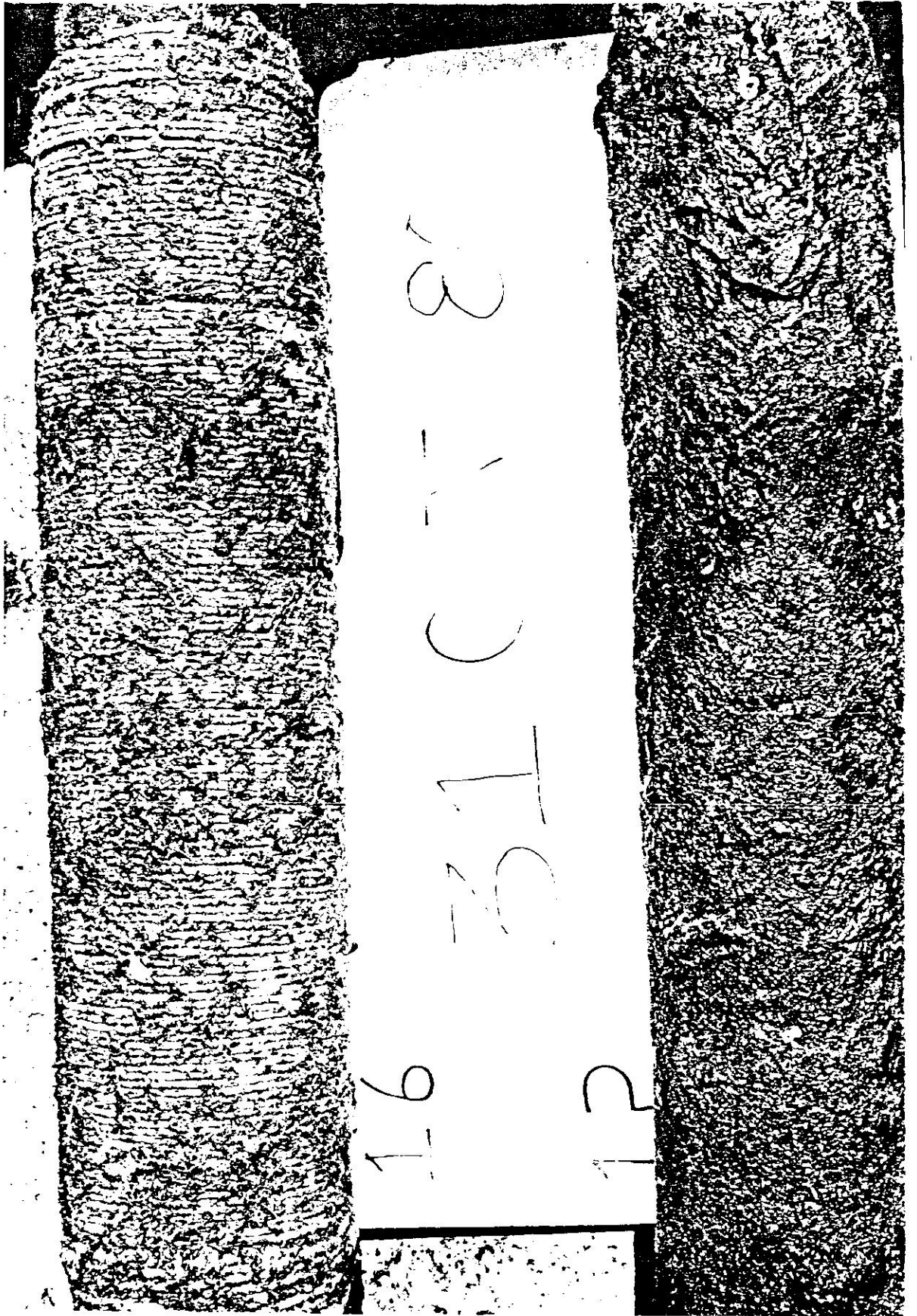
Biofouling on samples 4, 8, 12, 16, 27, 119

algae	80 % cover
<u>Cladophora</u>	algae dominant
<u>Heterosiphonia</u>	
<u>Microcoleus</u>	
<u>Neomeris</u>	
<u>Polysiphonia</u>	
bryozoan	
ascidian	
<u>Diplosoma</u>	
hydroid	
<u>Plumularia</u>	
sea anemone	occasional
<u>Aiptasiogeton</u>	
serpulid worms	several per sample
<u>Filograna</u>	
<u>Hydroides</u>	
amphipod	numerous
<u>Podocerus</u>	
<u>Stenothoe</u>	
bivalve	occasional
<u>Atrina</u>	









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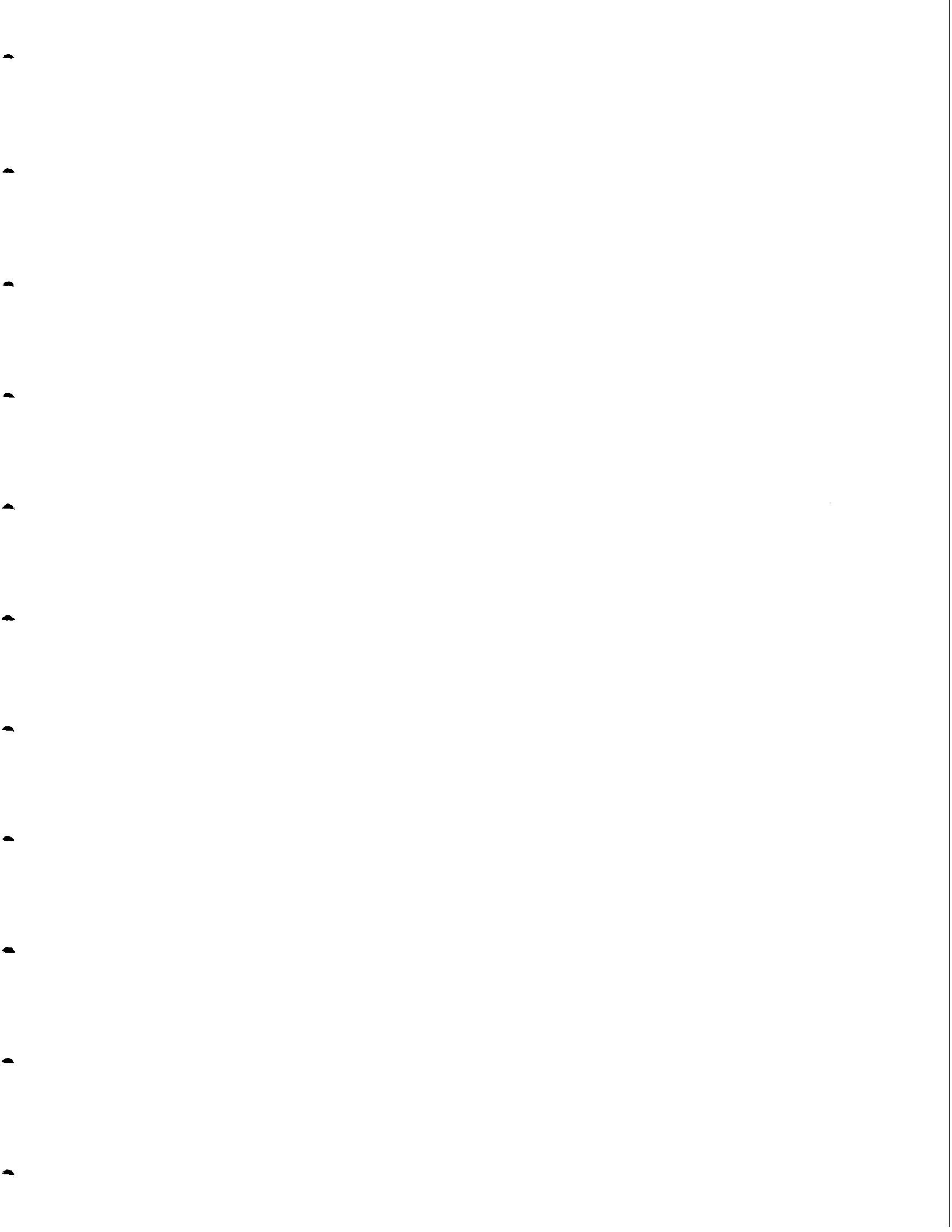
67

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119

31 OCT

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SIMPLEX CABLE EXPERIMENT

MONTHLY INSPECTION FORM

BUOY      1            2  
DEPTH    25'          200'  
INSPECTOR Thomas Morgan

DATE 31 October 1980  
TIME OUT 0950  
TIME IN 1030

SAMPLE #	EROSION	CORROSION	BIOFOULING
1	None	None	See Detailed Analysis
5	None	None	" " "
9	None	None	" " "
13	None	None	" " "
17	None	shallow pitting	None
20	None	cover gone - shallow pitting	None
26	None	None	See Detailed Analysis
118	None	None	" " "

DETAILED ANALYSIS

Buoy:   2  

Depth:  25' 

Date:  31 October 1980 

Biofouling on samples 1, 5, 9, 13, 26, 118

algae	80 % cover
<u>Cladophora</u>	algae dominant
<u>Microcoleus</u>	
<u>Polysiphonia</u>	
bryozoan	
ascidian	
<u>Diplosoma</u>	
hydroid	
<u>Plumularia</u>	
anemone	occasional
<u>Aiptasiogeton</u>	
serpulid worm	several per sample
<u>Filograna</u>	
<u>Hydroides</u>	
bivalve	occasional
<u>Pinctada</u>	
amphipod	numerous
<u>Podocerus</u>	
<u>Stenothoe</u>	



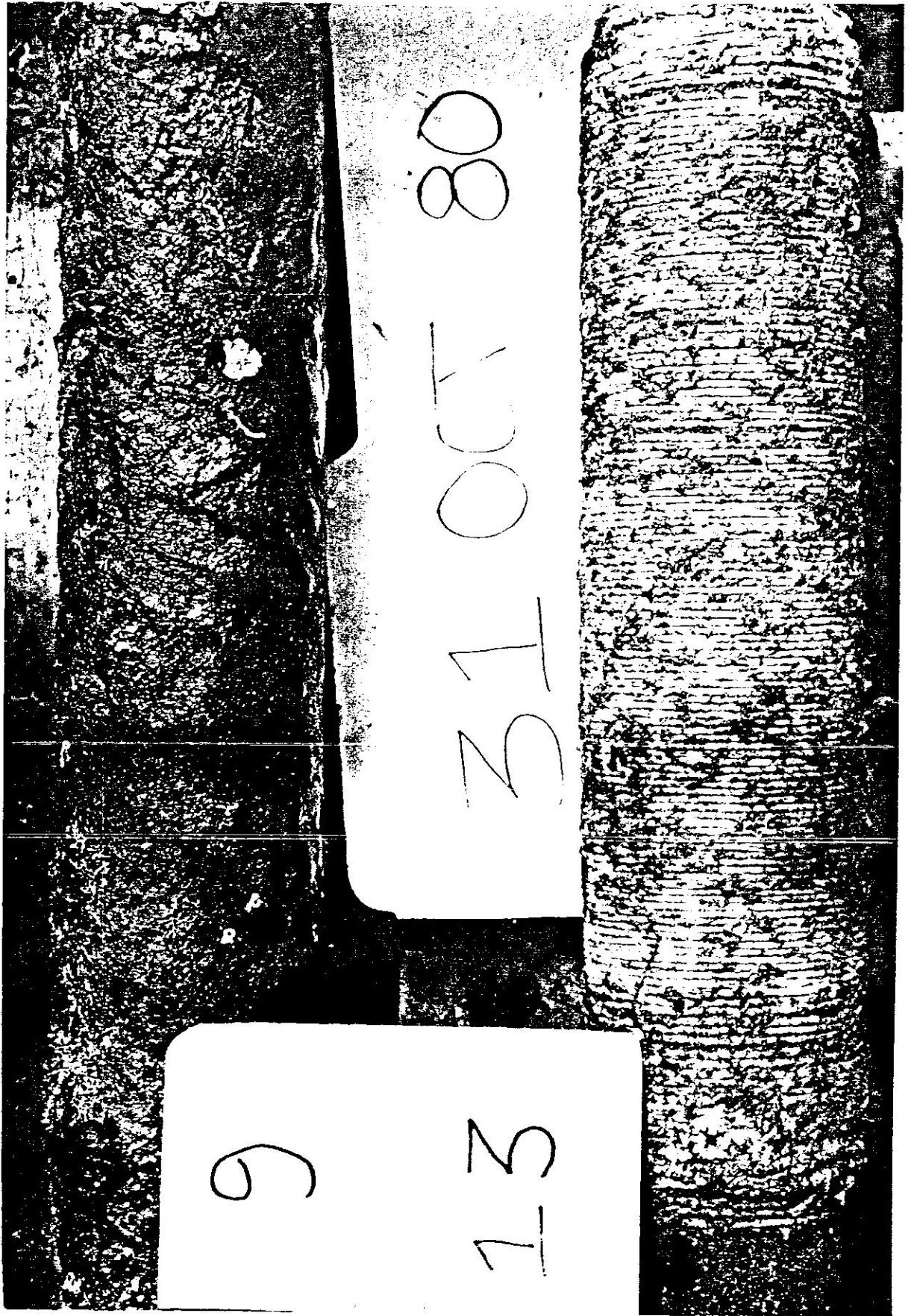




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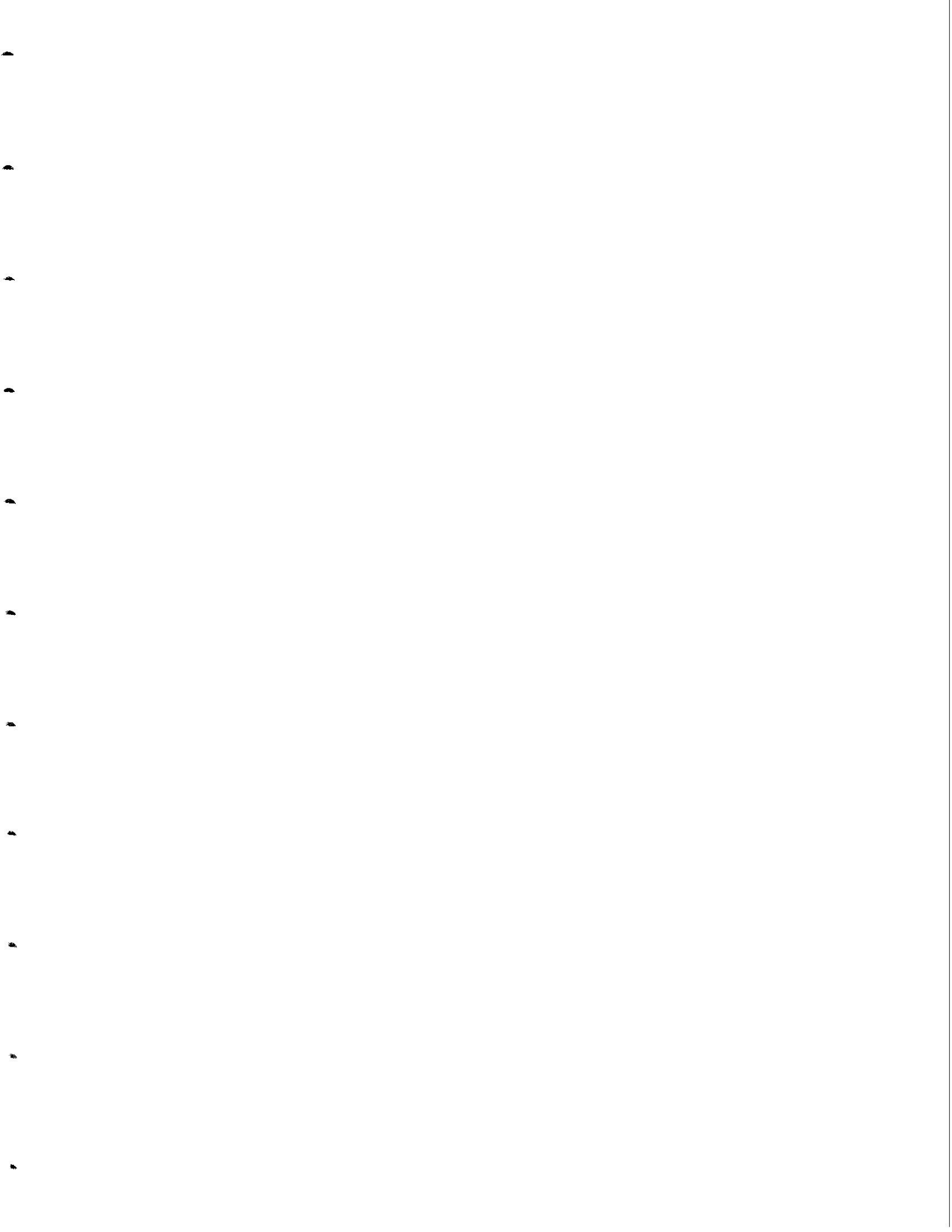
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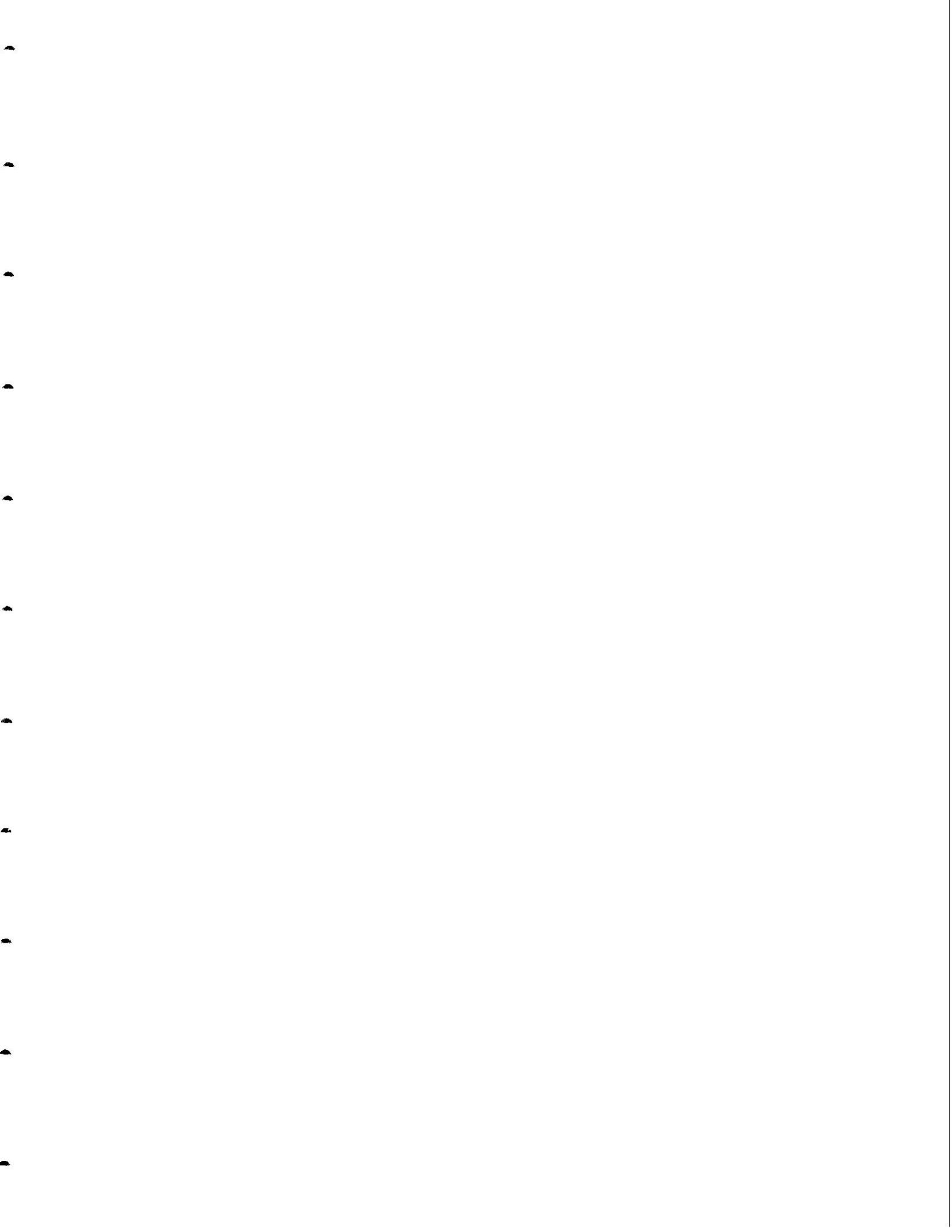


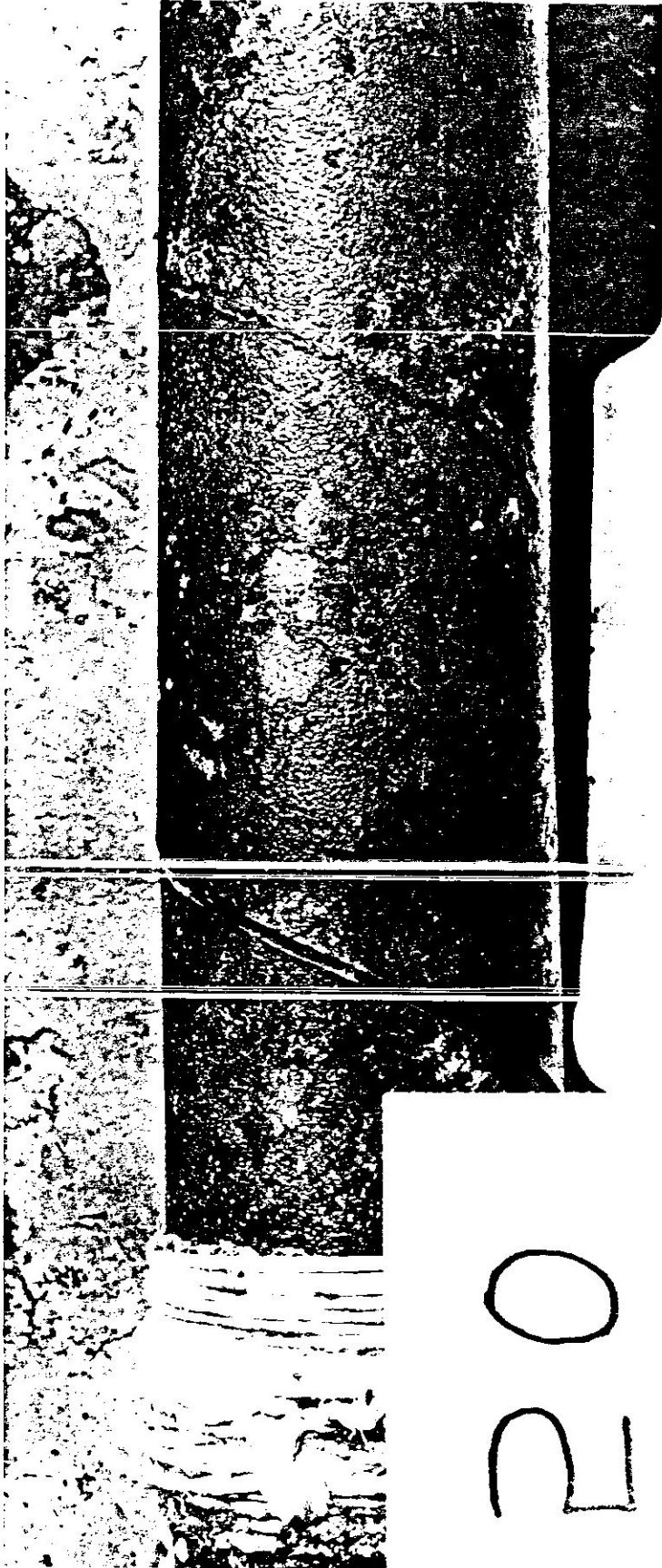


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17

31 OCT 80

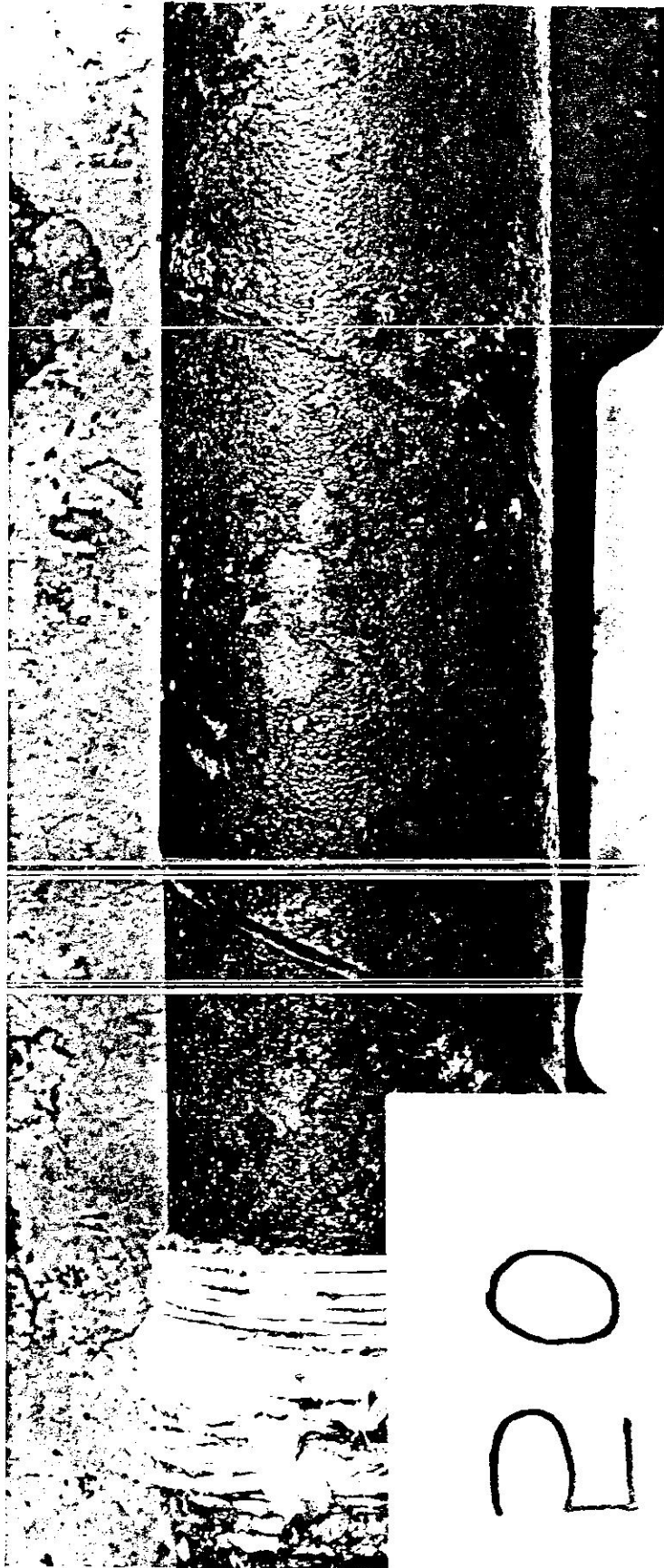




20



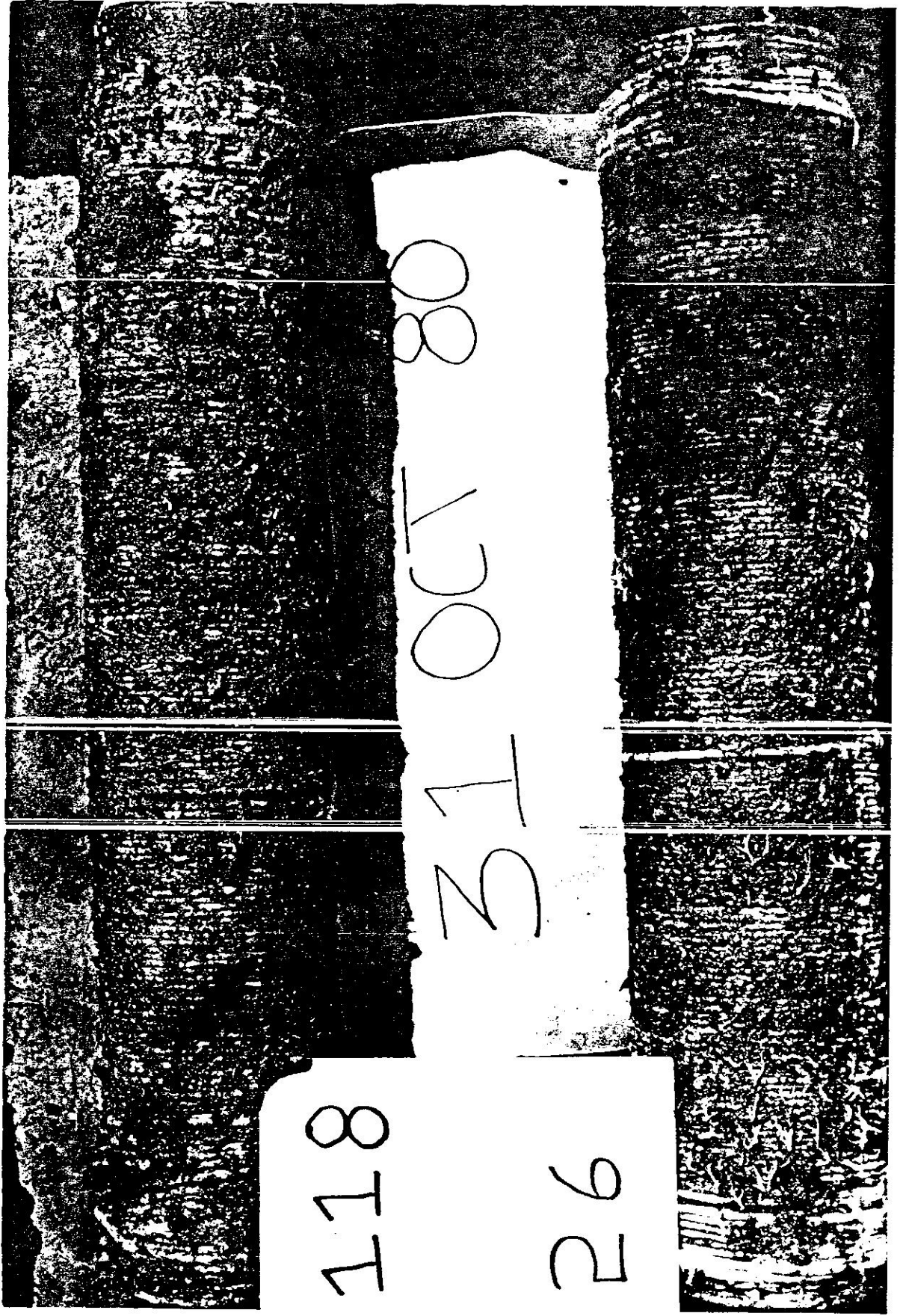




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SIMPLEX CABLE EXPERIMENT

MONTHLY INSPECTION FORM

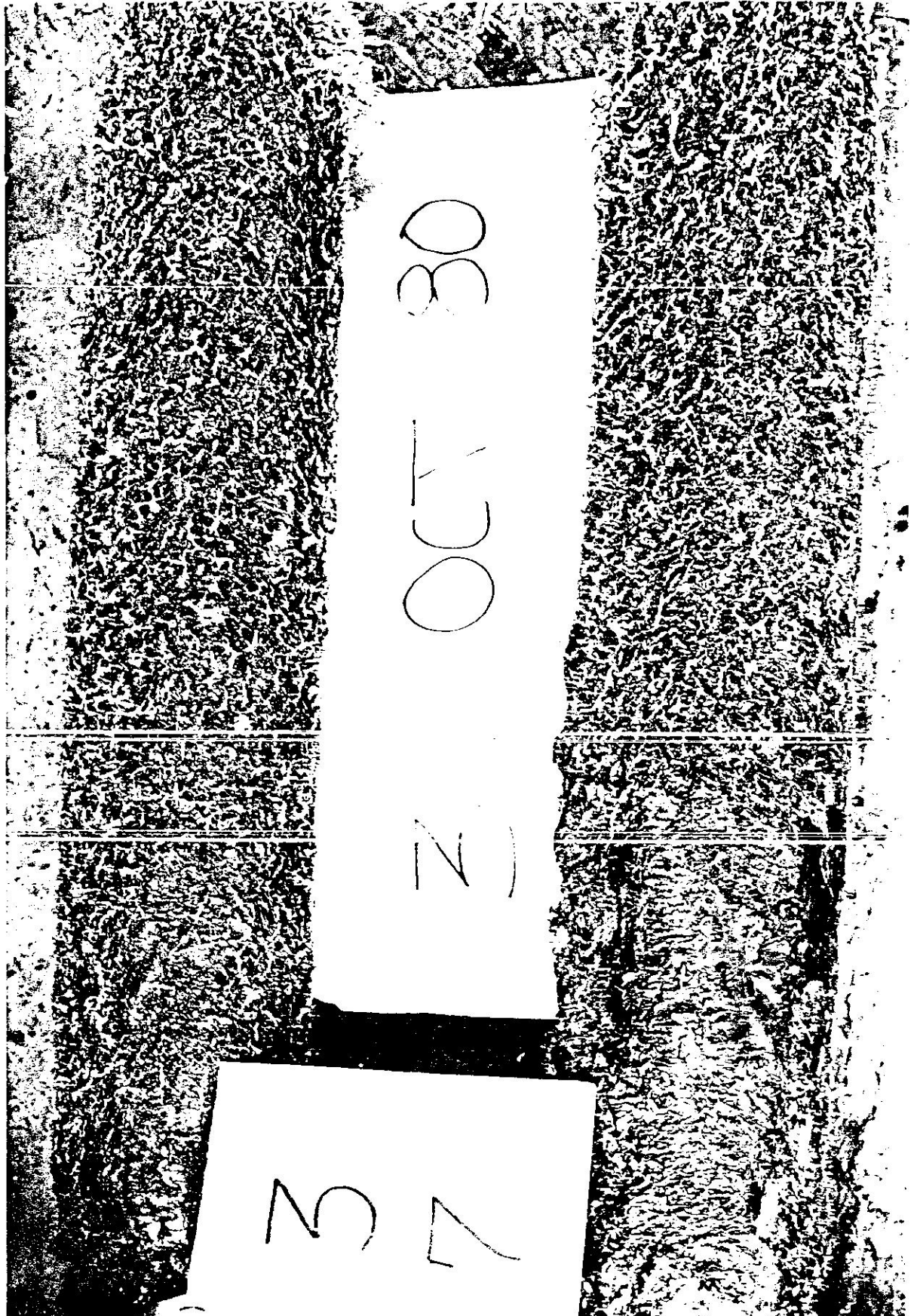
BUOY 1 2  
 DEPTH 25' 200'  
 INSPECTOR Thomas Morgan

DATE 31 October 1980  
 TIME OUT 1300  
 TIME IN 1530

SAMPLE #	EROSION	CORROSION	BIOFOULING
3	None	None	A 80% cover C few D numerous
7	None	None	A 80% cover C few D numerous
11	None	None	A 20% cover C few D few E 1
15	None	None	A 60% cover B < 5% cover C few D numerous
18	None	shallow pitting	A in crevice
22	None	Cover torn shallow pitting	
25	None	None	A 80% cover C few D numerous
117	None	None	A 60% cover C few D numerous

A. hydroid Obelia  
 B. hydroid Halocordyle  
 C. Serpulid worm Hydroides, Filograna  
 D. amphipod Podocerus, Stenothoe, caprellid  
 E. gooseneck barnacle Lepas



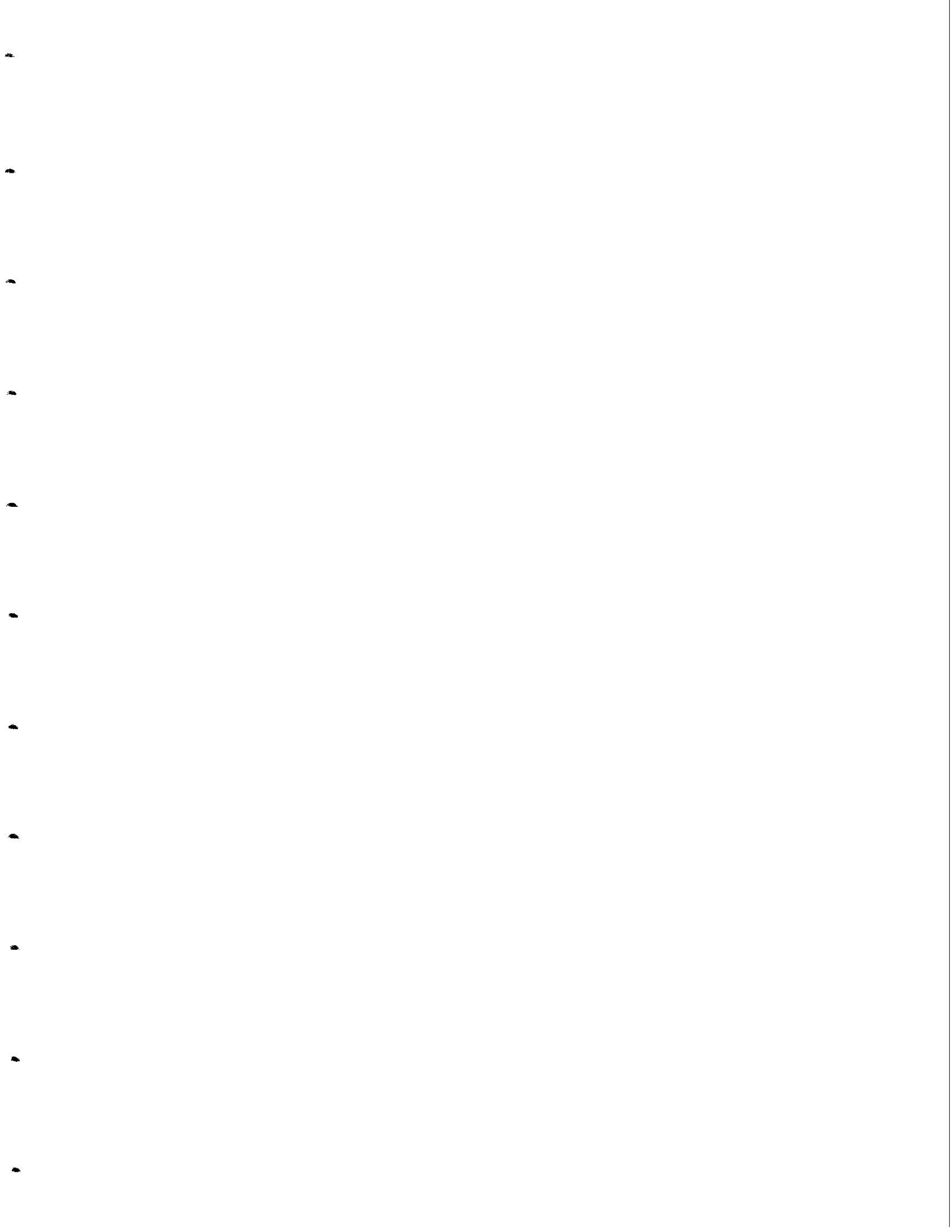


30

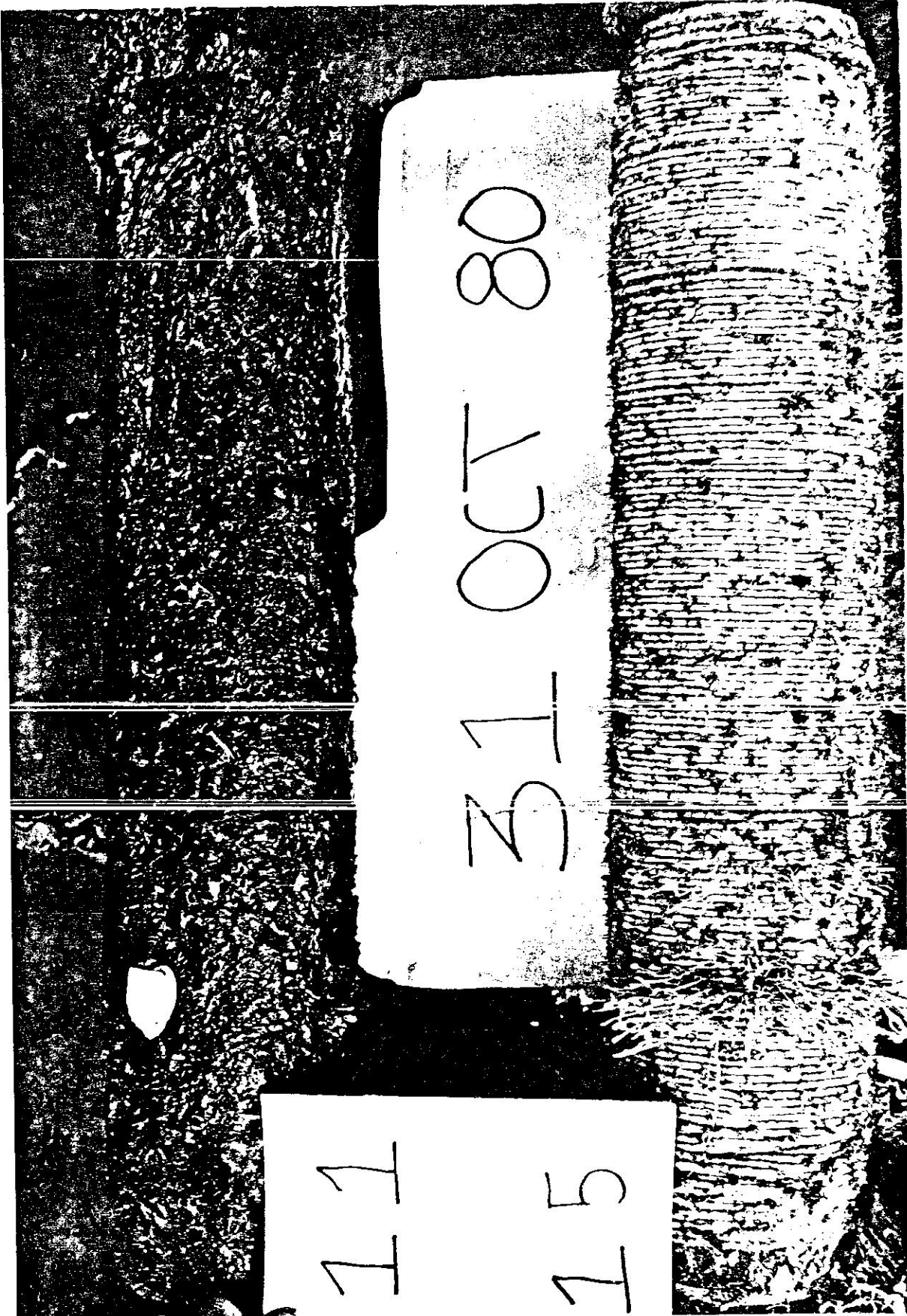
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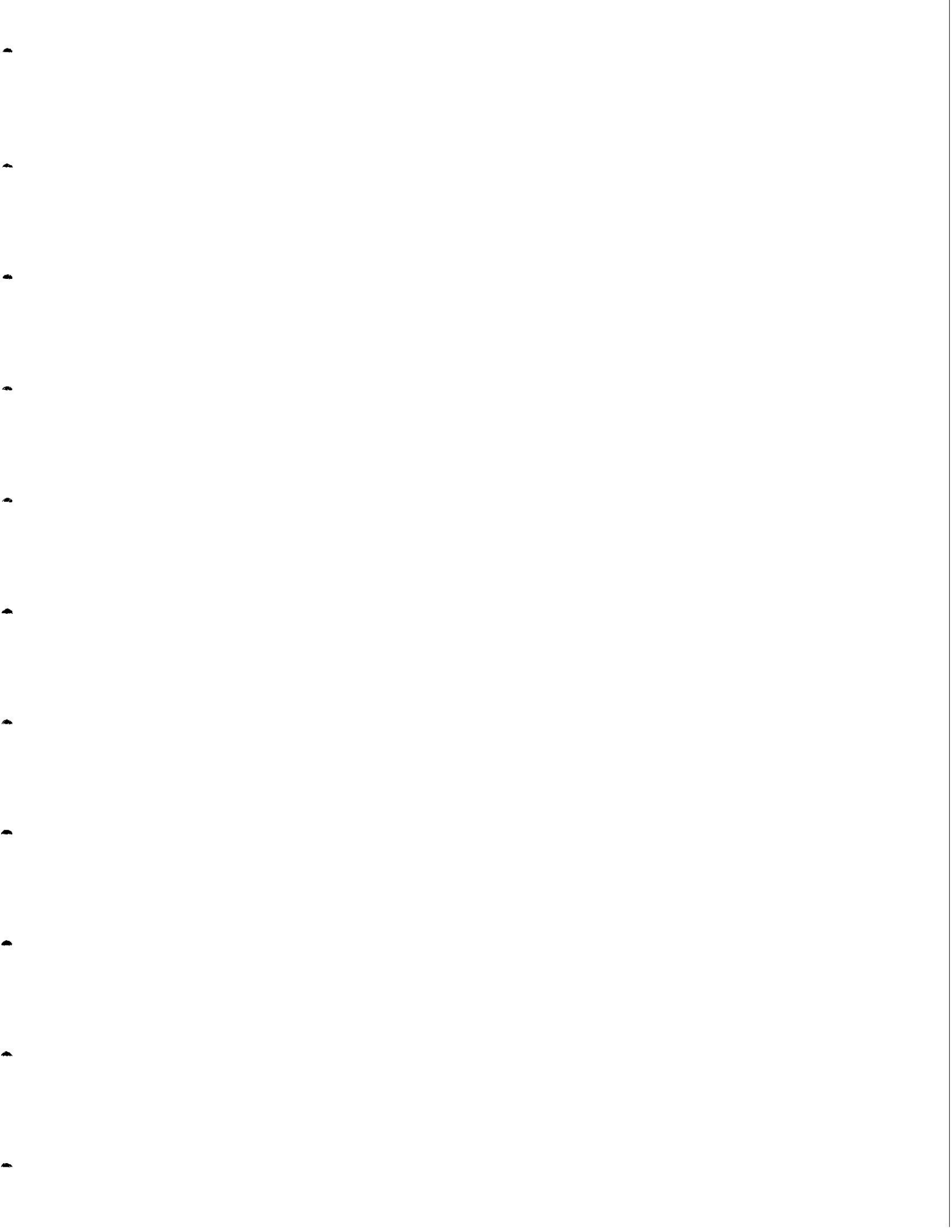
80

OCT

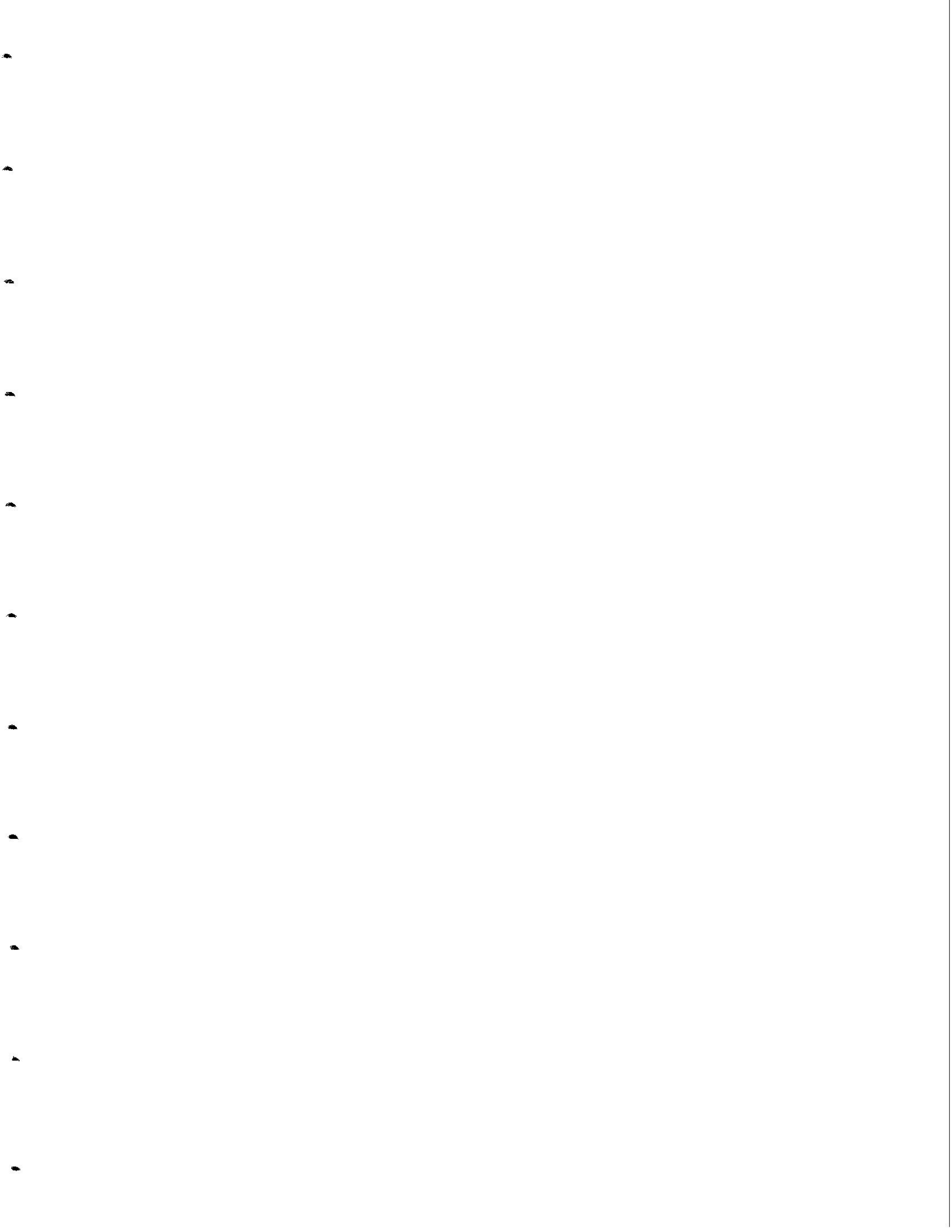
31

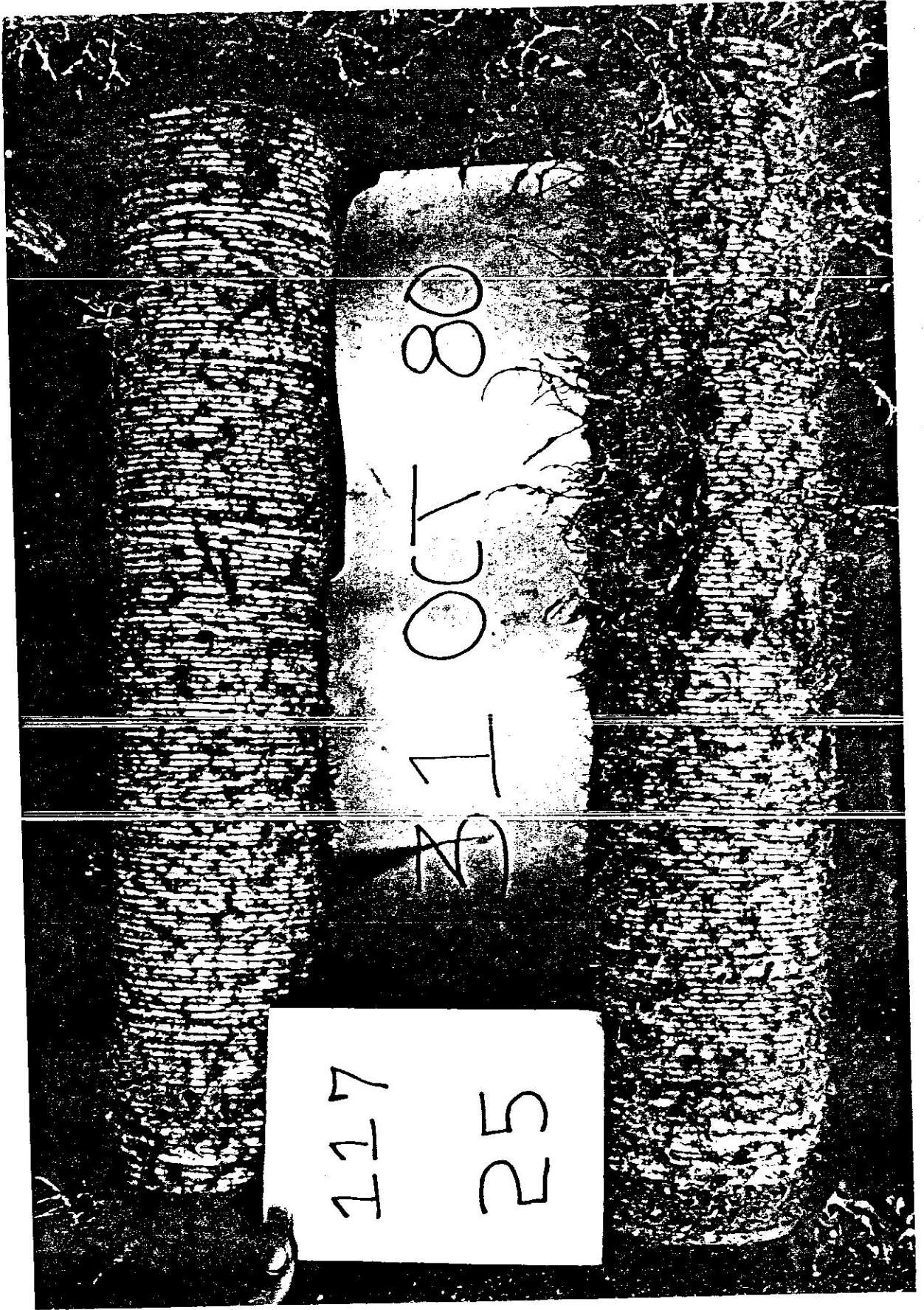
11

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25

SIMPLEX CABLE EXPERIMENT

MONTHLY INSPECTION FORM

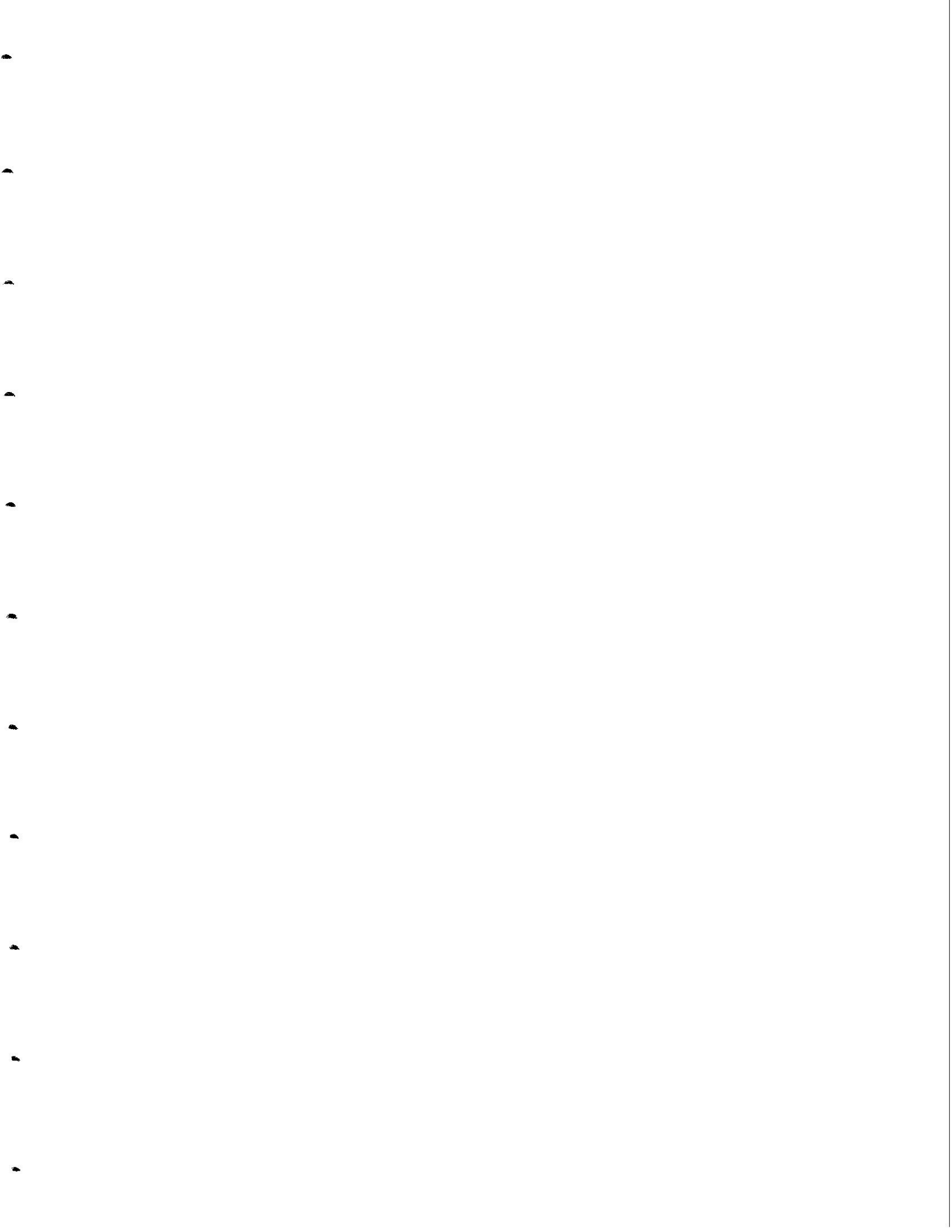
BUOY      1      2      DATE 31 October 1980

DEPTH    25'      200'      TIME OUT 1030

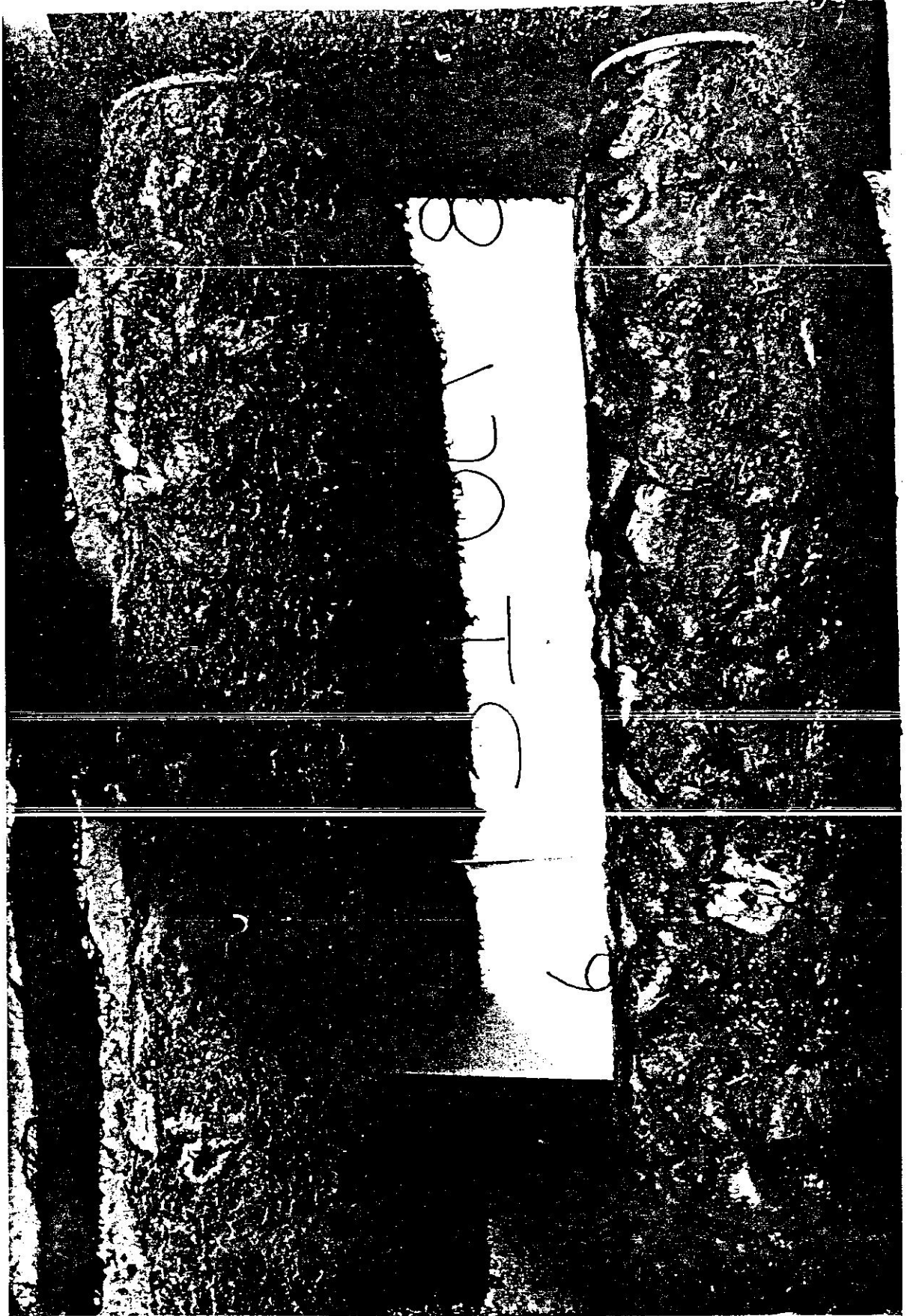
INSPECTOR Thomas Morgan      TIME IN 1115

SAMPLE #	EROSION	CORROSION	BIOFOULING
2	None	None	A 80% cover C few D numerous
6	None	None	A 20% cover C few D few E 1
10	None	None	A 20% cover C few D few
14	None	None	A 80% cover C few D numerous
21	None	shallow pitting	C few
24	None	Cover torn shallow pitting	C few
28	None	None	A 20% cover C few D few
120	None	None	A 30% cover B < 1% C few D few

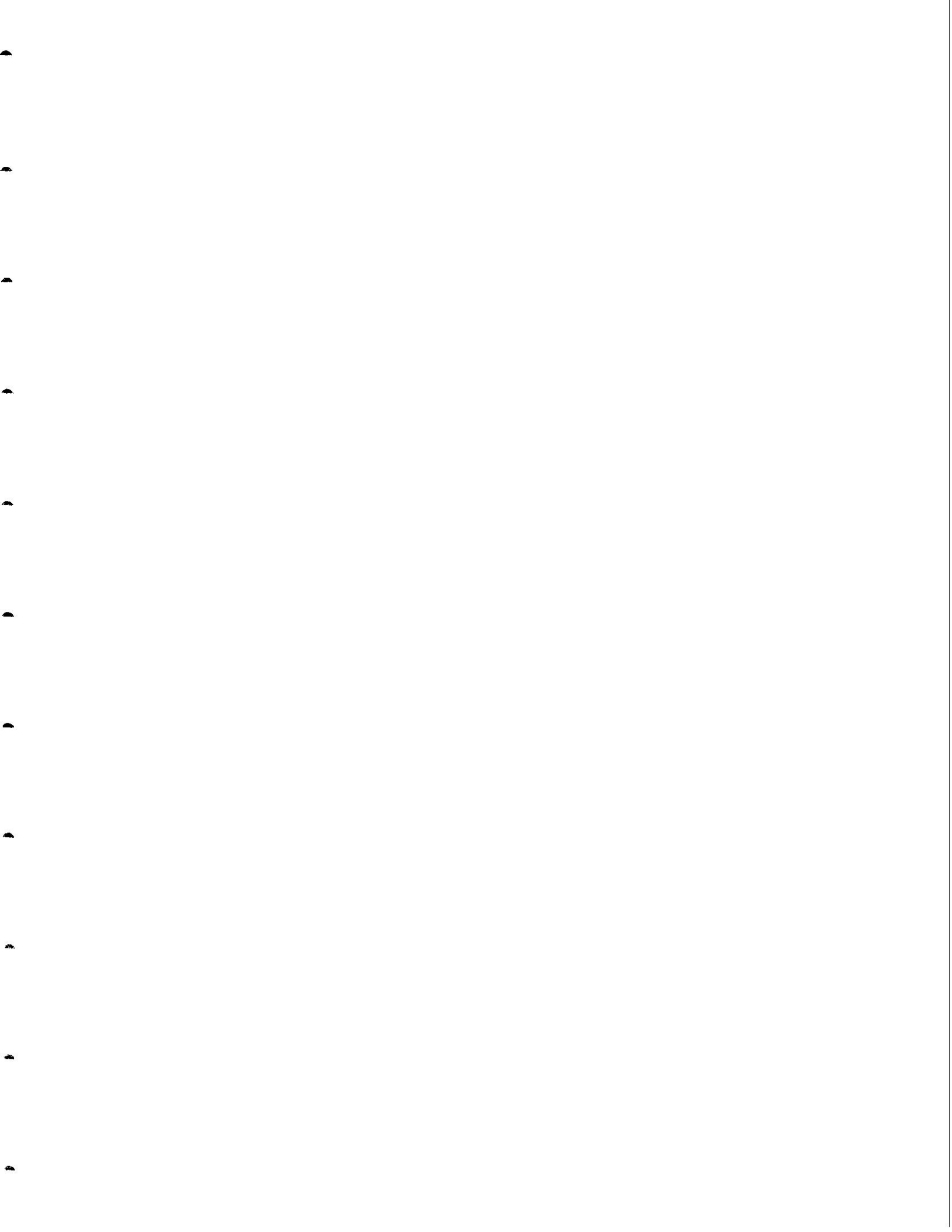
A. hydroid Obelia  
 B. hydroid Halocordyle  
 C. Serpulid worm Hydroides, Filograna  
 D. amphipod Podocerus, Stenothoe, caprellid  
 E. gooseneck barnacle Lepas



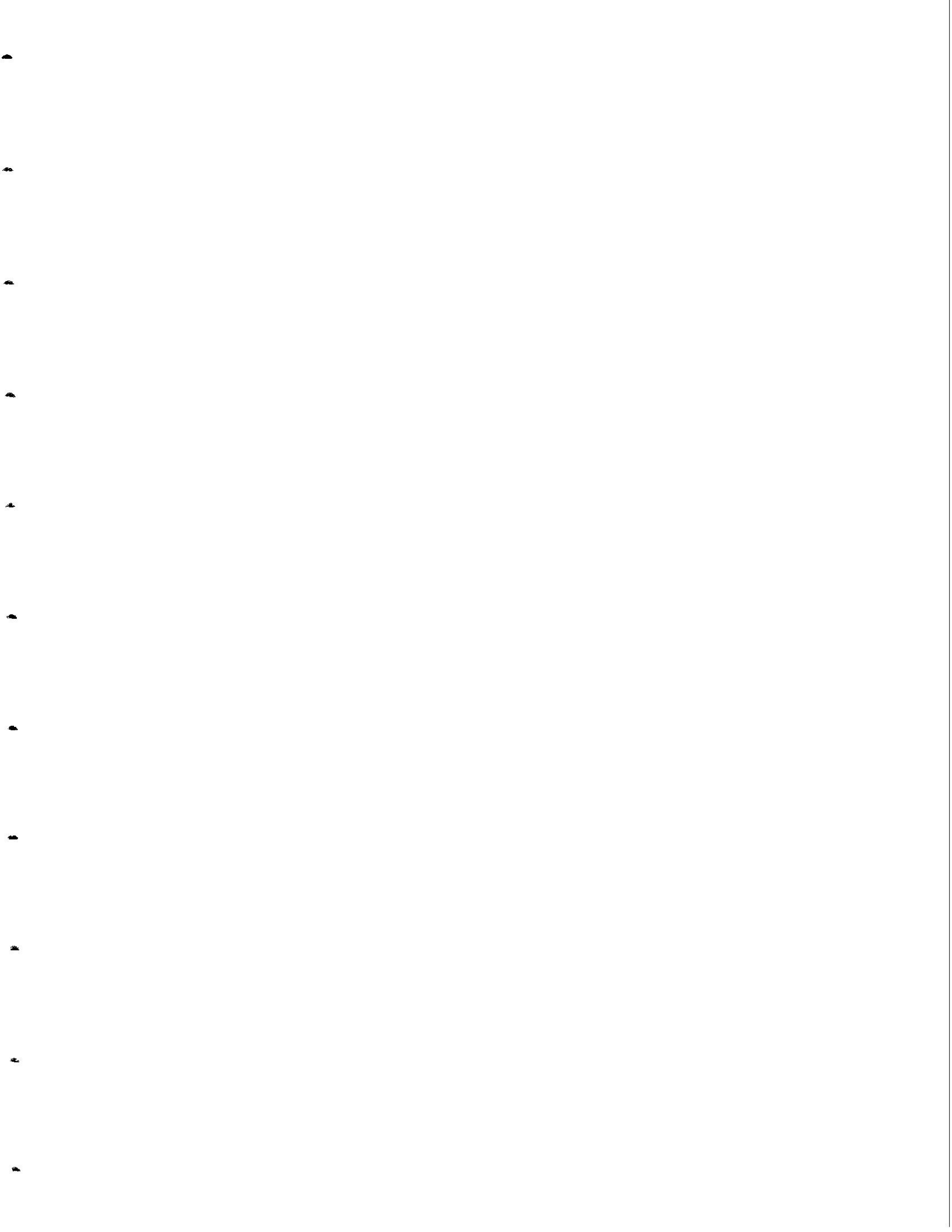




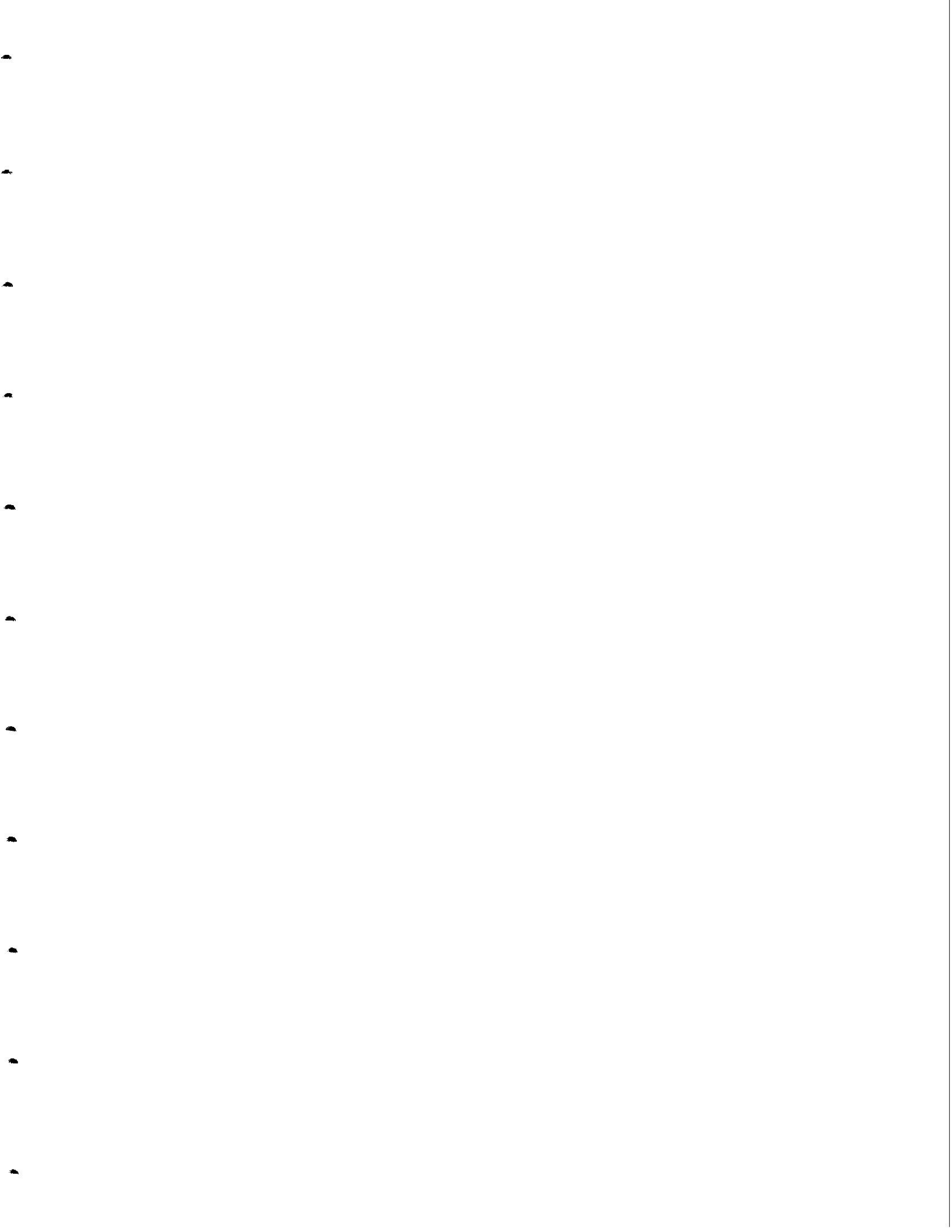


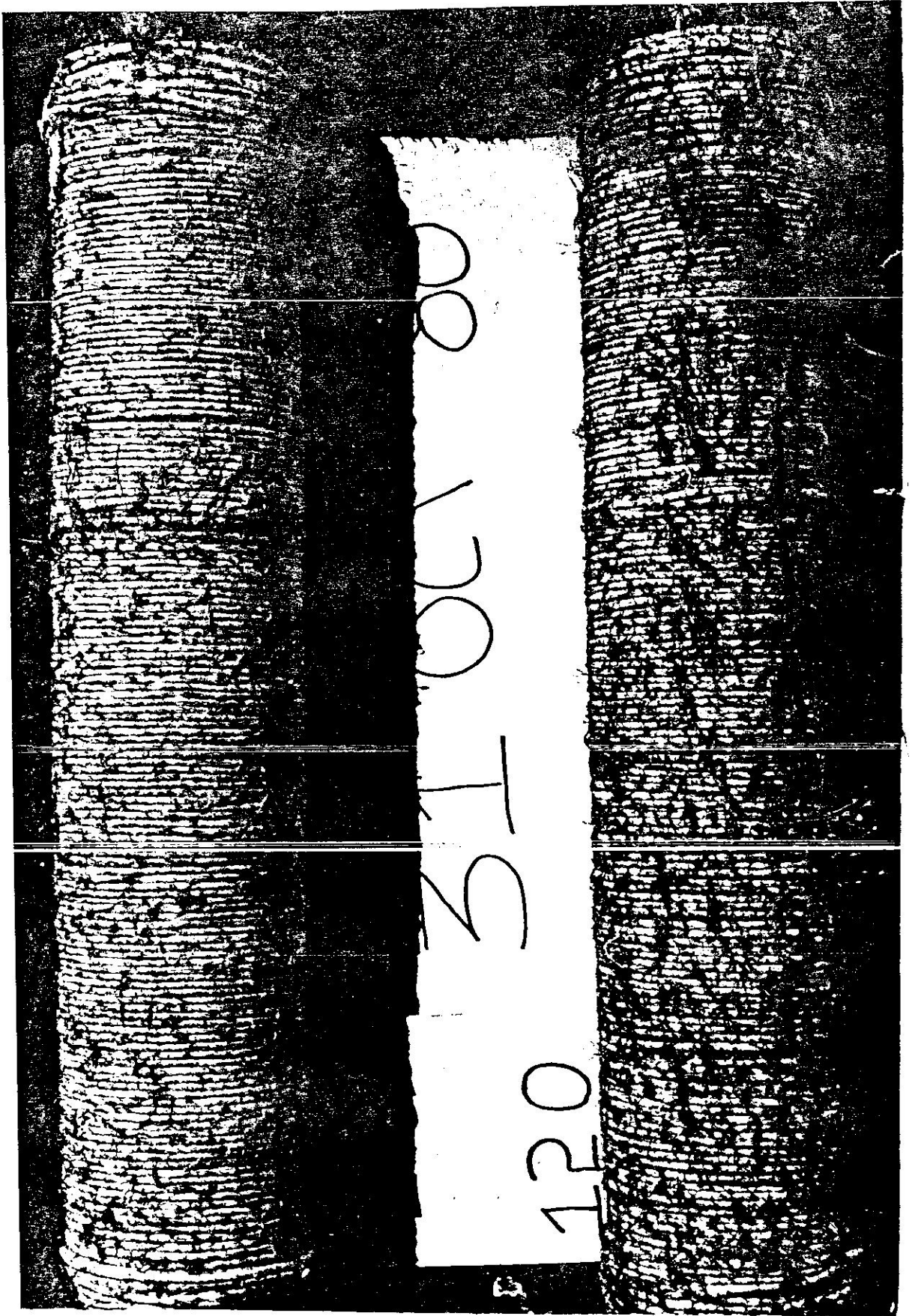












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## RESULTS

January Inspection

January

1981



SIMPLEX CABLE EXPERIMENT

MONTHLY INSPECTION FORM

BUOY 1      2

DATE 20 January 1981

DEPTH 25'      200'

TIME OUT \_\_\_\_\_

INSPECTOR Thomas Morgan

TIME IN \_\_\_\_\_

SAMPLE #	EROSION	CORROSION	BIOFOULING
4	None	None	See Detailed Analysis
8	None	None	" " "
12	None	None	" " "
16	None	None	" " "
19	None	considerable pitting	} amphipod (numerous) <u>Podocerus</u> <u>Stenothoe</u>
23	None	cover torn considerable pitting	
27	None	None	See Detailed Analysis
119	None	None	" " "

DETAILED ANALYSIS

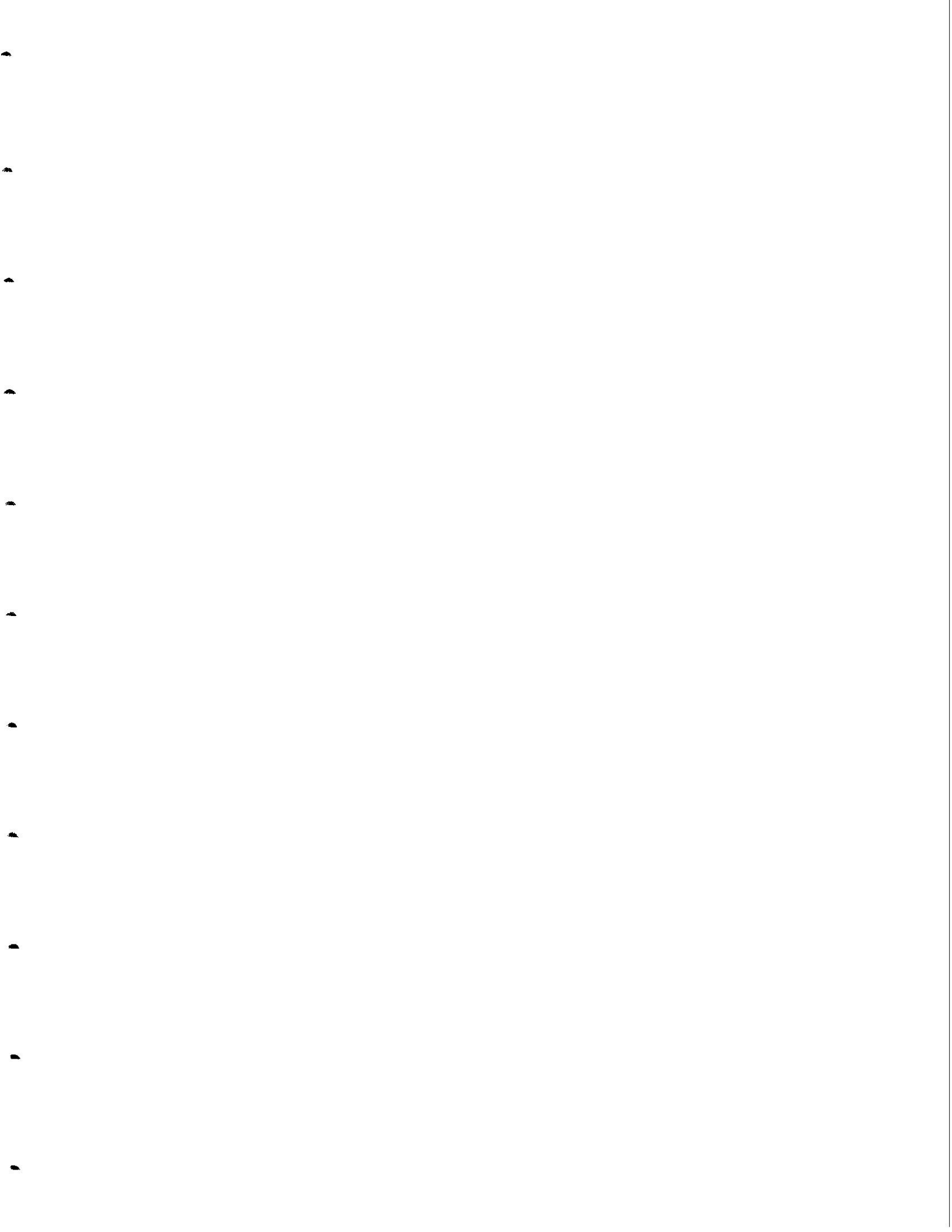
Buoy: 1 & 2

Depth: 25'

Date: 20 & 21 January 1981

Biofouling on samples 4, 8, 12, 16, 27, 119  
1, 5, 9, 13, 26, 118

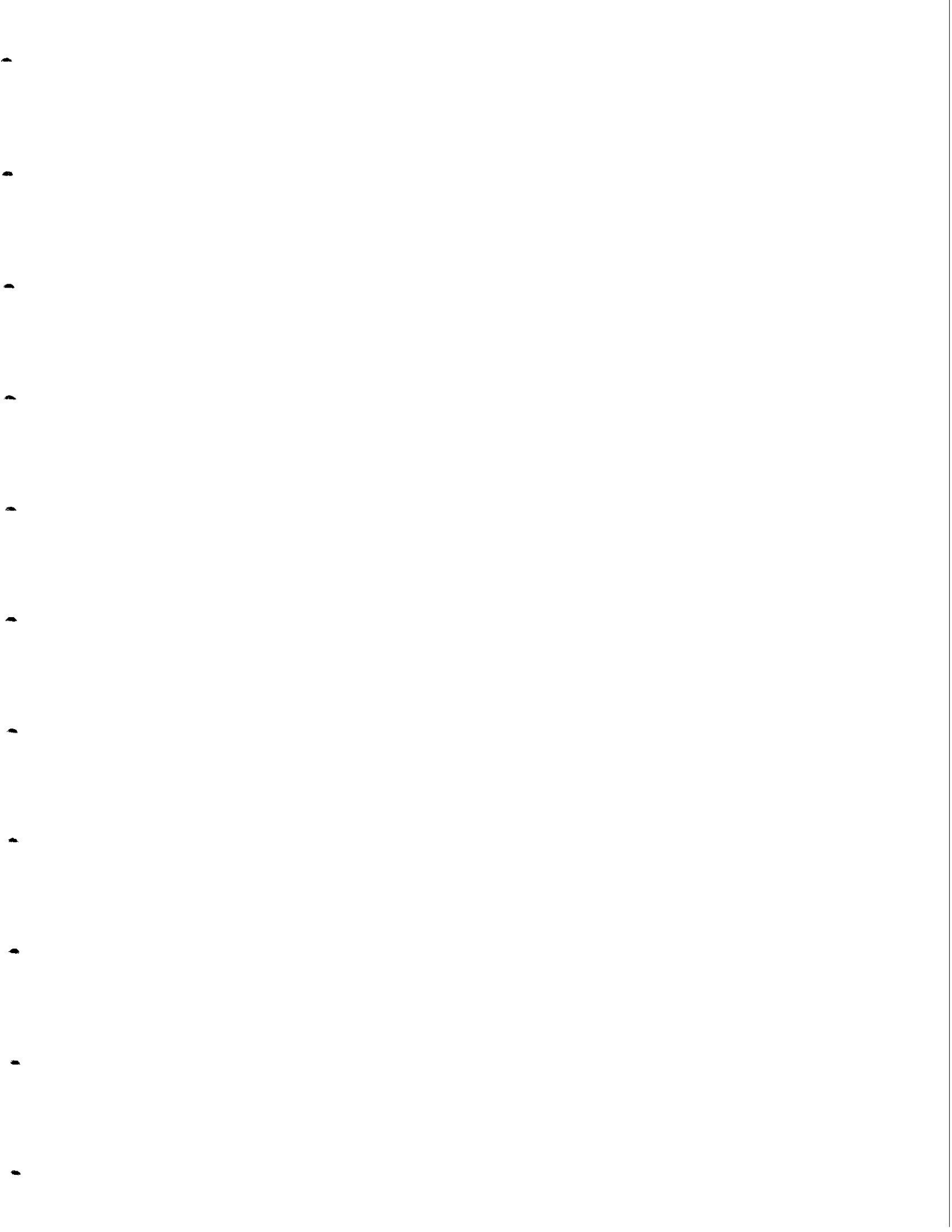
algae	100 % cover
<u>Antithamnion</u>	algae dominant
<u>Ceramium</u>	
<u>Chondria</u>	
<u>Dasya</u>	
<u>Heterosiphonia</u>	
<u>Microcoleus</u>	
<u>Neomeris</u>	
<u>Polysiphonia</u>	
<u>Spermothamnion</u>	
hydroid	
<u>Plumularia</u>	
bryozoan	
ascidian	
<u>Diplosoma</u>	
sponge	several per sample
<u>Scypha</u>	
anemone	
<u>Aiptasiogeton</u>	
serpulid worm	several per sample
<u>Filograna</u>	
<u>Hydroïdes</u>	
gastropod	several per sample
<u>Alaba</u>	
<u>Cerithium</u>	
bivalve	occasional
<u>Atrina</u>	
<u>Musculus</u>	
amphipod	numerous
<u>Elasmopus</u>	
<u>Podocerus</u>	
<u>Stenothoe</u>	
<u>caprellid</u>	
sipunculid	few per sample



00

4

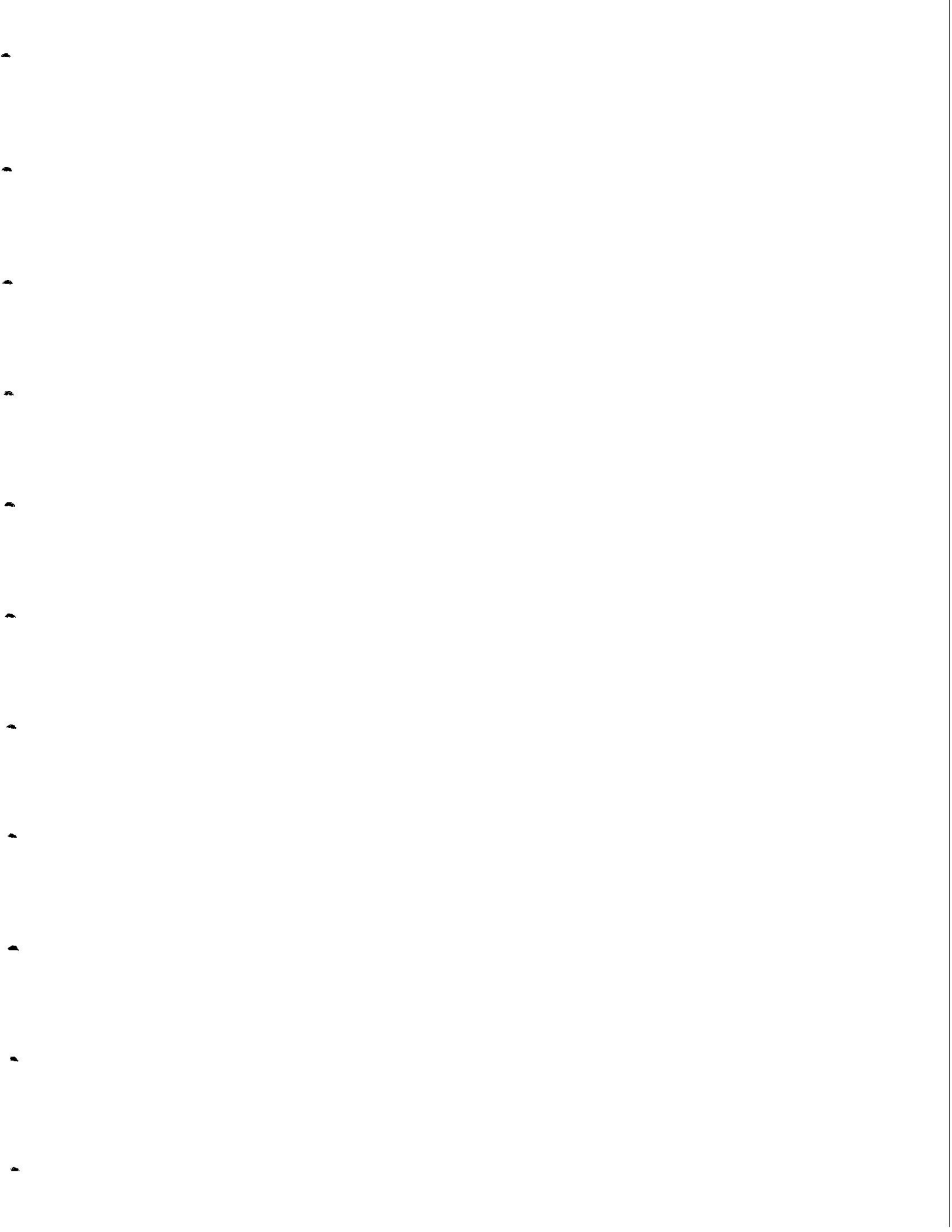
20 JAN 81



16

12

20 JAN 81





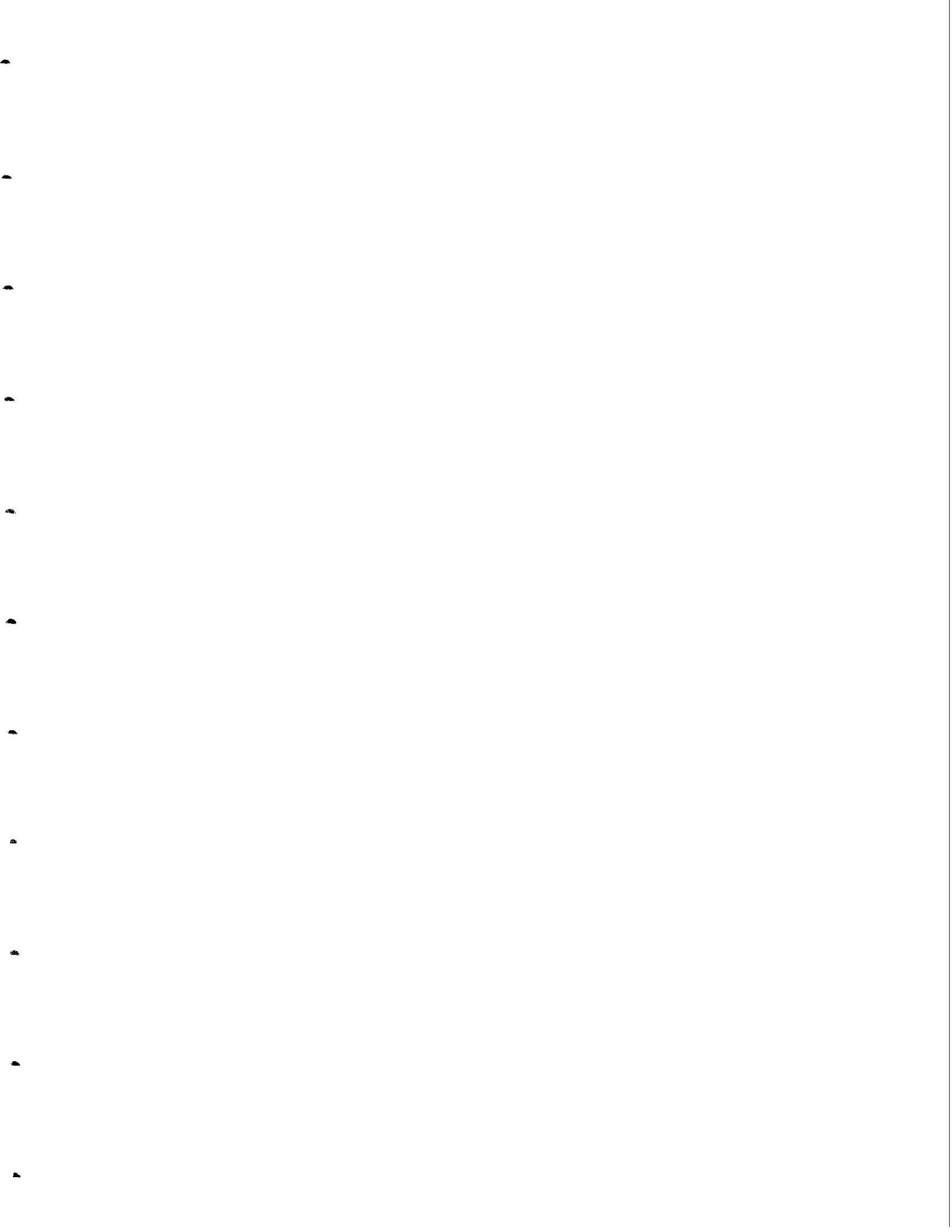
19

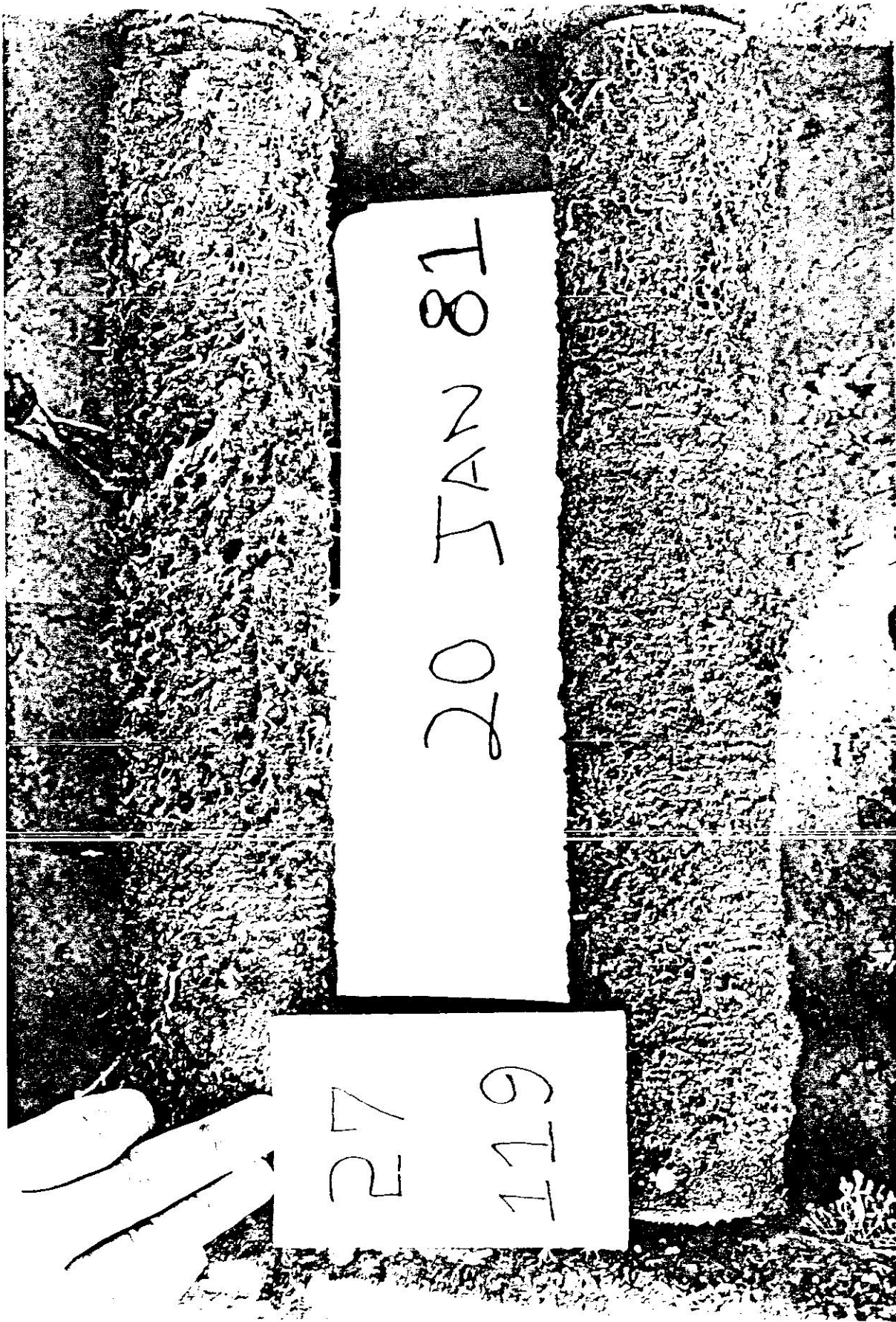
23

20 JAN 20 81

81







20 JAN 81

27  
119

SIMPLEX CABLE EXPERIMENT

MONTHLY INSPECTION FORM

BUOY 1 2

DATE 21 January 1981

DEPTH 25' 200'

TIME OUT \_\_\_\_\_

INSPECTOR Thomas Morgan

TIME IN \_\_\_\_\_

SAMPLE #	EROSION	CORROSION	BIOFOULING
1	None	None	See Detailed Analysis
5	None	None	" " "
9	None	None	" " "
13	None	None	" " "
17	None	considerably pitting	amphipod (numerous)
20	None	cover gone considerable pitting	<u>Podoceros</u> <u>Stenothoes</u>
26	None	None	See Detailed Analysis
118	None	None	" " "

DETAILED ANALYSIS

Buoy: 1 & 2

Depth: 25'

Date: 20 & 21 January 1981

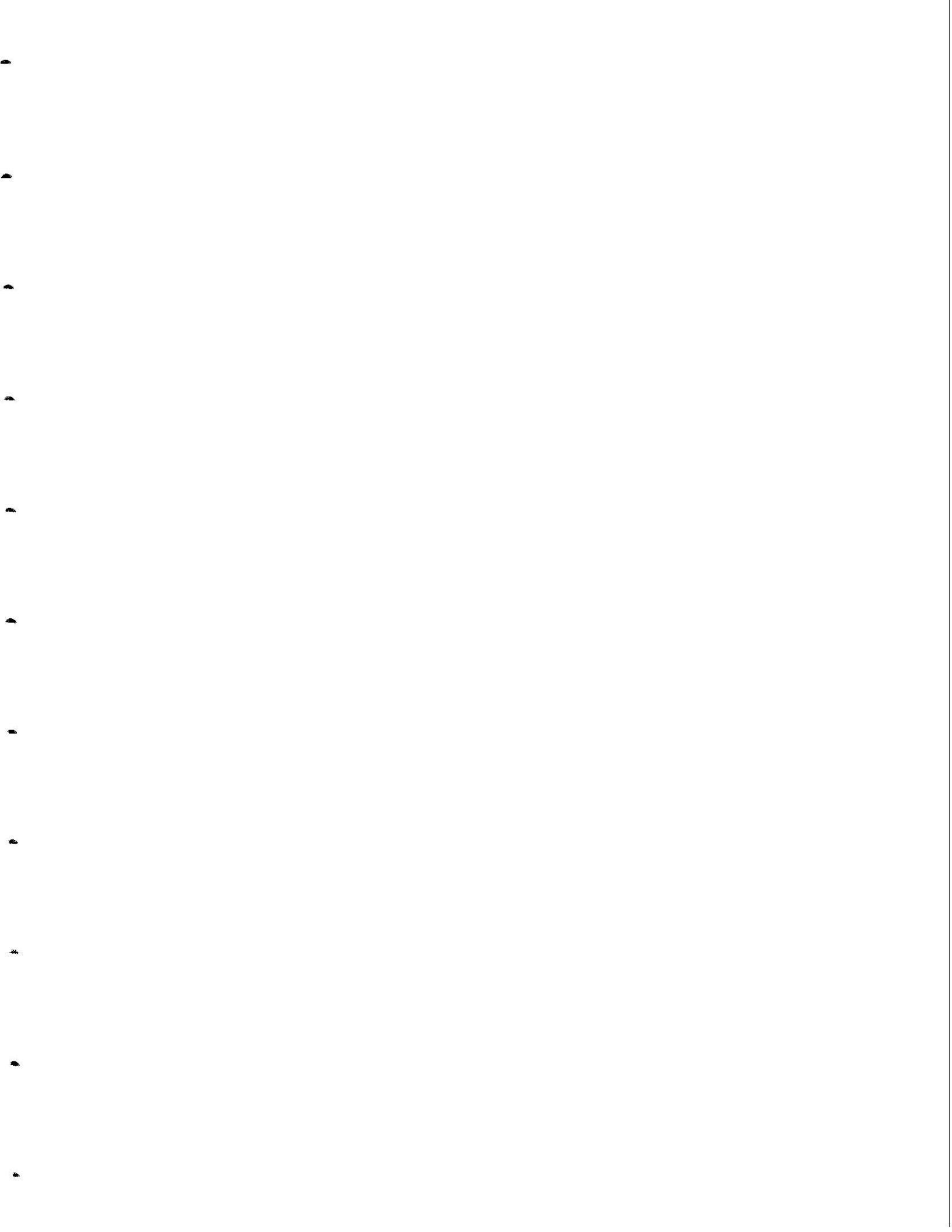
Biofouling on samples 4, 8, 12, 16, 27, 119  
1, 5, 9, 13, 26, 118

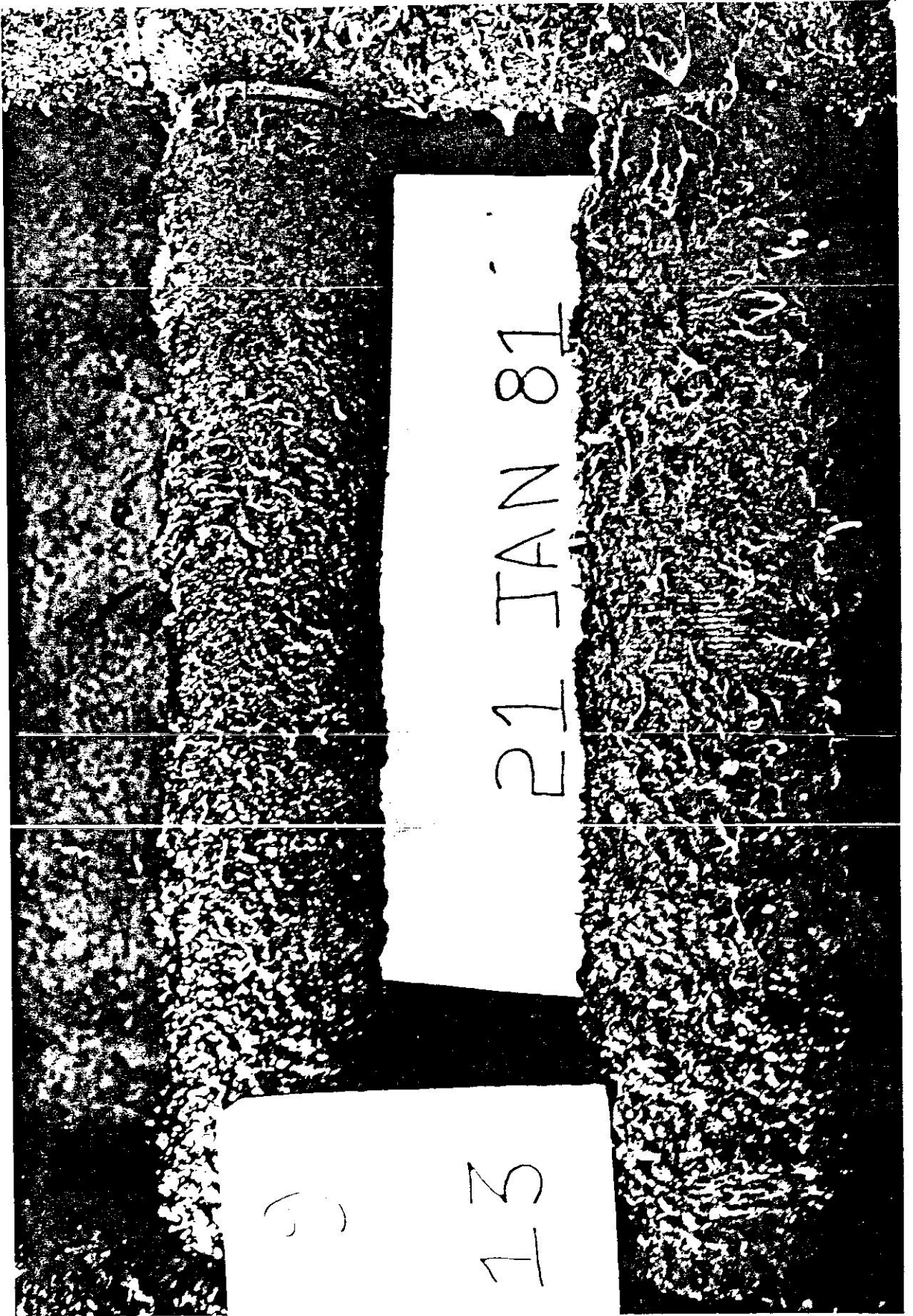
algae	100 % cover
<u>Antithamnion</u>	algae dominant
<u>Ceramium</u>	
<u>Chondria</u>	
<u>Dasya</u>	
<u>Heterosiphonia</u>	
<u>Microcoleus</u>	
<u>Neomeris</u>	
<u>Polysiphonia</u>	
<u>Spermothamnion</u>	
hydroid	
<u>Plumularia</u>	
bryozoan	
ascidian	
<u>Diplosoma</u>	
sponge	several per sample
<u>Scypha</u>	
anemone	
<u>Aiptasiogeton</u>	
serpulid worm	several per sample
<u>Filograna</u>	
<u>Hydroides</u>	
gastropod	several per sample
<u>Alaba</u>	
<u>Cerithium</u>	
bivalve	occasional
<u>Atrina</u>	
<u>Musculus</u>	
amphipod	numerous
<u>Elasmopus</u>	
<u>Podocerus</u>	
<u>Stenothoe</u>	
<u>caprellid</u>	
sipunculid	few per sample



21 JAN 81

75





21 JAN 81

13

13



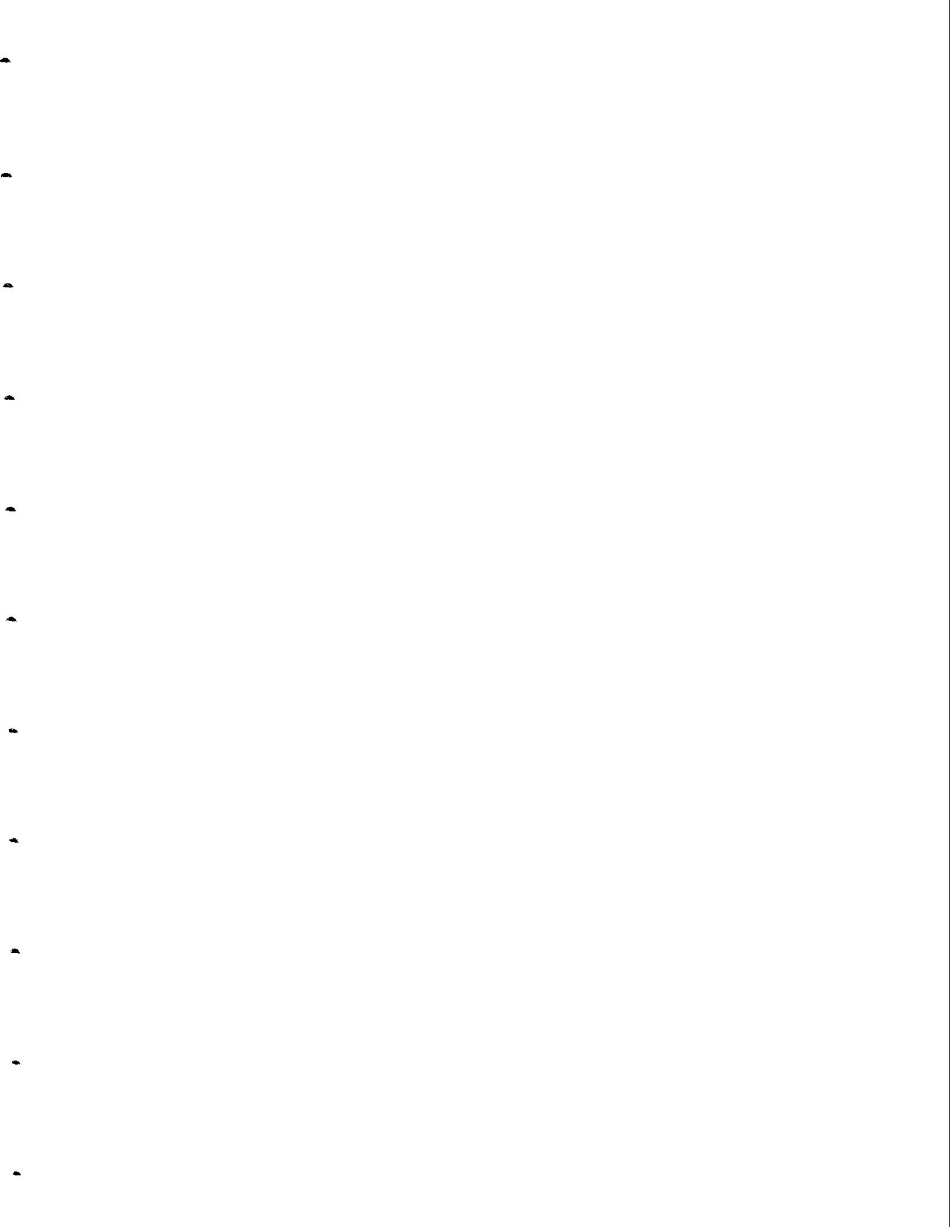




20

17

21 JAN 81





118

26

21 JAN 81

SIMPLEX CABLE EXPERIMENT

MONTHLY INSPECTION FORM

BUOY 1 2  
 DEPTH 25' 200'  
 INSPECTOR Thomas Morgan

DATE 21 January 1981  
 TIME OUT \_\_\_\_\_  
 TIME IN \_\_\_\_\_

(1") SAMPLE #	(1 1/4") EROSION	(1 1/4") CORROSION	BIOFOULING
2	None	None	See Detailed Analysis
6	None	None	" " "
10	None	None	" " "
14	None	None	" " "
21	None	considerable pitting	} amphipod Podocerus <u>Stenothoe</u>
24	None	cover gone considerable pitting	
28	None	None	See Detailed Analysis
120	None	None	" " "

DETAILED ANALYSIS

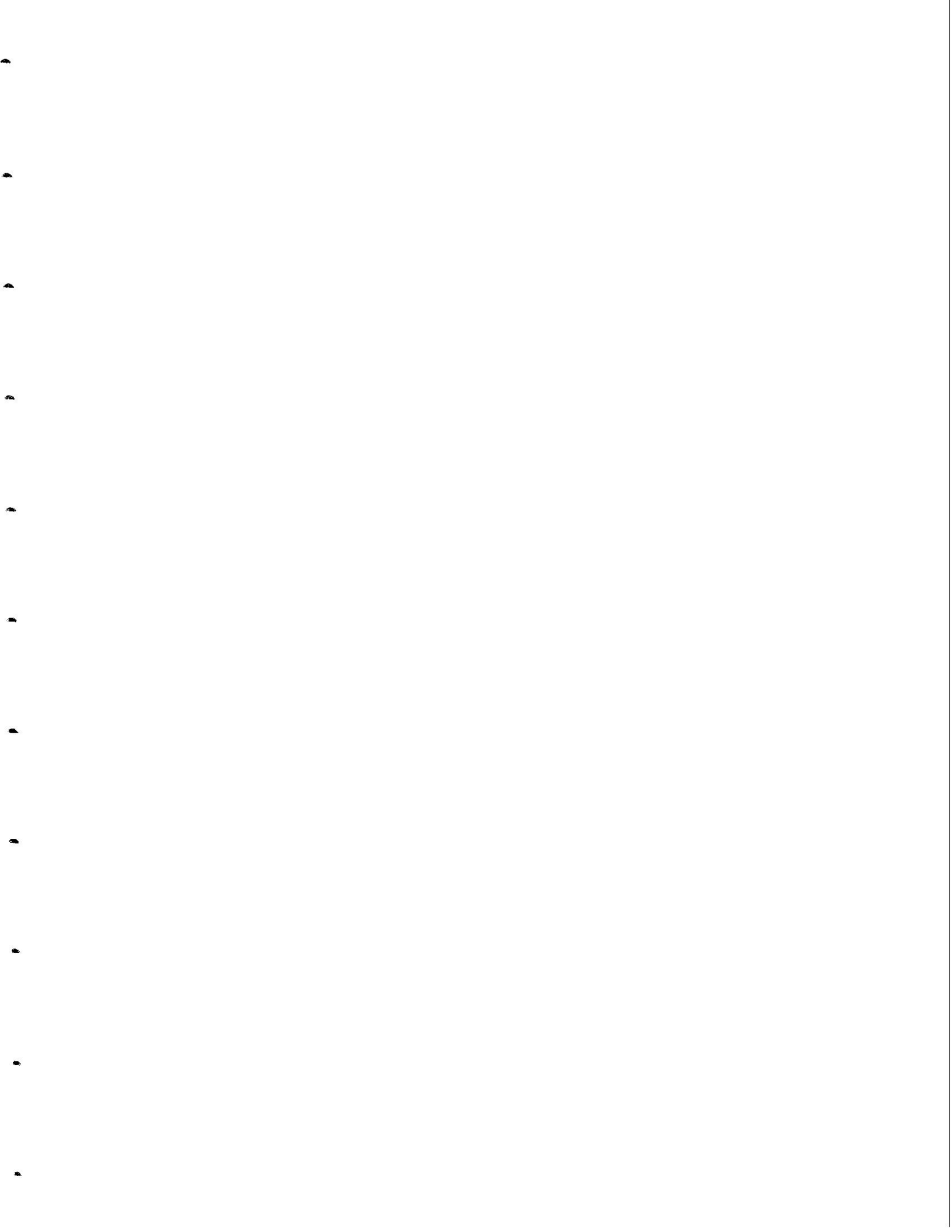
Buoy: 2

Depth: 200'

Date: 20 January 1981

Biofouling on samples 2, 6, 10, 14, 28, 120

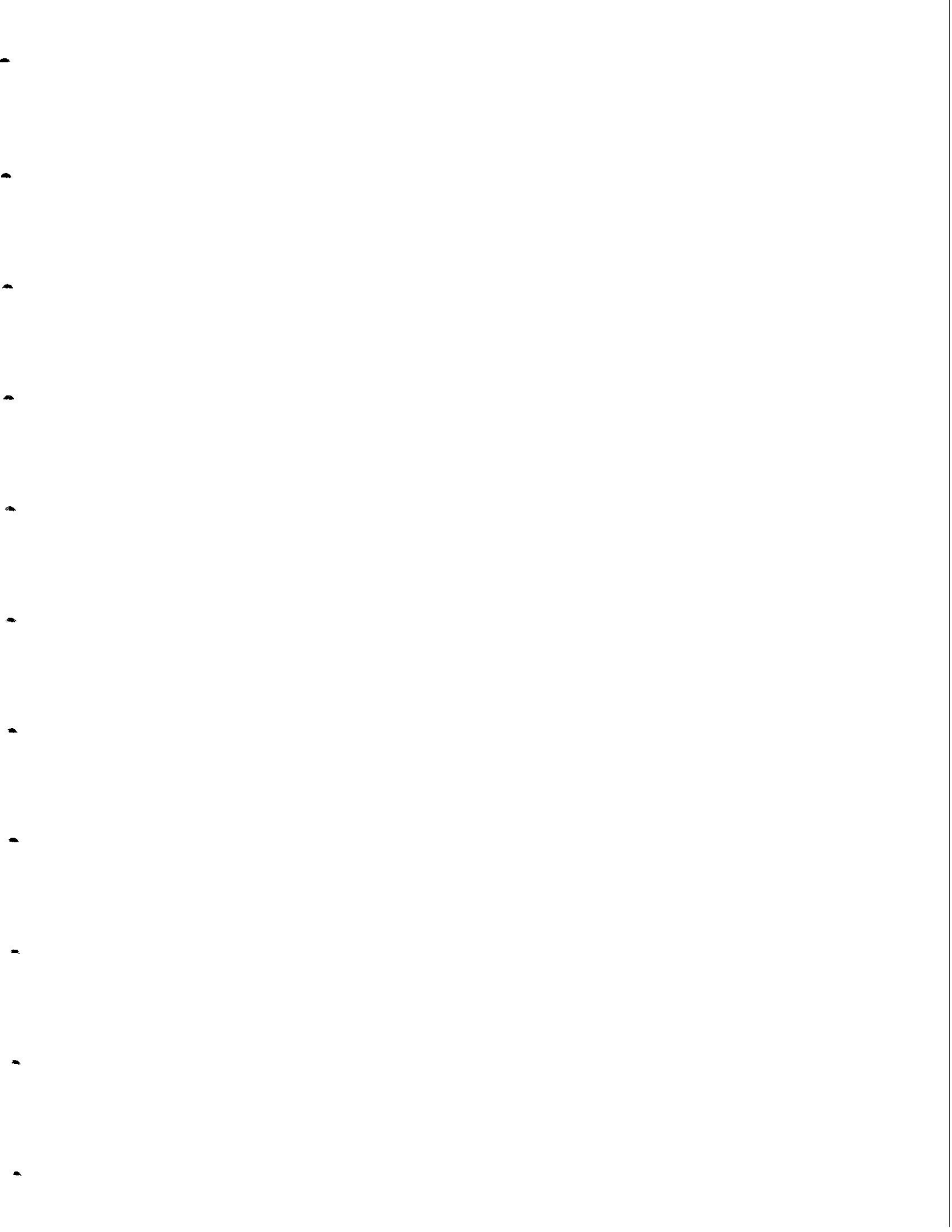
hydroid	100% cover
<u>Halocordyle</u>	
<u>Obelia</u>	
sponge	few per sample
<u>Scypha</u>	
serpulid worm	few per sample
<u>Filograna</u>	
<u>Hydroides</u>	
bivalve	occasional
<u>Atrina</u>	
gooseneck barnacle	occasional
<u>Lepas</u>	
amphipod	several per sample
<u>Podocerus</u>	
<u>Stenothoe</u>	
<u>caprellid</u>	
ascidian	1 specimen
<u>Herdmania</u>	





26

21 JAN 81



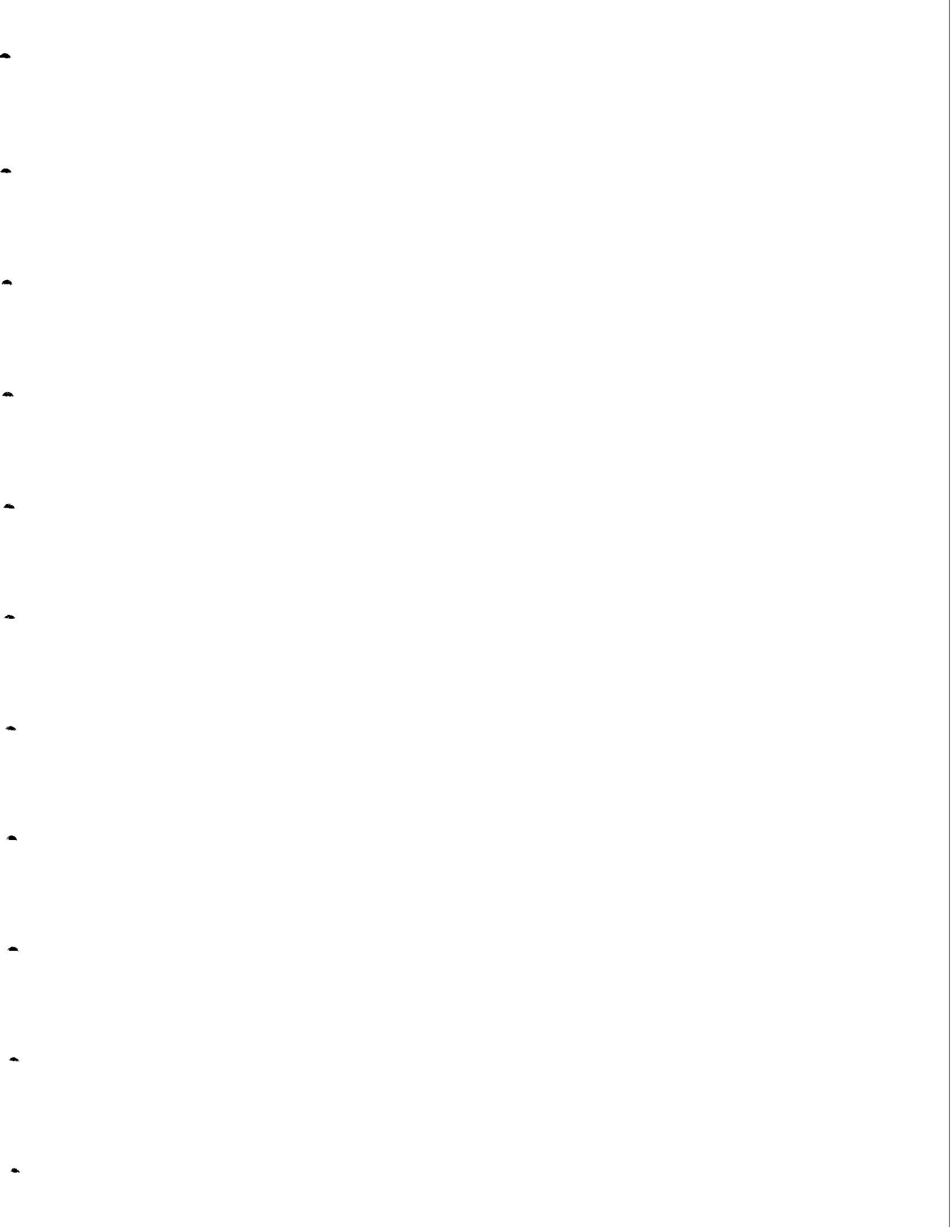




21 JAN 81

10  
14



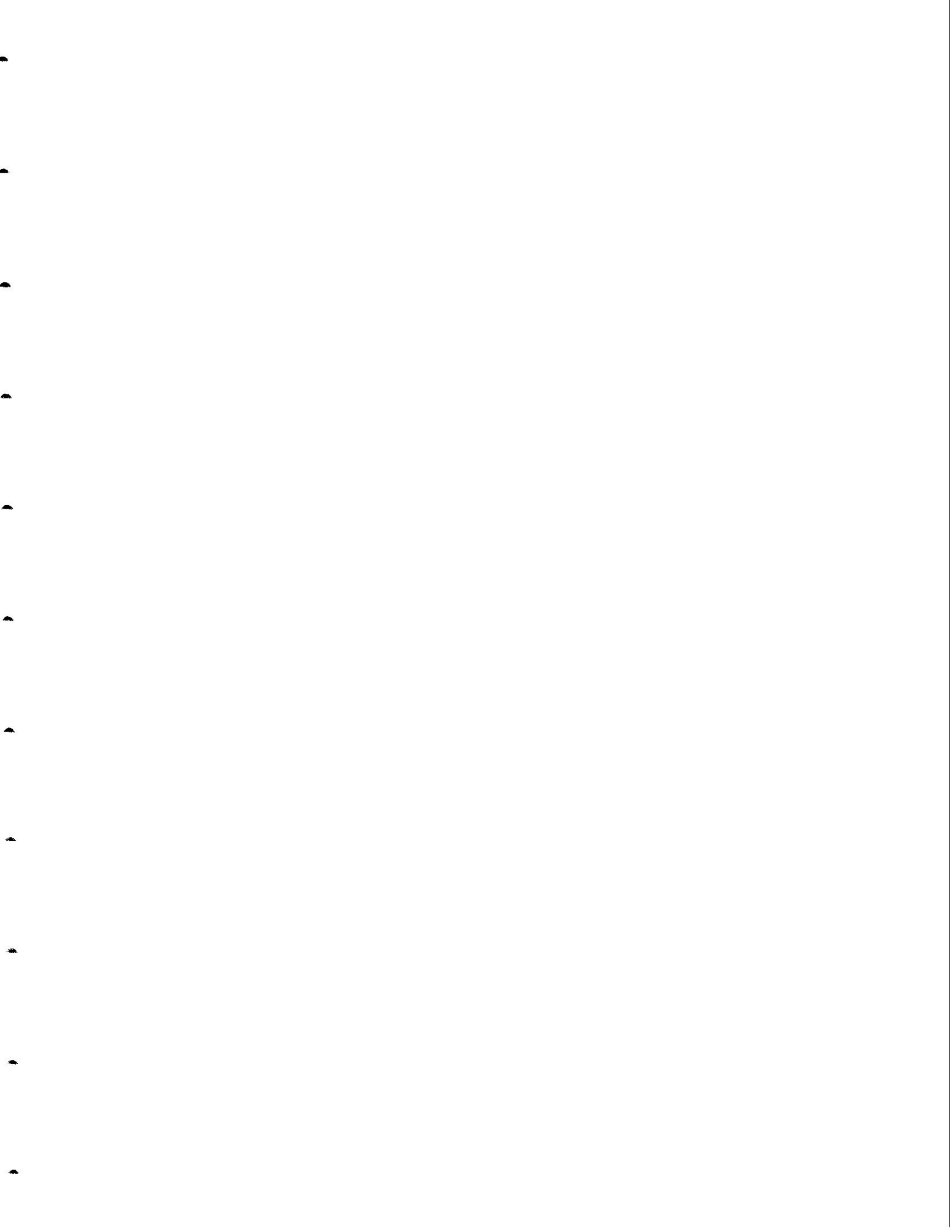




21

24

21 JAN 81





38

120