Interoffice

NATIONAL RADIO ASTRONOMY OBSERVATORY

TUCSON, ARIZONA

September 16, 1981

To: W. Horne

From: J. Davis

Subject: Paint

25 METER MILLIMETER WAVE TELESCOPE

MEMO No. 146

The proposed construction of the 25m telescope and the resurfacing of the 36-ft telescope together with the construction of receivers for use at wavelengths of 1 mm and beyond has renewed interest in the RF properties of the paint used to coat the primary reflector. Measurements made at various times by both the engineering staff of NRAO and visiting astronomers indicated that there may be a problem with paint absorption at 1 mm. A small investigation of the properties of paints was undertaken.

An insight into the problem maybe gained from consideration of the following hypothetical example: A typical coating of paint is of the order of .005 inch thick. If one assumes that the average dielectric constant of the paint is of the order of four, then this represents 1/4 wavelength at 1 mm. The paint layer is a potentially lossy transmission line with a length which is a significant fraction of a wavelength. A typical paint is a suspension of pigment particles in a binder. The particles may be metallic, metal oxide or nonmetallic. In the case of metal and metallic oxide pigments, currents will flow in the paint. There is a potential for loss. One reasonably sure way of characterizing the RF performance of the paint is to measure the paint reflectance at the wavelength of interest.

During a recent trip to Queen Mary College I performed RF reflectance measurements on several aluminum plates which had been previously coated with typical paints. The paint samples were provided by the Triangle Paint Company, Berkeley, California. Three different paints were applied using three different surface preparation techniques for each paint for a total of nine panels. The paint was applied by Triangle Paint Company. I have attached a copy of the information supplied by Triangle Paint with these panels.

The reflectivity of the paint-panel combination was measured between 100 GHz and 420 GHz. The measurements set up is shown in Figure 1. The measurement apparatus consisted of a Beckman RIIC FS-720 Fourier photo-spectrometer equipped with a reflection module. The spectrometer is a polarizing Michelson Interferometer with free standing wire grid polarizers. A high pressure mercury arc lamp provided a source of radiation. The detector was a pumped helium -4 bolometer with a Flourogold low pass filter. The optical path contained only mirrors and light pipes. The entire spectrometer was evacuated to less than 5 mm mercury.

The data from the bolometer was amplified using an LN-6 preamplifier. Synchronous detection was performed using an Ithaco Lock-In Amplifier. The modulation was sinusoidal. The intergration time constant of the Ithaco was 125 ms. with 12 db per octave roll off. The output of the Ithaco was digitized by an analog to digital converter. The position of the moving interferometer mirror, relative to the central maximum, together with the digitized output of the Ithaco were recorded by a DEC 11/40 minicomputer. This same computer performed the fast Fourier transform of the interferogram.

A typical background spectra is presented in Figure 2. This spectra is obtained by replacing a paint sample with a highly polished flat aluminum plate. The spectrometer would then be evacuated to less than 5 mm Hg. The moving mirror was stepped in increments of 32 microns total optical path difference for a total travel of approximately 2.5 centimeters. The Figure represents the Fourier transform of the interferogram. The rapid drop in intensity beginning at about 400 GHz was caused by a low pass filter. The purpose of this filter was to limit the energy to the spectral region of interest there by improving the dynamic range of the system. The low frequency rolloff beginning at approximately 300 GHz and extending to longer wavelengths was caused by the decrease in output of the mercury arc lamp.

A typical sample measurement would proceed as follows: A section of the aluminum plate large enough to allow for the filling of the 1 cm diameter aperture of the reflection module was cut from the plate. A reference background measurement would have been made using the procedure outlined above. The polished aluminum blank would be removed and replaced by a painted aluminum plate sample. The spectrometer would then be evacuated as above. The interferogram of the paint sample would then be recorded and transformed. The ratio between the sample transform and the background transform would be calculated. Periodically background interferograms would be measured, transformed and compared to the original background to check for instrument drift.

The results of the measurements are organized by sample number following Figure 2. The first 10 plots represent an "eyeball" smoothing of the data. The plots are intended to give the reader a feel with the overall response of each paint sample and to allow for the rapid comparison of paint samples. The first nine plots are the samples provided by the Triangle Paint Company. In addition a sample of unknown origin is included for interest. This sample was provided by Peter Ade who stated that he thinks the sample was provided him by NRAO as a sample of the original paint which was applied to the 36ft antenna. The sample appears very similar to a baked high-gloss enamel of the type found on home appliances. The second 10 plots represent the actual output of the Fourier transform routine as ratioed against the background. They are included to give the reader a feel for the fine structure and the noise present in the measurement. Please note that the reflectance scale varies significantly from plot to plot and that the frequency scale is in units of inverse centimeters. It will be noted that the noise increases significantly as one proceeds to longer wavelengths. This is due to the falling energy output of the mercury arc lamp.

There is surprisingly little variation from sample to sample among the samples provided by Triangle Paint Company. I am unable to say anything about skin depth of the paint as only amplitude measurements were performed. All of the Triangle samples appear to be surprisingly good, although there is a significant variation from sample to sample.

NRAO currently possesses the capability to make amplitude reflection and transmission measurements of the type done at Queen Mary College, to an upper frequency limit of approximately 1000 GHz.

I would like to acknowledge the extensive help given by Dr. Peter Ade and Charles Cunningham of Queen Mary College, London.

Attachments

c: S. von Hoerner
S. Weinreb
M. Balister
G. Peery
A. Henry
B. Ulich

TABLE I

Approximate Paint Thickness

Plate #	Area #1	Area #2
1	0.0006	0.0006
2	0.0009	0.0010
3	0.0011	0.0010
4	0.0008	0.0010
5	0.0012	0.0007
6	0.0007	0.0006
7	0.0011	0.0013
8	0.0016	0.0012
9	0.0015	0.0016

Units are inches. Comparison of two different spots on each plate. The paint was carefully removed with MEK. Surfaces were carefully cleaned with alcohol. Measurement was made with constant force micrometer readable to at least nearest 0.00005 inches.

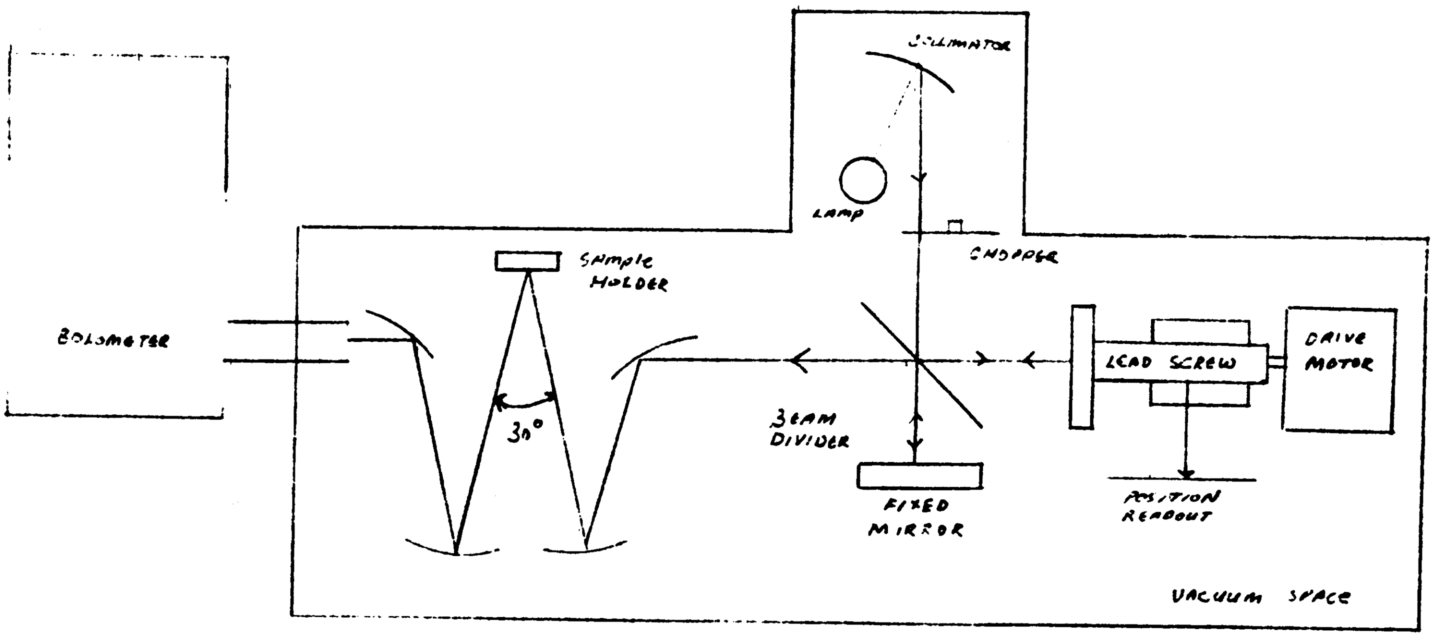
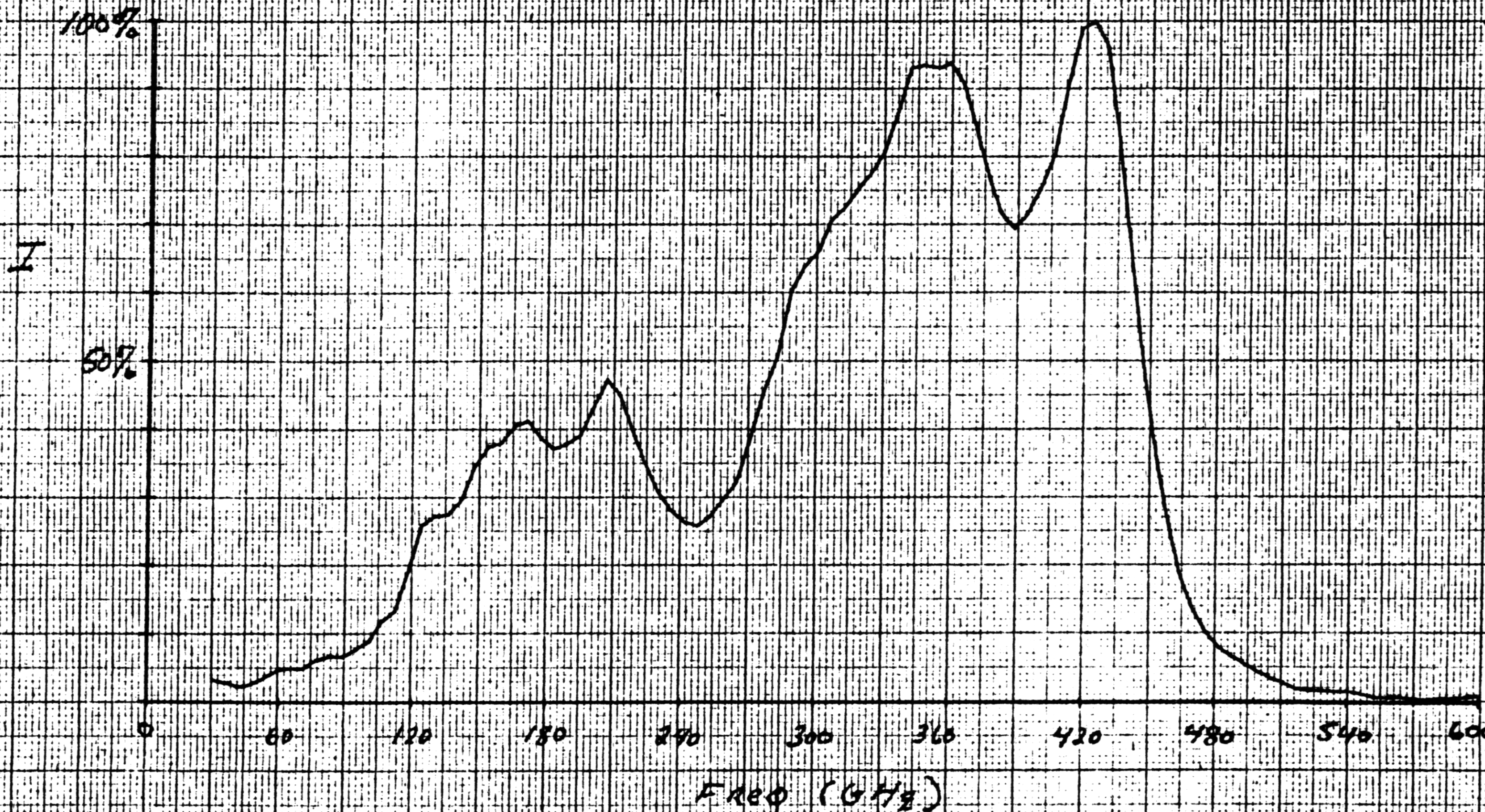
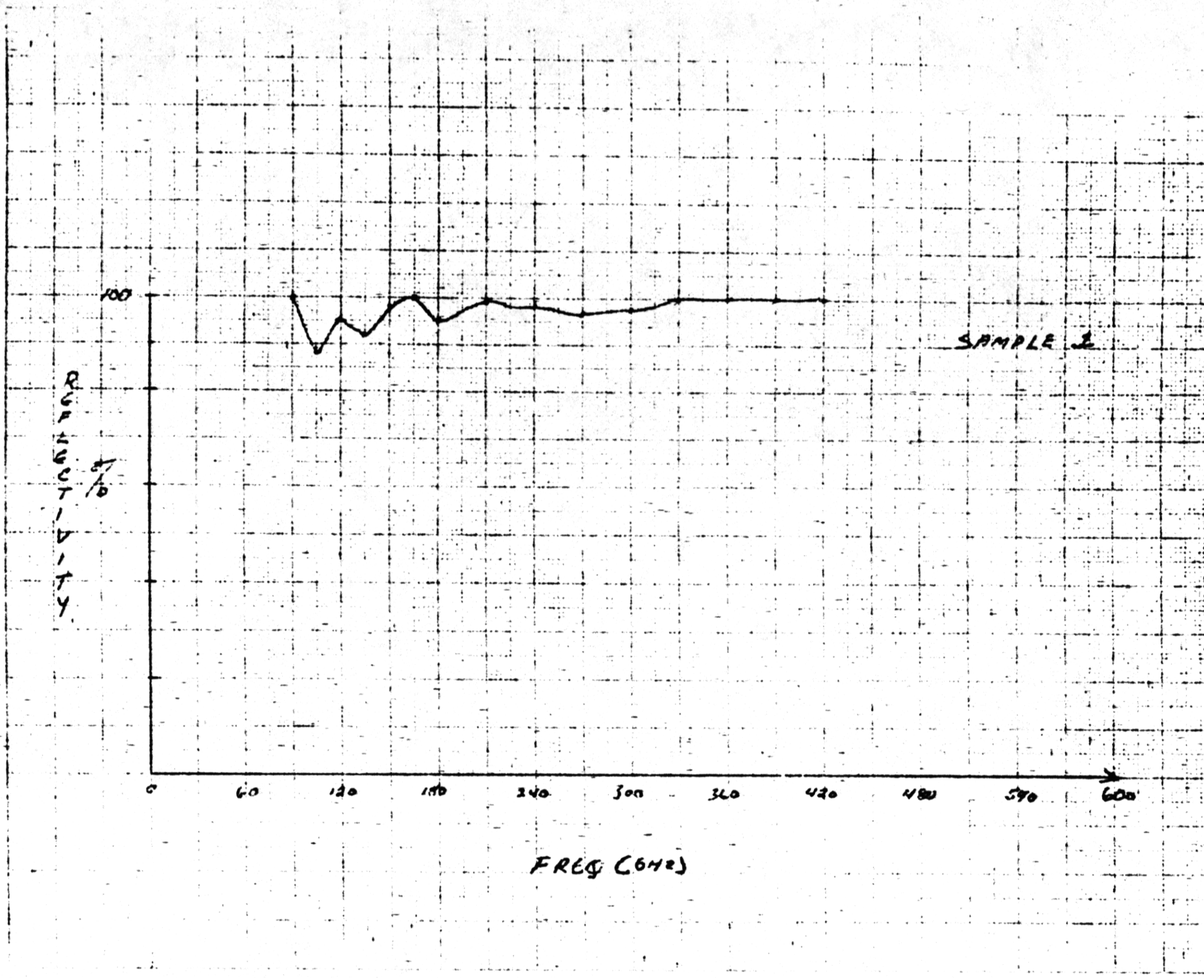


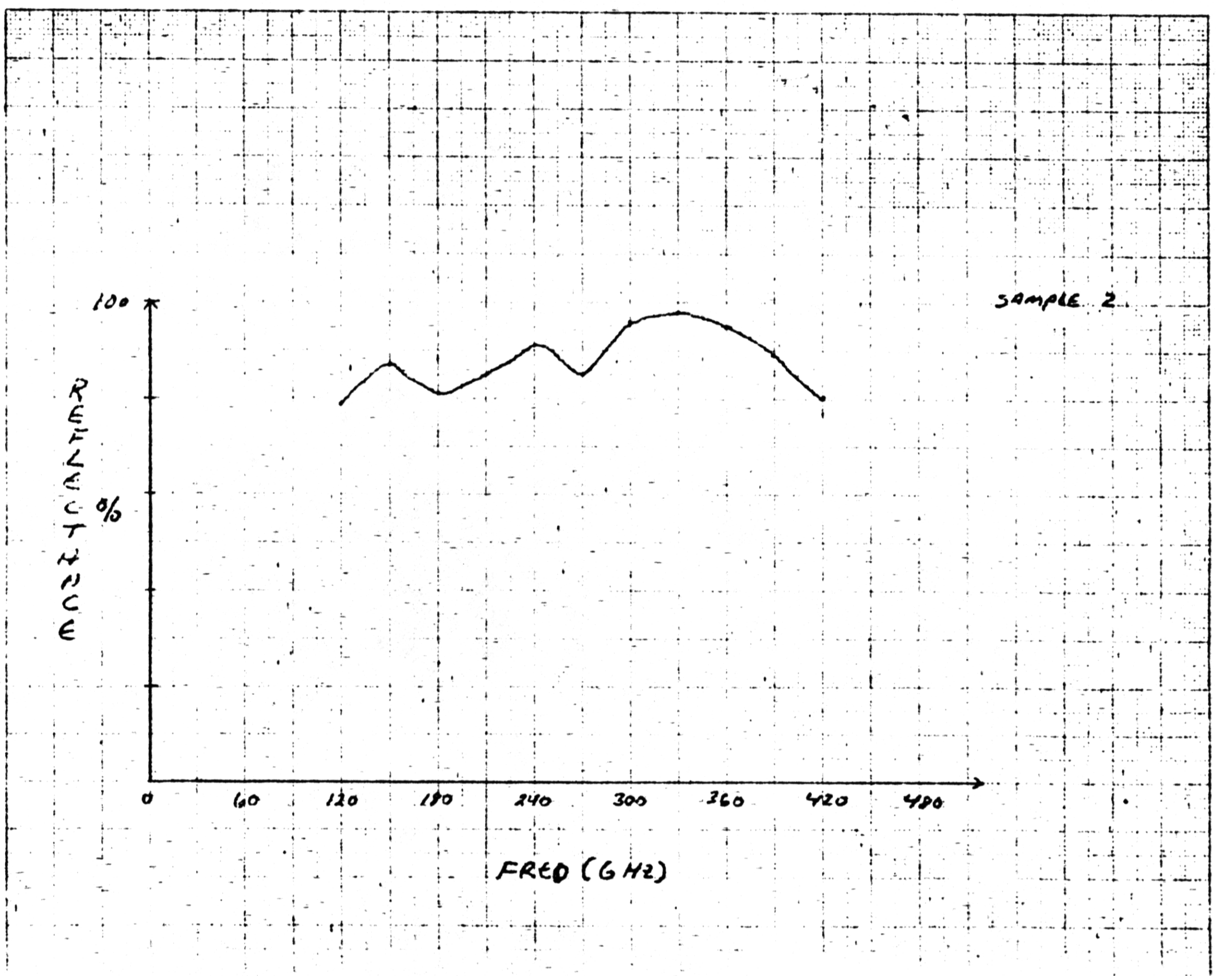
FIGURE 1 MEASUREMENT SET-UP

FIG 2: SAMPLE BACKGROUND

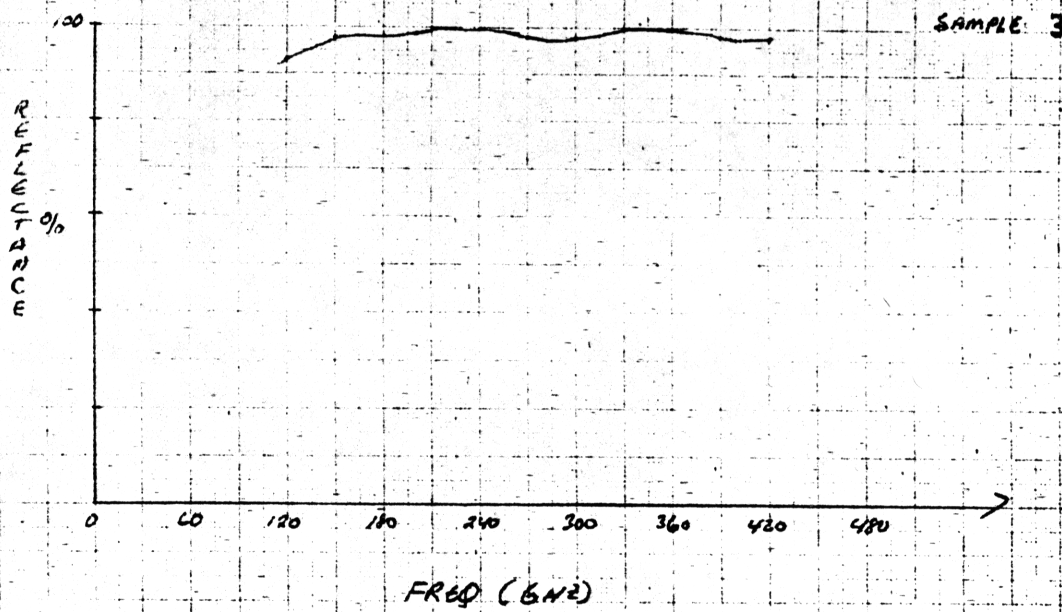




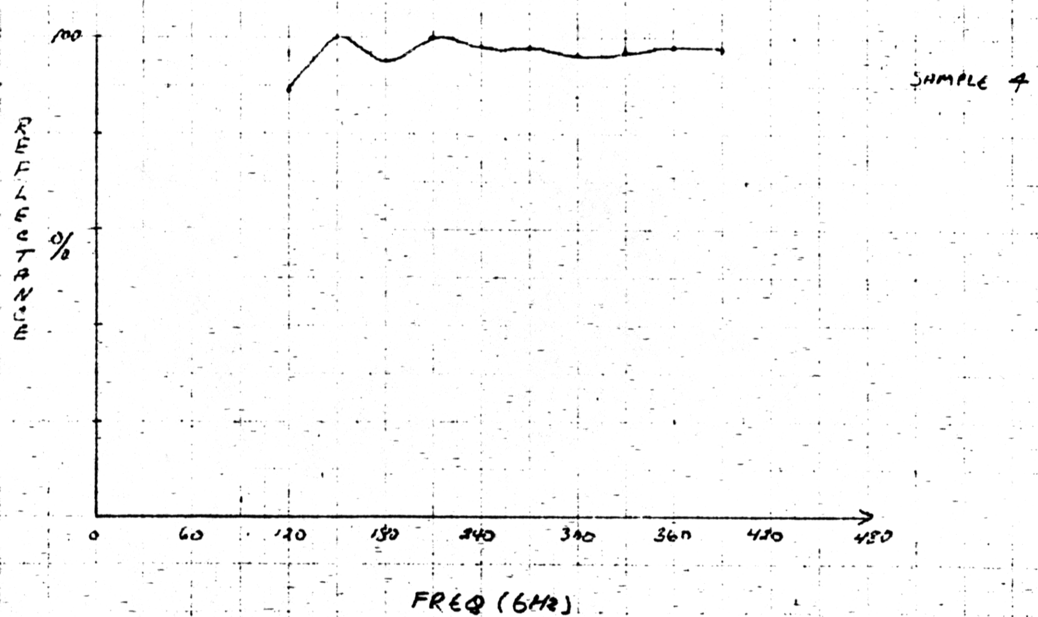
100
REFLECTIVITY
%
0
60
120
180
240
300
360
420
480
540
600
FREQ (GHz)
SAMPLE 1



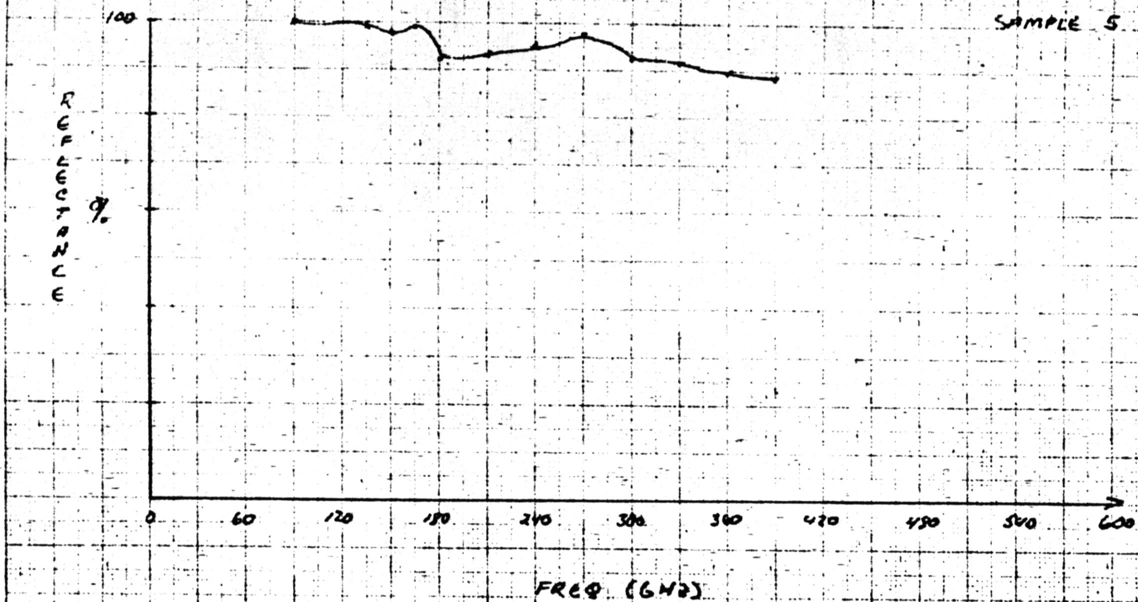
100
REFLECTANCE
%
0
60
120
180
240
300
360
420
480
FREQ (GHz)
SAMPLE 2

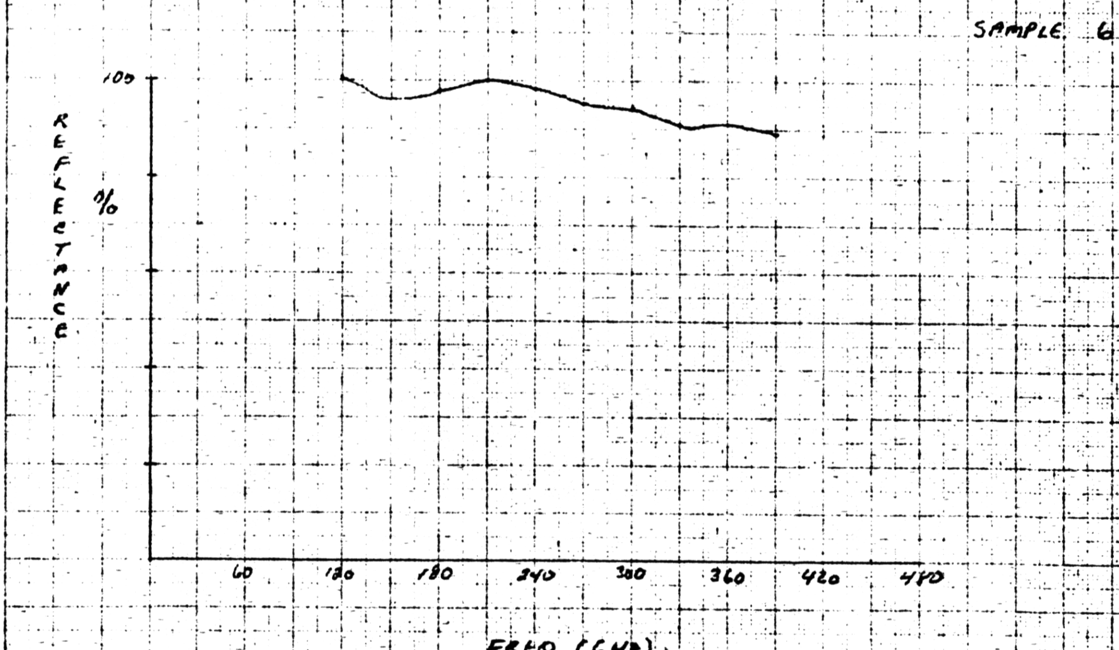


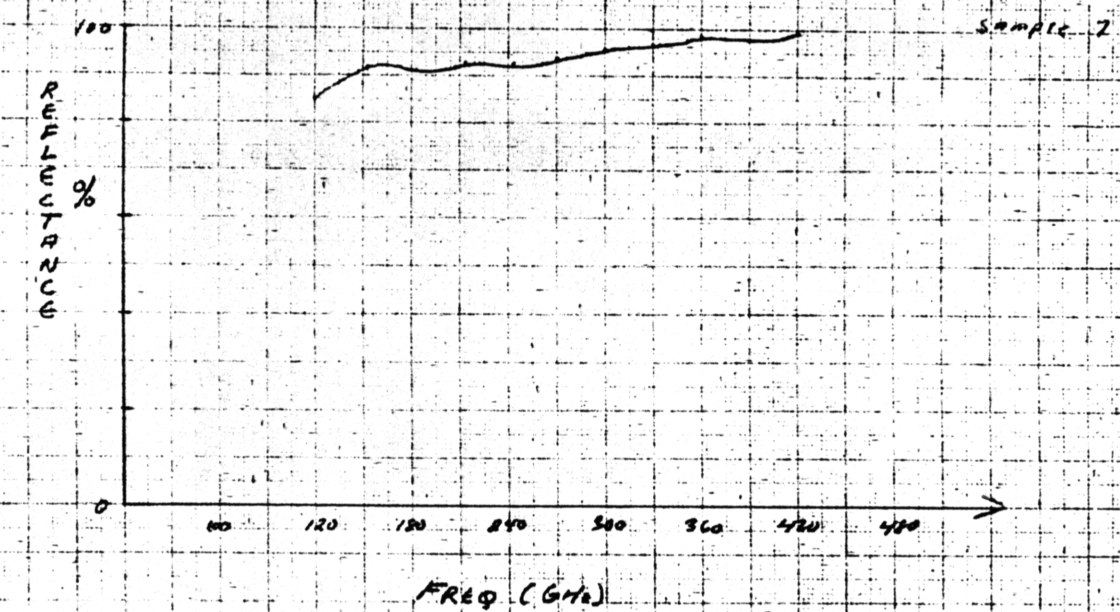
SAMPLE 3
100
REFLECTANCE %
0
60
120
180
240
300
360
420
480
FREQ (GHz)

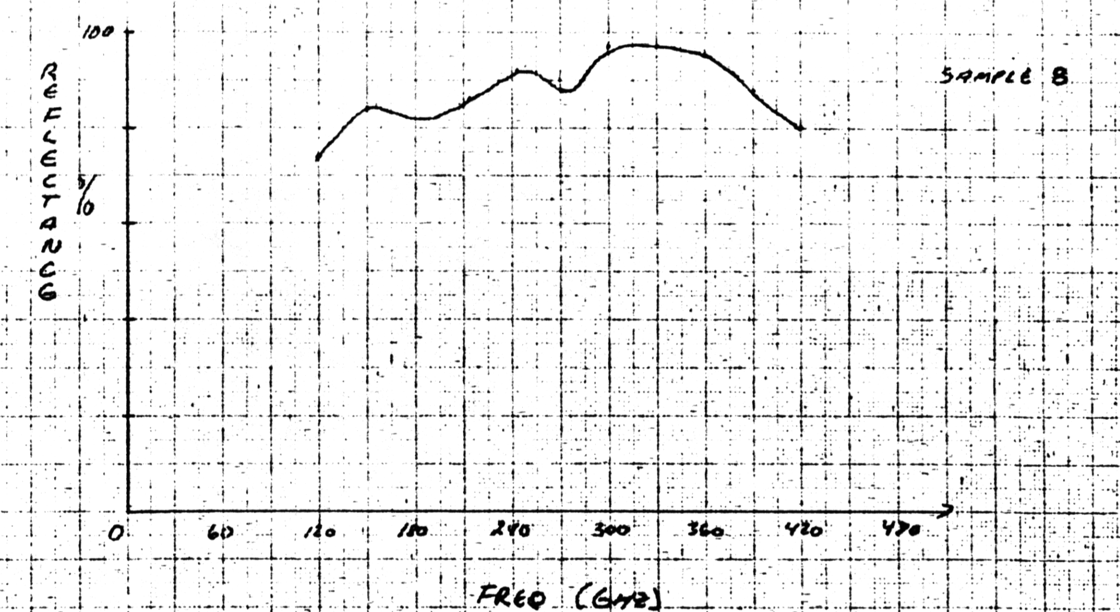


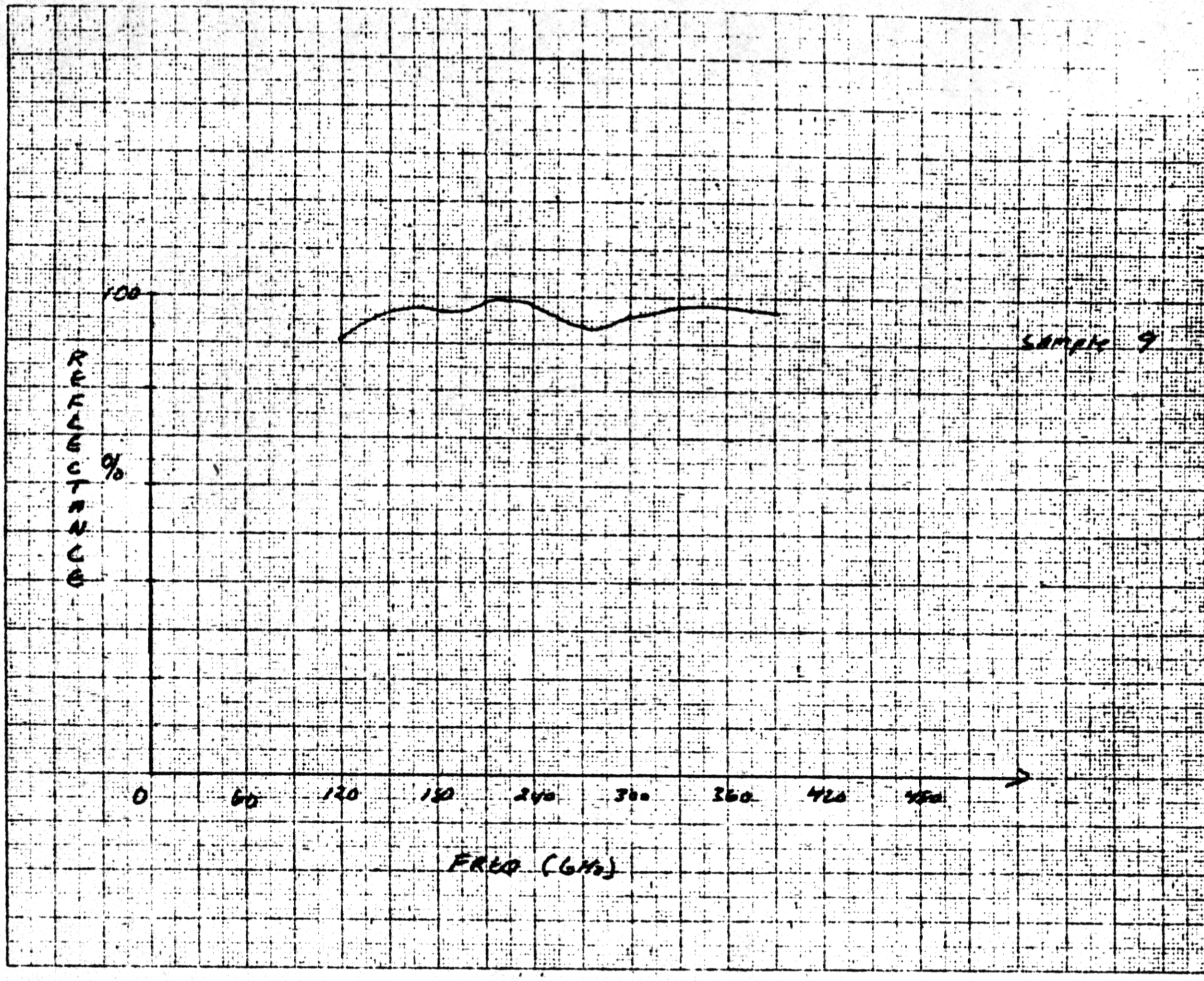
SAMPLE 4
100
REFLECTANCE %
0
60
120
180
240
300
360
420
480
FREQ (GHz)

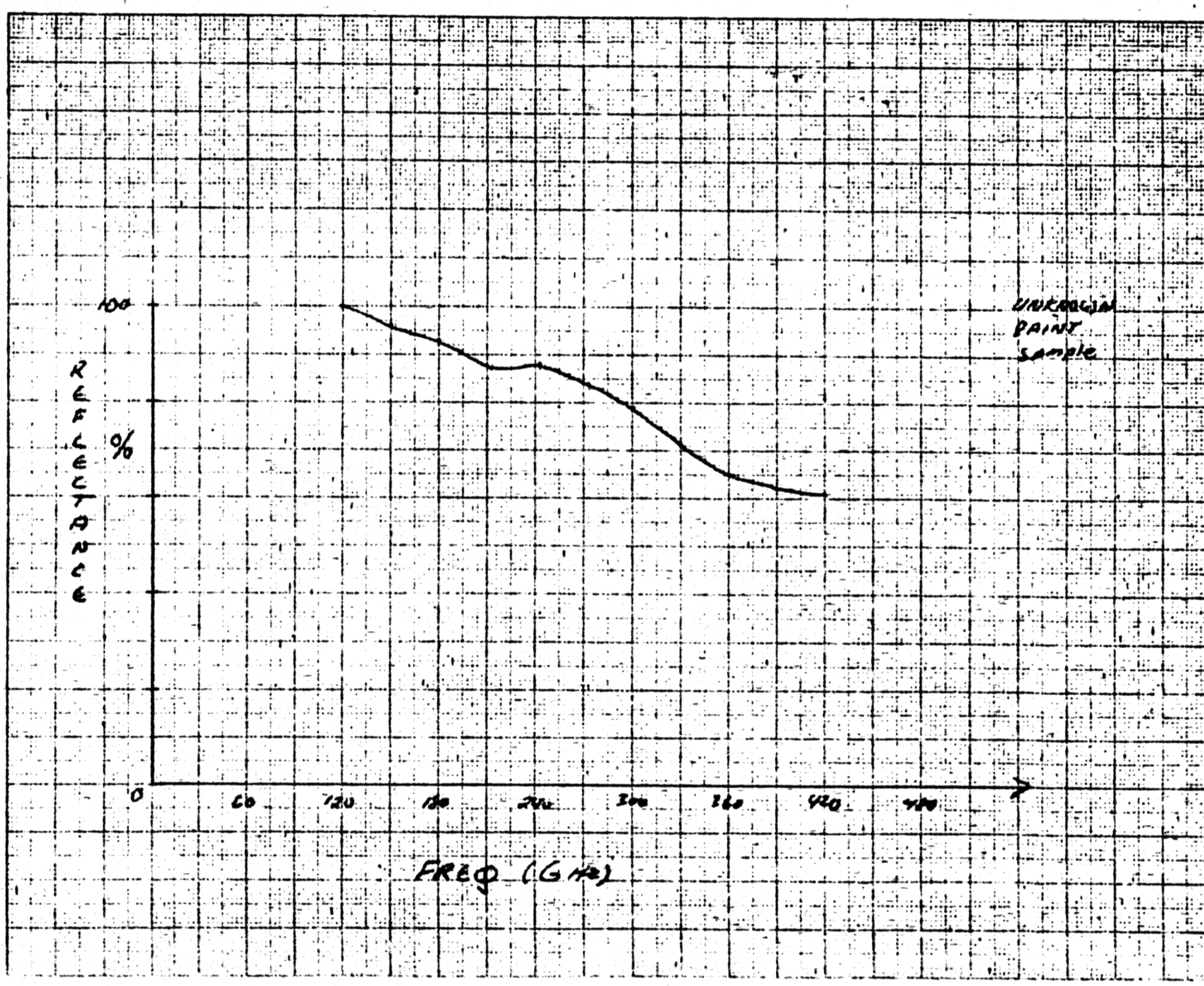

SAMPLE 5
100
REFLECTANCE
%
0
60
120
180
240
300
360
420
480
540
600
FREQ (GHz)

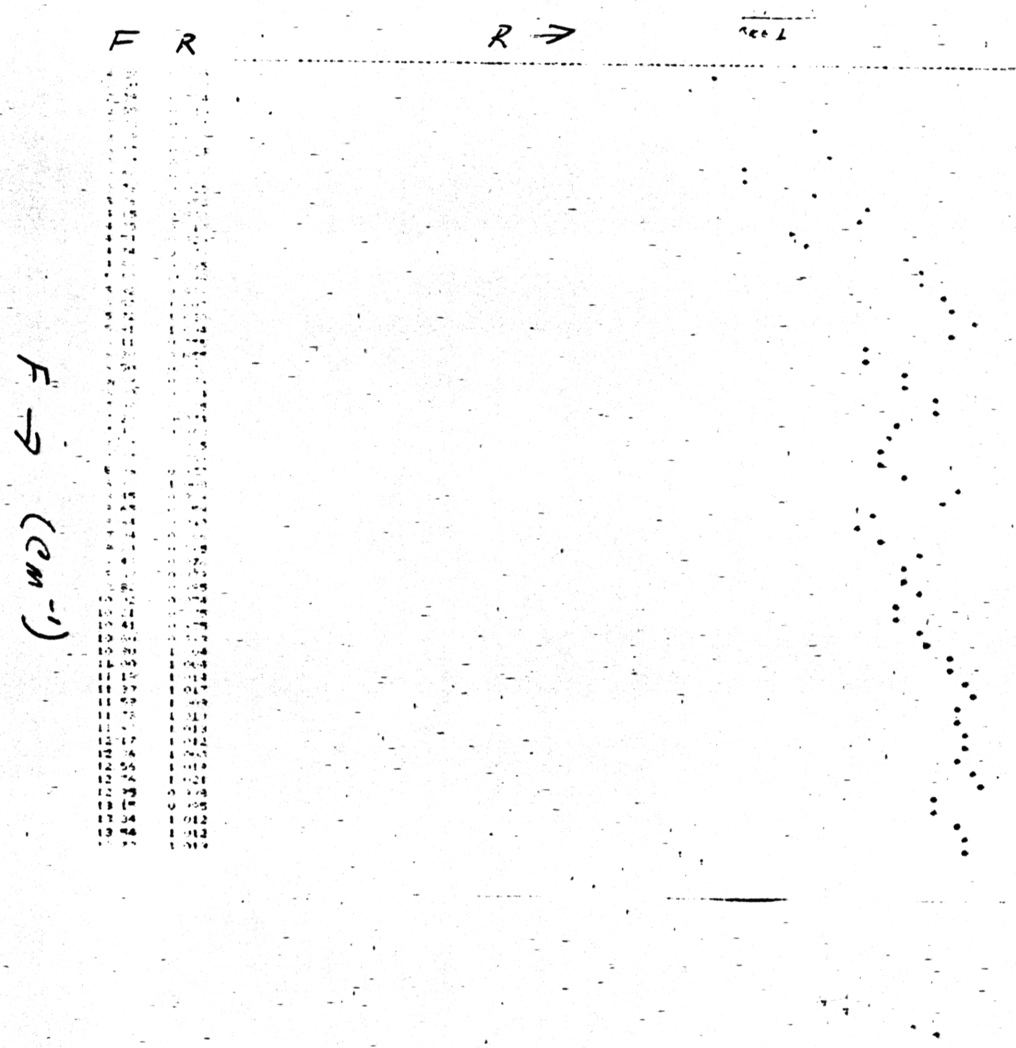

SAMPLE 6
100
REFLECTANCE
%
60
120
180
240
300
360
420
480
FREQ (GHz)


Sample 7
100
0
REFLECTANCE
%
60
120
180
240
300
360
420
480
FREQ (GHz)

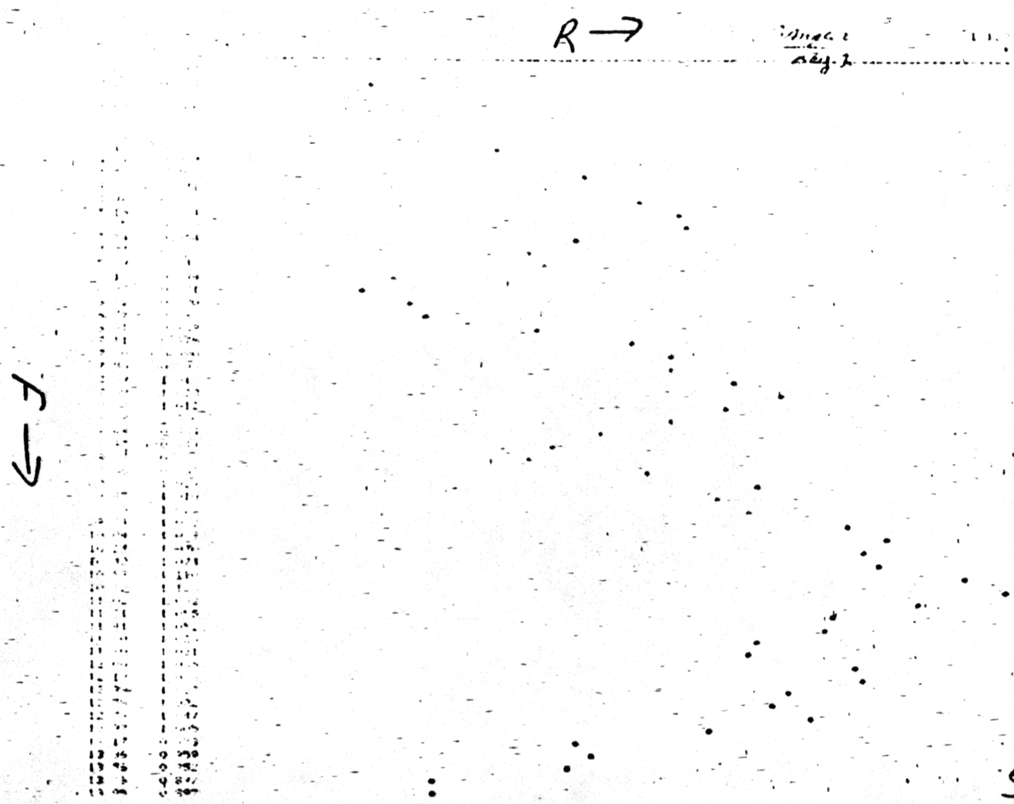

SAMPLE 8
100
0
REFLECTANCE
%
60
120
180
240
300
360
420
480
FREQ (GHz)


100
REFLECTANCE
%
0
60
120
180
240
300
360
420
480
FREQ (GHz)
sample 9


100
REFLECTANCE
%
0
60
120
180
240
300
360
420
480
FREQ (GHz)
UNKNOWN PAINT sample



Sample 1



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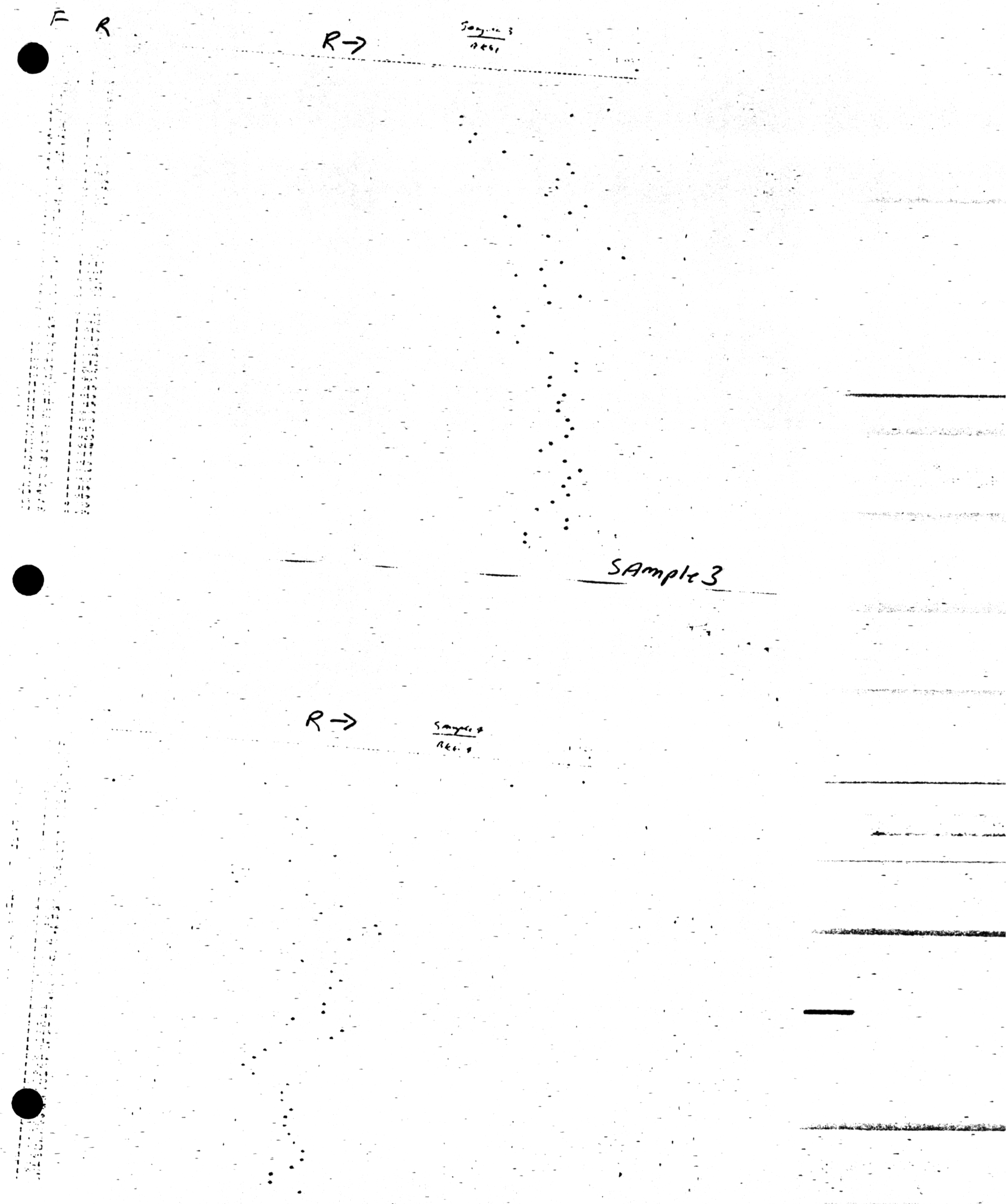
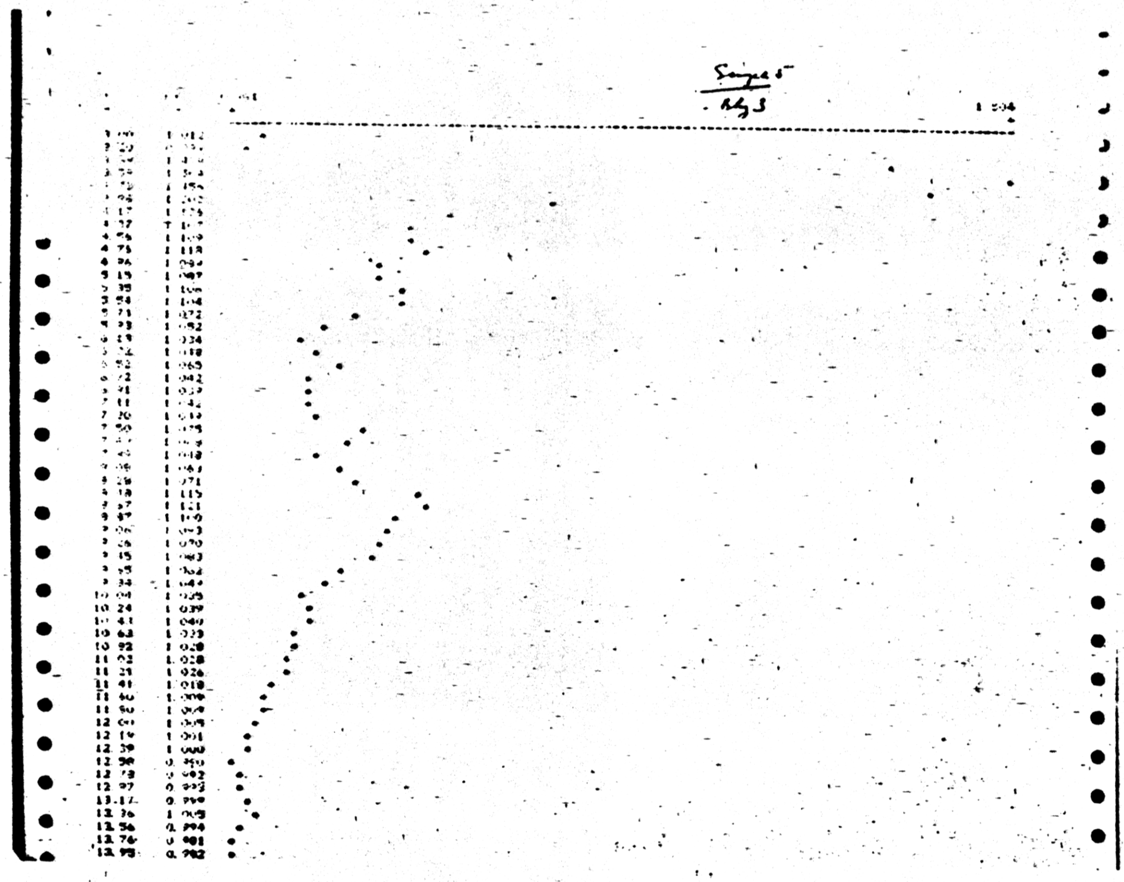
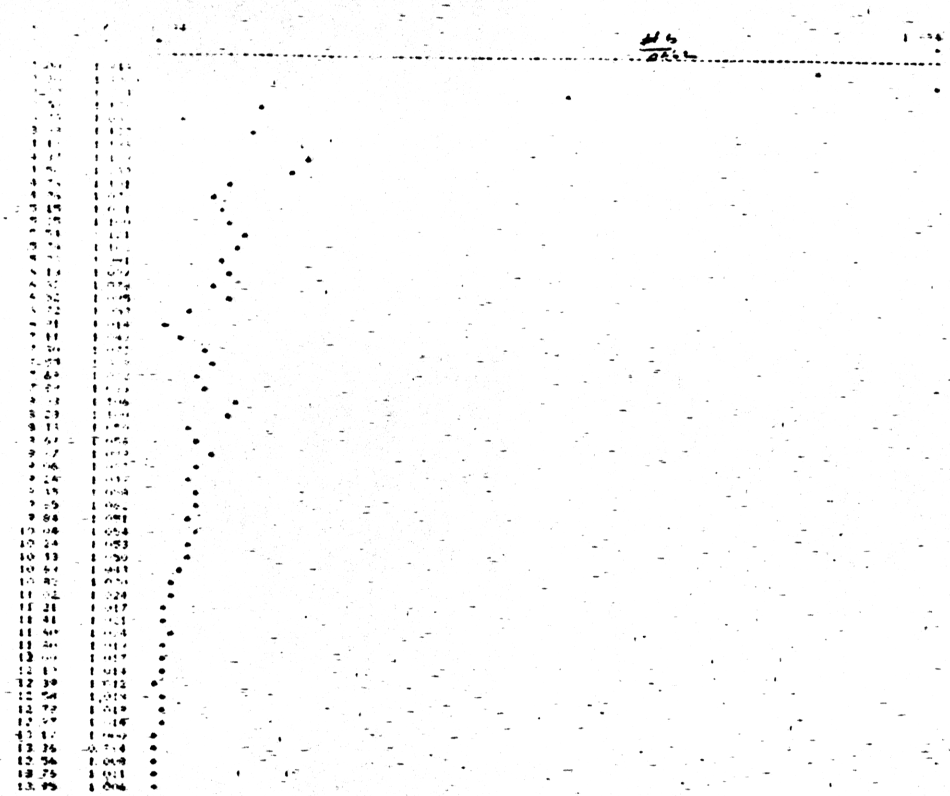

F R
R →
SAmple 3
R →





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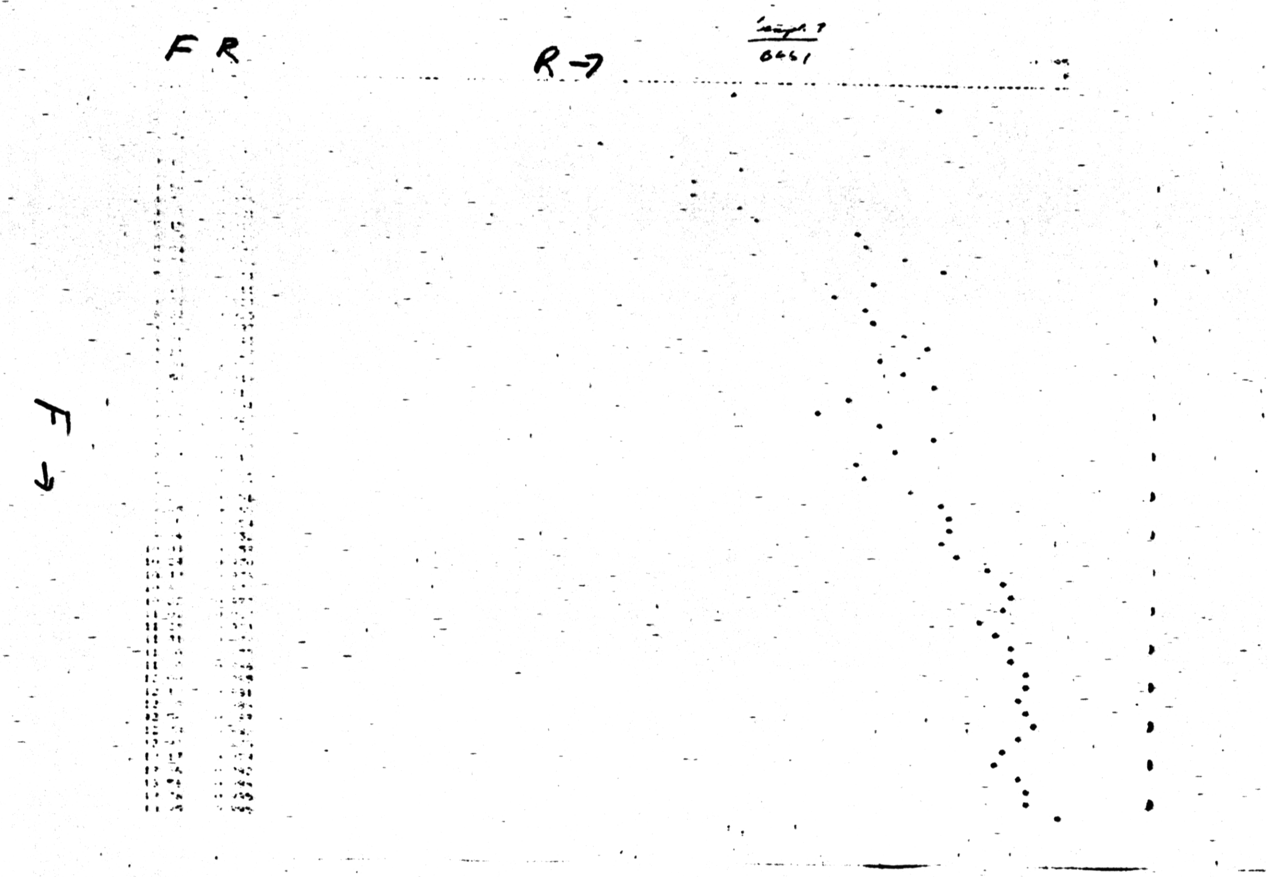
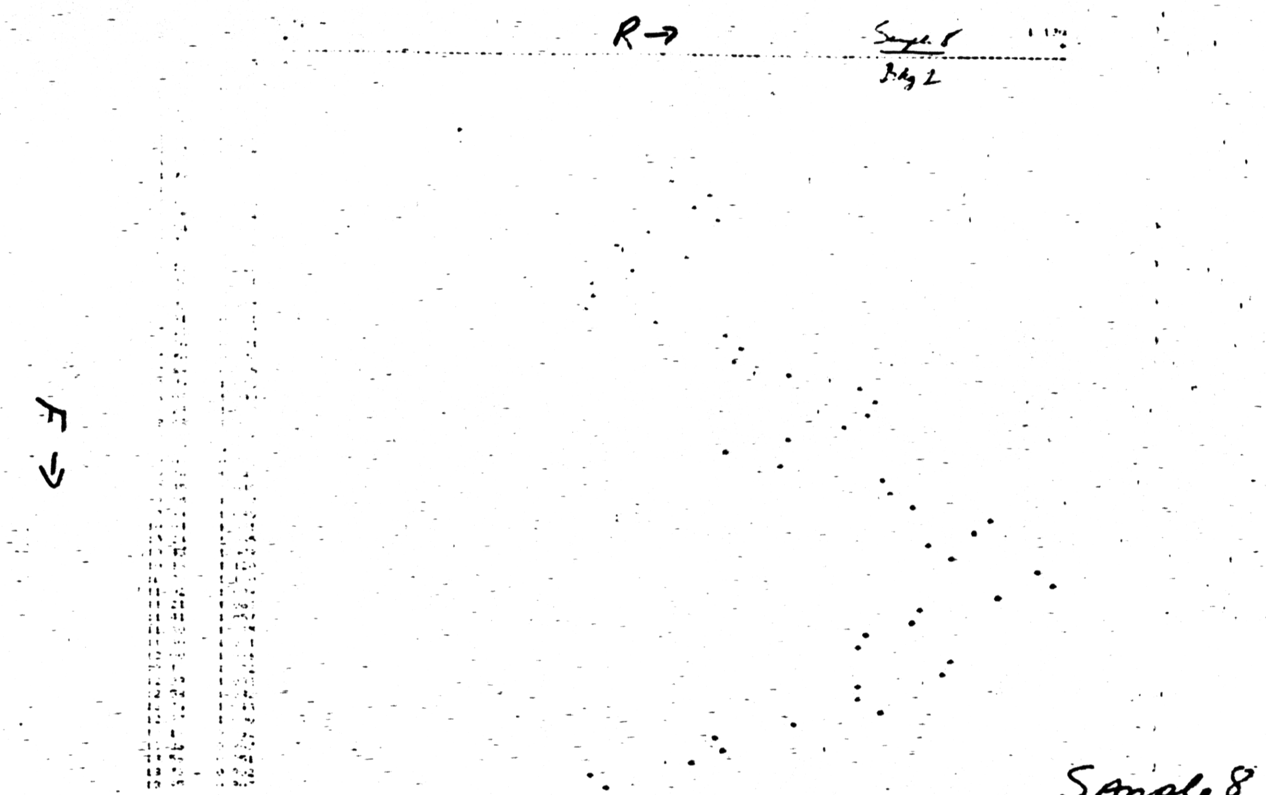
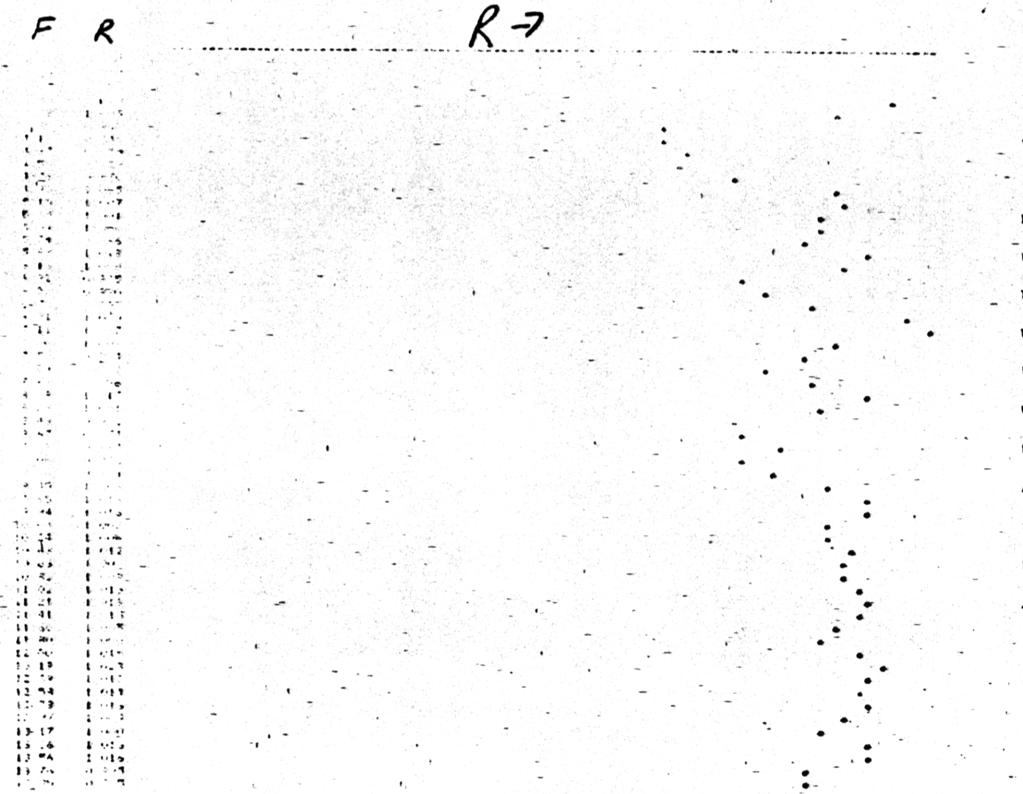
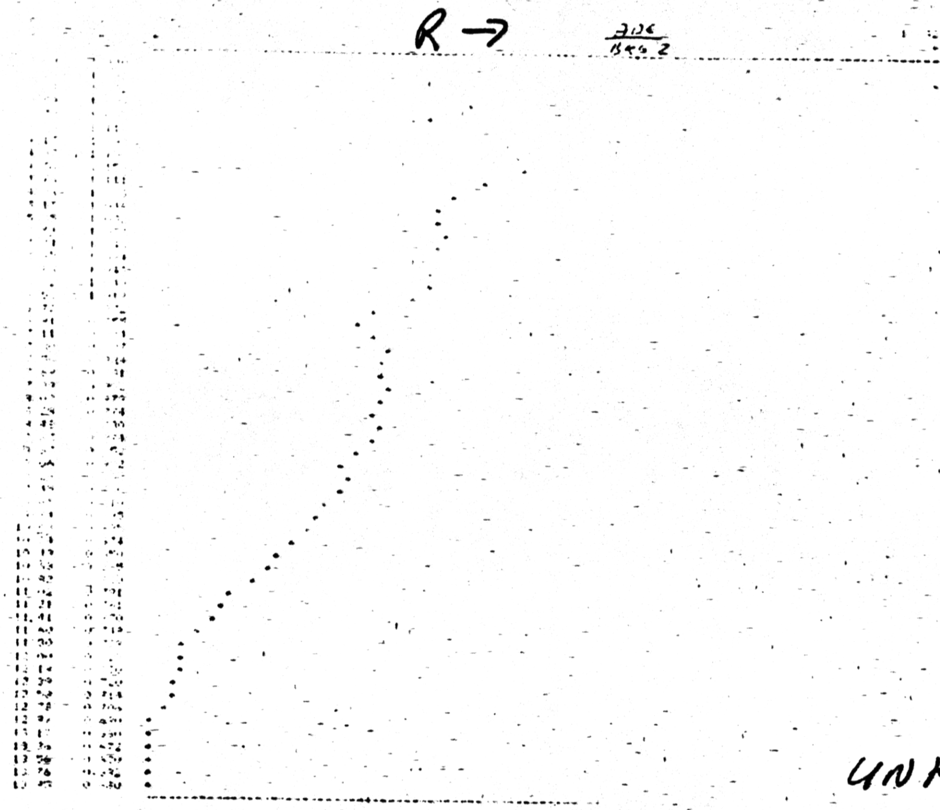




Sample 8



Sample 9



UNKNOWN

TRIANGLE PAINT COMPANY, INC.

Manufacturers of

PAINTS • VARNISHES • INDUSTRIAL COATINGS

2222 THIRD STREET • BERKELEY, CALIFORNIA 94710 • Phone (415) 845-6931

May 26, 1981

Mr. W. G. Horne,
National Radio Astronomy Observatory
P. O. Box O
Socorro, New Mexico 87801

Dear Mr. Horne,

I have forwarded 9 panels to Mr. Payne for testing in accordance to your letter of April 23. As the Aluminum you sent was extruded I included 3 additional panels of rolled Aluminum as I thought it another variable we could check easily.

I formulated three coatings and used two methods of preparing metal. My thoughts were that particle size of pigment and thickness of film were important, so I did not use a primer but used excellent surface preparation.

Panels 1, 2, and 3 are a water thinned, one component Aliphatic Urethane, 1 and 2 use your Aluminum and #3 my rolled Aluminum. Number 1 was etched with a 10% solution of phosphoric acid in alcohol for 45 minutes and rinsed, dried and coated. Number 2 and 3 were cleaned and etched in accordance to the enclosed sheets on Ridoline and Alodine.

Panels 4, 5, and 6 were coated with a finish I have used on aluminum for several years that has over 5 years exposure and though, only 3/4 of a mil thick is in excellent condition. It is an acrylic polymer. Panels 4 and 5 are panels you furnished with 4 etched with the phosphoric acid and 5 and 6 with the Ridoline and Alodine treatment. Number 6 is the rolled Aluminum.

Panels 7, 8, and 9 are coated with an acrylic polymer pigmented with all oxide free pigments. One of my customers using Hi-Reflectant coating for antennae had me make this type of coating. They are excellent engineers and I thought they might know something a bit different and as you are not a competing company I thought it should be tested. They are using it on one special overseas installation. Panels 7 and 8 are your Aluminum with panel 7 etched with the phosphoric acid. Panel 9 is the rolled Aluminum. Panels 8 and 9 were prepared with the Ridoline Alodine method.

I shall be waiting to hear the results of your tests. Even if they do not work out perfectly if there is an improvement it may give me some clues as to further work.

Yours Very Truly,

Alan P. Henry, President

technical service data sheet

AMCHEM PRODUCTS INC
AMBLER, PA.

RIDOLINE 322-IMMERSION OR SPRAY APPLICATION

A. INTRODUCTION:

Ridoline 322 is a powdered, mildly alkaline, heavy-duty production cleaner for aluminum.

The cleaning bath made from Ridoline 322 is non-etching and free-rinsing. It readily removes both mill soil and alloy marking inks.

The organic surfactants contained in Ridoline 322 are classified by the manufacturer as biodegradable.

Ridoline 322 is readily adaptable to automatic bath control using Lineguard electronic control equipment which is available for use with this material when used in multi-stage spray-processing equipment.

B. SUMMARY OF OPERATING DATA:

1. Cleaning Bath Make-Up:

For each 100 gallons of bath, add to the water with stirring:

Ridoline 322	Immersion	-	20 lb. (3.2 oz./gal.)
	Spray	-	12 lb. (1.92 oz./gal.)

NOTE: Ridoline 322 should be dissolved in a pail of water before adding to the bath.

2. Control Points (for Normal Operating Conditions):

Ridoline Titration	Immersion	-	16.0 ml.
	Spray	-	9.5 ml.
Temperature		-	150° to 190° F.
Treating Time	Immersion	-	~~1 to 5~~ minutes 10 MIN.
	Spray	-	30 to 60 seconds

NOTE: See Sect. C for details of titration, Sect. D for operational recommendations, and Sect. E for the materials needed to operate the Ridoline 322 bath.

C. MAINTENANCE OF THE BATH:

The Ridoline 322 bath is manually controlled in the plant by a titration using Amchem Chemical Test Set 3634 or its equivalent; this chemical test set is also used to monitor the bath concentration/condition when Lineguard electronic control equipment is used.

Ridoline Titration:

1. Pipette a 10-ml. sample of the Ridoline bath into a beaker.

2. Add approximately 100 ml. of distilled water and 4 to 6 drops of Indicator Solution 2 (Brom Cresol Green). The solution will turn blue.

3. Fill the automatic burette to the zero mark with Titrating Solution 20 (0.1 N Hydrochloric Acid).

4. While stirring the sample, slowly run in Titrating Solution 20 until the color changes from blue to yellow.

5. Record the number of milliliters of Titrating Solution 20 used as the Ridoline Titration (see Sect. B-1).

Replenishment: Add 0.13 lb. of Ridoline 322 per 100 gallons of bath for each 0.1 ml. lacking. The bath should be kept within 0.5 ml. of the specified titration (see Sect. B-2).

NOTE: Whenever a portion of the bath is discarded or lost by leakage, the volume should be restored with the same proportion of chemical and water as used in the original bath.

D. OPERATIONAL RECOMMENDATIONS:

1. The initial charge and replenishment data contained herein are normal for most installations; however, your Amchem technical representative may suggest a deviation from this data if indicated by local conditions.

2. If the work is heavily soiled and additional cleaning power is needed, a Ridosol (a detergent cleaner additive) may be added to the bath. Your Amchem technical representative will recommend the proper type of Ridosol.

3. Operators should be equipped with rubber gloves, aprons, and goggles to avoid contact with the solution.

E. CHEMICALS AND TESTING MATERIALS:

The following chemical and testing materials are needed to operate the Ridoline 322 bath and may be obtained from Amchem Products, Inc., Ambler, Pennsylvania 19002:

Ridoline 322	-	See Sect. B-1 and C
Amchem Chemical Test Set 3634	-	See Sect. C

No. RL-322-DS
August 1972 (rev.)

technical service data sheet

AMCHEM PRODUCTS INC
AMBLER, PA.

ALODINE® 407-47 – IMMERSION OR SPRAY APPLICATION

A. INTRODUCTION:

The Alodine 407-47 bath, made from two liquid chemicals, is used to produce on aluminum and its alloys a chemical conversion coating which ranges in color from light blue-green through a darker green. The coating, when properly applied, has excellent paint-bonding properties and affords underfilm corrosion protection.

Alodine 407-47 is readily adaptable to automatic bath control using Lineguard® electronic control equipment which is available for use with this material.

B. SUMMARY OF OPERATING DATA:

1. Coating Bath Make-Up:

For each 100 gallons of bath, add to the water with stirring:

Alodine 47	-	0.75 gal.
Alodine 407	-	4.4 gal.

2. Control Points (for Normal Operating Conditions):

Alodine 407 Titration	-	15 ml.
Temperature	-	100° to 120° F.
Immersion Time	-	30 sec. to 2 min.
Spray Time	-	15 to 30 sec.

NOTE: See Sect. E for details of the Alodine 407 Titration, Sect. F for operational recommendations and Sect. J for the materials needed to operate the Alodine 407-47 bath.

C. PROCESS SEQUENCE:

Operation No. 1 - Clean }
Operation No. 2 - Rinse } See Sect. D
Operation No. 3 - Coat with Alodine 407-47
Operation No. 4 - Rinse }
Operation No. 5 - ~~Acidulated~~ Rinse HOT } WATER See Sect. G

The work, after processing and drying, is ready to be painted.

NOTE: When aluminum to be treated with Alodine has corrosion products or heavy oxide on the surface, the corrosion or heavy oxide should be removed by installing two additional tanks between Operation Nos. 2 and 3, above; one tank for deoxidizing with an Amchem Deoxidizer and one for an additional cold water rinse.

D. SURFACE PREPARATION:

1. For Immersion Application:

A mildly alkaline, inhibited Ridoline® is recommended for most cleaning applications. Dykasol®, an acid emulsion cleaner, may be recommended in some instances for difficult-to-clean castings. Aluminum castings, after cleaning, should be deoxidized (see Note in Sect. C, above).

2. For Spray Application:

A mildly alkaline, inhibited Ridoline is recommended for most cleaning applications. In some cases where cleaning time is short (10 to 30 seconds), an etching-type Ridoline may be recommended. If the work is heavily soiled and additional cleaning power is needed, a Ridosol® (a detergent cleaner additive) may be added to the Ridoline bath.

After cleaning, the work should be rinsed with water. This rinse should be continuously overflowed to avoid contamination.

NOTE: Your Amchem technical representative will recommend the proper type of cleaner for each processing line.

E. MAINTENANCE OF THE BATH:

The Alodine 407-47 bath is manually controlled in the plant by an Alodine 407 Titration which determines needed replenishment of the Alodine 407, and a check of the Alodine 47 concentration to determine necessary replenishment.

The Alodine 407 Titration is accomplished using Amchem Chemical Test Set 2266 or its equivalent; this chemical test set is also used to monitor the bath concentration/condition when Lineguard electronic control equipment is used.

1. Alodine 407 Titration:

a. Pipette a 5 ml. sample of the Alodine bath into an iodimetric flask and dilute to approximately 100 ml.

b. Add approximately 1 gm. (1/2 teaspoonful) of Titrating Compound 2 (Potassium Iodide) and agitate the solution until the Titrating Compound 2 is dissolved.

c. Add approximately 10 ml. of Acid Test Solution 2 (C.P. Hydrochloric Acid) in two equal portions to the lip of the flask, raising the stopper slightly after each addition to allow the acid to run into the flask.

d. Rinse the lip several times with water and replace the stopper.

e. Fill the automatic burette to the zero mark with Titrating Solution 31 (0.1 N Sodium Thiosulfate).

f. After the sample has settled for approximately one minute, titrate with Titrating Solution 31 until a straw color is obtained.

g. Add several milliliters of Indicator Solution 11 (Soluble Starch Solution) to the sample and continue the titration with Titrating Solution 31 (without returning the burette to zero) until the blue-black color disappears.

h. Record the number of milliliters of Titrating Solution 31 used as the Alodine 407 Titration.

Replenishment of Alodine 407: Add 1.2 quarts of Alodine 407 per 100 gallons of bath for each milliliter lacking. The bath should be kept within 1 ml. of the specified Alodine 407 Titration (see Sect. B-2).

NOTE: The Alodine bath, as per Sect. B-1, will have an Alodine 407 titration of approximately 15 milliliters. The Alodine bath make-up may be varied to vary the coating color (see Sect. F-2). Your Amchem technical representative will advise and assist if such changes are desired.

2. Alodine 47 Control and Replenishment (using Lineguard Meter 101):

After the Alodine 407-47 bath has been made up and, if needed, adjusted to any special requirements regarding coating or color, the Alodine 47 (active fluoride component) bath content is determined by use of the Lineguard Meter 101.

The Lineguard Meter 101 reading, showing the initial Alodine 47 concentration (bath content), is to be recorded and will be used in comparison with later Alodine 47 concentration/meter readings to determine the amount of Alodine 47 needed for bath replenishment.

Your Amchem technical representative will assist in establishing the initial Alodine 47 concentration/meter reading and the use of the Lineguard Meter 101.

Replenishment of Alodine 47:

After the Alodine 407 content has been restored (see Sect. E-1, above), the existing Alodine 47 concentration/meter reading is determined by use of the Lineguard Meter 101; the replenishment/addition of Alodine 47 will be made using the following table as a guide.

This table is generally applicable to the standard Alodine 407-47 bath; however, the type of coating desired and the operating conditions prevailing on a given installation may require modification. The applicability or modification of this suggested table of replenishment will be determined as the result of actual operating experience.

For maximum processing economy and coating uniformity, it is advisable to make frequent, small additions of Alodine 47.

NOTE: Whenever a portion of the bath is discarded or lost by leakage, the volume should be restored with the same proportion of chemicals and water as used in the original bath (see Sect. B-1).

Lineguard Meter 101 Reading	Gallons of Alodine 47 required to replenish each 100 gal. of bath
1080	0
1000	0.035
900	0.080
800	0.120
700	0.160
600	0.200
500	0.250
400	0.300
300	0.360
200	0.440

F. OPERATIONAL RECOMMENDATIONS:

1. The initial charge and replenishment data contained herein are normal for most installations; however, your Amchem technical representative may suggest a deviation from this data if indicated by local conditions.

2. The depth of color is dependent upon the concentration of Alodine 47, the processing time, and the temperature. An increase in any of these factors will increase the depth of color.

3. There are certain precautions to be observed during the operation of the Alodine 407-47 process:

   a. Adequate ventilation should be provided for tanks containing the Alodine 407-47 bath.

   b. Operators must not breathe vapors from the bath or concentrated liquid chemicals.

   c. Operators handling Alodine chemicals should be equipped with rubber gloves and face shields.

   d. The bath and the concentrated chemicals should be immediately flushed from the skin with water.

G. AFTER-TREATMENT:

After the work is treated, it should be given two rinses - an unheated water rinse and a final rinse in water acidulated with Deoxylyte®. The final acidulated rinse may be heated to facilitate drying. Your Amchem technical representative will recommend the Deoxylyte best suited to local conditions.

H. DRYING PAINT-BONDING COATINGS:

Parts coming from the final acidulated rinse should be dried as soon as possible in an indirectly fired oven or by other means which will not contaminate the metal with fumes, oil, or partially burnt gases. In many cases, heavy-gauge metal will retain enough heat to dry completely and rapidly without using an oven.

Products with cavities or pockets which trap moisture should be blown dry with a jet of clean, compressed air. Moisture splatters should be dried with clean rags.

If handling of the dried, unpainted work is necessary, operators should wear clean cotton gloves.

I. EQUIPMENT NOTES:

The work is processed in conventional immersion or power spray processing equipment. The equipment for the Alodine (and Deoxidizer, if used) stage should be constructed of stainless steel (Type 316 preferred). All other stages may be constructed of mild steel.

All heated tanks should be equipped with steam plate coils and side heating (preferred for a more even temperature distribution) or other heat sources capable of rapidly heating the bath to the specified temperature.

Acid-resistant crates, baskets, tumbling barrels, or conveyors, etc., should be provided to carry the work through the various stages.

NOTE: Detailed equipment specifications for a particular processing line may be obtained from either your Amchem technical representative or Amchem Products, Inc., Ambler, Pennsylvania 19002.

J. CHEMICALS AND TESTING MATERIALS:

The following chemicals and testing materials are needed to operate the Alodine 407-47 bath and may be obtained from Amchem Products, Inc.:

Alodine 407	-	See Sect. B-1 and E-1
Alodine 47	-	See Sect. B-1 and E-2
Amchem Chemical Test Set 2266	-	See Sect. E-1
Lineguard Meter 101	-	See Sect. E-2

Alodine®, Ridoline®, Ridosol®, Dykasol® and Deoxylyte® are registered Trademarks of Amchem Products, Inc., for metal coating, cleaning and rinse-additive chemicals; Lineguard® for electronic solution-control apparatus.

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