SUPERCONDUCTING
SUPER
COLLIDER

MATERIAL SPECIFICATION

NO. SSC-MAG-P-505

TITLE: SUPERCONDUCTING WIRE INVENTORY PROCEDURES MANUAL

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REVISION RECORD

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SUPERCONDUCTING WIRE

INVENTORY PROCEDURES MANUAL

SUPERCONDUCTING WIRE INVENTORY PROCEDURES MANUAL

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INTRODUCTION

This Inventory Procedures Manual is intended to give a brief summary of the Superconducting Wire Inventory Management, Quality Control, and Cable Operation currently engaged in at the Lawrence Berkeley Laboratory. This draft does not qualify its readers to conduct any portion of the test or procedures without further instruction. At this printing, the reader must realize this is only a vehicle to develop the procedures and quality control necessary to transfer the technology to Industry in order to produce the superconductor cable required for the SSC.

INCOMING SUPERCONDUCTING WIRE INVENTORY PROCEDURES

WHEN A WIRE SHIPMENT ARRIVES:

Duplicate Papers:

Original in invoice book

Copy to J. Royet

Copy to R. Scanlan

Working copy

Unpack Wire:

Record manufacturer's information on a wire receival form and label each spool with an LBL number. An LBL number consists of the first four numbers of the manufacturer's billet and a 1-100 number. Record the LBL number, footage, and weight.

Check the footage of wire on each spool.

Note inconsistencies on the receival form.

- different wire ø's
- Cu ratios
- twist

Record the LBL number on an inventory sheet and put it in the inventory book under the manufacturer's name.

From this point forward the only relevant identification is the LBL number. Be sure it is securely fastened to its spool.

Cut Samples: (from each spool)

20' for tests, at LBL

12' for short sample electrical test

Record footage removed on inventory sheet and wire spool.

Samples for testing go into a manila envelope labelled with all possible information from manufacturer (specific identification of the supply spool, heat treatment, twist pitch, etc.)

The 20 foot LBL sample is sent to the wire test department.

The 12 foot sample is given to Ron Scanlan.

Each supply spool is then put in a storage bin and grouped by manufacturer and LBL number. Label the storage bin with the manufacturer's information.

WIRE RECEIVING REPORT

DATE RECEIVED:
MANUFACTURER:
P.O. NUMBER:

WIRE SIZE:
TWIST:
FILAMENT:
Cu/SC:

ANNEAL:
NOTES:

MFG'S BILLET *	MFG'S SPOOL *	LBL IDENTIF.	LENGTH	WEIGHT	SPOOL SIZE

'WIRE INVENTORY'

DATE RECEIVED: WIRE SIZE: ANNEAL:

MANUFACTURER: TWIST: NOTES:

P.O. NUMBER: FILAMENT:

Cu/SC:

BILLET #	S/L #	LENGTH	S/C #	REMAINS	S/C #	REMAINS	S/C #	REMAINS

INCOMING STRAND INSPECTION REPORT PROCEDURES

1. Each superconducting strand material received for any manufacturer will be inspected and characterized before deemed acceptable for cabling.

2. The inspection reports are measured values that verify the manufacturer's data and also measurements of the wire mechanical properties.

3. Each billet will be randomly checked. A minimum of two spools from each billet will be examined initially. If any discrepancies are found, more spools may be examined.

4. Fill in the incoming inspection report information. Determine this information by measuring and performing 5 different tests.
   - o Etch a 3" long sample; record the filament twist direction and twist per inch.
   - o Follow the instructions for determining copper-to-superconductor ratio.
   - o Perform a sharp bend test and evaluate the results under a microscope. Etch this test sample and indicate filament condition.
   - o Follow instructions for springback test.
   - o Perform tensile test to determine ultimate tensile strength and percent elongation.

5. Each test will be performed 3 times and evaluated.

6. Record all test results and comment on any peculiar observations.

7. In the event the wire does not pass any test or is contrary to manufacturer data, fill out a Material Non-Conformance Report and notify R. S. Scanlan or J. O'Neill.

8. The springback sample and sharp bend are saved and stored in the archive.

9. The archive to date is being organized and eventually will contain an additional length of wire from the billets tested.

INCOMING STRAND INSPECTION REPORT

MANUFACTURER:	P.O. #:	INSPECTOR:
BILLET #:	SPOOL #:	DATE:

STRAND SURFACE APPEARANCE:

STRAND DIAMETER:

TWIST PITCH MEASUREMENT:

TWIST DIRECTION:

Cu/SC RATIO BY WEIGHING:

Cu + SC WEIGHT: ________

SC WEIGHT: - ________

Cu WEIGHT:

SHARP BEND TEST RESULTS:

SHARP BEND ETCHING RESULTS:

SPRINGBACK TEST RESULTS: #1	#2	#3

TENSILE TEST RESULTS:

ULTIMATE TENSILE STRENGTH:

PERCENT ELONGATION:

COMMENTS:

COPPER TO SUPERCONDUCTOR RATIO TEST PROCEDURE

1. Materials List:

Deep Petri Dishes	50% Nitric Acid Solution
Scale	Oven
Tweezers	Alcohol
Wire sample - 12" Length	Sodium Bicarb

2. Label a clean petri dish the LBL number for each wire to be tested.

3. Wipe each 12" long wire sample with alcohol, coil and place in its assigned petri dish. Use tweezers to handle wire for the rest of testing procedure. Weigh the wire sample to the nearest 1000th of a gram and record its weight on the incoming strand inspection form.

4. Place 1 tabsp. of sodium bicarb in a container and dissolve in water. Use this to neutralize any acid spills.
   DANGER - Nitric acid can cause severe burns and may be fatal if swallowed. Read all labels and use all safety precautions in handling acids.

5. Under fume hood, pour 50% nitric acid and 50% water into each petri dish to cover the wire samples. Place signs (WARNING NITRIC ACID).

6. Allow 30 min. then check each wire sample to see if all of the copper is etched away. This is done visually and by using tweezers to check for stiffness. Be careful not to cause damage to the sample. Stiffness indicates presence of copper. If copper is present, but acid appears to have stopped etching, pour the acid into a used acid container and add fresh solution.

7. After the copper is completely etched away, pour acid into a well labeled used acid container. The remains left in the petri dish are the superconductor filaments.

8. Gently rinse the filaments in the petri dish. Be careful not to rinse away loose filaments. Repeat 4-5 times or until thoroughly rinsed.

9. Put the petri dish containing the sample in the oven at 60°C - 70°C for approximately 15 minutes. Gently move the filaments to prevent sticking to the petri dish.

10. Dry the filaments for approximately 45 min.. Weigh the sample to the nearest 1000th of a gram and record weight on the incoming inspection form. With these weights, you can compute the copper-to-superconductor ratio.

11. Repeat steps 10 and 11. These two measurements should agree to within 5%.

12. Use the filament weight and copper weight in the following formula:

$$\text{Cu/SC, Ratio} = \frac{\dfrac{\text{Weight of copper}}{8.95}}{\dfrac{\text{Weight of Superconductor}}{6.02}}$$

8.95 (Specific gravity of cu.)

6.02 (Specific gravity of SC.)

13. Record step 12 on incoming strand report.

SHARP BEND TEST PROCEDURE

The purpose of this test is to approximately simulate the deformation to the superconductor wire that may occur during cabling. The sharp bend fixtures are made to produce 20% deformation for each of the two wire diameters used. The fixtures are labeled accordingly

.0255 Dia.	Part No. 21M925 A-C
.0318 Dia.	Part No. 21M925 1-3

1) Cut a 3 inch sample of wire to be tested. Bend the sample in half and place the bend in the slot of the appropriate fixture.

2) Slide the mating top of the fixture in the slot and squeeze them together until closed using a bench vise.

3) Remove the top of the fixture and loosen the side screw.

4) The sample now resembles a hairpin. Examine the bend under a microscope to determine if the wire cracked or deformed in a way to inhibit cabling. This requires some knowledge of cabling and the limitation of sample deformation.

5) Etch the sharp bend sample in nitric acid. Use all precautions in handling acids. Examine the sample again to determine possible filament damage. This also requires some knowledge of filament characteristics.

6) Repeat this test a minimum of three times and fill in the inspection report as to whether the sample passed or not.

SPRINGBACK TEST PROCEDURES

THE PURPOSE OF THIS TEST IS TO DETERMINE THE STIFFNESS OF SUPERCONDUCTING STRAND MATERIAL BEFORE CABLING

1. Cut 3 1/2 foot sample of wire to be tested. Do not bend wire unnecessarily.
2. Prepare one end with a 1/2 inch 90 degree bend, and the other end tie securely to a 5 pound weight.
3. Test the spring fixture to be sure it turns freely.
4. Thread the 90 degree bend through the test fixture and place in the hole in the spring winder with the locking pin in place.
5. Make sure the 90 degree bend is not affecting the "0" reading and the wire is tangent to the spring winding shaft.
6. Position the springback fixture at the edge of a table and clamp in a vertical orientation.
7. Hang the 5 pound weight over the end of the table. Release the clamp. Hold the spring winder handle and pull the locking pin.
8. Set "0" on the degree wheel.
9. Wind 10 complete turns and replace locking pin. Then tighten wire clamp.
10. Hold spring handle and remove locking pin. Gently let the spring unwind and note the number of revolutions.
11. Once the spring has stopped, gently touch the spring handle to make sure the spring has equalized and reached its full springback. Do not unwind the spring.
12. Note and record the total number of degrees of springback.
13. Cut the sample at the wire clamp and the 90 degree bend.
14. Carefully slide the spring winder out of its bearings and remove the sample.
15. Measure and record the inside diameter label sample and store in archives.
16. Each sample should be measured 3 times.

MATERIAL NON-CONFORMANCE REPORT

MANUFACTURER:	INSPECTOR:
SAMPLE :	DATE:

NON-CONFORMING MATERIAL:

STRAND ☐

CABLE ☐

DESCRIPTION OF NON-CONFORMANCE:

MATERIALS REVIEW BOARD CONCLUSIONS:

ACTION TAKEN:

SIGNED: DATE:

SPOOLING MACHINE INSTRUCTIONS

1. Turn on power supply to tensioner and adjust to 4.5 lbs. tension.

2. Turn on power to spooling machine and wire tracker.

3. Mount the supply spool of wire on tensioner and cable spool on the spooling machine.

4. Turn the spooling machine on slow lag and set the right and left limits.

5. Thread wire through counter to the wire take-up spool and anchor the wire to prevent slippage. Complete one full turn to guide wire across spool. Zero footage counter. Zero revolution counter on the spooling machine. Initially, slow at right and left limits or even stop just short to make fine adjustments to limit stops. Gradually increase revolutions to ~35 RPM.

   Spool wire to correct length on the spool. The indicated length terminates at the counter wheel, not at the spool. Cool the wire and secure the end.

   Mark the spool from 1-30 according to the location on the cable machine. Record the spool number, wire lengths, and cold welds on wire map. Record wire loss on the supply spool.

   Weigh each spools to check for gross errors. Revolution counter on spooling machine is another check.

   Turn off all three switches when finished.

7. Record information on Wire Map Log.

8. Label all spools for cabler as they are spooled, and record as you go.

9. Tag all supply spools with amount of wire used. Example: (12,895' minus 4 X 3000').

10. Make copies of Wire Map for:
    - R. Scanlan
    - J. Royet
    - Cable Book
    - Copy to Bldg. 46
    - Wire Map Book gets original

11. Consolidate short length of wire onto small spools for easy storage.

12. Update Inventory Log.

WIRE MAP LOG

DATE: ______

S/C #: ______

WIRE INFORMATION				CABLE INFORMATION			
MANUFACTURER	BILLET #	SPL. #	FEET	SPL. #	LENGTH	K/W's	NOTES

CABLE LOG SHEET

DATE: ______

S/C #:

MACHINE OPERATOR NAME: RESPOOLERS NAME:

WIRE INFORMATION

MANUFACTURER:

LENGTH SPOOLED:

ORDER No:

BILLET No:

SPOOL No:

WIRE DIA, THEORETICAL: MEASURED:

Cu/SC RATIO, THEORETICAL: MEASURED:

ORIGINAL TWIST X PER INCH: DIRECTION:

CABLE INFORMATION

PITCH LENGTH:

NUMBER OF STRANDS:

LAY DIRECTION:

PLANETARY GEARS USED:

TWIST DIRECTION:

DIMENSION, WIDTH: ETCHING TEST ON 3" LONG SAMLE:

MAJOR:

MINOR:

KEYSTONE ANGLE:

MEAN THICKNESS, THEORETICAL:

MEASURED 10 STACK TEST (START) (END):

COMMENTS

TURN OFF POWER

Adjust Turkshead for 23 st. or 30 st. cable.

Back off preload on top and bottom rollers equally.

Remove retaining plates. Remove outside rollers 1 & 3 being careful that top roller does not fall.

Remove zerk fitting from 1 & 3. Loosen set screws and remove rollers and axle assembly from holders. Place holders together in correct position.

Remove axle from roller; keep correct axle, nut, and holder together as match-marked.

Wrap rollers in Kim Wipe and remove rollers to be used from box. Check everything for dirt and burrs. Clean and stone if needed.

Place rollers on flat surface with major up. Then assemble shafts, nut, and holders. Watch for correct zerk location and correct preload on roller bearings, i.e., "0" clearance on bearings. (See Fig. 1).

Install roller assembly in Turkshead. Watch for top roller. Do not nick corners.

Install retaining plates and adjust rollers #2 and #4 so they are over each other.

Center left hand roller No.1 with preload screw to C/L of top roller, not bottom roller.

See Note #1 below.*

Check all rollers are free from dirt and oil.

Using top adjusting screw, rock up and down until top roller is in equal contact with two side rollers. (See Fig. 2).

Using preload screw, take up play on top and bottom, then tighten both equally.

Install mandrel with 6-1/2 inch of mandrel showing. Bring set screws to touch and pull mandrel forward. Set end mandrel tip vertical and tighten set screws. (See Fig. 3).

Adjust height and sideways location of Turkshead relative to mandrel.

*Note: Close roller No.3 with right hand adjusting screw so that it is nearly touching roller No.1 before leveling. (See Fig. 4).

Load spools of wire on machine. Thread wire over pulleys around capstans twice through wire guides, through Turkshead and back to puller. Tension at 5 to 6 lbs. Using capstans, set machine for proper rotation and pitch.

Clamp all wires in puller, rotate machine by hand until all wires have tension and are in pulleys.

Check for proper cable pitch, planetary rotation, and direction of cable lay. Put all guards in place.

Turn on power (two operators mandatory).

Start machine turning and bring side adjustment on Turkshead in until cable starts to form. Turn on oil.

Move Turkshead into mandrel until cross overs are gone.

Bring side adjustment on Turkshead in until cable is on size, move Turkshead into mandrel until cable stops, back away .030 and set zero on indicator.

Do ten stack measurements and run cable through measuring head and back to take up reel.

Fig. 1.

Fig. 2.

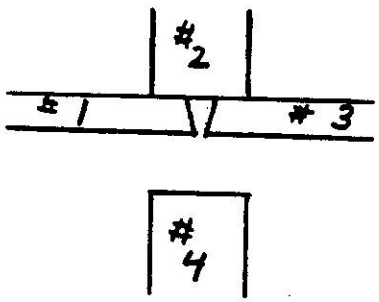
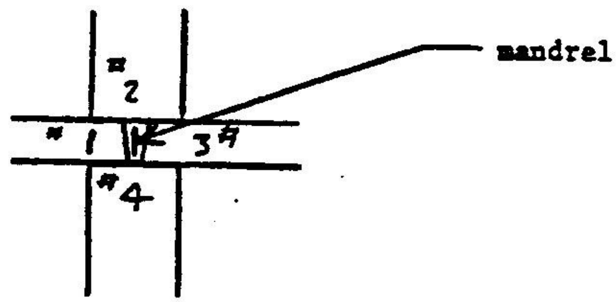


Fig. 3.



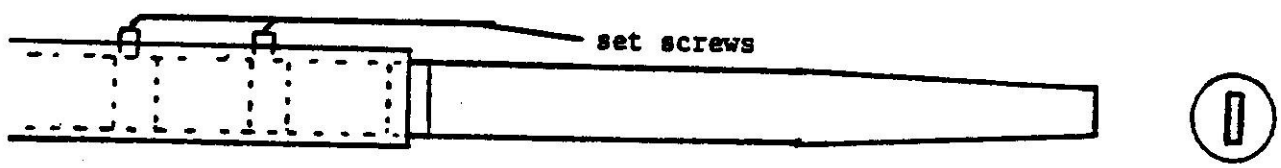
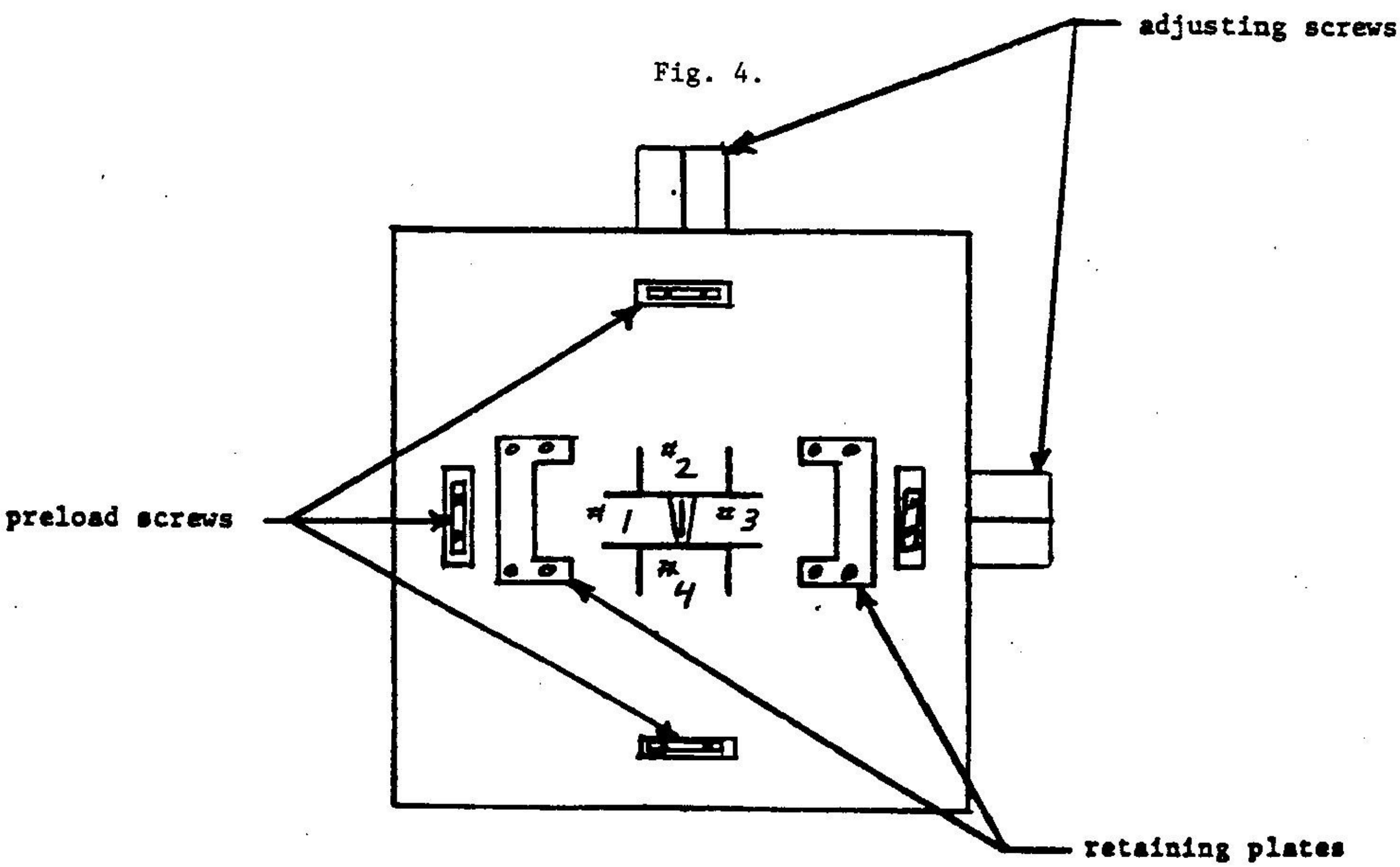


Fig. 4.



CABLE MEASURING MACHINE PROCEDURES

Introduction

The Cable Measuring Machine (CMM) is a tool which measures and records the SSC type cable dimensions in a nondestructive fashion. It is used in-line with the superconductor cable as it is being made and can be used off-line for ckecking dimensions. The CMM is intended to be used as a standard method of measuring by the various manufacturers involved in the SSC cable process. (See Fig. 1.)

Method of Operation

The CMM is driven by a mechanical and electrical system. The mechanical function of the CMM is operated by an air actuated hydrolic system. This system controls the pressure applied to the measuring head. The measuring head clamps the cable in two directions and travels with the cable flow when taking measurements. First, an edge load of 30 psi centers the cable. Second, a load of 5,000 psi compresses the cable thickness.* The cable is held at these pressures for a specified time, typically 3 to 5 seconds, allowing the dimensions to stabilize.

The measuring head is measured by the electronic system. Three LVDT's are used to measure the position of the measuring head when clamped on the cable. (See Fig. 2.)

The LVDT output, hydraulic pressure, and cable footage measurements are then sent to the computer for processing. Recorded measurements and calculated dimensions are displayed on the CRT, kept on disk, and printed on paper. (See Appendix C, D, and E.)

* These are actual pressures on conductors, not the system pressure required to achieve these pressures.

LIST OF POSSIBLE COMPUTER COMMANDS

```
Q  => Quit
GO => Start taking data
ST => STop taking data
RX => Take RelaXation curve for single cycle
WT => choose Wire Type
D  => Display system status
SU => Set Up TAURUS cable counter
      (also change relaxation time and measurement #)
PD => Print last 100 lines of Data on line printer
PR => Print last Relaxation data run on line printer
OD => Open new Data file (closes any existing file)
CM => add CoMment to data file
CC => Check or change Calibration of measuring head
LE => List TAURUS Error codes
HELP => list HELP file (this file)

( shift-PrtSc prints current display screen )

Enter new command line
```

Prerequisites to Operation

The CMM must only be operated by persons specifically trained in its use, as damage to the cable and the LVDT's may result.

- The cable must be clean, no chips or oil, and be free from defects such as broken strands, fractured edges or cross overs.
- The take-up spool or level winder must be capable of supplying approximately 40 lbs. of constant tension.
- The cabling machine and the CMM must be set up to allow the cable to enter the CMM in the correct orientation. The direction of cable travel (right to left or left to right), and front-to-back orientation of the major edge must be determined for each individual CMM.

The LBL CMM cable travels from left to right and the major edge faces the operator.

Set Up and Operation Procedures

1. Complete routine maintenance
   A. Keep measuring head free of dust and chips.
   B. Inspect all moving parts for proper lubrication and adjustment.
   C. Inspect hydraulic, pneumatic, and electrical lines for leaks or wear.
   D. Refill printer with paper, as needed.

2. Turn on computer and run program.
3. Maintain log book. Log book entries should include:
   A. Date and operator's initials.
   B. "Run Title" or Cable No., Disk No., File No., and number of bytes free on data disk.

C. Steps taken by operator. For example, change in cable type, calibration of measuring head, relaxation time, adjustment of system pressures, routine maintenance, and operator observations. (See Appendix F.)

4. Calibrate measuring head. (See Appendix A, B, and C.)
5. String cable through the CMM to the take-up spool.
6. Take relaxation time measurements. (See Appendix D.)
7. Run CMM and collect data. (See Appendix E.)

APPENDIX A

SET UP INSTRUCTIONS FOR FIXED GUIDE SLIDE:

1. Make sure machine is switched off, and run light is not lit.
2. Loosen hold down screws for fixed guide slide. (The two inner shoulder screws are guide pins. They should be left alone.)
3. Pull fixed guide slide as far back as possible. (Move moving guide slide back by backing off LVDT No. 2 and then backing out over travel stops.)
4. Select the displayed calibration gage and the appropriate calibration slot blocks that match wire size. Each calibration gage is identified with a serial number. The individual calibration gages are not to be interchanged.
5. Wipe as clean as possible all gaging surfaces, blocks, gages, and fingers (of guide slides). Make sure no grit is visible in gage head opening. Blow out with compressed air.
6. Place slot blocks in their appropriate 'V' notch, and slide flat calibration gage through slot blocks and measuring head.
7. Making sure all gages stay flat and seated in position, push fixed guide slide against gage and clamp securely in place with hold down screws.
8. Fixed guide slide is now set for specific wire type.
9. Remove calibration slot blocks and return to their protective case.

APPENDIX B

SET UP INSTRUCTIONS FOR LVDT's

1. Loosen set screws on adjustable indicator bases for all three LVDT's, and back them clear of moving parts.
2. clamp measuring head on selected calibration gage. (Make sure all surfaces are clean. (See set up for fixed guide slide, #4.)
3. Set each LVDT to the position displayed on the computer screen. Lock securely in place with set screws on indicator bases.
4. Tighten the three over travel stops until they make contact. (One on top, two on the side.)
5. Unclamp head. Overtravel stops should hold head in place. Back stops out until they leave sufficient clearance for wire, but do not allow pressure on the LVDTs. DO NOT ALLOW HEAD TO BOTTOM OUT ON LVDTs. Lock over travel stops into place.
6. Clamp and unclamp head several times to insure LVDT readings' fall within tolerance range.
7. LVDTs are now set for specific wire type.

APPENDIX C

CALIBRATION

Note: In this case, the LVDT's are too unstable to read. This means the procedure must be run again, or the LVDT's are not adjusted properly.

Reel ID= 1 Relaxation time 5 sec. Current cal. block serial number 2366011

POINT	FEET	L0-MILS	L1-MILS	L2-MILS	PRS-PSI	ANGLE	WIDTH	THICK
+1	+0.0	-85.30	+88.49	+0.21	+2651	-0.004	+.3662	+.0575
+2	+0.0	-85.20	+88.39	+0.18	+2651	-0.002	+.3661	+.0575
+3	+0.0	-85.25	+88.44	+0.15	+2656	-0.003	+.3661	+.0575
+4	+0.0	-85.25	+88.49	+0.18	+2656	-0.004	+.3661	+.0575
+5	+0.0	-85.20	+88.39	+0.15	+2656	-0.002	+.3661	+.0575
+6	+0.0	-85.25	+88.44	+0.15	+2661	-0.003	+.3661	+.0575
+7	+0.0	-85.25	+88.44	+0.18	+2666	-0.003	+.3661	+.0575
+8	+0.0	-85.25	+88.44	+0.15	+2666	-0.003	+.3661	+.0575
+9	+0.0	-85.25	+88.39	+0.15	+2671	-0.003	+.3661	+.0575
+10	+0.0	-85.25	+88.44	+0.15	+2671	-0.003	+.3661	+.0575

Finished taking points. Now checking offsets.

LVDTS are too unstable to read offsets!

LVDT #	TOLERANCE	DIFFERENCE
0	0.16	0.20
2	0.16	2.70

Start again (Y or N)?Y

APPENDIX D

RELAXATION TIME

Note: The second column indicates elapsed time. LVDT's 0, 1 and 2 are reasonably stable at 2.91 seconds. The minimum RX time would be the next even number of seconds after the LVDT's have stablized.

.366 Bare Cable SSC Design "D" Inner Coil 04-10-1987 10:11:05
RELAXATION DATA
S/C #356 , 23 ST.
Reel ID = 1 Relaxation time 10 sec. Cable counter = 2 FEET

POINT	TIME (sec)	L0 (MILS)	L1 (MILS)	L2 (MILS)	PRS (PSI)
1	+0.17	+15.20	-10.62	+3.05	+102.5
2	+0.88	+13.30	-10.67	+3.29	+2304.7
3	+1.54	+13.15	-10.76	+3.32	+2651.4
4	+2.25	+13.15	-10.71	+3.29	+2661.1
5	+2.91	+13.15	-10.71	+3.32	+2661.1
6	+3.63	+13.15	-10.71	+3.29	+2661.1
7	+4.29	+13.15	-10.71	+3.32	+2666.0
8	+5.00	+13.15	-10.71	+3.32	+2666.0
9	+5.66	+13.15	-10.71	+3.32	+2666.0
10	+6.37	+13.10	-10.71	+3.32	+2666.0
11	+7.03	+13.10	-10.71	+3.32	+2666.0
12	+7.75	+13.10	-10.71	+3.32	+2666.0
13	+8.41	+13.10	-10.71	+3.32	+2670.9
14	+9.12	+13.10	-10.71	+3.29	+2670.9
15	+9.78	+13.10	-10.71	+3.32	+2670.9

Enter new command line

APPENDIX E

EXAMPLE OF CABLE DATA

CABLE OR CALIBRATION BLOCK DATA
.366 Bare Cable SSC Design "D" Inner Coil 04-08-1987 10:10:5(
FURUKAWA LOT # SG-6215 , 23 ST. , 100 M , NET. WT. 9.4 KG.
Reel ID = 1 , Relaxation time 4 sec.
FURUKAWA FIRST 100 POINTS

POINT	FEET	LO-MILS	L1-MILS	L2-MILS	PRS-PSI	ANGLE	WIDTH	THICK
+1	+1.0	+2.83	-0.68	+0.15	+2671	+1.640	+.3655	+.0568
+2	+1.0	+3.26	-1.02	+0.12	+2676	+1.647	+.3654	+.0569
+3	+1.0	+4.29	-1.95	+0.09	+2681	+1.665	+.3654	+.0569
+4	+1.0	+4.09	-1.90	+0.21	+2681	+1.663	+.3655	+.0568
+5	+1.0	+3.60	-1.41	+0.09	+2686	+1.654	+.3654	+.0569
+6	+1.0	+3.70	-1.46	+0.15	+2686	+1.655	+.3655	+.0569
+7	+1.0	+4.09	-1.85	+0.26	+2686	+1.662	+.3656	+.0569
+8	+1.0	+3.17	-0.88	+0.29	+2686	+1.645	+.3656	+.0569
+9	+1.0	+3.46	-1.22	+0.09	+2686	+1.651	+.3654	+.0569
+10	+1.0	+4.38	-2.09	+0.12	+2686	+1.667	+.3654	+.0569
+11	+1.0	+4.68	-2.39	+0.15	+2686	+1.673	+.3655	+.0569
+12	+1.0	+4.34	-2.05	+0.12	+2681	+1.666	+.3654	+.0569
+13	+1.0	+3.99	-1.80	+0.09	+2686	+1.661	+.3654	+.0568
+14	+1.0	+4.09	-1.80	+0.09	+2681	+1.662	+.3654	+.0569
+15	+1.0	+3.31	-1.07	+0.06	+2686	+1.648	+.3654	+.0569
+16	+19.0	+3.90	-1.61	+0.21	+2681	+1.658	+.3655	+.0569
+17	+20.0	+3.90	-1.61	+0.23	+2686	+1.658	+.3655	+.0569
+18	+20.0	+3.65	-1.41	+0.29	+2681	+1.654	+.3656	+.0569
+19	+21.0	+3.51	-1.22	+0.21	+2681	+1.651	+.3655	+.0569
+20	+21.0	+2.63	-0.34	+0.29	+2686	+1.635	+.3656	+.0569
+21	+22.0	+3.36	-1.07	+0.35	+2681	+1.648	+.3657	+.0569
+22	+22.0	+2.92	-0.68	+0.32	+2686	+1.641	+.3656	+.0569
+23	+23.0	+4.29	-1.95	+0.32	+2686	+1.665	+.3656	+.0569
+24	+23.0	+4.09	-1.75	+0.26	+2686	+1.661	+.3656	+.0569
+25	+24.0	+3.60	-1.27	+0.32	+2681	+1.652	+.3656	+.0569
+26	+24.0	+3.31	-1.07	+0.23	+2686	+1.648	+.3656	+.0569
+27	+25.0	+3.31	-1.02	+0.26	+2686	+1.648	+.3656	+.0569
+28	+25.0	+3.41	-1.12	+0.35	+2686	+1.649	+.3657	+.0569
+29	+25.0	+4.14	-1.80	+0.21	+2681	+1.662	+.3655	+.0569
+30	+26.0	+3.70	-1.31	+0.21	+2681	+1.654	+.3655	+.0569

APPENDIX F

EXAMPLE OF LOG SHEET

4/8/87 H.H.

Furukawa Lot #SG-6215, 23 st., 100m
Disk #0, File #17, 233 K bytes free
Relaxation time 4 sec.
- changed wire type to 23 st.
- calibrated measuring head
- adjusted pressure to 2686 psi.

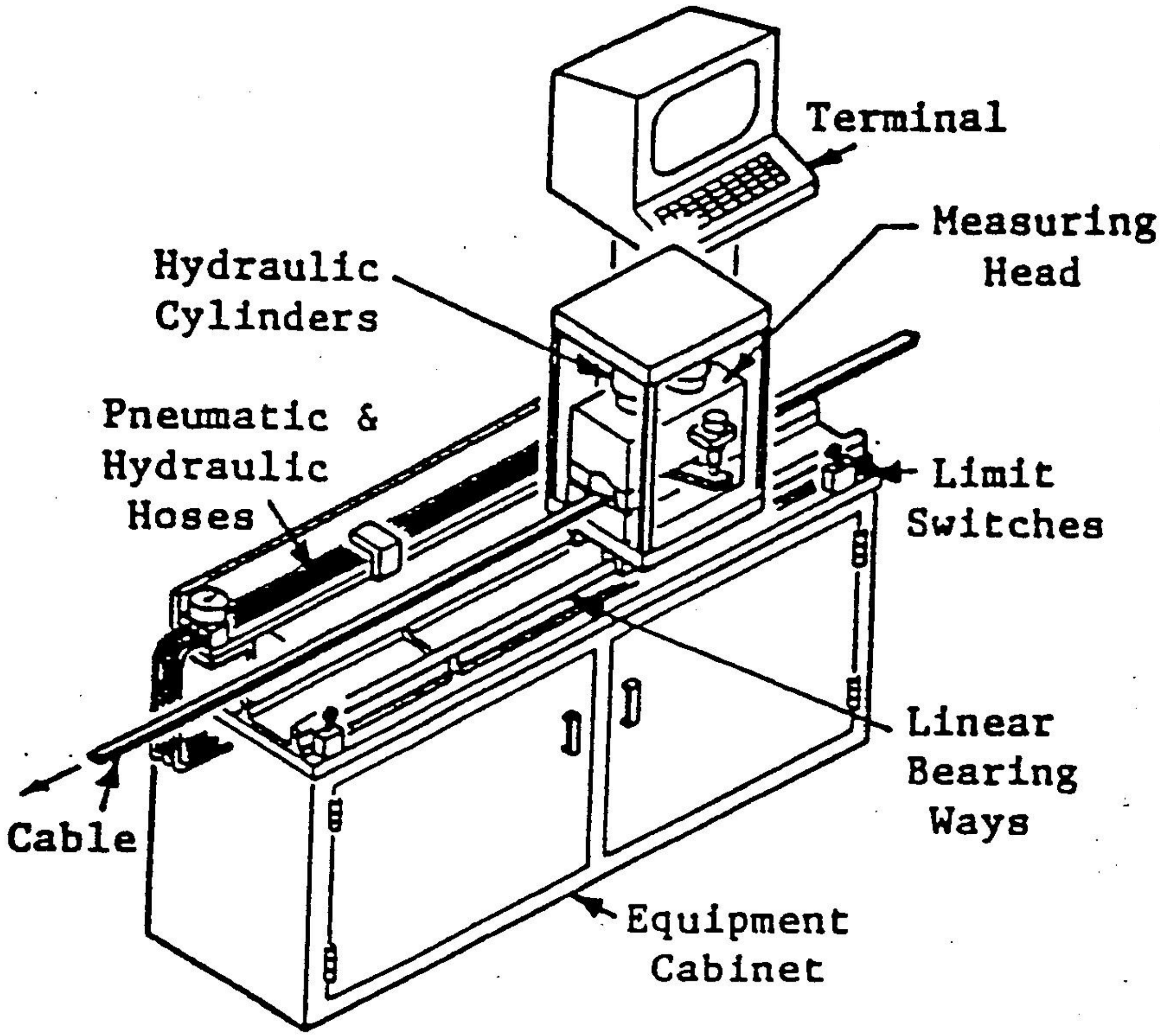
Run O.K.

4/27/87 H.H.

S/C 356, 30 st., 700'
Disk #0, File #18, 198 K bytes free
Relaxation time 5 sec.
- changed wire type to 30 st.
- calibrated measuring head
- adjusted pressure to 2750 psi.

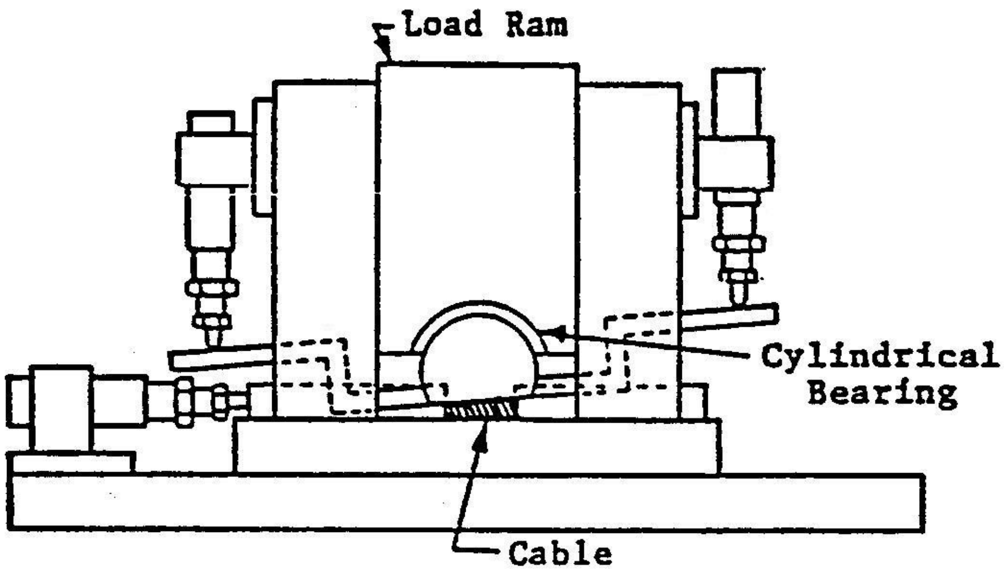
Minor difficulty calibrating measuring head, stopped run at 97 feet, readjusted. Rest of run O.K.

Fig. 1.

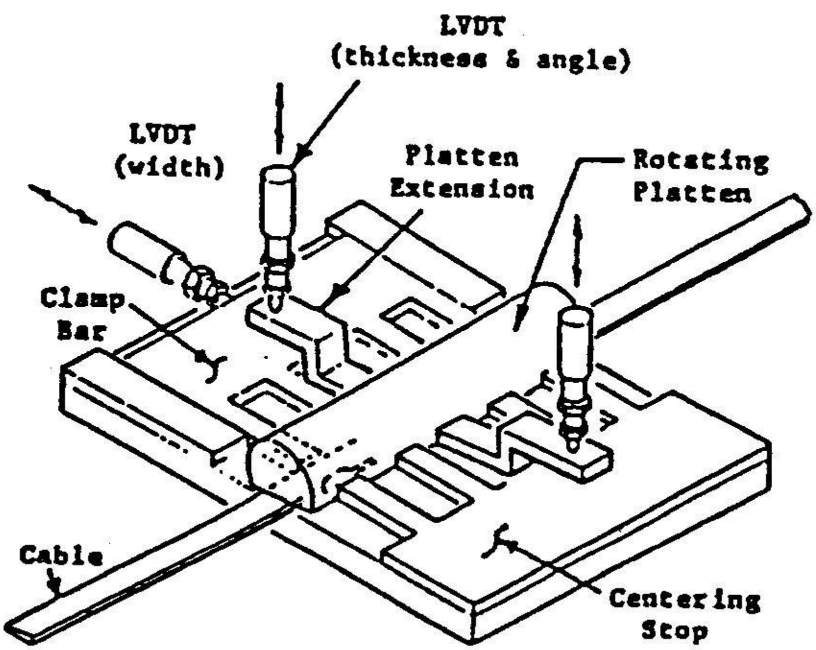


This figure illustrates the measuring machine installed in the cable insulation line.

Fig. 2.



An end view of cable head showing cable during measurement.



Isometric illustration of the measuring head
with the load ram and guides removed for clarity.