Title
A UNIQUE CABLING MACHINE DESIGNED TO PRODUCE RUTHERFORD TYPE SUPERCONDUCTING CABLE FOR THE SSC PROJECT

Author
Jacques, Grisel

Publication Date
1988-08-01

LBL-25777

Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA

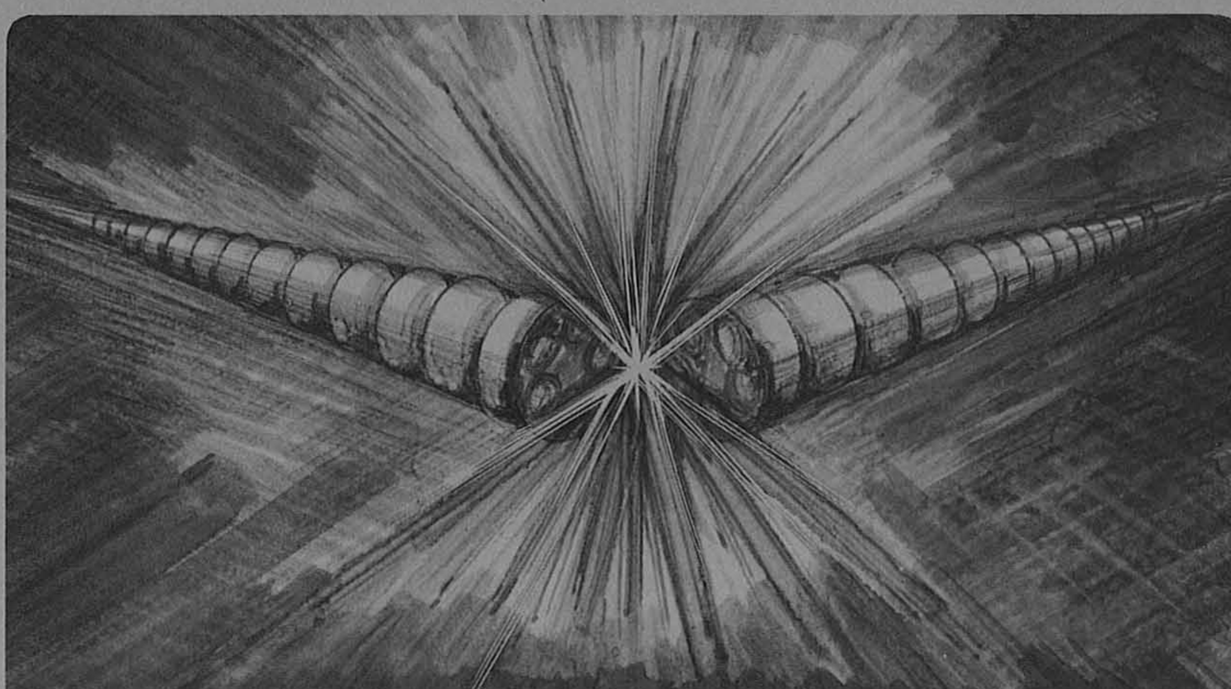
Accelerator & Fusion Research Division

Presented at the 1988 Applied Superconductivity Conference,
San Francisco, CA, August 21–25, 1988

A Unique Cabling Designed to Produce Rutherford-Type Superconducting Cable for the SSC Project

J. Grisel, J.M. Royet, R.M. Scanlan, and R. Armer

August 1988



Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098.

SSC-MAG-214
LBL-25777

A UNIQUE CABLING MACHINE DESIGNED TO PRODUCE RUTHERFORD-TYPE SUPERCONDUCTING CABLE FOR THE SSC PROJECT*

Jacques Grisel

DOUR-METAL
Zoning Industriel de Dour-Elonges
B.P. 20, B 7270 Dour
Belgium

John M. Royet, R. M. Scanlan, and R. Armer

Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

1988 APPLIED SUPERCONDUCTIVITY CONFERENCE

San Francisco, CA

August 21-25, 1988

*This work was supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, High Energy Physics Division, U.S. Dept. of Energy, under Contract No. DE-AC03-76SF00098.

A UNIQUE CABLING MACHINE DESIGNED TO PRODUCE RUTHERFORD-TYPE SUPERCONDUCTING CABLE FOR THE SSC PROJECT*

Jacques Grisel

DOUR-METAL
Zoning Industriel de Dour-Elonges
B.P. 20, B 7270 Dour
Belgium

John M. Royet, R. M. Scanlan, and R. Armer

Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

Abstract

Up to 25,000 Km of keystoned flat cable must be produced for the SSC project. Starting from a specification developed by Lawrence Berkeley Laboratory (LBL), a special cabling machine has been designed by DOUR-METAL. It has been designed to be able to run at a speed corresponding to a maximum production rate of 10 m/min. This cabling machine is the key part of the production line which consists of a precision Turkshead equipped with a variable power drive, a caterpillar, a dimensional control bench, a data acquisition system, and a take-up unit. The main features of the cabling unit to be described are a design with nearly equal path length between spool and assembling point for all the wires, and the possibility to run the machine with several over- or under-twisting ratios between cable and wires. These requirements led DOUR METAL to the choice of an unconventional mechanical concept for a cabling machine.

Introduction

A unique industrial cabling machine designed to produce Rutherford-type superconducting cable for the SSC project was built at DOUR Metal in Belgium. This machine was successfully tested in the plant on June 28, 1988, and is on its way to the United States where it will be very useful in the technology transfer program for SSC cable manufacturing.

Definition of Characteristics

The definition of an ideal industrial cabling line was the result of more than three years of R&D at LBL where two hundred samples of Rutherford cable representing some 50 kilometers were produced.[1,2,3]

The result of these studies was the specification M-686 published by LBL on August 13, 1986. This technical specification was the basis of a Request For Quotation (RFQ) for an industrial prototype.

Dour Metal, subsidiary of a reputable European cabling company and involved in super-conducting projects and SC cables fabrication of various types, was the successful bidder.

The main characteristics of this cabling line are:

- high speed production: up to 10 meters/minute
- 30 strand cable capability
- 5 planetary ratios in each direction
- equal path length for each strand
- constant wire tension
- broken strand detector
- quick emergency stop
- thermal stability and control
- accurate and stable positioning of the Turkshead
- electronic monitoring and recording of the main parameters
- constant traction and variable speed take-up associated with its dancer
- capability to introduce in the line a measuring machine recently developed at Fermi National Accelerator Laboratory[4]
- data acquisition system compatible with the unit used on the measuring machine for complete quality assurance documentation

The Resulting Cabling Machine

In order to obtain the same path length for each strand, the machine concept is somewhat unconventional. Instead of successive barrels holding 6 or 12

---

*This work was supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, High Energy Physics Division, U.S. Dept. of Energy, under Contract No. DE-AC03-76SF00098.

Manuscript received August 22, 1988.

spools each, the Dour Metal design consists of one single barrel with 15 spools back to back on each side.

The main problem was to install the spool supports on the shortest possible diameter in order to reach the maximum cabling speed without excessive centrifugal forces.

Most of the machine weight resides in the spools and their brakes in containers, the superconducting wire load, and the cast iron wheel. This assembly is supported directly through a large diameter bearing installed on the outside diameter of the wheel. The result is an 8 ton mass able to reach 120 R.P.M. without excessive stress.

A second bearing at the rear end of the machine stabilizes the assembly on its main axis. Motion and braking torques are transmitted through a tubular structure.

Due to the back to back position of the spools, each side set has to be moved in a reverse planetary direction with an additional 2 twists differential in order that, in the resulting cable each strand shows an equal twist in amount and direction. The kinematic chain is represented in Fig. 1.

three slip rings installed on the back of the rotating assembly.

- The assembling point consists of traditional rosette guide plate and the LBL designed mandrel attached to a rigid tube, the position of which can be adjusted from the rear of the machine. A thermocouple is installed in the tip of the mandrel whose temperature will be recorded.

- The Turkshead is of a classic type with symmetrical roller configurations. The keystone angle of the cable is given by two of the rollers ground conically to one-half of the keystone angle needed. We choose to have a power drive possibility for the conical rollers. A magnetic coupling gives a constant torque to the roller's shaft and the speed is monitored through a speed sensor on the cable. This system gives the possibility of reducing the cable tension between the Turkshead and the caterpuller.

- The rollers and mandrel lubrication is performed through a mist of synthetic oil and solvent mixture which, in addition, provide a beneficial cooling effect at high speed.

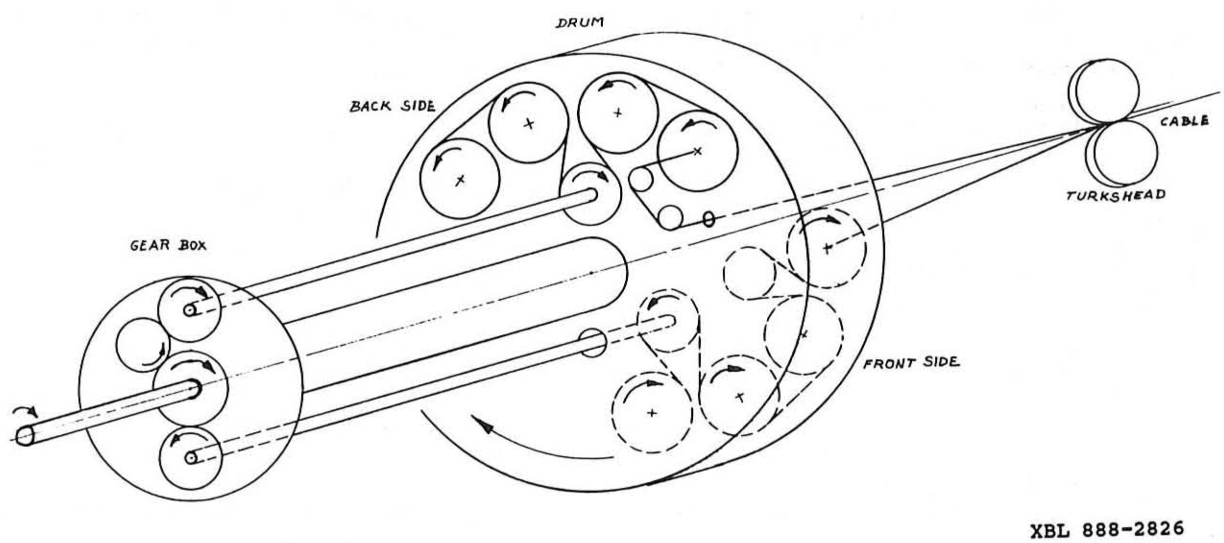


Fig. 1. Kinematic Chain of the Actual Machine

The LBL R&D machine is able to generate an alternate equal twist for every other strand; such a feature was not reproduced on the industrial prototype due to the gearing complication shown in Fig. 2. The other characteristics are as follows:

- The constant wire tension is obtained through magnetic brakes with iron powder.

- The broken strand detectors are installed on each strand and any rupture signal is collected through

- The caterpuller which is responsible for the production speed is mechanically connected to the barrel assembly in order to get a constant pitch of the cable lay. The belts have a T shape cross section, and the cable is pulled by friction between the narrow tracks on those belts in order to avoid any detrimental contact between the two belts. The pressure on the cable and the tension of the belts is obtained by pneumatic rams. This oversized machine works well even with the adverse effect of the lubrication in the Turkshead.

The caterpuller assembly is supported by four air cushions, the resulting frictionless axial motion allows a very accurate control of the cable tension between Turkshead and capstan.

- Number of strands 30 maximum
- Take-up traction 110 to 200 Newton
- Take-up reel Diam. 1000/800 mm X 600 mm width
- Data acquisition 16 binary channels
  12 analog channels

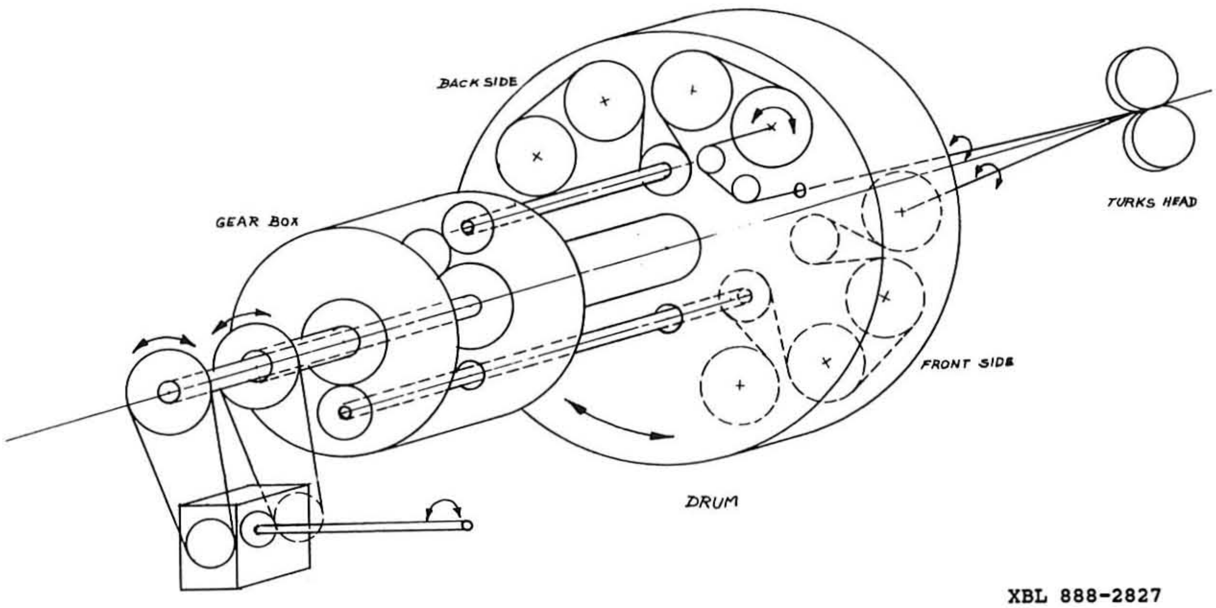


Fig. 2. Kinematic Chain needed for Alternate Twist.

The dimensional control bench developed at Fermi National Accelerator Laboratory[4] is installed after the caterpuller, and all the parameters recorded are transmitted to the main data acquisition system of the machine (an IBM PS 30).

The system records all the manufacturing parameters as well as the potential problems occurring during the run. The other informations periodically recorded are (i) cable dimensions, (ii) room temperature, (iii) mandrel temperature, (iv) Turkshead roller temperature, (v) caterpuller traction, (vi) Turkshead drive power, (vii) speed and length produced.

The take-up unit is of a classic design, but the leveling mechanism was used to generate the lateral alternate travel of the machine in order to keep the cable in the main axis of the line. The associated dancer is responsible for the constant tension and the speed of the respooling which is coordinated with the production speed.

Main installation features are as follows:

- Main engine power 41 Kw
- Maximum cabling speed 10.6 meter/minute
- Cable lay pitch 63.5 to 89 millimeters
- Planetary ratio 0, ±1, ±1.4, ±2, ±2.8, ±4, ±5.6
- Wire tension 15 to 45 Newton

Conclusions

With this equipment, the first trial run using 30 strands of superconducting wire led to cable within the dimensional tolerances at speeds up to 10 meter/minute without any crossovers.

References

1. J. M. Royet, "Magnet Cable Manufacturing," Technical Note, LBL-20129, July, 1985.
2. J. M. Royet and R. M. Scanlan, "Manufacture of Keystoned Flat Superconducting Cables for Use in SSC Dipoles," proceeding of Applied Superconducting Conference, Baltimore, MD, September 29-October 3, 1986; LBL-21295, September, 1986.
3. R. M. Scanlan, J. Royet, and R. Hannaford, "Fabrication of Rutherford-Type Superconducting Cables for Construction of Dipole Magnets," ICMC Conference, Shenyang, PR China, June 7-10, 1988; LBL-24321, May, 1988.
4. J. A. Carson, E. Barezak, R. Bossert, H. Fisk, P. Mantsch, R. Rileg, E. E. Schmidt and E. E. Schmidt, Jr., "A device for precision dimensional measurements of superconducting cable," proceed ings of Workshop on Magnets and Cryogenics, Brookhaven National Laboratory, May, 1986.