Fermi National Accelerator Laboratory

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Fermi National Accelerator Labs SSC GTAW Welding Camera System

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Fermi National Accelerator Labs
SSC GTAW Welding Camera System
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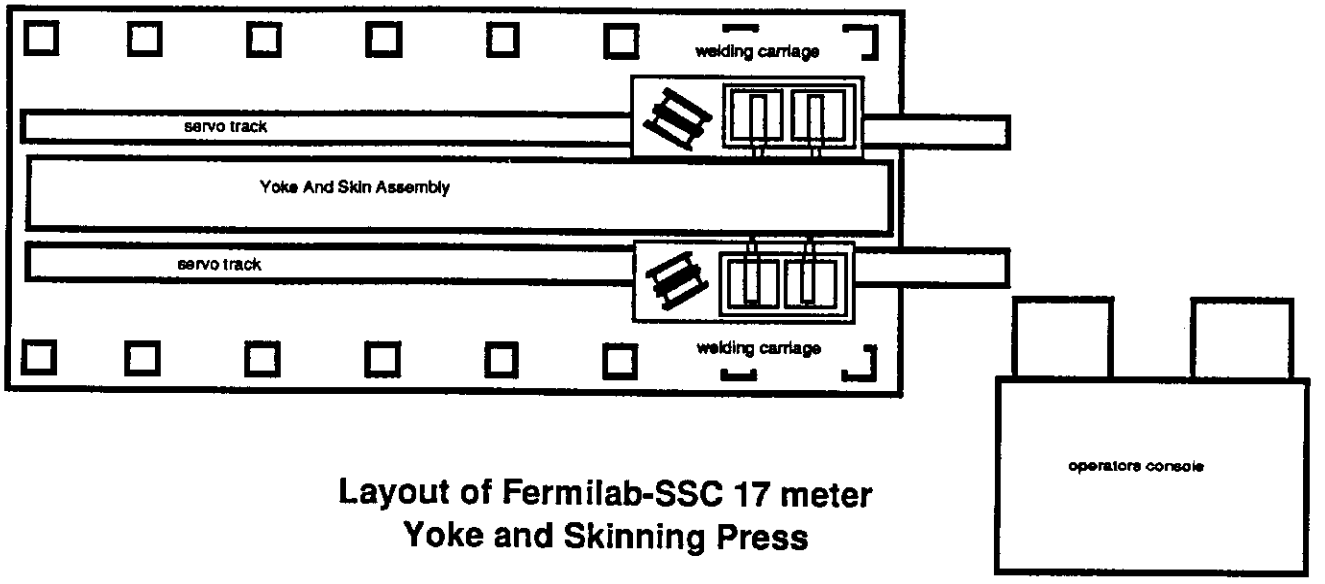
Fermi National Accelerator Laboratory, Dept. of Energy, has designed and installed a four camera vision system on a 60 ft.long press for the welding of prototype superconducting magnets for the Superconducting Super Collider at its industrial facility in Batavia, Illinois. The two operator - four torch system features 4 small water cooled cameras with remote set-up/weld jog, set-up lighting, joystick control of wire feed tips and torch placement, and a unique light filter arrangement.

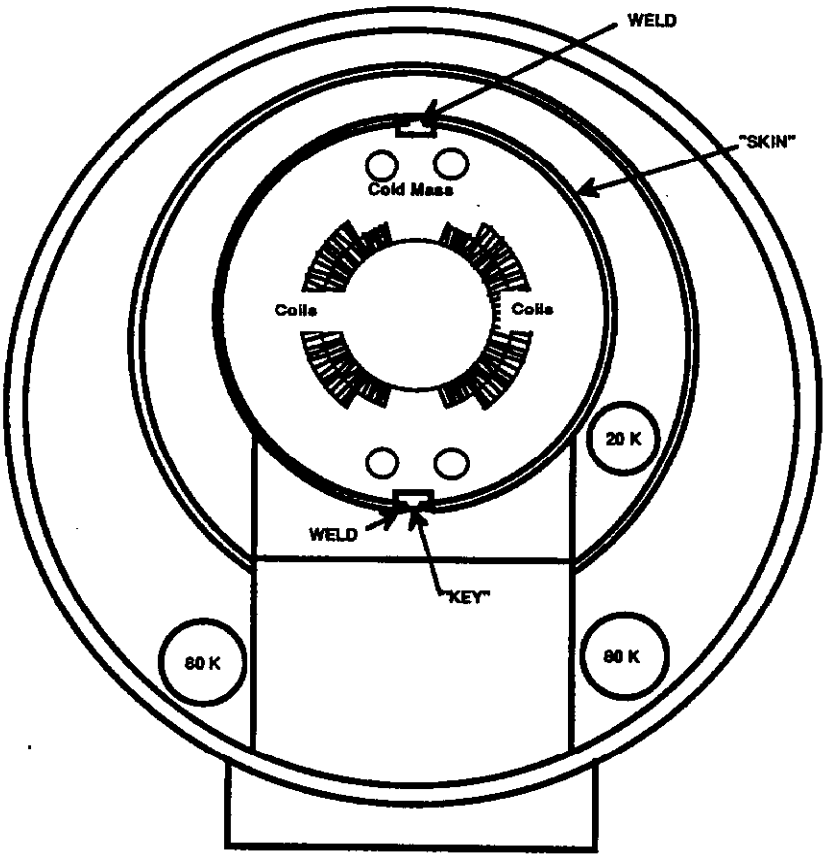


Layout of Fermilab-SSC 17 meter Yoke and Skinning Press

The superconducting magnets being produced are 55 foot long (17 meter) prototype dipole magnets. The magnetic field produced by the niobium-titanium coils of the magnet keep the particle beam of the accelerator turning around the 35 mile circumference ring of magnets. By pumping liquid helium through the iron mass of the magnet, The coils are kept near absolute zero and achieve superconductivity and maximum efficiency. The iron mass which surrounds and supports the coils is know as the "cold mass".The skin of the cold mass acts to contain the liquid helium and, also, is the structural

member which keeps the coils straight and twist free. The welding and vision system was developed to weld the skin over the iron of the magnet.

Welding the skin on the "cold mass" requires four welds. The materials being welded are a 304L stainless steel "skin" and a 304 stainless steel "key" with 308L annealed filler wire on 8 lb. spools. The yoke and skin components are loaded into the 60 ft. long press bed tooling and aligned. The yoke and skin assembly is then pressed to 2500 lb. per lineal inch and welding takes place.

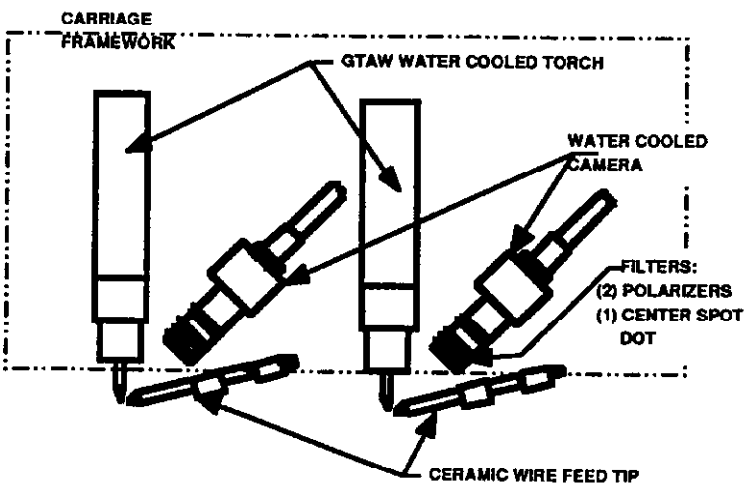


Simplified Cross Section of SSC Collider Dipole Magnet

The original welding carriage system provided operators with hand adjustments at the welding carriage. This required the operators to walk along the 60 ft. length of the cold mass and stick their heads into the press to see the arc and puddle. The operators were also required to lay their weight on the ball bearing rails of the torch carriage. Operators required to work 8 hours found this method "cruel and unusual". Ozone levels in this confined space were also less than ideal. The original system of welding

these skins proved unnecessarily dangerous and labor intensive, as well as physically exhausting, to the operators. The new design places two operators at a control console where they make position adjustments to wire feed tips, torch - work gap, torch to base distance, and wire feed rate.

The original custom controller ,featuring automatic gap control, servo wire feed, current and pulsed current control, was designed and built by Magnatech Industries of East Granby, Connecticut. Upon this base, Technical Support Engineers at Fermi designed and built two-dual torch carriages and added remote manual positioning of torch tip and wire feed tip. The positioning motors (Newport Corp.) for torch and wire feed tips were modified to be water cooled to endure near-welding temperatures. Wire feed tips of alumina ceramic were made to provide a measure of safety against shorts and allow the tip to be placed nearer to the puddle. The positioning motor controller (Newport Corp.) has velocity control, as well as, the ability to be computer controlled. The cooling system for cameras and position motors is a standard Bernard Model 3500ss water cooler with a 50/50 mix of water and ethy. glycol.



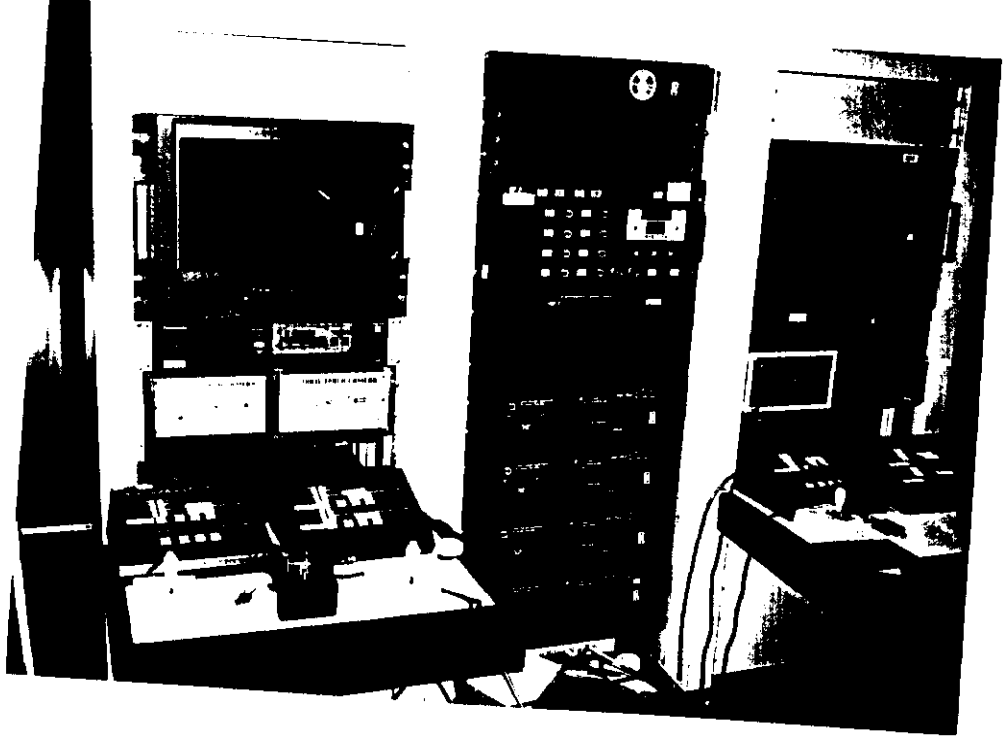
Torch, Feed Tip and Camera Set-up

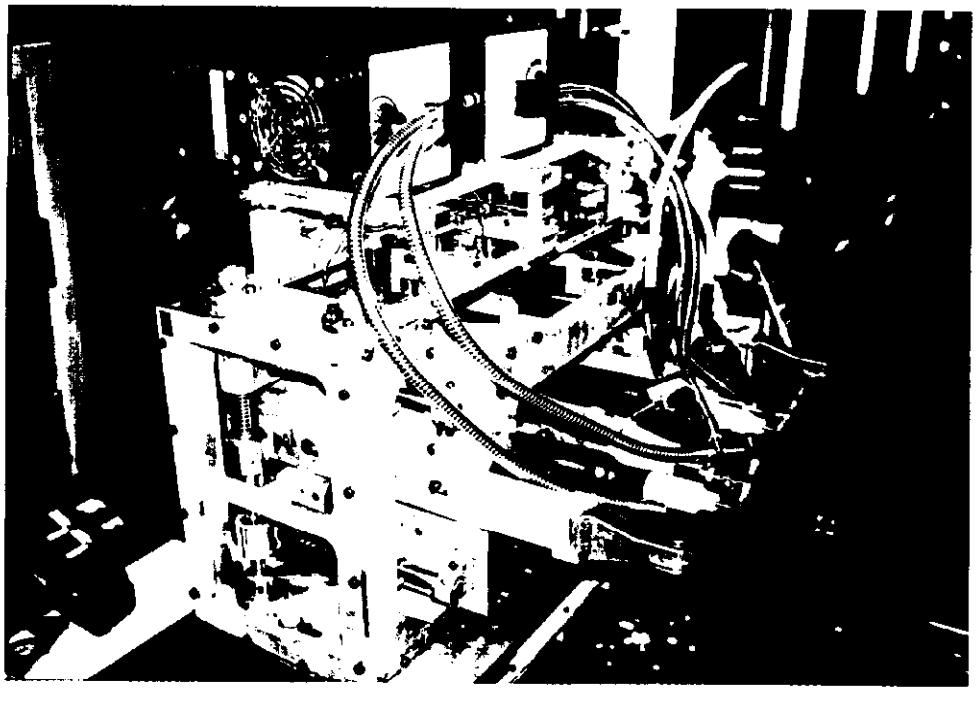
The camera used was the Elmo EM102II microcamera. It features 768 horizontal x 494 vertical pixel CCD elements. The controller has automatic gain control and auto white balance control. The small physical size of the remote camera head was the reason it was chosen. (4 3/4" lg. x 1" dia.) including the connector.The custom camera cooling bodies were obtained from Bartz

Technology in Santa Barbara, CA. Bartz Technology also designed and built a variable polarizer which is a central part of the filtering scheme.

The final filtering scheme chosen was 1/1000 sec.shutter with a variable polarizing lense combination and a neutral density center spot. The polarizer combination is used to vary the transmittance of light to the camera sensor as the orientation of grating goes through 90 degrees of rotation about the axis of the camera body. Also, important to the filtering scheme is a neutral density center spot. The dot is used to damp the flash of the tungsten electrode and keep the camera sensor from saturating. The dot's transmittance is approx. 1% of the source's light. The light intensity is further reduced by the iris which is set at about 1/3 of the maximum open position.

The control system for the cameras is a simple relay affair. During set-up, shuttering is disabled and the work lights, four 150 watt dual-fiber optic bundle work lamps (Reichter-Jung) are enabled. While welding, the shuttering is enabled and the work lights disabled. The capability to remotely switch shuttering on and off is not a stock feature of the camera controller and had to be added by replacing the shuttering switch with a toggle at the control cabinet and lengthening the switch leads. While in set-up mode, the wire feed tip and tungsten are clearly visible. Each has light coming from two directions which makes depth perception possible due to shadows of the tips projecting on the tooling. The camera image area is about 1 1/8" square using an Elmo JK-L15, 15 mm, F=2.0 lense. The camera is mounted about 2 1/2" away from the weld pool. The image obtained is superior to anything the welders have seen with mask and goggles. The colors present on the edge of the plasma can be seen with this filtering scheme, should gas coverage become inadequate. This is something which cannot be said of all filtering schemes. The cost savings of the camera and monitor system was about half the price of a purchased turn-key camera system.





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