REAL TIME COMPUTER CONTROLLED WELD SKATE

by

William A. Wall
Laboratory Support Branch
Materials and Processes Laboratory

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

A real time, adaptive control, automatic welding system has been developed at MSFC. This system utilizes the general case geometrical relationships between a weldment and a weld skate to precisely maintain constant weld speed and torch angle along a contoured workpiece. While proven to work with the Gas Tungsten Arc (GTA) weld process, it is also adaptable to other weld processes as well as for heli-arc cutting and machine tool routing operations.

Outside the aerospace industry, it is believed that this development has potential uses in the shipbuilding, automotive, storage tank, outdoor sign, solar collector, and other commercial industries. Significant savings in both time and money can be realized by eliminating the need for programming and/or precise weld tooling. Thus, for perhaps the first time, it may be economically feasible to automatically weld parts which could hitherto only be joined manually.

MAINTAIN:

- WELD SPEED CONSTANT ± 3 percent
- TORCH ANGLE ± 1 degree
- CROSS SEAM GUIDANCE ± 0.032 in. (±0.8 mm) ACCURACY
- USE CONVENTIONAL COMMERCIAL WELD POWER SUPPLIES AND WELD PROCESSES
- REDUCE OVERALL COST OF AUTOMATICALLY WELDING BOTH LARGE AND SMALL COMPLEX SHAPES

Figure 1. Computer skate with arc guidance performance goals.

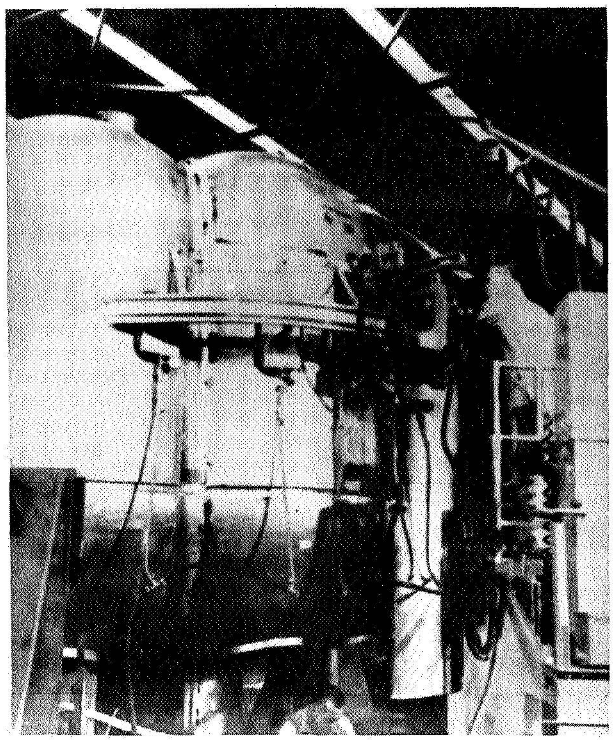

Figure 2. Multicell test tank GTA welder.

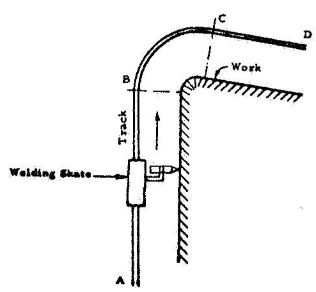

Figure 3. Straight to curves weld contour.

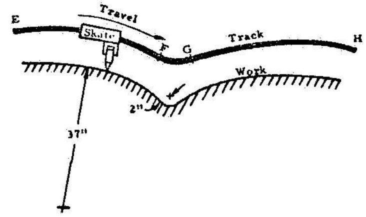

Figure 4. Reverse track and work situation.

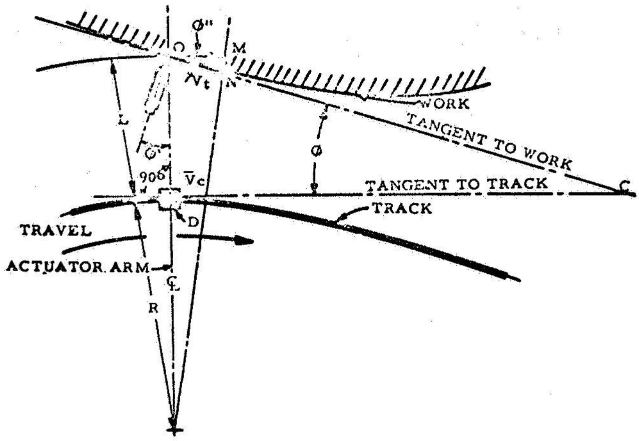

Figure 5. Torch vector and rotational speed diagram.

$$\text{SKATE SPEED} = V_C = V_t\left(\frac{R}{R \pm L}\right)\cos\phi$$

$$\text{TORCH ANGLE} = \phi = \pm \text{ ARC SINE } \frac{dL}{V_t}$$

Figure 6. Mark I speed and torch angle.

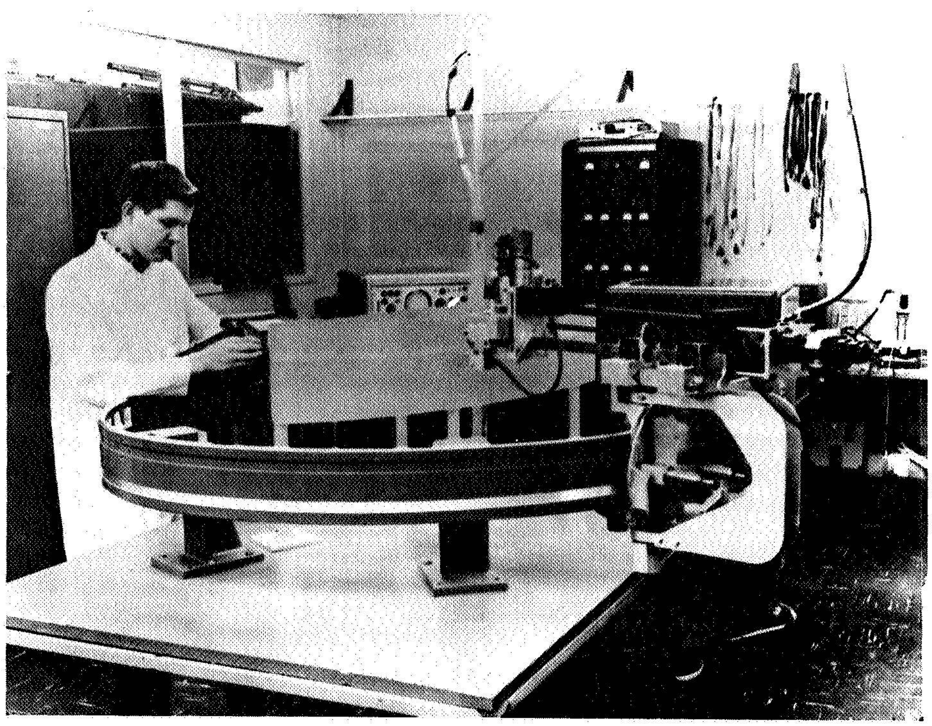

Figure 7. Prototype lab model, Mark I weld skate.

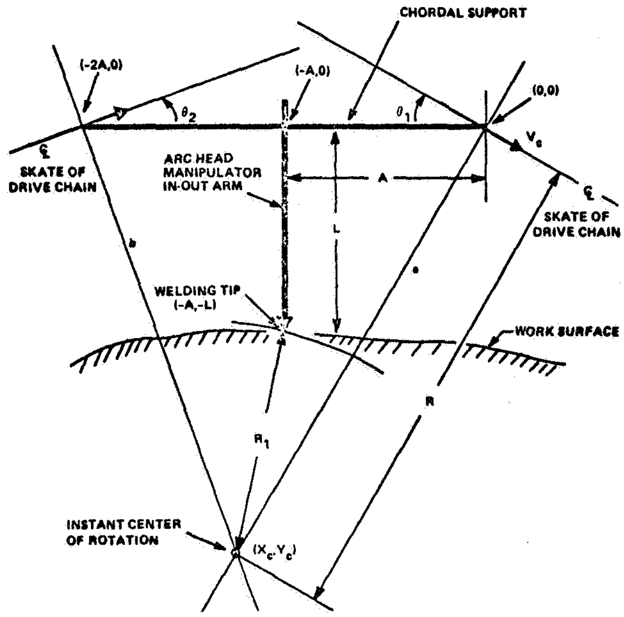

Figure 8. Mark III weld skate geometrical diagram.

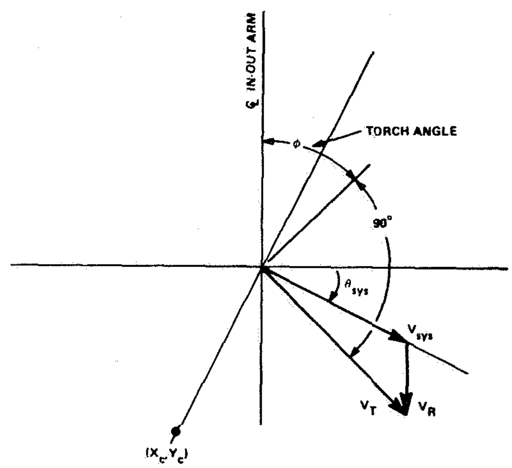

Figure 9. Mark III weld skate vector relationship at torch tip.

- V_C = INST SKATE SPEED $= \frac{R}{R_1}\left(\sqrt{V_T^2 - V_R^2 \cos^2\theta_{SYS}} - V_R \sin\theta_{SYS}\right)$

WHERE

$$\frac{R}{R_1} = \frac{2\cos\theta_2}{\sqrt{\left[1+\left(\frac{L}{A}\right)^2\right]\sin(\theta_1+\theta_2) + 4\cos\theta_1\cos\theta_2\left[\cos(\theta_1+\theta_2) - \frac{L}{A}\sin(\theta_1+\theta_2)\right]}}$$

- TORCH ANGLE $= \pm \arcsin\phi = \frac{V_R + V_C\left(\frac{R_1}{R}\right)\sin\theta_{SYS}}{V_T}$

Figure 10. Mark III configuration formula.

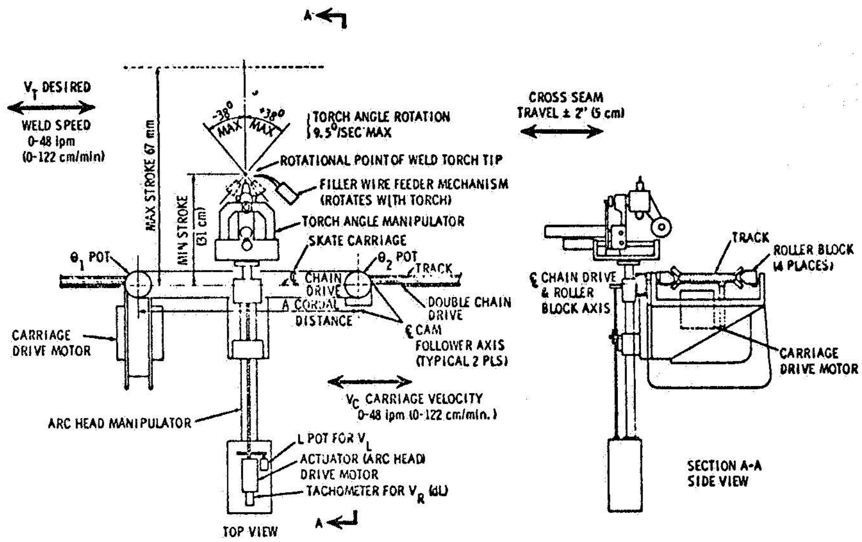

Figure 10. Mark III weld skate.

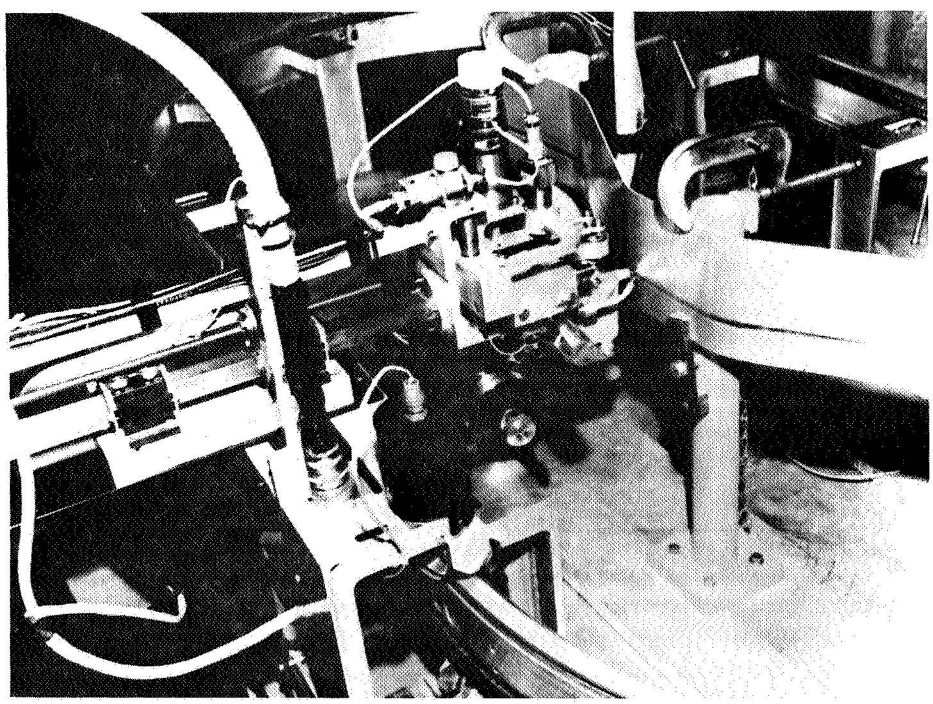

Figure 11. Mark III weld skate on test track.