AMERICAN CONSULTING ENGINEERS COUNCIL'S

HEAVY MOVABLE STRUCTURES
MOVABLE BRIDGES AFFILIATE

3RD BIENNIAL SYMPOSIUM

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ST. PETERSBURG HILTON & TOWERS
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SESSION
WORKSHOP NOTES

Session (1-1)
" Mechanical Automatic Program Control for Low Velocity Machinery",
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Mechanical Automatic Program Control for Low Velocity Machinery.

Identification of Problem

When problems arose with the trouble-shooting of electronic span control equipment, the author perceived a need for a simpler non-electronic system. The repair of complex electronic systems has been a frequent dilemma for electricians not acquainted with solid state circuitry.

The common complaints about electronic systems are:

1. High initial outlay cost.
2. Complex beyond the training of many elecricians.
3. Require additional support equipment, such as logic controllers.
4. Lightning damage susceptability.
5. High maintenance cost.

Thus the decision was made to design simple electrical circuits using principally pushbutton switches, relays, contactors and limit switches.

The design objectives of this effort were as follows:

1. Simple automatic electro-mechanical control system.
2. Minimal addition of components.
3. High reliability.
4. Ease of operation.
5. Ease of repair.
6. Low initial outlay cost.

Background of Existing Equipment

For many decades, the standard method of controlling heavy machinery, such as bridge spans has been the use of drum programmers, which are a device having a swing handle arm connected to a long shaft. This shaft in turn has a series of segment cams with peripheral copper contacts connected to them. These contacts allow the shorting out of sections of a resistance bank in a wound rotor secondary. Shorting out or removing resistance across sections of the resistance bank permits variations in speed. This manual system is controlled by an operator and creates the risk of hard seating of the span travel. Use of an automatic control system would eliminate the above complaint.

One of the objectives listed in the design objectives is simple automatic control. It follows that a program cam assembly attached to the trunion shaft would be the logical way to control the span automatically, thus removing the need for operator judgement.

Drawing Figures - The drawing figures included in this paper are -

Figure 1A - This Figure shows a typical automatic program cam assembly with two (2) segment cams. These cams have an adjustable collar and operate as a unit for time period control of the motor speed by activating control of contactors shorting the resistance bank.

Figure 1B - An alternate connection between the main work shaft output and the program wheel is the insertion of a step-up gear to increase the program wheel's travel distance and thus improve angle resolution for switching purposes.

Figure 1C - The devices shown are different type limit switches which can be used with the program cam assembly, such as a lever arm limit switch or a thruster limit switch.

Reference symbols and legends in the drawings are:

Figure 1.

(1) Program cam assembly.

(2) Sensors to detect position (LS3 and LS4 in Figure 2).

(3) Step-up gearing.

(4) Wheel calibration (degrees)

Figure 2.

S1 - Raise momentary switch

S2 - Lower momentary switch

S3 - Stop momentary switch

S4 - Speed increase momentary switch

R1 - Raise control relay

R2 - Lower control relay

L1 - Latching control relay

LS1 - Seating limit switch

LS2 - Maximum height limit switch

LS3 - Program wheel limit switch (sensor)

LS4 - Program wheel limit switch (sensor)

M2 - Medium speed contactor

M3 - High speed contactor

I1* - Raise indicator

I2* - Lower indicator

I3* - Stop indicator

I4* - Creep indicator

I5* - Seated indicator

I6* - Maximum height indicator

* Not required for functional operation of equipment.

Static Description of Drawings

The logical place to install a program cam assembly (Figure 1-2), is on the low velocity trunnion shaft.

This program cam system will have segmented cams which are notched to provide the specified number of degrees of travel at a specified speed. The on-off points can be adjusted by set screws in the collar of the notched cam.

Two notched cams make up the program for one speed. One cam is set for the on-point, the other is set for the off-point. The cam limit switch operates on both cams as shown in Figure 1-1 to cover the entire range of travel.

For a medium and high speed, an identical set of cams are adjusted for a different travel distance (in degrees). As the program cam assembly travels through its normal operation, limit switches are closed (or opened), which in turn activate contactors, whose contacts short out part of the resistance bank, producing a change in the motor speed. Thus the program cam assembly controls the motor speed by the resistance inserted in the secondary of the motor.

A calibrated degree scale is provided as a means of setting the on/off points of the cam limit switches.

For the creep mode, no cams are used. The initial taps for this mode are connected on the resistance bank for a permanent slow speed.

Limit switches interfaced with the program cam assembly can be of various types, such as a thruster limit switch or a lever arm limit switch each preferably with a roller at the impact point.

Operational Description -

A typical operation of the span would be as follows referencing Figure 2. The solid lines are the innovations and the dotted lines are the existing standard components.

The span operation from seating is initiated by pressing the raise push-button switch which closes the raise circuit to ground and seals in the parallel contact across the switch. At the same time the motor contactor and the machinery thrustor brake contactor are closed, activating the raising of the span. As the span creeps up a few degrees, the first limit swithc (LS4A) closes to accelerate the motor speed. When the second switch (LS3A) is encountered and closed M3 shorts the resistance bank and the motor runs at high speed.

When the high speed cam drops out, deceleration occurs reducing the RPM's to medium speed. On reaching the end of the medium speed cam (LS3A), M2 is deactivated and the system returns to creep speed until the span travel is complete and the motor shuts off.

For the opposite direction of travel, the same sequence of events takes place.

A 'unique' circuit is incorporated when a span stop is required at any point between the extreme limits of travel. The stop push-button is pushed and the control circuit and all contactors are opened producing a stop. At the same time, the latching relay circuit contacts are set, opening the voltage circuit to the contactors, thus only the creep mode is available until the return to the extreme travel limits of the span. When the end of travel is reached the associated limit switch resets the latching relay to its normal fast-speed capabilities. The one exception to this is the depressing of the push-button which, when held in will allow the span to operate at medium speed until released.

If the speed pushbutton continues to be depressed, the speed will return to creep when its cam (M2) drops out, finally seating and shutting off the span motors.

In Summation -

The advantages of this system are that it does not require operator judgement and all speed decisions are made automatically by means of the program cam assembly.

Other advantages are the addition of very few parts, ease of maintenance and elimination of the requirement for highly trained electronic personnel.

This equipment can also be used on low velocity machinery, such as milling tables whose work shaft travels less that 360 degrees.

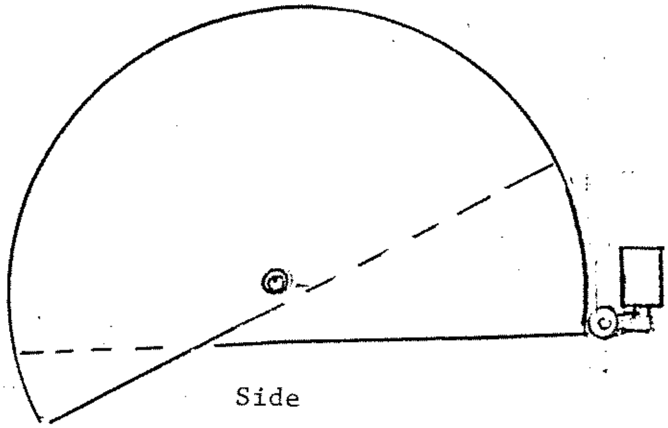
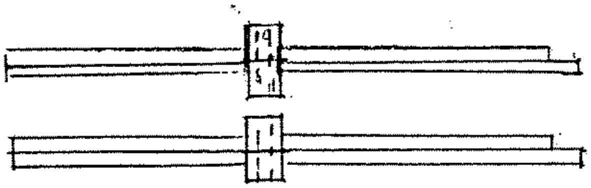


Figure 1.1 Program Cam Assembly



Top (Two Cam Sets)

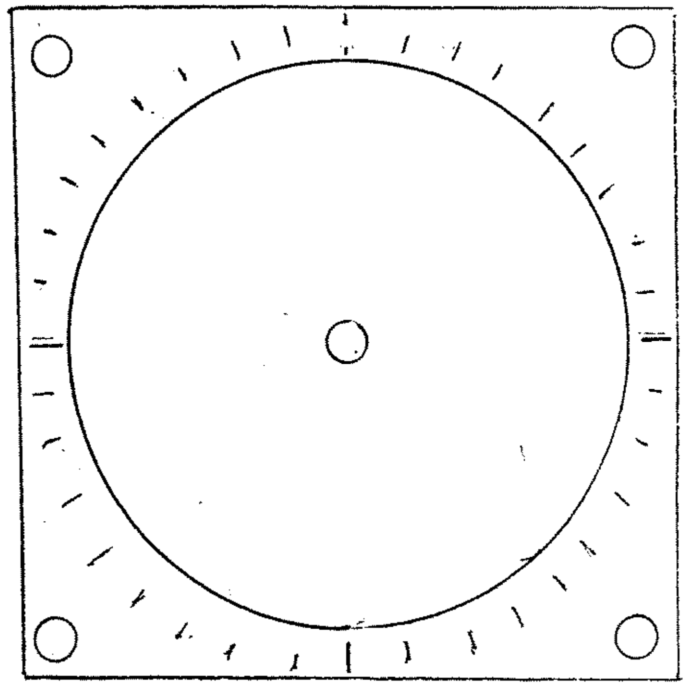


Figure 1.1C Calibration Scale (Degrees)

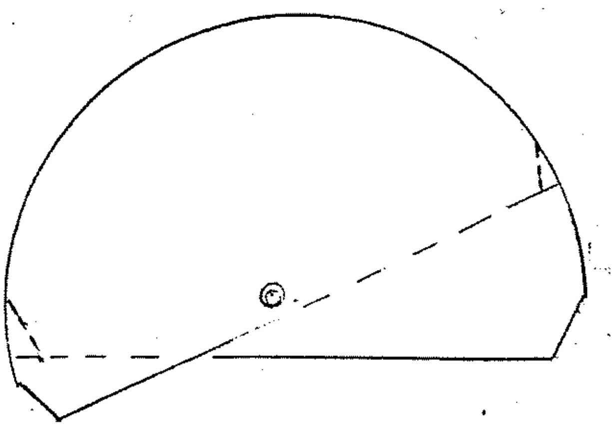


Figure 1.1A Alternate Cam

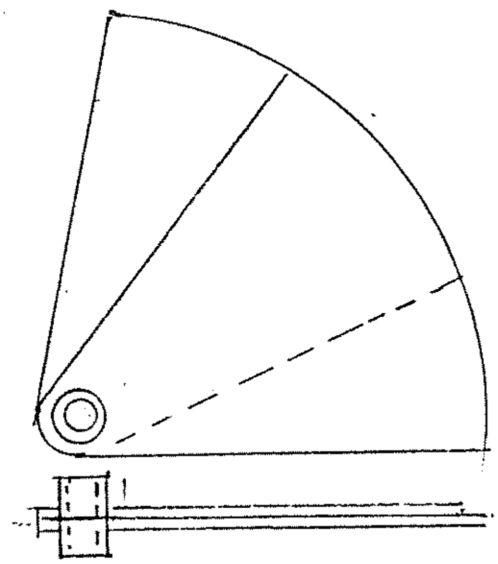


Figure 1.1B Direct Drive Cam

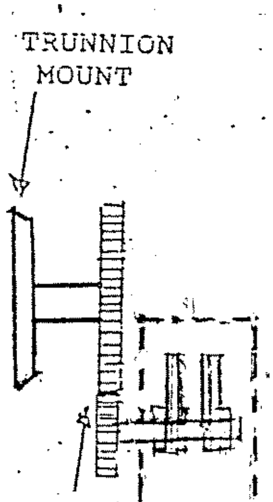


Figure 1.3

Step-up Gearing

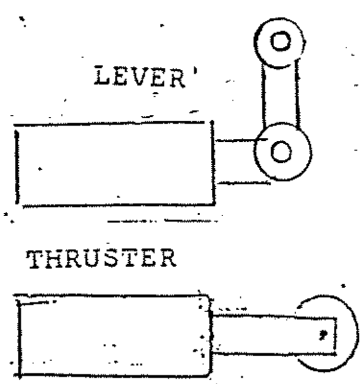
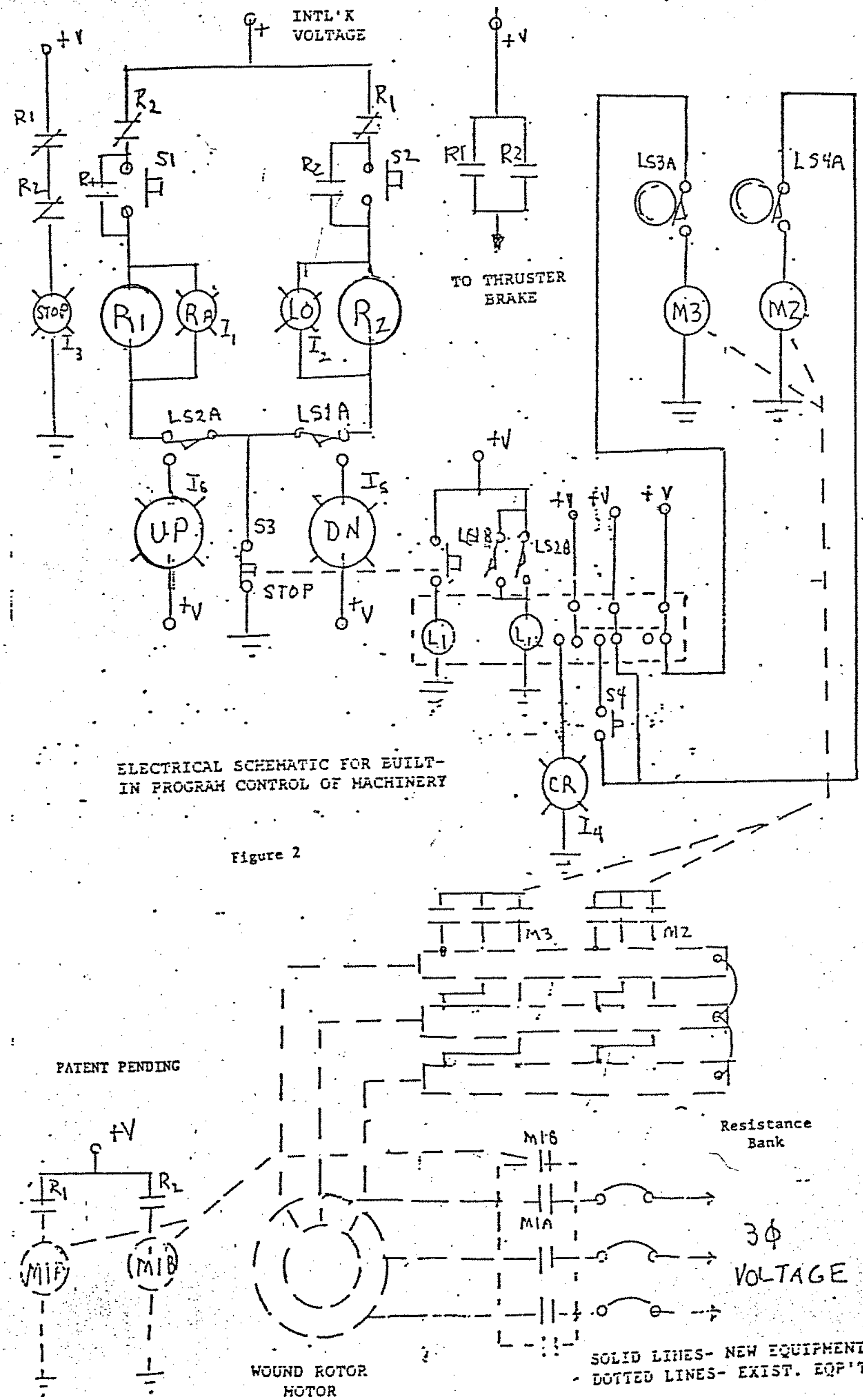


Figure 1.2 Sensors

PATENT PENDING



ELECTRICAL SCHEMATIC FOR BUILT-IN PROGRAM CONTROL OF MACHINERY

Figure 2