INSTRUCTIONS
for
INSTALLATION, OPERATION
and MAINTENANCE

SLO-SYN® PRESET INDEXER

TYPE TBM155

CAUTION

Since this product will be used in applications beyond the control of The Superior Electric Company, the system designer is advised to incorporate protection features which will insure user and equipment safety.

Superior Electric
Bristol, Connecticut 06010 USA

INSPECTION

When unpacking the unit, examine it carefully for any shipping damage. The "Damage and Shortage" instruction packed with the unit outlines the procedure to follow if any parts are damaged or missing. Check to see that the following items have been received.

1. **SLO-SYN Preset Indexer type TBM155** (specific model depends on motor to be used).
2. **Six female quick-disconnect terminals for #14-#16 wire,** Superior Electric part number BT37939-G2.
3. **Twenty-four female quick-disconnect terminals for #18-#22 wire,** Superior Electric part number BT37939-G1.
4. **Base Speed control potentiometer,** 10K ohm, ½ watt, linear. Superior Electric part number BM144664-G4.
5. **High Speed control potentiometer,** 500K ohm ¼ watt, CCW logarithmic. Superior Electric part number A201893-G1.

DESCRIPTION

The TBM155 is an open chassis unit incorporating a d-c power supply together with the sequencing and logic switching circuits needed for bidirectional control of a SLO-SYN motor in indexing and other positioning applications. It drives the motor at rates to 5000 full steps or 10,000 half-steps per second with adjustable acceleration and deceleration. Acceleration is adjustable within a 100 milliseconds to 1 second range and deceleration within a 100 to 500 millisecond range minimum.

The TBM155 can provide indexing motions up to 99,999 motor steps, controlled from external BCD logic switches or from a computer or microprocessor. When an index command cycle is completed, the preset indexer will accelerate the motor to the desired rate and continue to step the motor until a specific number of steps remains of the preselected count. At this point the unit will decelerate the motor, stopping it exactly at the selected position.

The TBM155 can drive the motor in either the full-step switching sequence (1.8° motor steps) or the half-step switching sequence (0.9° motor steps).

The preset indexer will drive the motor at base speed or high speed and also provides Jog and Run modes of operation. The base speed mode provides a low range of 0 to 1000 full-steps or 0 to 2000 half-steps per second with no acceleration or deceleration. In the high speed mode the stepping rate can be adjusted within a 200 to 5000 full-step or 400 to 10,000 half-step per second range. Acceleration and deceleration are provided in the high speed mode. The Jog circuit will drive the motor one step in the selected direction each time the Jog switch is closed and opened. In the Run mode, the indexer will "free run" the motor in the selected direction as long as the Run switch is closed. A Clear circuit, when actuated, will reset all information in the counters and will also inhibit the Index, Run and Jog functions. External switches or voltage levels must be used to control the index count and other control functions.

A TBM155 preset indexer is adjusted at the factory for compatibility with a specific motor. Be sure you have selected the model intended for the motor which will be used. Performance characteristics for appropriate TBM155 preset indexer/SLO-SYN motor combinations are shown in this instruction.

MODELS

TBM MODEL	USED WITH MOTOR TYPE
TBM155-6209	M062-FC09* M062-FD09*
TBM155-6309	M063-FC09* M063-FD09*
TBM155-9109	M091-FC09* M091-FD09*
TBM155-9214	M092-FD310†
TBM155-9322	M093-FD301†
TBM155-1230	M112-FJ326†
TBM155-1218	M112-FJ327†

*Have external wire leads

†Have cast housing with enclosed screw terminals

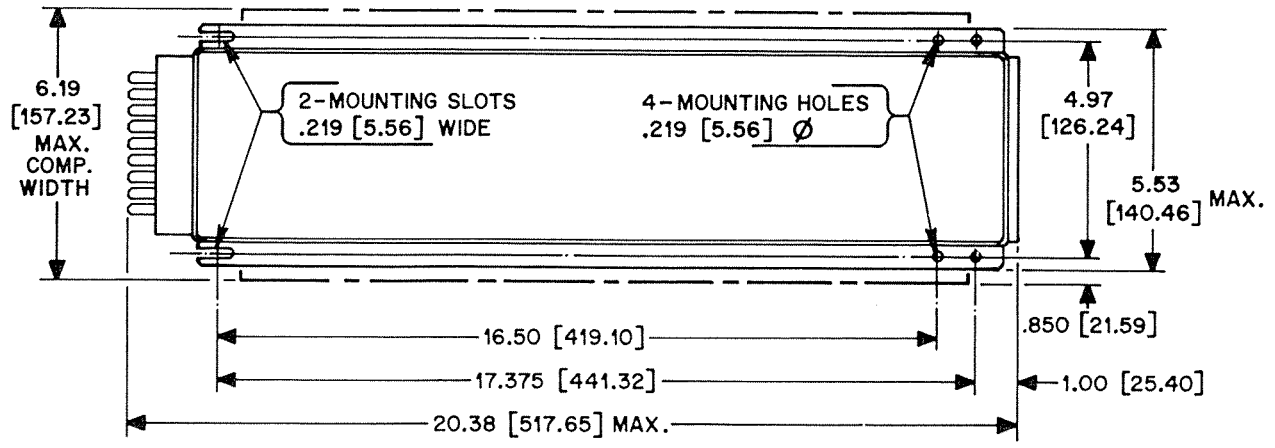
SPECIFICATIONS

Dimensions	length: 21" (533mm) max. width: 7" (178mm) max. height: 8" (203mm) max.
Weight	33 pounds (15kg) max.
Power Input	120/220/240 VAC $^{+10\%}_{-15\%}$, 50/60 hertz, fused at 5 amperes
Temperature Range	operating: 0°C to +50°C storage: −55°C to +85°C
Internal Oscillator Range	
Base Speed	0 to 1000 pulses per second (full-step mode) or 0 to 2000 pulses per second (half-step mode)
High Speed	200 to 5000 pulses per second in full-step mode; 400 to 10,000 pulses per second in half-step mode
High Speed Control	500K ohm ten-turn CCW logarithmic potentiometer (supplied)
Base Speed Control	10K ohm single-turn linear potentiometer (supplied)
Oscillator Stability	±10% or 20 steps per second, whichever is greater, over temperature and voltage range

Acceleration	
Range (Adjustable)	100 milliseconds to 1 second
Deceleration	
Range (Adjustable)	100 milliseconds to 500 milliseconds minimum
External Functions	
Index, Run, Jog, High Speed:	
High Level	open circuit, +10VDC to +30VDC
Low Level	0 to 1.25VDC
Loading	5 mA sink max., 1 microfarad through 4.7K ohms minimum
Pulse Width	20 milliseconds min.
Rise and Fall Times	1 millisecond max.
Bounce (settling time)	10 milliseconds max.
Done Signal:	
High Level	open collector rated 30VDC max., clamped to 20VDC
Low Level	0 to 1VDC
Loading	100 mA sink max.
Clear Signal:	
High Level	2VDC to 5.25VDC
Low Level	0 to +0.5VDC
Loading	7 mA max., 100 microfarads through 47 ohms minimum
Minimum Duration	20 milliseconds
Count and Direction Insertion:	
Method	external BCD logic switches (customer supplied) or voltage levels
Maximum Count	99,999 motor steps
Number and Direction Insertion Lines:	
High Level	open circuit, +10VDC to +30VDC
Low Level	0 to 1.7VDC
Loading	5 mA sink max., 0.01 microfarad through 4.7K ohms minimum
Rise and Fall Times	10 microseconds max.
Data Input Command Lines:	
High Level	open collector, rated at 30VDC
Low Level	0 to 0.7VDC at 30 mA sink
Loading	40 mA sink max.
Directional Pulse Output:	
High Level	open collector, rated at 30VDC
Low Level	0 to 0.5VDC
Loading	100 mA sink max.
Half-Step/Full-Step Mode Selection Controls:	
High Level	2VDC to 5.25VDC
Low Level	0 to 0.5VDC
Loading	2 . 5mA sink max., 0.001 microfarad through 100 ohms minimum
Stepping Mode	full-step, 2-phase, bifilar; half-step, 2-phase, bifilar

MOUNTING

The TBM155 is an open chassis unit designed for base mounting. The unit must be mounted with the heat sink cooling fins in the vertical position to allow proper flow of cooling air. Mounting holes are provided in the flanges at the base of the unit for fastening the preset indexer in place.



MOUNTING DIMENSIONS

ELECTRICAL INSTALLATION

Note: Six female quick-disconnect terminals for #14-#16 wire are supplied for connecting the motor leads to the TBM155 terminal board. Twenty-four female quick-disconnect terminals for #18-#22 wire are supplied for the balance of the connections to the TBM155.

Motor Connections

The SLO-SYN Motor must be connected to terminals 1 through 6 on the TBM155 terminal board as shown in the Connection Diagram, Figure 1.

The unit is adjusted at the factory to provide rated current (see chart) with the wire sizes recommended. Use of a larger than recommended wire size (lower AWG number) for a given wire length may result in excessive motor current. A smaller wire size or poor connections will result in less current and lower holding and starting torque.

TBM MODEL	USED WITH MOTOR TYPE	RATED CURRENT DC AMPERES
TBM155-6209	M062-FC09 M062-FD09	4.5
TBM155-6309	M063-FC09 M063-FD09	4.5
TBM155-9109	M091-FC09 M091-FD09	4.5
TBM155-9214	M092-FD-310	5
TBM155-9322	M093-FD-301	5
TBM155-1230	M112-FJ-326	5
TBM155-1218	M112-FJ-327	5

When less than 5-feet of wire is required for each connection between motor and drive, use no. 16 wire. Use no. 14 wire when wire lengths between 5 feet and 15 feet are required. The quick-disconnect terminals supplied can be used for no. 16 or no. 14 wire. When using any type of crimp-on connector, be sure to inspect the crimp to insure a good connection. If leads longer than 15 feet are required, use no. 10 wire. In addition, when leads longer than 15 feet are used, the motor current should be measured and, if necessary, adjusted as described in the procedure which follows. The recommended quick-disconnect terminal for no. 10 wire is Burndy part no. PQ10R258M or equivalent.

WARNING

Adjustment to effect a model number change should be done only by a qualified person having access to the required instruments. Misadjustment may cause permanent damage to the preset indexer, the motor or the equipment driven by the motor as well as injury to personnel.

The Superior Electric Company assumes no liability for any such damage or injuries. Furthermore, the user, in making the adjustments described in this instruction, shall void all Warrantees otherwise applicable to this product and the SLO-SYN motors connected thereto.

Measuring and adjusting current

This procedure is not intended to compensate for low current caused by poor connections. Inspect all connections between the preset indexer and the motor before proceeding.

1. Connect ammeters having meter resistance of 0.01 ohm or less and capable of reading 0 to 10 amperes d-c, in series with **each** motor common (the white and black motor leads or motor terminals no. 2 and no. 6). Be sure all connections are completed before energizing the unit.

2. If necessary, adjust potentiometer HP on the Logic circuit board until both ammeters indicate rated current as shown in the chart. The ammeters may not show exactly the same current, but should be within 5%. **DO NOT EXCEED 5 AMPERES.**

Any change in wire size or significant change in wire length **must** be followed by a measurement and, if necessary, a readjustment of the motor current. Units or circuit boards returned for service will be adjusted to the original factory specifications.

Base Speed Control

The 10K ohm, ½ watt linear potentiometer supplied with the unit should be connected to terminals 12, 13 and 14 as shown in Figure 1.

High Speed Control

Connect the 500K ohm, ¼ watt, 10-turn potentiometer supplied with the unit between terminals 15 and 16 as shown in the connection diagram (Figure 1). If the potentiometer does not provide a smooth change in speed as the knob is rotated, reverse the potentiometer connections to terminals 15 and 16. The high speed control adjusts the high speed within a 200 to 5000 pulse per second range in the full-step mode or a 400 to 10,000 pulse per second range in the half-step mode.

HALF-STEP, RUN, HIGH SPEED, INDEX, JOG and CLEAR Switches

These functions can be controlled using single-pole, two-position switches as shown in the Connection Diagram, Figure 1. They can also be controlled electronically from a minicomputer or microprocessor. Requirements for electronic control are given in the Electronic Control section of the Electrical Installation instructions.

$\overline{\text{CW}}$ $\overline{\text{PU}}$ and $\overline{\text{CCW}}$ $\overline{\text{PU}}$

These pins provide access to the oscillator pulses for monitoring clockwise and counterclockwise pulses when troubleshooting. The pulses can also be used for feedback to a computer or other control device to keep track of implied motor position. Pulses are available at pin 23 for clockwise pulses and pin 24 for counterclockwise with the direction of shaft rotation determined looking at the nameplate end of the motor. Since these outputs are open collector devices, pull-up resistors are necessary.

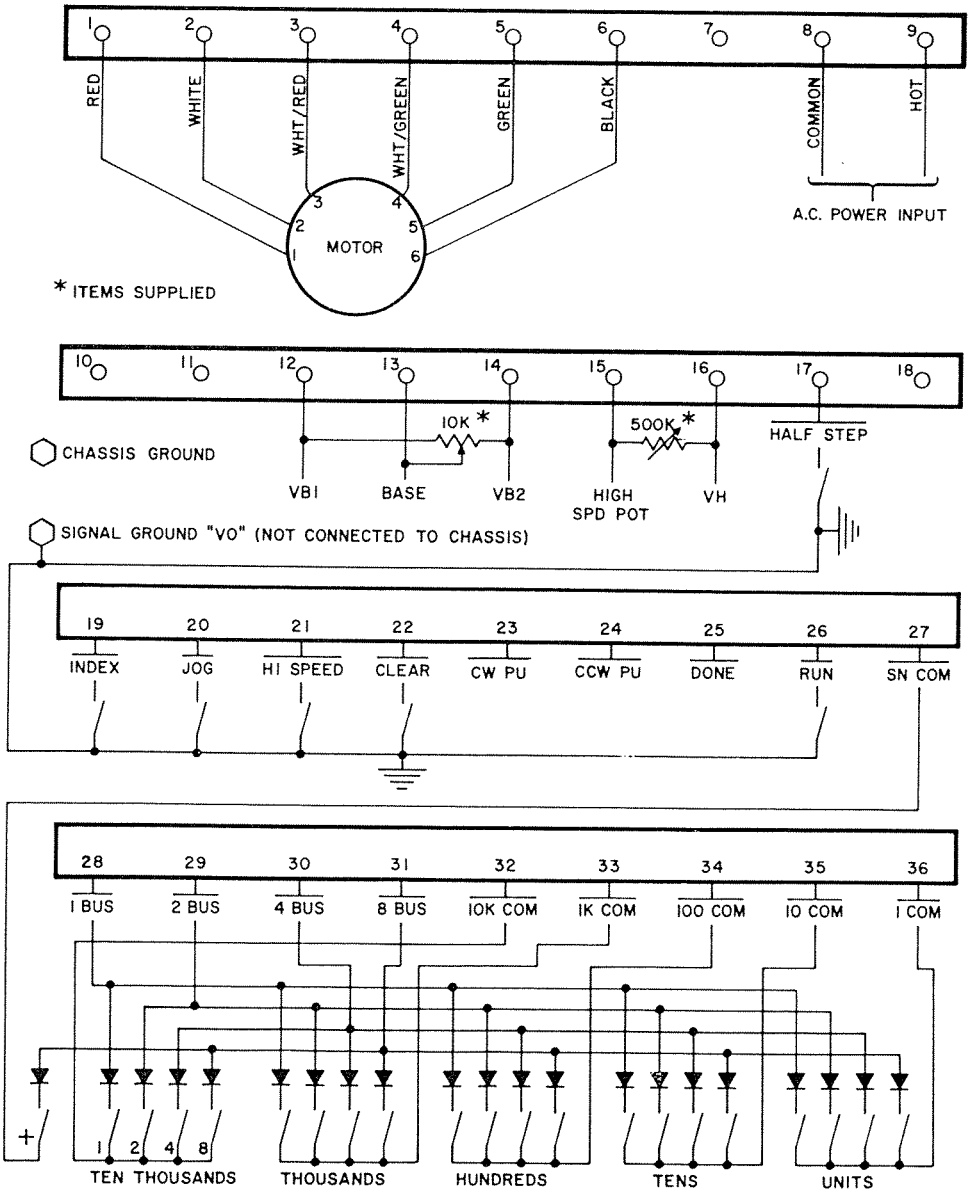
$\overline{\text{DONE}}$ Signal

The $\overline{\text{Done}}$ signal will go to a logic 0 level (0 to 1VDC) at the completion of motor motion when in the Index mode. This signal will be a logic 1 (open collector device rated 30VDC max., clamped to 20VDC) while the motion is taking place. Maximum sink current is 100 milliamperes.

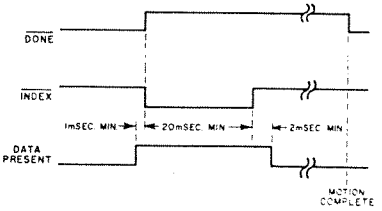
Direction and Count Selection Switches

A method of externally controlling the number of motor steps the indexer will drive the motor is also necessary if a remote control panel is to be used. Figure 1 shows how BCD logic switches can be used for this purpose. Recommended switch assemblies for this use are Digitran Company, Pasadena, California part number 29-S-82 or Amp Incorporated, Harrisburg, Pennsylvania part number 435693-2. These switches have the logic diodes mounted in place. The 5-decade and direction BCD switch is included as part of Switch Kit A207051-1, available from The Superior Electric Company.

The timing diagram, Figure 2, shows when data must be presented on the BCD logic switches. The Data Present waveform indicates that data must be available at least 1 millisecond before the Index switch is closed and must remain until at least 2 milliseconds after the Index switch is opened. Figure 2 also shows that the $\overline{\text{Done}}$ line makes the logic 0 to logic 1 transition on the Index switch closure and that the Index closure must be held for a minimum of 20 milliseconds. The $\overline{\text{Done}}$ line will go from logic 1 to logic 0 when the motion is completed.



TBM155 CONNECTION DIAGRAM
FIGURE 1



TIMING CHART
LOADING OF PARALLEL DATA
FIGURE 2

The TBM155 preset indexer can also be connected to provide a fixed indexing count by wiring the common for each decade (SN COM, 10K COM, 1K COM, etc.) directly to the required BCD bus pins. Figure 3 shows a TBM155 wired for a fixed count of 19,654 steps.

Another possible arrangement is to have two sets of count selection switches with a four-pole, two-position switch to select one set of switches or the other. A typical scheme for connecting two sets of count switches is shown in Figure 4.

Electronic Control

The TBM155 preset indexer can also be directed using voltage levels from a minicomputer, microprocessor or other electronic control systems. Functions that can be directed in this way include Index, Run, Jog, High Speed, Half-Step and Clear as well as Direction and Count Insertion.

INDEX, RUN, JOG, HIGH SPEED, HALF-STEP and CLEAR can be controlled using the circuit shown in Figure 5. When the signal applied to point A of this circuit goes high (2.0VDC to 5.25VDC) the appropriate function is activated. The function is deactivated when the signal returns to the low level (0 to 0.5VDC). Standard open collector TTL gates such as SN7406 or SN7407 may also be used.

Direction and Count Insertion can be done in a parallel manner as shown in the Timing Chart in Figure 2. However, the recommended method for direction and count insertion from a "smart" controller is the serial data method as illustrated by the timing chart in Figure 6.

For serial data input, the $\overline{10K\ COM}$, $\overline{100\ COM}$ and $\overline{1\ COM}$ open collector outputs (pins 32, 34 and 36, respectively), are tied together and pulled up to +5V with a 1K ohm resistor. This technique will produce the DATA STROBE waveform shown in Figure 6. Information will be strobed into the TBM155 on each edge of the DATA STROBE waveform, starting with the sign, proceeding to the most significant digit and ending with the least significant digit.

The sequence begins by presenting the sign information on the $\overline{8\ BUS}$ input **before** the index command cycle is started. This information can remain during the index command cycle, but must be removed when the DATA STROBE makes the first logic 1 to logic 0 transition. Each subsequent transition of the DATA STROBE in either direction **after** the index cycle is completed causes data to be strobed, starting with the 10K information and continuing through to the 1 information. Following each transition of the DATA STROBE, the information strobed by that transition must be removed from the bus lines. A 50 microsecond minimum time period (100 microseconds typical) is provided during which the information to be strobed on the next transition must be presented (see Figure 6).

The instructions for loading parallel data using the Count Selection Switches state that the minimum duration of the $\overline{INDEX}$ pulse when loading parallel data is 20 milliseconds. A 20 millisecond $\overline{INDEX}$ pulse duration when loading serial data will add unnecessarily to the time required to load data since the first logic 0 to logic 1 transition of DATA STROBE cannot occur until the $\overline{INDEX}$ has returned to the logic 1 state. As can be seen in Figure 6, delaying the first logic 0 to logic 1 transition of DATA STROBE will make period B unnecessarily long and unsymmetrical with the rest of the waveform. The minimum duration of the $\overline{INDEX}$ signal is actually determined by the time constant of an internal filter network and is typically 5 to 6 milliseconds. Ideally, the $\overline{INDEX}$ signal should be returned to logic 1 as soon as its logic 1 state has been recognized by the indexer. A simple technique which accomplishes this purpose uses the first logic 1 to logic 0 transition of DATA STROBE to reset the $\overline{INDEX}$ to a logic 1 since the initial transition of DATA STROBE indicates that the $\overline{INDEX}$ command has been recognized.

The final signal return to the "smart" controller will be the logic 1 to logic 0 transition of the $\overline{DONE}$ line. This signal represents completion of motor motion and can be used to initiate the next index sequence or some other controller function.

Figure 6 shows the timing for loading a count of —27980.

If it is necessary to monitor pulses in order to monitor motor positioning, CW pulses are available at terminal 23 and CCW pulses at terminal 24. Pull-up resistors should be used.

Input Voltage Selection

The TBM155 is wired at the factory for operation from a 120VAC $^{+10\%}_{-15\%}$, 50/60 hertz, 5 ampere maximum power source. The power supply can also be operated from 220/240VAC, 50/60 hertz, 5 ampere maximum power sources by making the proper changes to the primary of transformer T6568A. Connections to this transformer are made with quick disconnect terminals. Proceed as follows to change for operation from a 220VAC or 240VAC power source.

For 220 VAC, 50/60 Hertz, 5 Ampere Input

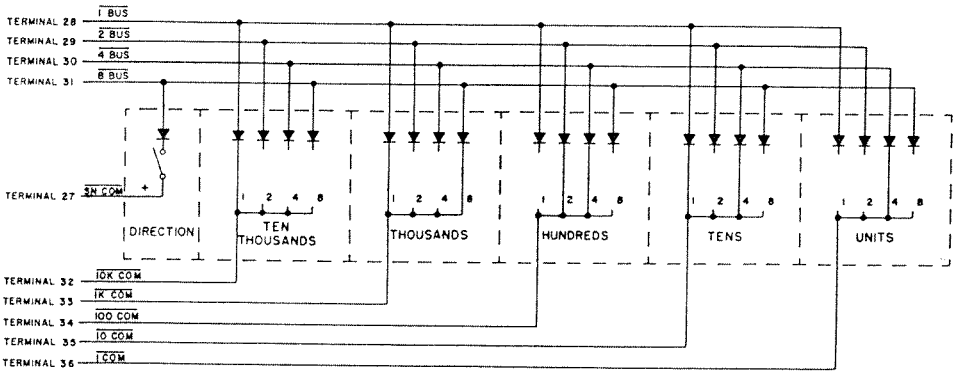
a. Remove the jumpers between terminals 1 and 3 and between terminals 2 and 5 on transformer T6568.
b. Add a jumper between terminals 2 and 3.
c. Be sure that the white/black wire is connected to terminal 1 and the white wire is connected to terminal 4.

For 240 VAC, 50/60 Hertz, 5 Ampere Input

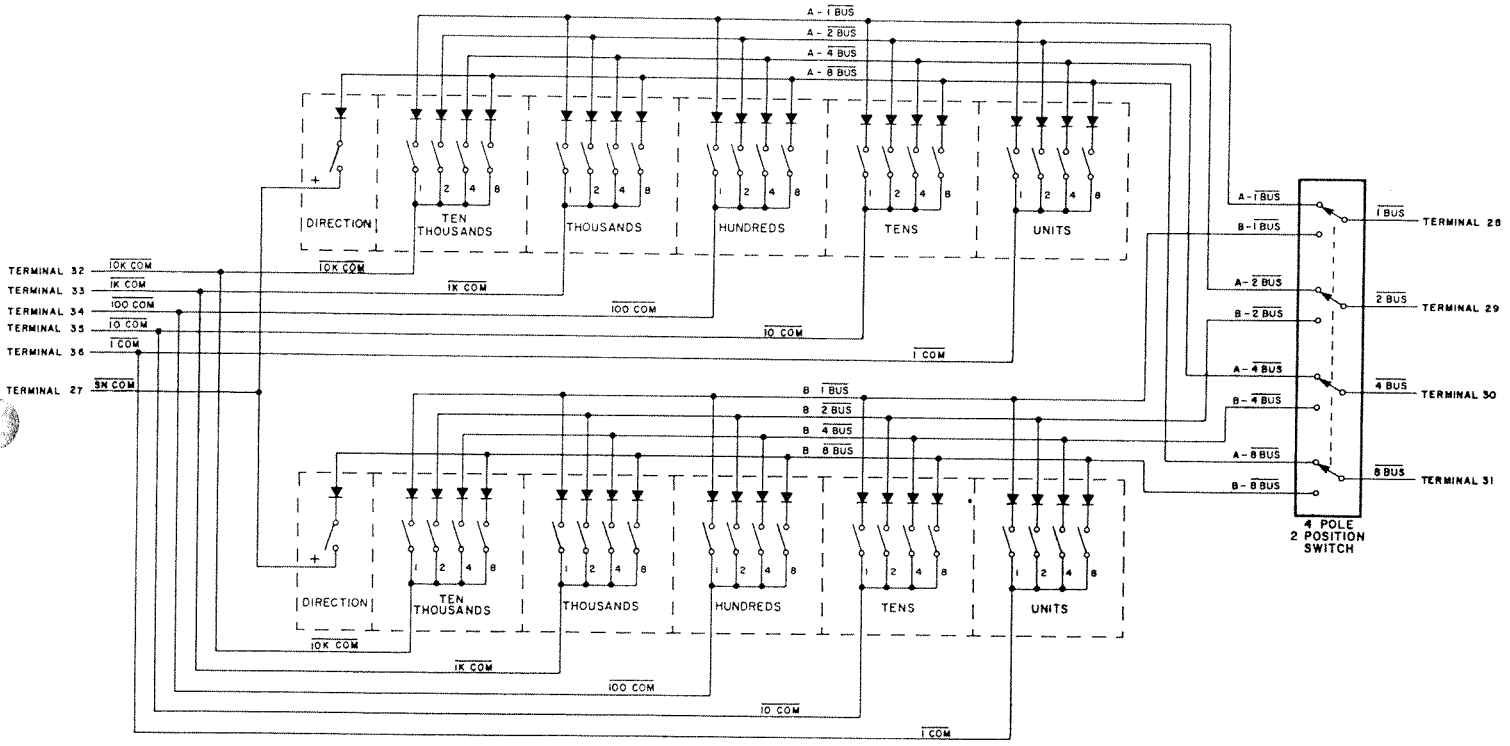
a. Remove the jumpers between terminals 1 and 3 and between terminals 2 and 5 on transformer T6568.
b. Add a jumper between terminals 2 and 3.
c. Be sure that the white/black wire is connected to terminal 1 and the white wire is connected to terminal 5.

Input Voltage Connections

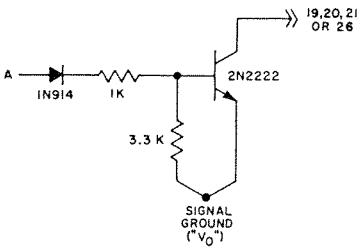
Be sure that the transformer primary connections have been changed as described in the preceding steps if the translator is to be operated from a 220 or 240 volt source. Changes are not required if 120 volt power is to be used. The indexer requires a frequency of 50/60 hertz and a maximum input current of 5 amperes. A 5 ampere fuse is provided in the input line from terminal 9. Be sure the Chassis Ground terminal is connected to a suitable earth ground before making the a-c input connections.



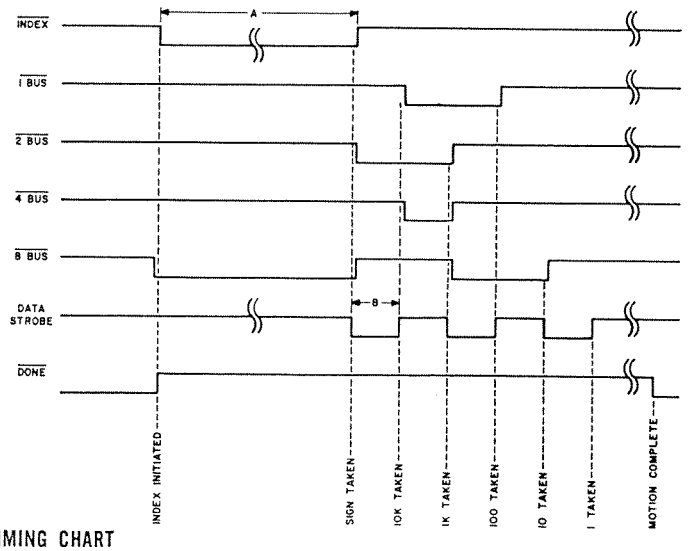
CONNECTIONS FOR FIXED COUNT
FIGURE 3



TWO SETS OF COUNT SELECTION SWITCHES
FIGURE 4



ELECTRONIC CONTROL CIRCUIT FOR
INDEX, RUN, JOG, HIGH SPEED,
HALF-STEP OR CLEAR
FIGURE 5



TIMING CHART
LOADING OF SERIAL DATA
FIGURE 6

OPERATION

CAUTION: At high stepping rates it is possible to overheat the motor unless a heat sink has been provided. Be sure that the motor frame temperature does not exceed 90°C under any combination of operating speed and ambient temperature conditions.

NOTE: Each time power is applied to the preset indexer, the CLEAR function must be actuated to clear the counters before indexing.

Operating Modes

The TBM155 SLO-SYN Preset Indexer can be operated in either of two modes: full-step and half-step. A description of each mode follows:

Half-Step Mode

The Half-Step switch controls the mode in which the preset indexer will drive the motor. When the switch is open the motor will be driven in the full-step mode. The indexer will drive the motor in the half-step mode when the switch is closed, providing a motor step increment of 0.9°. When the unit is operating in the half-step mode, the windings are energized in an eight-step sequence as shown in the switching sequence chart for half-stepping.

HALF STEP MODE

SWITCHING STEP†	MOTOR LEAD OR TERMINAL			
	RED (1)	WHITE/RED (3)	WHITE/GREEN (4)	GREEN (5)
1	OFF	OFF	OFF	ON
2	ON	OFF	OFF	ON
3	ON	OFF	OFF	OFF
4	ON	OFF	ON	OFF
5	OFF	OFF	ON	OFF
6	OFF	ON	ON	OFF
7	OFF	ON	OFF	OFF
8	OFF	ON	OFF	ON
1	OFF	OFF	OFF	ON

†Provides clockwise shaft rotation as viewed from nameplate end of motor. For counterclockwise rotation, switching steps will be performed in the reverse order.

Use of the half step operating mode provides greater positioning resolution together with a lessening of the effect of primary motor resonance. At rates above 1000 steps per second, motor torque is essentially the same for both half-step and full-step modes of operation.

Full-Step Mode

In this mode, the preset indexer applies power to two motor windings at all times and drives the motor in 1.8° step increments. The motor windings are energized in the following sequence.

FULL-STEP

SWITCHING STEP†	MOTOR LEAD OR TERMINAL			
	RED (1)	WHITE/RED (3)	WHITE/GREEN (4)	GREEN (5)
1	ON	OFF	OFF	ON
2	ON	OFF	ON	OFF
3	OFF	ON	ON	OFF
4	OFF	ON	OFF	ON
1	ON	OFF	OFF	ON

† Switching sequence for clockwise shaft rotation as viewed from nameplate end of motor. Steps are performed in reverse order for counterclockwise rotation.

Operating Controls

CAUTION: Check all installation wiring carefully for errors or poor connections before energizing the TBM155 preset indexer.

The functions of the various controls for the TBM155 are as follows:

INDEX Switch

Actuating this switch will initiate the index cycle. During the time interval that the switch is closed, the direction selected will be strobed into the preset indexer. When the switch is opened, the count selected on the BCD logic switches will be strobed into the indexer and the indexer will drive the motor the required number of steps. The minimum duration of the Index switch closure for parallel loading of data is 20 milliseconds.

RUN Switch

When the Run switch is closed, the indexer will drive the motor at the selected base speed or will accelerate the motor to the selected high speed, depending on the position of the Hi Speed switch. This switch is locked out while an index move is in progress. The Direction switch controls the direction of motor shaft rotation in the Run mode.

JOG Switch

Each cycle (closing and opening) of the Jog switch will cause the TBM155 to drive the motor one step in the direction selected on the Direction switch. The Jog switch will not have any effect if actuated while an Index move is taking place.

HI SPEED Switch

When the Hi Speed switch is closed, the indexer will drive the motor at the high speed when either the Run or the Index switch is actuated. Opening the switch will cause the indexer to drive the motor at the base speed when Run or Index is actuated. Closing the Hi Speed switch during motion will cause the unit to accelerate the motor from base speed to high speed. The motor will decelerate to base speed if the Hi Speed switch is opened during motion.

CLEAR Switch
Closing the Clear switch resets all information in the counters to zero. If actuated while an index move is taking place, the motor will stop with uncontrolled deceleration and will lose position information. The Clear switch must be deactivated before the motor can be indexed again.

HALF-STEP Switch
Closing this switch will cause the preset indexer to drive the motor in the half-step mode.

DIRECTION Switch
When the Direction switch is in the minus position, actuating the Index, Run or Jog functions will cause the motor shaft to rotate in the counterclockwise direction as viewed from the nameplate end of the motor. The Index, Run or Jog functions will cause motion in the clockwise direction when this switch is in the plus direction position.

COUNT Switches
These switches are used to select the number of steps the preset indexer will drive the motor when the Index switch is actuated.

Operating the TBM155 Preset Indexer
Check all installation wiring carefully before energizing the preset indexer.

1. Apply power to the preset indexer.
2. Select the direction of motor rotation with the Direction switch.
3. To jog the motor one step at a time, actuate the Jog switch. Each time the switch is closed and opened the indexer will drive the motor one step in the selected direction.
4. Closing the Run switch will cause the Indexer to "free step" the motor at the rate selected on the Base Speed control. The indexer will accelerate the motor to the High Speed when the Hi Speed switch is closed and will decelerate it back to the Base Speed when the switch is opened. Opening the Run switch will stop the motor.
5. If an index move is required, select the number of motor steps required to accomplish the move on the count switches. If the High Speed is required, close the Hi Speed switch. Actuate the Index switch cycle.
6. When positioning of the motor is no longer required, turn off the power to the preset indexer.

Base Speed Adjustment
The base speed is the rate at which a specific motor and load will start or stop without faltering, stalling or missing steps. Base speed is easily adjusted to match the motor and load characteristics of the application by means of the base speed adjustment potentiometer. The range is 0 to 1000 steps per second in the full-step mode and 0 to 2000 steps per second in the half-step mode. A base speed lower than 25 steps per second cannot be used when operating in the Index mode.

Base speed must be properly adjusted before setting the ramps (acceleration and decleration). Set the base speed using the following procedure.

1. Place all switches in the open position.
2. Select the desired mode of operation: Full-Step or Half-Step.
3. Energize the preset indexer.
4. Select the desired direction of motor rotation with the Direction control.
5. Close the Run switch. The preset indexer module will begin driving the motor at the base speed.
6. Adjust the Base Speed Control to select the fastest rate at which the motor will start and stop the load reliably. Then decrease the base speed by 20 steps or 10%, whichever is greater, to provide a safety margin. Obviously, the greater the safety margin the more reliable the system will be, especially in applications where load variations will occur.

   If necessary, the oscillator pulses can be monitored as described under "Pulse Monitor" when adjusting the base speed.

Acceleration and Deceleration Adjustments

Note: The Base Speed Adjustment must be completed before adjusting acceleration and deceleration.

Acceleration time is the time required to ramp the motor from the base speed up to the preset high speed. This ramp can be observed by monitoring the voltage rise at terminal 16 (VH) with an oscilloscope. The voltage will rise from approximately 5 volts to 15 volts and the time required for the voltage rise is factory preset at 1 second. If necessary, the acceleration time can be changed by adjusting the appropriate potentiometer on the Indexer/Translator circuit board (see Figure 8). To observe the voltage change, operate the indexer with the Run switch closed and trigger the scope externally with the Hi Speed switch.

Deceleration differs from acceleration in that it is generated internally using a different technique and it is greatly influenced by the base speed and high speed settings. The specified deceleration range is 100 to 500 milliseconds, with 500 milliseconds representing the longest deceleration time possible when ramping from 10,000 half-steps per second (maximum speed with an M062, M063, M091, M092 or M093 motor) down to a base speed of 400 half-steps per second. Since deceleration occurs over a fixed number of steps, a reduction in the high speed setting will increase the maximum deceleration time capability. The M112-FJ326 and M112-FJ327 motors are rated for maximum stepping rates of 5000 and 2500 half-steps per second, respectively, and therefore are capable of much higher maximum deceleration times.

Conversely, increasing the base speed settings will reduce the maximum possible deceleration time. The curve in Figure 7 illustrates the typical variation in deceleration time as a function of the high speed setting, with a fixed base speed of 200 full-steps per second. Deceleration times for the M112-FJ326 or M112-FJ327 motors operating at their maximum speeds or for any of the motors when operated at less than their maximum rate can be determined from this curve.

If the deceleration time adjustment is made in the half-step mode, this time will double when operating in the full-step mode at the same RPM. For example, if the time to decelerate from 10,000 to 400 half-steps per second is set at 400 milliseconds, the deceleration time will double to 800 milliseconds when ramping from 5000 down to 200 full-steps per second. Conversely, the deceleration time in the half-step mode will be half that provided in the full-step mode at any given motor shaft speed.

It is often desirable to decrease the acceleration and deceleration times to shorten the time required for an operation. However, if the times are too short the motor may miss steps, stall when starting or overshoot when stopping. The ramp times

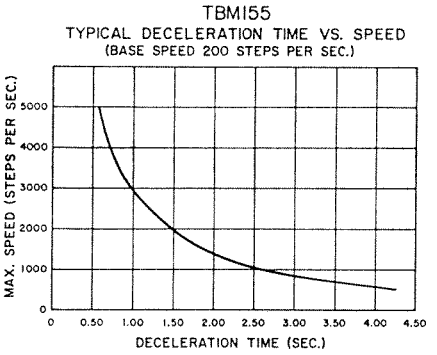
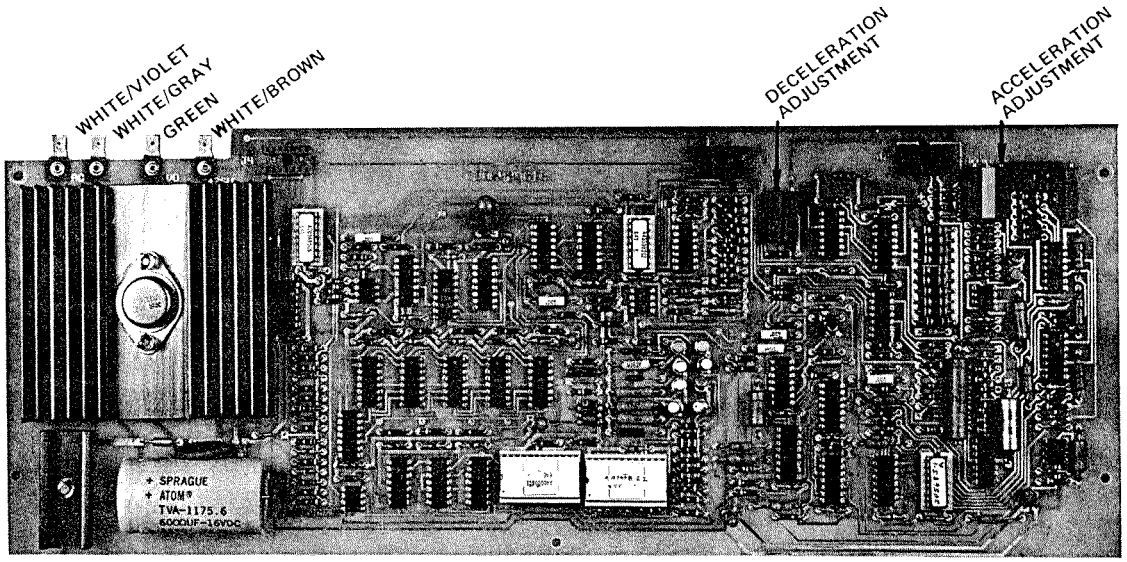
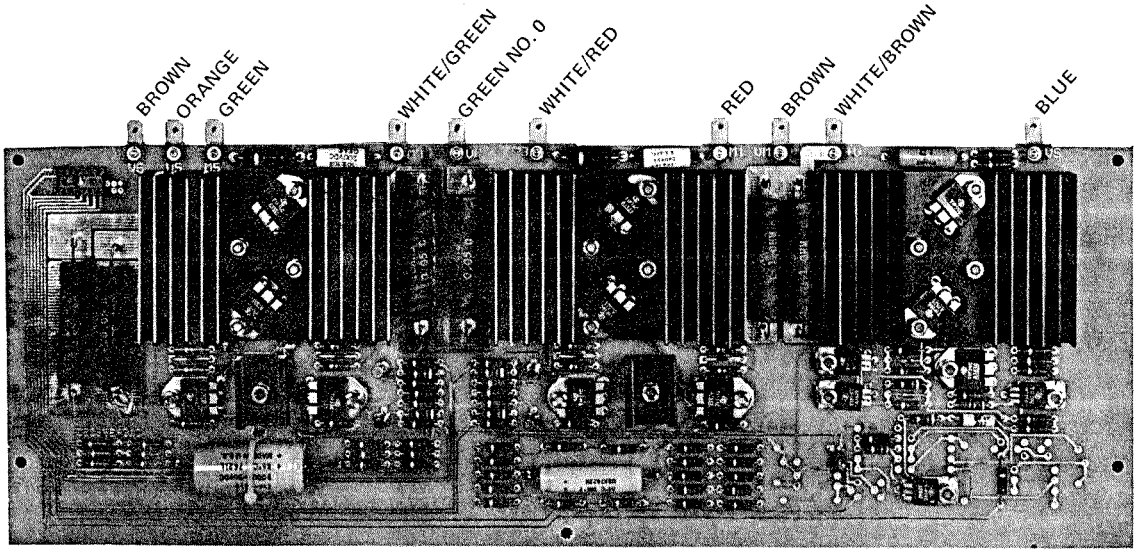


FIGURE 7



INDEXER/TRANSLATOR CIRCUIT BOARD
FIGURE 8



MOTOR DRIVE CIRCUIT BOARD
FIGURE 9

should not be adjusted below the minimum times given in the chart.

MINIMUM ACCELERATION AND DECELERATION TIMES

PRESET INDEXER MODEL	MINIMUM TIME (milliseconds)
TBM155-6209	125
TBM155-6309	125
TBM155-9109	150
TBM155-9214	175
TBM155-9322	200
TBM155-1230	175
TBM155-1218	100

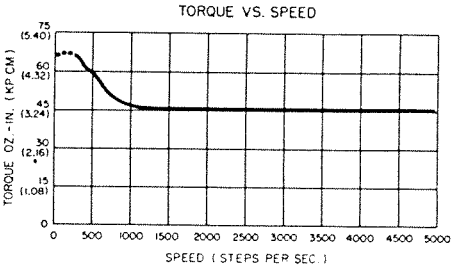
After connecting the motor to the load, adjust the ramps as follows:

1. Place all switches in the open position.
2. Select the desired mode of operation: Full-Step or Half-Step.
3. Energize the preset indexer.
4. Connect the scope probe to pin 16 and the scope probe ground to Signal Ground.
5. Select a base speed as described in the base speed adjustment procedure.
6. With the Run switch closed, close the Hi Speed switch and adjust the High Speed Control to attain the desired frequency. Leave the Hi Speed switch closed and open the Run switch.
7. Select a positioning motion of at least 8000 motor steps on the count switches.
8. Actuate the Index switch and check to see that the motor moves the correct number of steps. If the acceleration time is too short, the motor will miss steps when starting. Too long an acceleration time will add unnecessarily to the time required for an operation. To select the ideal acceleration time, turn the ACCEL potentiometer (see Figure 8) counterclockwise to shorten the time. Select the minimum time which will allow the motor to start the load reliably. Then increase the acceleration time from this point by 10% to provide an adequate safety margin.
9. Again, start and stop the motor repeatedly by actuating the Index switch, this time observing the interval from the time the motor begins decelerating until it stops. To select the ideal deceleration time, turn the DECEL potentiometer (see photo) counterclockwise to shorten the deceleration time. Find the shortest time which will allow the motor to stop without gaining or losing steps. To allow an adequate safety margin, increase the deceleration time approximately 10% from this point.

TYPICAL SPEED VS. TORQUE CHARACTERISTICS

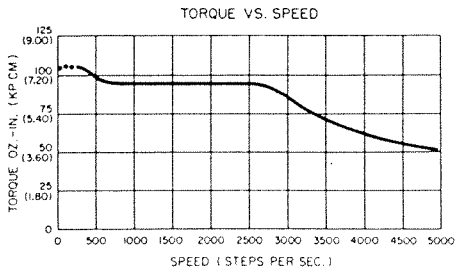
Typical performance characteristics for all models of the TBM155 preset indexer when driving the appropriate motors are given in the speed vs. torque curves. The indexer will automatically accelerate the motor to and from these speeds.

The part of each curve represented with a dotted line is an area of possible motor resonance. **Depending on the load driven**, the motor may not operate satisfactorily at the speeds shown in the dotted area. If poor performance is experienced

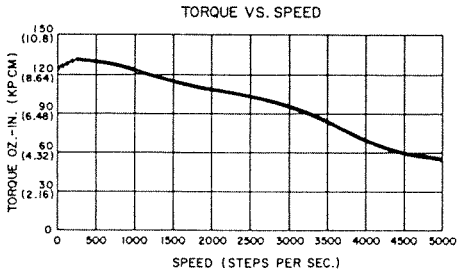


TBM155-6209 PRESET INDEXER WITH M062-FC09 or M062-FD09 MOTOR

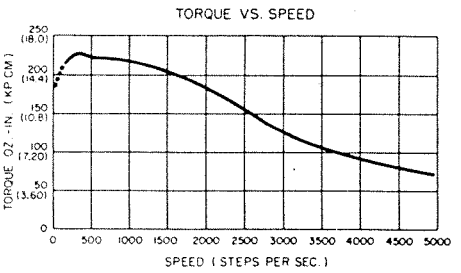
TYPICAL SPEED VS. TORQUE CHARACTERISTICS



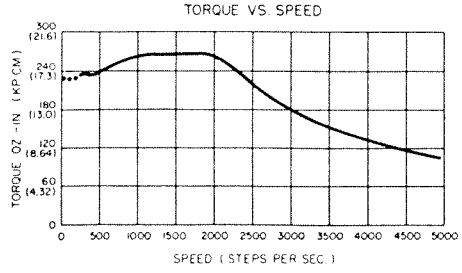
TBM155-6309 PRESET INDEXER WITH M063-FC09 or M063-FD09 MOTOR



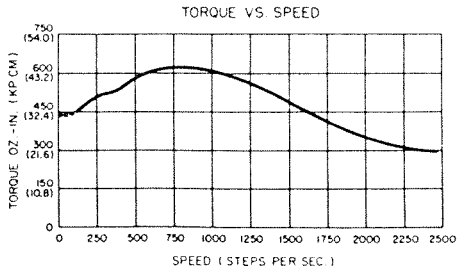
TBM155-9109 PRESET INDEXER WITH M091-FC09 OR M091-FD09 MOTOR



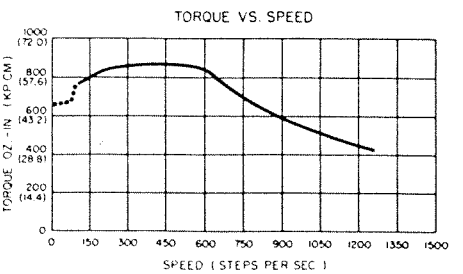
TBM155-9214 PRESET INDEXER WITH M092-FD310 MOTOR



TBM155-9322 PRESET INDEXER WITH M093-FD301 MOTOR



TBM155-1230 PRESET INDEXER WITH M112-FJ326 MOTOR



TBM155-1218 PRESET INDEXER WITH M112-FJ327 MOTOR

at these speeds, the speed should be increased to avoid the area of possible resonance. Changing from full-step to half-step operation may also provide a satisfactory improvement in performance.

The following chart shows maximum safe operating speeds for each preset indexer/motor combination for both the half-step and full-step modes of operation. Although speeds higher than those shown in the chart can be achieved, observance of these maximum rates will assure accurate positioning and maintenance of correct motor and indexer operating temperature over the specified ambient temperature and input voltage ranges.

RECOMMENDED MAXIMUM STEPPING RATES

PRESET INDEXER MODEL	STEPPING MOTOR TYPE	MAXIMUM RATE (Steps per Second)	
		FULL-STEP MODE	HALF-STEP MODE
TBM155-6209	M062-FC09 M062-FD09	5000	10,000
TBM155-6309	M063-FC09 M063-FD09	5000	10,000
TBM155-9109	M091-FC09 M091-FD09	5000	10,000
TBM155-9214	M092-FD310	5000	10,000
TBM155-9322	M093-FD301	5000	10,000
TBM155-1230	M112-FJ326	2500	5,000
TBM155-1218	M112-FJ327	1250	2,500

READJUSTMENT TO CHANGE MODEL NUMBER

Each TBM155 model is factory adjusted for use with a specific motor type and the last four digits of the preset indexer model number identify the motor to be driven by that model. It is possible to change the model number of a TBM155 preset indexer by readjusting to match the unit to a motor type different from that for which the unit was factory adjusted. However, before attempting to readjust the unit according to the procedure outlined in this instruction, consideration should be given to the following warning.

WARNING

Adjustment to effect a model number change should be done only by a qualified person having access to the required instruments. Misadjustment may cause permanent damage to the preset indexer, the motor or the equipment driven by the motor as well as injury to personnel.

The Superior Electric Company assumes no liability for any such damage or injuries. Furthermore, the user, in making the adjustments described, shall void all Warranties otherwise applicable to this product and the SLO-SYN motors connected thereto.

Adjustment Procedure

Be sure to read the preceding warning before readjusting the unit.

Equipment required: 1. two ammeters capable of reading 0 to 10 amperes d-c
2. oscilloscope

1. Connect one ammeter in each motor common. With the system energized and the motor at a standstill, adjust potentiometer HP on the Logic circuit board until both ammeters read rated motor current, but do not exceed 5 amperes per phase.
2. Operate the system in the full-step mode while monitoring the oscillator frequency at terminal 23 (CCW motion) or at terminal 24 (CW). Adjust the high speed control until the frequency is correct for the motor as specified in the following chart.

PRESET INDEXER MODEL	MOTOR TYPE	FREQUENCY (Hertz)	LOGIC BOARD PART NO.	REQUIRED CAPACITOR C50
TBM155-6209	M062-FC09 M062-FD09	5000	A206431G1	0.1 microfarad, 80 volt
TBM155-6309	M063-FC09 M063-FD09	2600	A206431G2	0.1 microfarad, 80 volt
TBM155-9109	M091-FC09 M091-FD09	2400	A206431G7	0.1 microfarad, 80 volt
TBM155-9214	M092-FD-310	1700	A206431G3	0.1 microfarad, 80 volt
TBM155-9322	M093-FD-301	2000	A206431G4	0.18 microfarad, 80 volt
TBM155-1230	M112-FJ-326	1200	A206431G5	0.18 microfarad, 80 volt
TBM155-1218	M112-FJ-327	600	A206431G6	0.18 microfarad, 80 volt

3. It may be necessary to change capacitor C50 on the Logic circuit board to obtain the correct frequency adjustment. The required capacitor value for each model is given in the chart.

Connect the scope probe to the Motor Drive circuit board terminal which is labeled VS, and which has a blue wire connected to it. With the system operating, the scope should show a 30 to 35 volt switching waveform. Adjust the potentiometer labeled MP on the Logic board until the switching stops and the scope shows a constant high level. To be sure that the adjustment is correct, lower the speed about 50 steps per second using the High Speed control. The switching action should resume.

Whenever the unit has been readjusted using this procedure, it is essential that the preset indexer model number and the logic circuit board number be changed to reflect this readjustment. Find the correct logic circuit board part number for the new preset indexer model in the chart and change the number which follows the letter G to reflect the correct new board number. The type number on the preset indexer nameplate should also be changed to the new preset indexer type number.

TROUBLE SHOOTING

The TBM155 SLO-SYN Preset Indexer requires no regular maintenance and should provide long service with no attention. Should the unit fail to step the motor properly, perform the following check.

1. Check all installation wiring carefully for wiring errors or poor connections. Check for a blown 5 ampere fuse.
2. Check to be sure the a-c power to the preset indexer is the correct voltage and that the step down transformer

primary connections are correct for the input voltage.

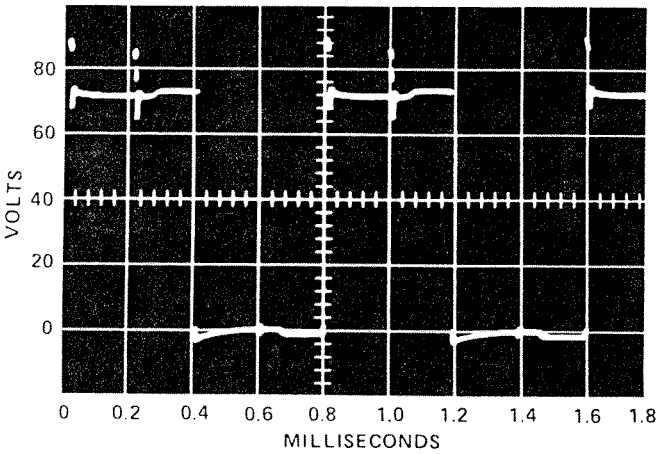
3. Be sure that the SLO-SYN motor is the correct model for use with the preset indexer and check the motor windings for continuity.
4. Be sure that the proper procedure is being used in operating the preset indexer.
5. Check to see that triggering pulses are present at terminal 23 for CW motion or at terminal 24 for CCW motion. Pulses must not be present on terminals 23 and 24 simultaneously. Since these are open collector outputs, pull-up resistors should be used.

If the preceding checks have not corrected the problem and the unit exhibits any of the following symptoms proceed as outlined.

1. Motor operates from the Run and Jog switches, but positions incorrectly in the Index mode.
   a. Check the wiring from the Count switches.
   b. Check the wiring to the Index switch and verify the closure to Signal Ground.
   c. Verify proper count insertion from the Count switches.
   d. Check for proper operation at both base speed and high speed.
   e. Recheck the base speed and acceleration/deceleration adjustments with the drive motor connected to its actual load.
2. The unit does not operate from the Run switch but operates correctly from the Index and Jog switches.
   a. Check the wiring to and from the Run switch. Verify the closure to Signal Ground.
3. The TBM155 will not jog the motor, but operates correctly from the Index and Run switches.
   a. Check the wiring to and from the Jog switch. Verify the closure to Signal Ground.
4. The Clear function does not occur when the switch is actuated.
   a. Check the wiring to and from the Clear switch. Verify the closure to Signal Ground.
5. The motor goes the wrong number of steps during an Index operation.
   a. Check the wiring to and from the Count switches.
   b. Check for proper count insertion.
   c. Check for proper motion as described under Symptom #1, Steps d and e.
   d. Check for pulses at pins 24 (CCW) and 23 (CW) complying with the Directional Pulse Output specifications. Pull-up resistors should be used.
   e. Check with a d-c voltmeter to verify that voltage to the motor windings is being switched on and off in the proper sequence. Voltage to the motor windings can be checked at terminals 1, 3, 4 and 5. In the Full-Step mode, each winding should be energized for two steps and deenergized for the next two steps. When operating in the Half-Step mode, each of the four motor windings will be energized for three steps and deenergized for five steps. These tests should be performed using the Jog switch.

      Set the voltmeter on the 0–10V scale and check between the appropriate motor common (2 or 6) and terminals 1, 3, 4 and 5 one at a time. The positive voltmeter probe should be connected to the motor common. A properly energized winding should indicate greater than 1.5 volts and a properly deenergized winding should indicate 0 volts.

      Proper energizing of the motor windings can also be checked at higher speeds using an oscilloscope to check the collector to emitter waveform (VCE) of the four power transistors. Connect the scope ground to Signal Ground. With the scope probe (triggered internally or externally) check at terminals 1, 3, 4 and 5 one at a time. A typical waveform is shown in Figure 10 for operation at a high stepping rate.
6. If the motor will not drive the load at the desired speed and the preceding checks have shown that the preset indexer is operating correctly, the combination of friction load and inertia may be too great for the motor to overcome. This situation can usually be rectified by reducing the operating speed. In severe cases it, may be necessary to use a motor having a higher torque rating or to drive the load through a speed reducing gear train.



TYPICAL VCE WAVEFORM
FIGURE 10

7. If erratic operation or random positioning errors are experienced and the checks listed for Symptom #1 did not locate the problem, check for one of the following two conditions.
   a. The driven load may be approaching the torque limit of the motor. If this condition exists, the errors will be made in multiples of four motor steps. The situation can be corrected by using a motor which has a higher torque rating or by driving the load through a speed reduction gear train.

b. Erratic operation or random positioning errors can also be caused by electrical noise entering the preset indexer. The errors can be consistent or random depending on the type and degree of noise present. Malfunctions from this cause can include self-indexing, resetting and positioning errors ranging from one to several thousand motor steps.

The most effective cure is to add suppression to a-c solenoids, a-c relay contacts and other sources of electrical noise located in the vicinity of the preset indexer. Consult The Superior Electric Company for recommended suppression techniques. Do not run wires from these external sources of electrical noise through the same raceway with the indexer control wiring.

Another effective cure is to use shielded cable, with the shield grounded at one end only, between the preset indexer and the controls. Keep the wires as short as possible. As with all electrical equipment, proper grounding techniques must be followed.

If any unusual problems are encountered in the installation or operation of the SLO-SYN Preset Indexer, contact the factory or the nearest Superior Electric sales office.

WARRANTY AND LIMITATION OF LIABILITY

The Superior Electric Company (the "Company"), Bristol, Connecticut, warrants to the first end user purchaser (the "purchaser") of equipment manufactured by the Company that such equipment, if new, unused and in original unopened cartons at the time of purchase, will be free from defects in material and workmanship under normal use and service for a period of one year from date of shipment from the Company's factory or a warehouse of the Company in the event that the equipment is purchased from the Company or for a period of one year from the date of shipment from the business establishment of an authorized distributor of the Company in the event that the equipment is purchased from an authorized distributor.

THE COMPANY'S OBLIGATION UNDER THIS WARRANTY SHALL BE STRICTLY AND EXCLUSIVELY LIMITED TO REPAIRING OR REPLACING, AT THE FACTORY OR A SERVICE CENTER OF THE COMPANY, ANY SUCH EQUIPMENT OR PARTS THEREOF WHICH AN AUTHORIZED REPRESENTATIVE OF THE COMPANY FINDS TO BE DEFECTIVE IN MATERIAL OR WORKMANSHIP UNDER NORMAL USE AND SERVICE WITHIN SUCH PERIOD OF ONE YEAR. THE COMPANY RESERVES THE RIGHT TO SATISFY SUCH OBLIGATION IN FULL BY REFUNDING THE FULL PURCHASE PRICE OF ANY SUCH DEFECTIVE EQUIPMENT. This warranty does not apply to any equipment which has been tampered with or altered in any way, which has been improperly installed or which has been subject to misuse, neglect or accident.

THE FOREGOING WARRANTY IS IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, and of any other obligations or liabilities on the part of the Company; and no person is authorized to assume for the Company any other liability with respect to equipment manufactured by the Company. The Company shall have no liability with respect to equipment not of its manufacture. THE COMPANY SHALL HAVE NO LIABILITY WHATSOEVER IN ANY EVENT FOR PAYMENT OF ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING, WITHOUT LIMITATION, DAMAGES FOR INJURY TO ANY PERSON OR PROPERTY.

Written authorization to return any equipment or parts thereof must be obtained from the Company. The Company shall not be responsible for any transportation charges.

IF FOR ANY REASON ANY OF THE FOREGOING PROVISIONS SHALL BE INEFFECTIVE, THE COMPANY'S LIABILITY FOR DAMAGES ARISING OUT OF ITS MANUFACTURE OR SALE OF EQUIPMENT, OR USE THEREOF, WHETHER SUCH LIABILITY IS BASED ON WARRANTY, CONTRACT, NEGLIGENCE, STRICT LIABILITY IN TORT OR OTHERWISE, SHALL NOT IN ANY EVENT EXCEED THE FULL PURCHASE PRICE OF SUCH EQUIPMENT.

Any action against the Company based upon any liability or obligation arising hereunder or under any law applicable to the sale of equipment, or the use thereof, must be commenced within one year after the cause of such action arises.

DISTRIBUTION COAST-TO-COAST AND INTERNATIONAL

Superior Electric products are available nationwide through an extensive authorized distributor network. These distributors offer literature, technical assistance and a wide range of models off the shelf for fastest possible delivery.

In addition, Superior Electric sales engineers and manufacturers' representatives are conveniently located to provide prompt attention to customers' needs. Call the nearest office listed for ordering and application information or for the address of the closest authorized distributor.

EASTERN USA

BRISTOL
383 Middle Street
Bristol, CT 06010
Tel: (203) 582-9561
TWX: 710-454-0682

CENTRAL USA

CHICAGO
799 Roosevelt Road, Bldg. 6 Suite 100
Glen Ellyn, IL 60137
Tel: (312) 858-2960
TWX: 910-651-3250

WESTERN USA

LOS ANGELES
22010 S. Wilmington Ave., Suite 301
Carson, CA 90745
Tel: (213) 830-7750
TWX: 910-321-4481

IN EUROPE

Superior Electric Nederland B.V.
Koperwerf 33
2544 EM The Hague, Netherlands
Tel: (070) 679590
TELEX: 31436 Supe nl
Cable: SUPELEC

IN CANADA

The American Superior Electric Company, Ltd.
38 Torlake Crescent
Toronto, Ontario M8Z 1B3
Tel: (416) 255-2318
TELEX: 06-967806

Superior Electric Subsidiaries

ELECTRO-KINESIS, INC.
300 Corporate Pointe
Suite 420
Culver City, CA 90230
Tel: 213/410-1664

Unitron Incorporated
10925 Miller Rd.
Dallas, TX 75238
Tel: 214/340-8600
Telex: 882511
Toll Free: 800/527-1279
In Texas: 800/442-1652

Superior Electric
Bristol, Connecticut 06010 USA
TEL: (203) 582-9561 TELEX: 96-2446 TWX: 710-454-0682
Cable Address: SUPELEC FAX: (203) 584-1483

Superior Electric
Bristol, Connecticut 06010 USA
TEL: (203) 582-9561 TELEX: 96-2446 TWX: 710-454-0682
Cable Address: SUPELEC FAX: (203) 584-1483

SE-I88614 PRINTED IN USA MS2105G227