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National Electrical Manufacturers Association
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Washington, D.C. 20037 (202) 457-8400

PROPOSED, NEW AND REVISED STANDARDS

TO ALL REPRESENTATIVES OF MEMBER COMPANIES IN THE
INDUSTRIAL CONTROL AND SYSTEMS SECTION

Subject: Revision No. **2** to NEMA Standards Publication
No. **ICS 5-1983,** *Resistance Welding Control*

Dear Representative:

Revision No. 2, dated March 1985, is enclosed for insertion in your copy of the subject publication. This revision was approved by the Codes and Standards Committee in March 1985.

Paragraphs ICS 5-009 and ICS 5-010 have been rescinded. Please make a note of this in your copy of the standard.

A revised cover indicating that the standard now includes Rev. 2 is also attached. Please insert the revised pages carefully, as extra copies are not available.

Sincerely yours,

Krystyna Bagnato

Krystyna Bagnato
Standards Publications Editor

cc: Technical Committee
All known holders of ICS 5-1983

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STANDARDS PUBLICATION/NO. ICS 5-1983

INCLUDING: Editorial Rev. No. 1—September 1984
Rev. No. 2—March 1985

nema

Resistance Welding Control

NEMA

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such a way that the polarity of the voltage is reversed for the purpose of reducing the current to zero in a minimum amount of time.

NEMA Standard 7-13-1960.

Load Distribution Control

A load distribution control is a device intended for use with resistance welding machines having two or more welding transformers, the control being arranged to distribute the load by energizing the welding transformers in sequence on one or more phases or simultaneously on two or more phases.

NEMA Standard 6-22-1950.

Load Scanning

Load scanning as applied to resistance welding process is a control system for limiting the application of loads to prevent the supply voltage from dropping below a predetermined level at the welding station(s).

NEMA Standard 11-21-1968.

Method of Initiation—Delayed Firing

Delayed firing is the delayed initiation of the first half cycle of weld current with respect to the voltage wave in order to minimize the initial transient of magnetizing current of the welding transformer.

NEMA Standard 7-13-1960.

Nonbeat Control

Nonbeat control is the feature or method of connection which provides that, once the welding cycle has been initiated from the pilot switch, the welding cycle will then be carried through to completion, regardless of whether or not the pilot switch remains closed.

NEMA Standard 3-7-1946.

Nonrepeat Control

Nonrepeat control is the feature or method of connection which provides that, once the welding cycle has been initiated from the pilot switch, only one welding cycle will result. The pilot switch must be opened and reclosed for each additional welding cycle.

NEMA Standard 3-7-1946.

Repeat Control

Repeat control is the feature or method of connection which provides that, once the welding cycle has been initiated from the pilot switch, the welding cycle will be repeated after a controlled time interval (off time) as long as the pilot switch remains closed.

NEMA Standard 3-7-1946.

Retraction Valve Control

A retraction valve control is a device which provides for controlling a retraction solenoid valve by means of a pilot system.

NEMA Standard 1-21-1964.

Synchronous Timing

Synchronous timing is the initiation and termination of each half-cycle of welding transformer primary current so that each half-cycle of such current is the same whether in the same or succeeding welds.

NEMA Standard 3-7-1946.

Two-stage Pilot-switch Control

Two-stage pilot-switch control is the feature or method of connection which provides that the closure of the first stage of the pilot switch will energize the electrode force actuating means and a second stage will initiate the weld sequence. The closure of the second stage may or may not follow immediately the closure of the first stage. The first stage shall be nonbeat after closing the second stage.

In two-stage pilot-switch operation, the second stage shall not be capable of being initiated if the first stage is open.

Squeeze time shall start at the closure of the first stage of a 2-stage foot switch.

NEMA Standard 5-12-1969.

Voltage Compensator

A voltage compensator is a device which operates to maintain the primary rms current during line voltage fluctuations.

NEMA Standard 3-6-1985.

Voltage Regulator

A voltage regulator for resistance welding is a device which operates to maintain voltage on the primary of a resistance welder transformer at a predetermined pattern of values.

NEMA Standard 8-10-1949.

Voltage-Variations—Gradual and Sudden

The term "gradual voltage variation" as used in these standards is a change in rms line voltage at a rate of less than one percent per second.

The term "sudden voltage variation" as used in these standards is a change in rms line voltage at a greater rate than one percent per second.

NEMA Standard 9-19-1962.

Weld-Safe

In a weld-safe device, the termination of weld time is not dependent upon conduction of a single electronic tube.

NEMA Standard 7-27-1955.

ICS 5-001.05 TYPES OF TIMERS

Function Timer

A function timer is a device which controls the time interval between its initiation and the actuation of the output signal or relay contacts. Function timers can be serially connected to perform the functions of sequence weld timers as well as more complex sequences required by the welding process.

NEMA Standard 7-13-1960.

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Multiple Impulse Weld Timer

A multiple impulse weld timer is a device for multiple impulse welding which controls only the heat time, the cool time, and either the weld interval or the number of heat times.

NEMA Standard 7-13-1960.

Seam Weld Timer

A seam weld timer is a device for seam welding which controls the heat times and the cool times.

NEMA Standard 3-7-1946.

Sequence Timer

A sequence timer is a device for controlling: (1) sequence, and (2) duration of any or all of the elements of a complete resistance welding cycle except that control of the weld time or heat time is excluded; however, this device may also control other mechanical movements of the welding machine. Means are provided for initiating a separate weld timer or multiple impulse weld timer.

NEMA Standard 7-13-1960.

Sequence Weld Timer

A sequence weld timer is a device which performs the functions of a sequence timer and the functions of either a weld timer or a multiple impulse weld timer.

NEMA Standard 7-13-1960.

Water Saver Timer

A water saver timer is a device which opens a water valve at the beginning of a weld sequence and closes it at a predetermined time after the end of a sequence.

NEMA Standard 7-27-1955.

Weld Timer

A weld timer is a device which controls only the weld time.

NEMA Standard 3-7-1946.

TIMING DIAGRAMS

ICS 5.001.06 SINGLE-PHASE WELD CYCLE DIAGRAMS

(Frequency Converter Weld Cycle Diagrams Appear in Part ICS 5-008.)

Weld Cycle Diagrams

Figures 5-001-2 through 5-001-10 represent a comprehensive picture of the factors involved in the welding process. Each figure is keyed to a NEMA type of control more completely described in Part ICS 5-006.

The abscissa represents time, based on the supply line frequency. Various related ordinates are shown as follows:

(a) "Welding process times" are defined in ICS 5-001.03 and refer to the welding process which includes time constants of the welding machine, contactors and associated equipment.

(b) "Current" graphically describes the current during the welding cycle, including welding current and current used during the preweld or post-weld intervals.

(c) "Electrode force" is the force at the electrode during the weld cycle. "Machine operating time" includes the time constants of the relays and welding machine.

(d) "Solenoid valve coil voltage" is the electrical signal which controls the motion of the electrodes and is shown in time relation to the electrode force.

(e) "Timer" times are defined entirely from Figures 5-001-2 through 5-001-10 since they are of necessity referenced to electrical signals. Thus a comparison of "current" and "solenoid valve coil voltage" signals determines the "timer" time definitions.

Authorized Engineering Information 3-13-1968.

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.01 Solenoid Valve Operation

A contact shall be in series with the valve contactor circuit to prevent spurious operation. This contact will be open when the control is in standby condition.

.02 Weld Firing Circuit

A contact shall be in series with the weld firing circuit to prevent spurious operation. This contact will be open when the control is in standby condition.

NEMA Standard 1-21-1964.

A damped oscillatory voltage surge, having a peak equal to 1.41 times the line voltage and a base frequency of 5000 hertz, shall be applied so that it is additive to the primary control power supply. The surge shall be applied in both positive and negative polarities of the control power supply.

NEMA Standard 9-19-1962.

The above is a design test for component failure, timing accuracy and detection of spurious operation.

Authorized Engineering Information 9-19-1962.

ICS 5-002.20 VOLTAGE REGULATOR

A voltage regulator as used in connection with resistance welding control shall have the following characteristics:

.01 Accuracy

A voltage regulator shall hold the welding transformer primary rms voltage within ±2 percent of the preset value under line voltage variations of ±10 percent. This device is not required to operate beyond the limits of the heat control.

.02 Response Time

The regulator shall cause the voltage to be corrected at least 50 percent at the second cycle, 80 percent at the third cycle, and 97 percent at the fourth cycle, after the line voltage disturbance.

.03 Cut Off Means

A means shall be provided to disable the voltage regulator.

NEMA Standard 3-6-1985.

ICS 5-002.21 CURRENT REGULATOR

A current regulator as used in connection with resistance welding control shall have the following characteristics:

.01 Accuracy

The current regulator shall hold the rms primary welding current within ±3 percent under the same conditions which would cause the unregulated welding current to vary ±20 percent, providing the regulator is not required to operate beyond the limits of the heat control. The foregoing will hold true if the line voltage variations do not exceed ±10 percent.

.02 Response Time

The regulator shall return the current value to within 5 percent of the desired value in 3 cycles or less under conditions which cause up to a 20 percent disturbance of the current.

.03 Cut Off Means

A means shall be provided to disable the current regulator.

NEMA Standard 3-6-1985.

ICS 5-002.22 VOLTAGE COMPENSATOR

A voltage compensator shall respond to a ±10 percent change in line voltage within two line cycles and shall maintain the rms primary welding current within ±2 percent of that at nominal line voltage.

A means shall be provided to indicate those instances when the compensator is no longer able to compensate for existing line conditions.

NEMA Standard 3-6-1985.

ICS 5-002.23 SLOPE CONTROL AS USED IN RESISTANCE WELDING

.01 Calibration Accuracy of Up-Slope Controls

When the up-slope time is set for a given time, the current at that time shall be 90 percent plus or minus 5 percent. The following test conditions shall apply:

a. The final current shall be set for maximum.

b. The initial current shall be set for an rms value of 20 percent of maximum.

c. The load power factor shall be set for 40 percent.

d. The line voltage shall be constant.

e. The determination of slope accuracy shall be in terms of peak primary load current with reference to a straight line between initial current and the current line at time setting. In the eleven cycle slope time, the sixth cycle current shall not deviate from the straight line by more than plus or minus 10 percent of the maximum. The peak primary load current shall be measured with an oscilloscope or equivalent instrument.

.02 Calibration Accuracy for Down-Slope Control

When the down-slope time is set for a given time, the current at that time shall be 30 percent plus or minus 5 percent. The following test conditions apply:

a. The final postheat current shall be set for an rms current of 20 percent.

b. The maximum welding current shall be set for 100 percent.

c. The load power factor shall be set for 40 percent.

d. The line voltage shall be constant.

e. The determination of slope accuracy shall be in terms of peak primary load current with reference to a straight line between maximum current and the current line at time setting. In the eleven cycle slope time, the sixth cycle current shall not deviate from the straight line by more than plus or minus 10 percent of the maximum. The peak primary load current shall be measured with an oscilloscope or equivalent instrument.

.03 Timing Function for Slope Controls

A means shall be provided to completely remove the timing function from the control sequence.

.04 Accuracy of Precision Current Slope Controls

Precision current slope controls shall slope the rms current such that the current does not deviate by more than 5 percent from that of a straight line originating at the starting heat value and extending to the ending heat value.

NEMA Standard 3-6-1985.

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Resistance Welding Control

NEMA

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such a way that the polarity of the voltage is reversed for the purpose of reducing the current to zero in a minimum amount of time.

NEMA Standard 7-13-1960.

Load Distribution Control

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Voltage Regulator

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NEMA Standard 9-19-1962.

Weld-safe

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NEMA Standard 7-27-1955.

ICS 5-001.05 TYPES OF TIMERS

Function Timer

A function timer is a device which controls the time interval between its initiation and the actuation of the output signal or relay contacts. Function timers can be serially connected to perform the functions of sequence weld timers as well as more complex sequences required by the welding process.

NEMA Standard 7-13-1960.

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Multiple Impulse Weld Timer

A multiple impulse weld timer is a device for multiple impulse welding which controls only the heat time, the cool time, and either the weld interval or the number of heat times.

NEMA Standard 7-13-1960.

Seam Weld Timer

A seam weld timer is a device for seam welding which controls the heat times and the cool times.

NEMA Standard 3-7-1946.

Sequence Timer

A sequence timer is a device for controlling: (1) sequence, and (2) duration of any or all of the elements of a complete resistance welding cycle except that control of the weld time or heat time is excluded; however, this device may also control other mechanical movements of the welding machine. Means are provided for initiating a separate weld timer or multiple impulse weld timer.

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Sequence Weld Timer

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NEMA Standard 7-13-1960.

Water Saver Timer

A water saver timer is a device which opens a water valve at the beginning of a weld sequence and closes it at a predetermined time after the end of a sequence.

NEMA Standard 7-27-1955.

Weld Timer

A weld timer is a device which controls only the weld time.

NEMA Standard 3-7-1946.

TIMING DIAGRAMS

ICS 5.001.06 SINGLE-PHASE WELD CYCLE DIAGRAMS

(Frequency Converter Weld Cycle Diagrams Appear in Part ICS 5-008.)

Weld Cycle Diagrams

Figures 5-001-2 through 5-001-10 represent a comprehensive picture of the factors involved in the welding process. Each figure is keyed to a NEMA type of control more completely described in Part ICS 5-006.

The abscissa represents time, based on the supply line frequency. Various related ordinates are shown as follows:

(a) "Welding process times" are defined in ICS 5-001.03 and refer to the welding process which includes time constants of the welding machine, contactors and associated equipment.

(b) "Current" graphically describes the current during the welding cycle, including welding current and current used during the preweld or post-weld intervals.

(c) "Electrode force" is the force at the electrode during the weld cycle. "Machine operating time" includes the time constants of the relays and welding machine.

(d) "Solenoid valve coil voltage" is the electrical signal which controls the motion of the electrodes and is shown in time relation to the electrode force.

(e) "Timer" times are defined entirely from Figures 5-001-2 through 5-001-10 since they are of necessity referenced to electrical signals. Thus a comparison of "current" and "solenoid valve coil voltage" signals determines the "timer" time definitions.

Authorized Engineering Information 3-13-1968.

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.01 Solenoid Valve Operation

A contact shall be in series with the valve contactor circuit to prevent spurious operation. This contact will be open when the control is in standby condition.

.02 Weld Firing Circuit

A contact shall be in series with the weld firing circuit to prevent spurious operation. This contact will be open when the control is in standby condition.

NEMA Standard 1-21-1964.

A damped oscillatory voltage surge, having a peak equal to 1.41 times the line voltage and a base frequency of 5000 hertz, shall be applied so that it is additive to the primary control power supply. The surge shall be applied in both positive and negative polarities of the control power supply.

NEMA Standard 9-19-1962.

The above is a design test for component failure, timing accuracy and detection of spurious operation.

Authorized Engineering Information 9-19-1962.

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Resistance Welding Control

NEMA

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ICS 5

Resistance Welding Control

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Foreword▲

This Standards Publication, together with the others listed below, supersedes and revises the indicated Standards Publication of the Industrial Control and Systems Section. Also included in these publications is the information separately printed as NEMA Standards Publication No. ICS 2.2-1983, *Maintenance of Motor Controllers After a Fault Condition.* Standards Publication No. ICS 3.1-1983, *Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems,* is a supplement to Standards Publication No. ICS 3-1983 and is not included.

Since Standards Publication No. ICS 1 applies as a general standard and Standards Publication No. ICS 6 applies to enclosures used for controls and systems apparatus, these two standards should be used in conjunction with each of the product standards.

NEMA Standards Publication No.	Supersedes
ICS 1-1983 *General Standards for Industrial Controls and Systems*	ICS 1-1978, formerly Part 1 (white pages) of NEMA Standards Publication No. ICS-1970, *Industrial Controls and Systems*
ICS 2-1983, *Industrial Control Devices, Controllers, and Assemblies*	ICS 2-1978, formerly Part 2 (green pages) of NEMA Standards Publication No. ICS-1970, *Industrial Controls and Systems*
ICS 3-1983, *Industrial Systems*	ICS 3-1978, formerly Part 3 (yellow pages) of NEMA Standards Publication No. ICS-1970, *Industrial Controls and Systems*
ICS 4-1983, *Terminal Blocks for Industrial Control Equipment and Systems*	ICS 4-1977, formerly NEMA Standards Publication No. IS 4-1968, *Terminal Blocks for Industrial Control Equipment and Systems*
ICS 5-1983, *Resistance Welding Control*	ICS 5-1978, formerly NEMA Standards Publication No. IS 5-1974, *Resistance Welding Control*
ICS 6-1983, *Enclosures for Industrial Controls and Systems*	ICS 6-1978, formerly NEMA Standards Publication No. IS 1.1-1977, *Enclosures for Industrial Controls and Systems;* and Part ICS 1-110 of NEMA Standards Publication No. ICS-1970, *Industrial Controls and Systems*

In November of 1983, unrevised portions of all NEMA Standards Publications for Industrial Control and Systems (the ICS series) were reaffirmed.

This Standards Publication provides practical information concerning ratings, construction, test, performance, and manufacture of industrial control equipment. These standards are used by the electrical industry to provide guidelines for the manufacture and proper application of reliable products and equipment and to promote the benefits of repetitive manufacturing and widespread product availability.

NEMA standards represent the result of many years of research, investigation and experience by the members of NEMA, its predecessors, its Sections and Committees. They have been developed through continuing consultation among manufacturers, users and national engineering societies and have resulted in improved serviceability of electrical products with economies to manufacturers and users.

One of the primary purposes of this Standards Publication is to encourage the production of reliable control equipment which, in itself, functions in accordance with these accepted standards. Some portions of these standards, such as electrical spacings and interrupting ratings, have a direct bearing on safety; almost all of the items in the publication, when applied properly, contribute to safety in one way or another.

Properly constructed industrial control equipment is, however, only one factor in minimizing the hazards which may be associated with the use of electricity. The reduction of hazard involves the joint efforts of the various equipment manufacturers, the system designer, the installer and the user. Information is provided herein to assist users and others in the proper selection of control equipment.

▲ Editorially revised.

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The industrial control manufacturer has limited or no control over the following factors which are vital to a safe installation:

1. Environmental conditions.
2. System design.
3. Equipment selection and application.
4. Installation.
5. Operating practices.
6. Maintenance.

This publication is not intended to instruct the user of control equipment with regard to these factors except insofar as suitable equipment to meet needs can be recognized in this publication and some application guidance is given.

This Standards Publication is necessarily confined to defining the construction requirements for industrial control equipment and to providing recommendations for proper selection for use under normal or certain specific conditions. Since any piece of industrial control equipment can be installed, operated and maintained in such a manner that hazardous conditions may result, conformance with this publication does not by itself assure a safe installation. When, however, equipment conforming with these standards is properly selected and is installed in accordance with the *National Electrical Code* and properly maintained, the hazards to persons and property will be reduced.

NEMA Standards Publications are subject to periodic review. They are revised frequently to reflect user input and to meet changing conditions and technical progress. Users should secure the latest editions. See the postal return card attached to the front cover of the Standards Publication for the proper procedure to obtain revision service for your copy of the publication.

Proposed revisions to this Standands Publication should be submitted to:

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Scope

The standards of the Resistance Welding Group are periodically reviewed by a Joint Committee on Resistance Welding Controls consisting of representatives from both the National Electrical Manufacturers Association (NEMA) and the Resistance Welding Manufacturers Association (RWMA).

Scope of Resistance Welding Group

Control principally used to start, stop and/or control the operations of resistance welding machines.

Excluded from the product scope of this section are:

1. Automatic electric controls and panels of the types principally used in air-conditioning, refrigeration and comfort heating, which are in the scope of the Residential Controls Section.
2. Motors, generators, and motor-generators which function as control when constituting parts of adjustable-speed drives.
3. Controls of the type used specifically for railway and railroad locomotion.
4. Renewal parts.
5. Data logging and processing equipment other than industrial.
6. Temperature and humidity control.

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Part ICS 5-001

DEFINITIONS AND TIMING DIAGRAMS

The standards in this part apply to all other parts of this publication unless otherwise specified. The definitions and standards of NEMA Standards Publication No. ICS 1 apply to this part unless otherwise specified.

DEFINITIONS

ICS 5-001.01 TYPES OF WELDING

Faying Surfaces

A faying surface is that surface of a member which is in contact with another member to which it is to be joined.

NEMA Standard 7-13-1960.

Flash Welding

Flash welding is a resistance welding process wherein coalescence is produced, simultaneously over the entire area of abutting surfaces, by the heat obtained from resistance to electric current between the two surfaces, and by the application of pressure after heating is substantially completed. Flashing and upsetting are accompanied by expulsion of metal from the joint.

NEMA Standard 9-19-1962.

Multiple Impulse Welding

Multiple impulse welding is the making of spot, projection or upset welds by more than one impulse of current. When alternating current is used, each impulse may consist of a fraction of a cycle or a number of cycles.

NEMA Standard 1-22-1954.

Projection Welding

Projection welding is a resistance welding process wherein coalescence is produced by the heat obtained from resistance to electric current through the work parts held together under pressure by electrodes. The resulting welds are localized at predetermined points by the design of the parts to be welded. The localization is usually accomplished by projections, embossments or intersections.

NEMA Standard 9-19-1962.

Resistance Seam Welding

Resistance seam welding is a welding process wherein coalescence at the faying surfaces is produced by the heat obtained from resistance to electric current through the work parts held together under pressure by circular electrodes. The resulting weld is a series of overlapping spot welds made progressively along a joint by rotating the electrodes.

NEMA Standard 9-19-1962.

Resistance Spot Welding

Resistance spot welding is a welding process wherein coalescence at the faying surfaces is produced by the heat obtained from resistance to electric current through the work parts held together under pressure by electrodes. The size and shape of the individually formed welds are limited primarily by the size and contour of the electrodes.

NEMA Standard 9-19-1962.

Resistance Welding

Resistance welding is a group of welding processes wherein coalescence is produced by the heat obtained from resistance of the work to electric current in a circuit of which the work is a part, and by the application of pressure.

NEMA Standard 9-19-1962.

Roll-spot Welding

Roll-spot welding is the making of separated spot welds with one or more rotating circular electrodes. The rotation of the electrodes may or may not be stopped during the making of a weld.

NEMA Standard 7-13-1960.

Single Impulse Welding

Single impulse welding is the making of spot, projection or upset welds by a single impulse of current. When alternating current is used, an impulse may consist of a fraction of a cycle or a number of cycles.

NEMA Standard 1-22-1954.

Single-phase Resistance Welding

Single-phase resistance welding is a resistance welding process in which welding current is supplied at the same frequency as the single-phase power supply.

NEMA Standard 1-22-1954.

Stored Energy Welding

Stored energy welding is the making of a weld with electrical energy accumulated electrostatically, electromagnetically or electrochemically, at a relatively low rate and made available at the required welding rate.

NEMA Standard 1-22-1954.

Upset Welding

Upset welding is a resistance welding process wherein coalescence is produced, simultaneously over the entire area of abutting surfaces or progressively along a joint, by the heat obtained from resistance to electric current through the area of contact of those surfaces. Pressure is applied before heating is started and is maintained throughout the heating period.

NEMA Standard 9-19-1962.

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ICS 5-001.02 TYPES OF CURRENT

Alternate Polarity Operation

Alternate polarity operation is the mode of operation in which succeeding welds are made with impulses of opposite polarity.

NEMA Standard 7-13-1960.

Impulse

An impulse is an essentially continuous alternating or direct current. An impulse consists of a single pulse or of a series of pulses. The pulses may be separated by interpulse time.

NEMA Standard 9-19-1962.

Low-frequency Cycle

A low-frequency cycle consists of one positive and one negative pulse of current at a frequency lower than the power supply frequency and occurs during the same weld time or heat time.

NEMA Standard 9-19-1962.

Postheat Current

Postheat current is that part of the welding current which occurs during postheat time.

NEMA Standard 9-19-1962.

Preheat Current

Preheat current is an impulse or series of impulses of current which occurs prior to and separated from welding current.

NEMA Standard 9-19-1962.

Pulse

A pulse is a current of controlled duration of either polarity through the welding circuit.

NEMA Standard 9-19-1962.

Unipolarity Operation

Unipolarity operation is the mode of operation in which succeeding welds are made with impulses of the same polarity.

NEMA Standard 7-13-1960.

Welding Current

Welding current is the current in the welding circuit during the making of a weld and is exclusive of the current during preweld or postweld intervals.

NEMA Standard 9-19-1962.

ICS 5-001.03 TYPES OF TIMES

In order to clarify the definitions with regard to "times," typical resistance welding cycle diagram figures are included in this part of the standards. Word definitions which follow refer to "times" associated with the welding process and are compatible with the American Welding Society definitions of similar terms. However, the control industry has found it necessary to provide timers which are referenced to known electrical signals since time constants of the welding machine, contactors, and associated equipment are variable factors which are difficult if not impossible to predetermine. Timer definitions are defined graphically on the figures. In many instances the controls are arranged to compensate for variable factors by providing additional or unusual timing arrangements such as "squeeze delay time." Therefore, the figures include the "welding process times" as well as the "timer times" with reference to appropriate electrical signals. The machine operating times are noted for convenience.

It has been possible to develop standards for many types of controls. The figures contain references to those type numbers. Definitions of control types, including timer ranges and accuracies, are found in appropriate charts and paragraphs in Part ICS 5-006 and 5-007.

NEMA Standard 1-22-1954.

EXAMPLE—A squeeze timer setting is shown on Fig. 5-001-2. The timing period begins at the instant when solenoid valve coil voltage is applied and ends at the instant welding current begins. The control type N2 shown on Fig. 5-001-2 is described in ICS 5-006.03 which indicates that a 3B sequence weld timer is used. ICS 5-006.01 shows the squeeze timer range to be 3-120 cycles.

▲Authorized Engineering Information 1-22-1954.

Cool Time

In multiple impulse and seam welding, cool time is the time interval between successive heat times.

NEMA Standard 1-22-1954.

Down-slope time

In spot, seam, projection and upset welding, down-slope time is the time during which the welding current continuously decreases from the end of weld heat time.

NEMA Standard 1-22-1954.

Forge-delay Time

In a single-phase control, forge-delay time is the time elapsing between the beginning of weld time or weld interval and the instant of application of maximum forging force.

NEMA Standard 7-13-1960.

Heat Time

In multiple impulse and seam welding, heat time is the time that current occurs during any one impulse.

NEMA Standard 9-19-1962.

Hold Time

In spot and projection welding, hold time is the time during which force is applied at the point of weld after the last impulse of current ceases.

In seam, flash and upset welding, hold time is the time during which force is applied to the work after current ceases.

NEMA Standard 9-19-1962.

Interpulse Time

Interpulse time is the time between successive pulses of current within the same impulse.

NEMA Standard 1-22-1954.

▲ Editorially revised.

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Off Time

Off time is the time during which the electrodes are off the work. This term is generally applied where the weld cycle is repetitive.

NEMA Standard 3-7-1946.

Post-heat Time

Post-heat time is the time from the end of weld-heat time or the end of weld interval heat time to the end of weld time or weld interval, respectively.

NEMA Standard 7-13-1960.

Post-weld Interval

Post-weld interval is the total time elapsing between the end of welding current and the start of hold time.

NEMA Standard 9-19-1962.

Preheat Time

Preheat time is that part of the preweld interval during which preheat current occurs.

NEMA Standard 9-19-1962.

Preweld Interval

Preweld interval is the time elapsing between the end of squeeze time and the beginning of welding current. In flash welding, the preweld interval is the time during which the material is preheated.

NEMA Standard 9-19-1962.

Pulse Time

Pulse time is the duration of a pulse.

NEMA Standard 1-22-1954.

Quench Time

Quench time is that part of the post-weld interval from the end of weld time or weld interval to the beginning of temper time.

NEMA Standard 7-13-1960.

Squeeze Time and Squeeze Delay Time

Squeeze time is the time interval between the initial application of the electrode force on the work and the first application of current. When precompression is used, squeeze time is the time interval between the initial application of the electrode force on the work and the application of maximum force on the work.

Squeeze delay time is that additional squeeze time at the start of a repeat sequence to permit the movement of the electrodes through a greater distance. An equivalent result may be obtained by using an initial squeeze time greater than the subsequent squeeze times in a repeat sequence.

NEMA Standard 7-13-1960.

Temper Time

Temper time is that part of the post-weld interval during which temper current occurs.

NEMA Standard 9-19-1962.

Up-slope Time

In spot, seam, projection and upset welding, up-slope time is the time during which the welding current continuously increases from the beginning of welding current.

NEMA Standard 9-19-1962.

Weld Cycle

Weld cycle is the complete series of events involved in the making of a weld.

NEMA Standard 7-27-1955.

Weld-delay Time

Weld-delay time is the time by which the beginning of welding current is delayed with respect to the initiation of the forge-delay timer in order to synchronize the forging force with welding current.

NEMA Standard 9-19-1962.

Weld-heat Time

Weld-heat time is the time from the beginning of welding current to the beginning of post-heat time.

NEMA Standard 9-19-1962.

Weld Interval

In multiple impulse welding, weld interval is the total of all heat and cool times.

NEMA Standard 1-22-1954.

Weld Interval Heat Time

In a single-phase control, weld interval heat time is the time in multiple impulse welding from the beginning of welding current to the beginning of post-heat time.

NEMA Standard 9-19-1962.

Weld Time

In single impulse and flash welding, weld time is the time during which welding current is applied to the work in making a weld.

NEMA Standard 1-22-1954.

ICS 5-001.04 TYPES OF CONTROLS

Current Regulator

A current regulator for resistance welding is a device which operates to maintain the rms current in the primary of a resistance welder transformer at a predetermined value or predetermined pattern of values.

NEMA Standard 7-13-1960.

Dual Gun Control

A dual gun control is a control which provides for initiating control from a second gun with the switching of the solenoid valve circuit to this gun. The initiation circuits are interlocked to prevent operation of the unselected gun while the selected initiation circuit is closed.

NEMA Standard 9-28-1961.

When required by the particular application, additional dual functions (such as, dual weld time, dual heat, etc.) should be specified. Under dual gun operation, both guns are electrically connected to the welding transformer(s) at all times.

Authorized Engineering Information 9-28-1961.

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Dual Gun Dual Sequence Control

A dual gun dual sequence control is a control which provides for initiating control from a second gun with the switching of the solenoid valve circuit to this gun. The initiation circuits are interlocked to prevent operation of the unselected gun while the selected initiation circuit is closed. This control has an additional set of separate adjustments for squeeze, weld, hold, and off. When used with heat control, this control has a separate heat adjuster.

NEMA Standard 7-13-1960.

Dual Heat Control

There are two methods of dual heat control, as follows:

(a) Dual heat by internal switching means with external selection. See Fig. 5-001-1.

Dual heat allows a change in heat through internal switching means controlled by an external means with no discontinuity of the weld current. The figure shown below is a functional representation.

(b) Dual heat by dual initiation

NEMA Standard 5-12-1969.

Electronic Frequency Converter Control

An electronic frequency converter control is a device which converts the welding power from the frequency of the power supply to a different frequency.

NEMA Standard 9-19-1962.

Electronic Heat Control

Electronic heat control is a device for adjusting the rms value of the current in making a resistance weld by controlling the ignition or firing of the tubes in an electronic contactor. The current is initiated each half-cycle at an adjustable time with respect to a zero point on the voltage wave.

NEMA Standard 9-19-1962.

Ignitron Thermal Switch

An ignitron thermal switch is a temperature-sensitive device for detecting an overtemperature condition of the ignitron tube.

NEMA Standard 1-21-1964.

Inversion

Inversion, as applied to an electronic frequency converter control, is the action of retarding the firing angle of the electronic power tubes near the end of a pulse in

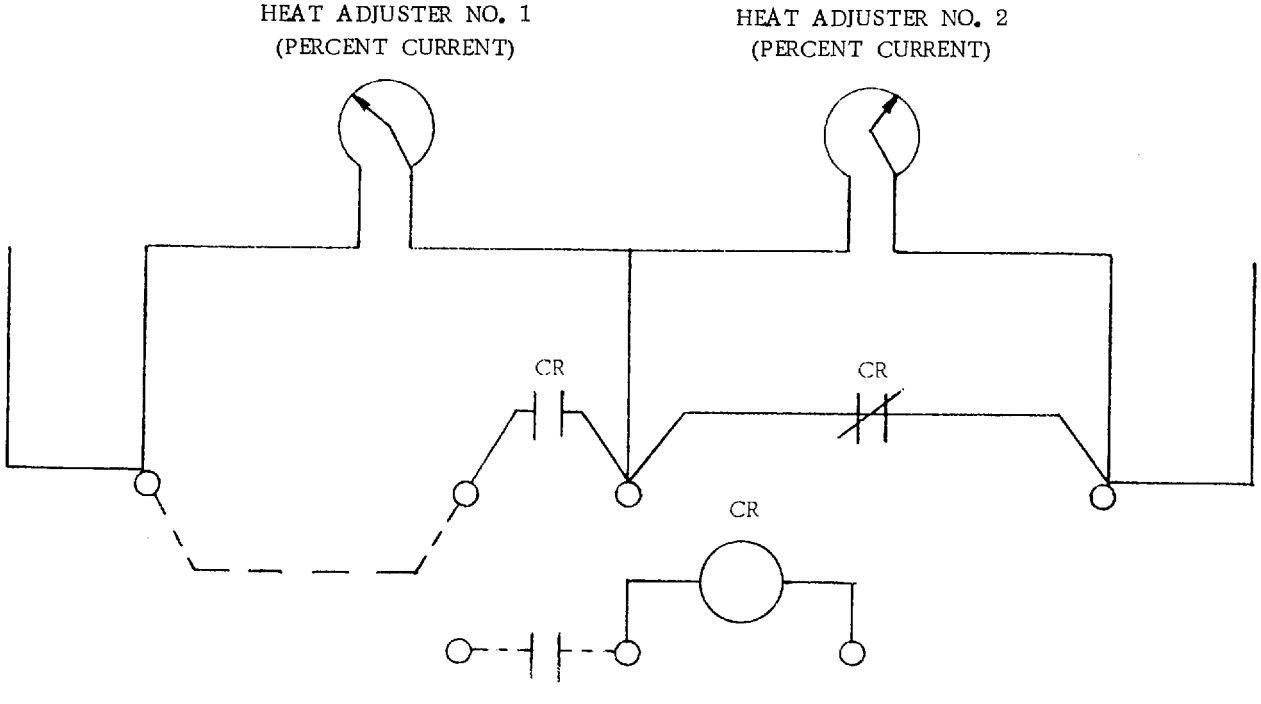


Fig. 5-001-1
EXTERNAL SELECTOR

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such a way that the polarity of the voltage is reversed for the purpose of reducing the current to zero in a minimum amount of time.

NEMA Standard 7-13-1960.

Load Distribution Control

A load distribution control is a device intended for use with resistance welding machines having two or more welding transformers, the control being arranged to distribute the load by energizing the welding transformers in sequence on one or more phases or simultaneously on two or more phases.

NEMA Standard 6-22-1950.

Load Scanning

Load scanning as applied to resistance welding process is a control system for limiting the application of loads to prevent the supply voltage from dropping below a predetermined level at the welding station(s).

NEMA Standard 11-21-1968.

Method of Initiation—Delayed Firing

Delayed firing is the delayed initiation of the first half cycle of weld current with respect to the voltage wave in order to minimize the initial transient of magnetizing current of the welding transformer.

NEMA Standard 7-13-1960.

Nonbeat Control

Nonbeat control is the feature or method of connection which provides that, once the welding cycle has been initiated from the pilot switch, the welding cycle will then be carried through to completion, regardless of whether or not the pilot switch remains closed.

NEMA Standard 3-7-1946.

Nonrepeat Control

Nonrepeat control is the feature or method of connection which provides that, once the welding cycle has been initiated from the pilot switch, only one welding cycle will result. The pilot switch must be opened and reclosed for each additional welding cycle.

NEMA Standard 3-7-1946.

Repeat Control

Repeat control is the feature or method of connection which provides that, once the welding cycle has been initiated from the pilot switch, the welding cycle will be repeated after a controlled time interval (off time) as long as the pilot switch remains closed.

NEMA Standard 3-7-1946.

Retraction Valve Control

A retraction valve control is a device which provides for controlling a retraction solenoid valve by means of a pilot system.

NEMA Standard 1-21-1964.

Synchronous Timing

Synchronous timing is the initiation and termination of each half-cycle of welding transformer primary current so that each half-cycle of such current is the same whether in the same or succeeding welds.

NEMA Standard 3-7-1946

Two-stage Pilot-switch Control

Two-stage pilot-switch control is the feature or method of connection which provides that the closure of the first stage of the pilot switch will energize the electrode force actuating means and a second stage will initiate the weld sequence. The closure of the second stage may or may not follow immediately the closure of the first stage. The first stage shall be nonbeat after closing the second stage.

In two-stage pilot-switch operation, the second stage shall not be capable of being initiated if the first stage is open.

Squeeze time shall start at the closure of the first stage of a 2-stage foot switch.

NEMA Standard 5-12-1969.

Voltage Compensator

A voltage compensator is a device which operates to maintain the primary rms current during line voltage fluctuations.

NEMA Standard 3-6-1985.

Voltage Regulator

A voltage regulator for resistance welding is a device which operates to maintain voltage on the primary of a resistance welder transformer at a predetermined pattern of values.

NEMA Standard 8-10-1949.

Voltage-Variations—Gradual and Sudden

The term "gradual voltage variation" as used in these standards is a change in rms line voltage at a rate of less than one percent per second.

The term "sudden voltage variation" as used in these standards is a change in rms line voltage at a greater rate than one percent per second.

NEMA Standard 9-19-1962.

Weld-Safe

In a weld-safe device, the termination of weld time is not dependent upon conduction of a single electronic tube.

NEMA Standard 7-27-1955.

ICS 5-001.05 TYPES OF TIMERS

Function Timer

A function timer is a device which controls the time interval between its initiation and the actuation of the output signal or relay contacts. Function timers can be serially connected to perform the functions of sequence weld timers as well as more complex sequences required by the welding process.

NEMA Standard 7-13-1960.

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Multiple Impulse Weld Timer

A multiple impulse weld timer is a device for multiple impulse welding which controls only the heat time, the cool time, and either the weld interval or the number of heat times.

NEMA Standard 7-13-1960.

Seam Weld Timer

A seam weld timer is a device for seam welding which controls the heat times and the cool times.

NEMA Standard 3-7-1946.

Sequence Timer

A sequence timer is a device for controlling: (1) sequence, and (2) duration of any or all of the elements of a complete resistance welding cycle except that control of the weld time or heat time is excluded; however, this device may also control other mechanical movements of the welding machine. Means are provided for initiating a separate weld timer or multiple impulse weld timer.

NEMA Standard 7-13-1960.

Sequence Weld Timer

A sequence weld timer is a device which performs the functions of a sequence timer and the functions of either a weld timer or a multiple impulse weld timer.

NEMA Standard 7-13-1960.

Water Saver Timer

A water saver timer is a device which opens a water valve at the beginning of a weld sequence and closes it at a predetermined time after the end of a sequence.

NEMA Standard 7-27-1955.

Weld Timer

A weld timer is a device which controls only the weld time.

NEMA Standard 3-7-1946.

TIMING DIAGRAMS

ICS 5.001.06 SINGLE-PHASE WELD CYCLE DIAGRAMS

(Frequency Converter Weld Cycle Diagrams Appear in Part ICS 5-008.)

Weld Cycle Diagrams

Figures 5-001-2 through 5-001-10 represent a comprehensive picture of the factors involved in the welding process. Each figure is keyed to a NEMA type of control more completely described in Part ICS 5-006.

The abscissa represents time, based on the supply line frequency. Various related ordinates are shown as follows:

(a) "Welding process times" are defined in ICS 5-001.03 and refer to the welding process which includes time constants of the welding machine, contactors and associated equipment.

(b) "Current" graphically describes the current during the welding cycle, including welding current and current used during the preweld or post-weld intervals.

(c) "Electrode force" is the force at the electrode during the weld cycle. "Machine operating time" includes the time constants of the relays and welding machine.

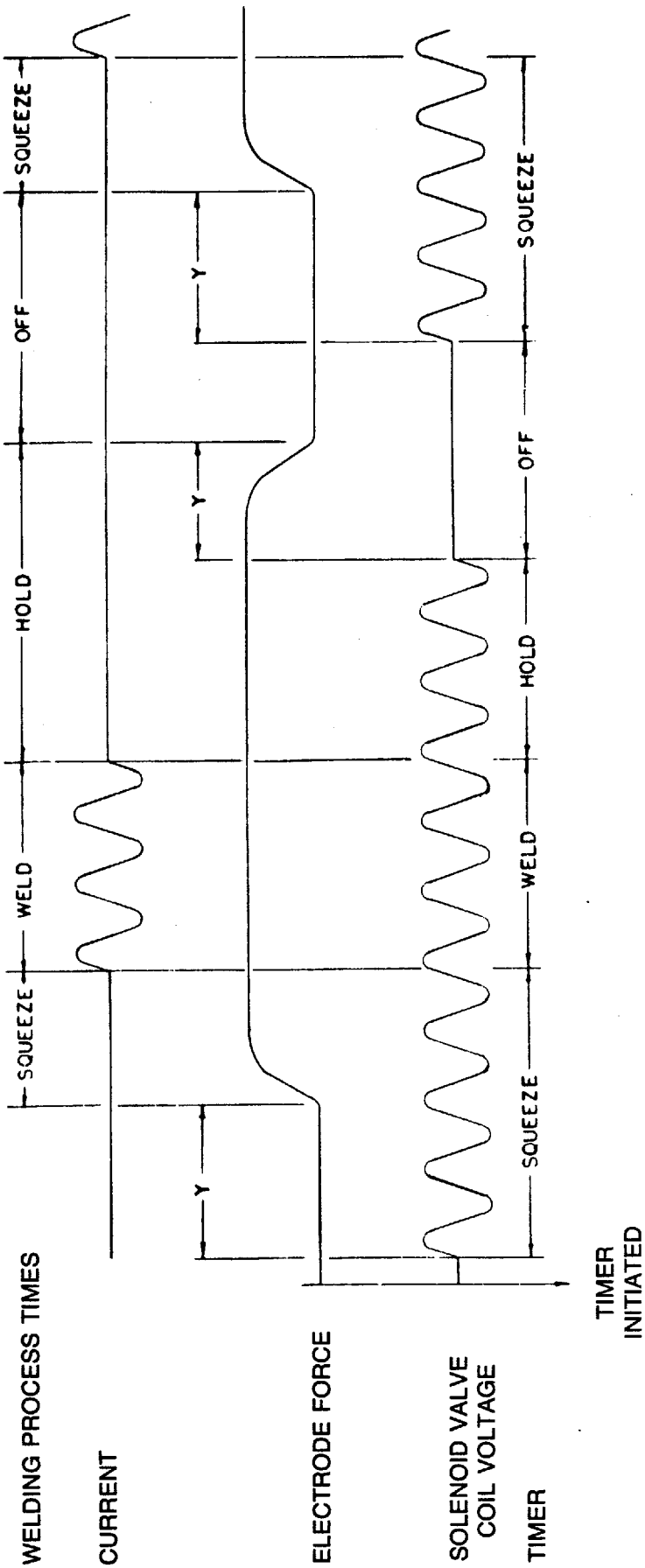
(d) "Solenoid valve coil voltage" is the electrical signal which controls the motion of the electrodes and is shown in time relation to the electrode force.

(e) "Timer" times are defined entirely from Figures 5-001-2 through 5-001-10 since they are of necessity referenced to electrical signals. Thus a comparison of "current" and "solenoid valve coil voltage" signals determines the "timer" time definitions.

Authorized Engineering Information 3-13-1968.

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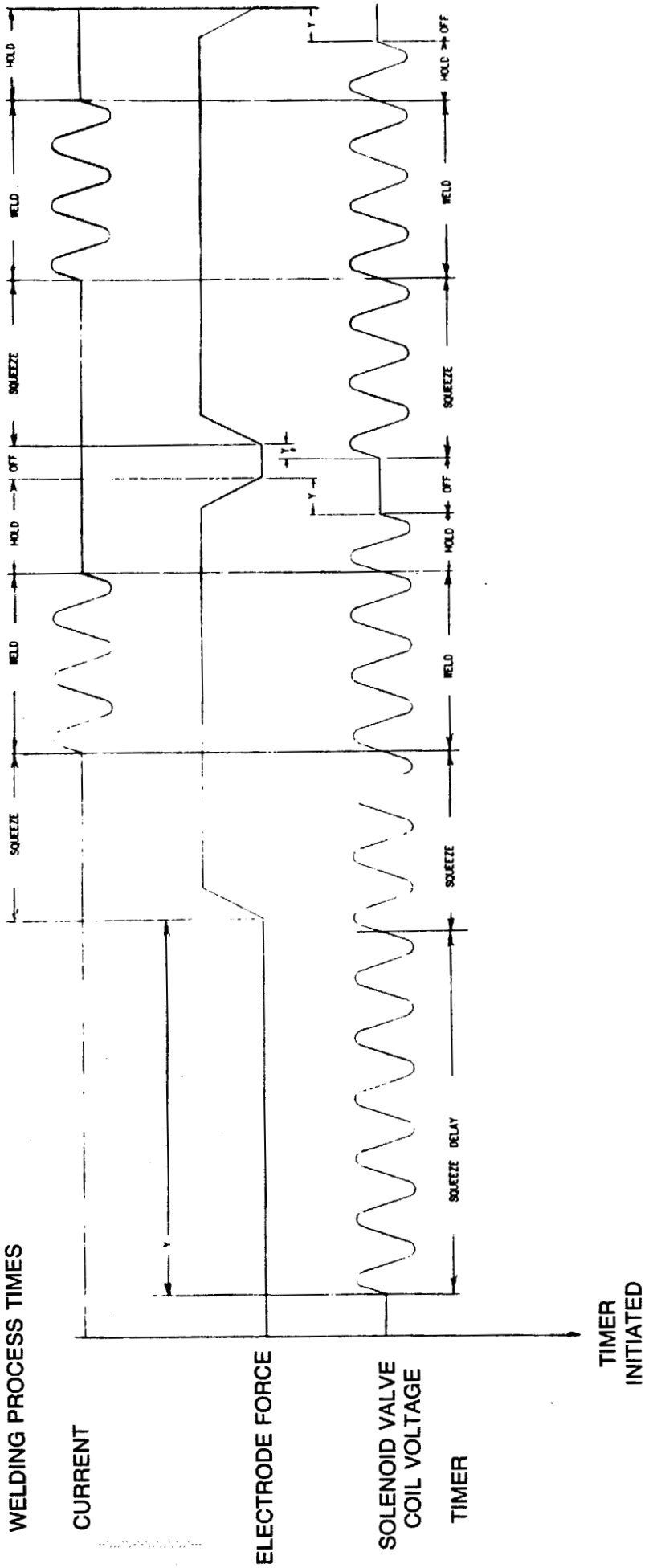


Y = Machine Operating Time

Fig. 5-001-2
SIMPLE WELD CYCLE (REPEAT) SIMULATES FUNCTIONS OF NEMA TYPE N2

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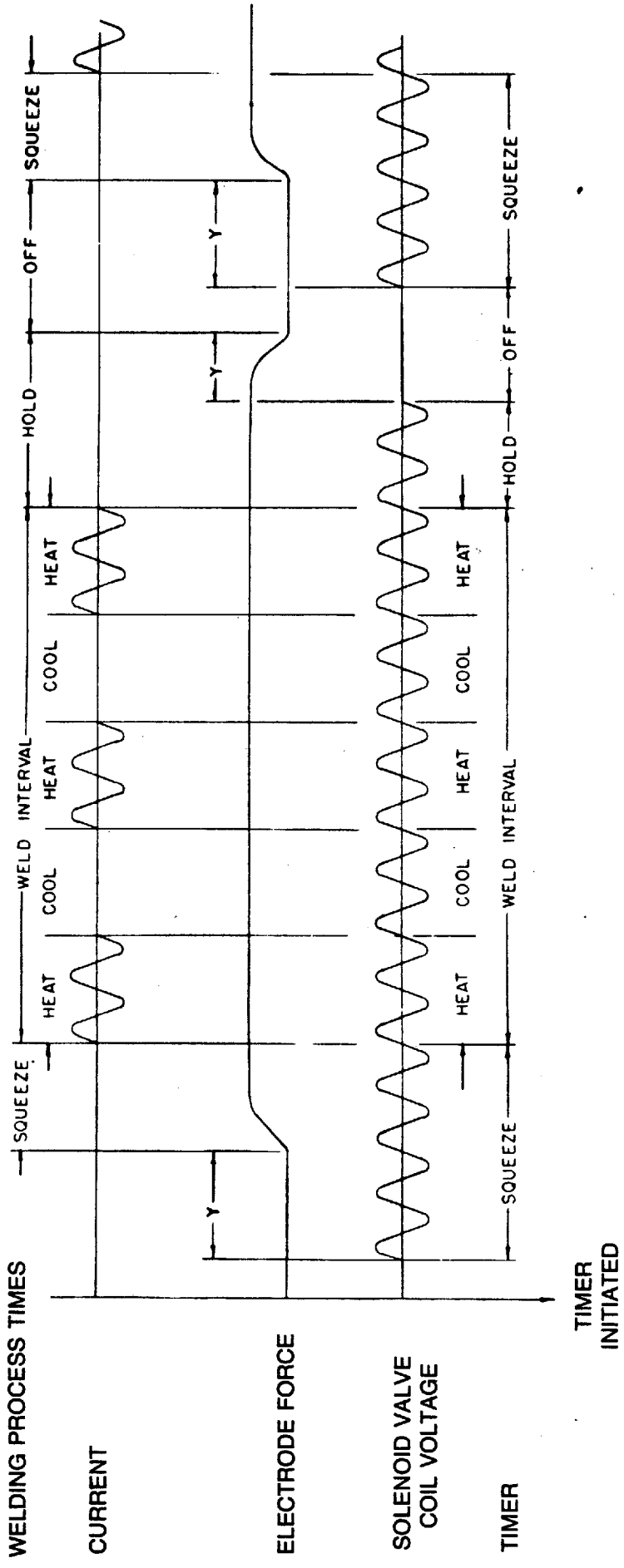
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Y = Machine Operating Time

Fig. 5-001-3
HIGH-SPEED WELD CYCLE (REPEAT) ILLUSTRATING SQUEEZE DELAY SIMULATES FUNCTIONS OF NEMA TYPE N6

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Y = Machine Operating Time

Fig. 5-001-4
SIMPLE MULTIPLE IMPULSE WELD CYCLE (REPEAT) SIMULATES FUNCTIONS OF NEMA TYPE N3

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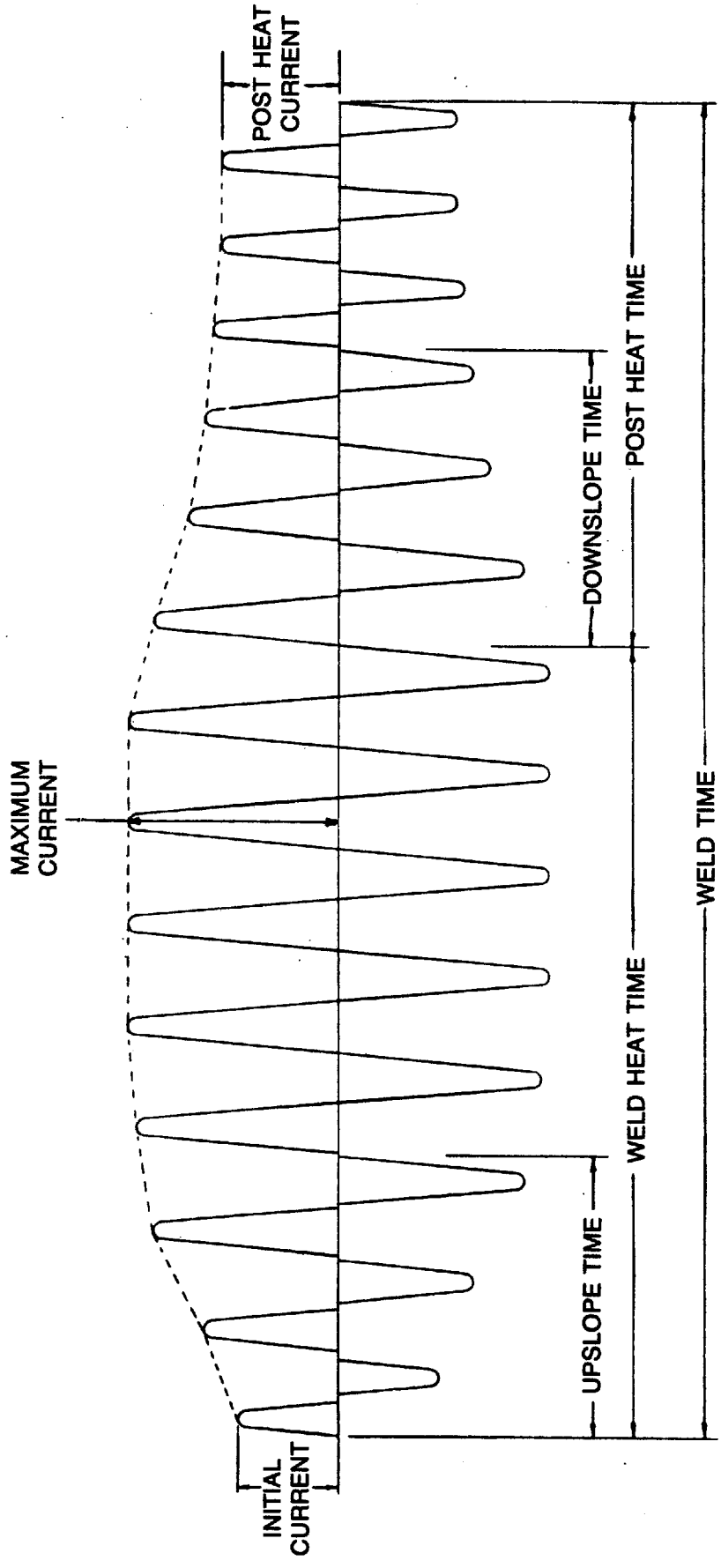


Fig. 5-001-5
WELDING CURRENT WITH SLOPE CONTROL SIMULATES FUNCTIONS OF NEMA TYPE N1AUD OR S1UD

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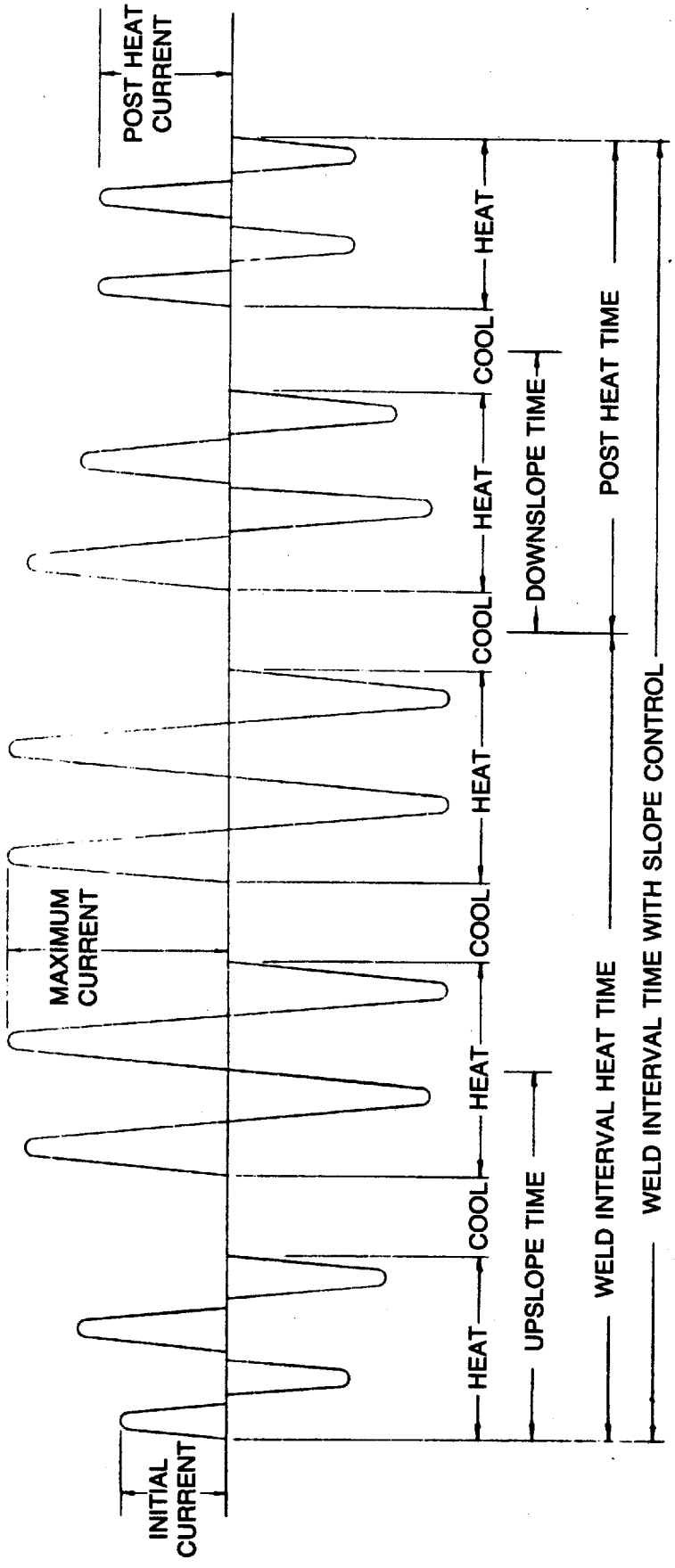
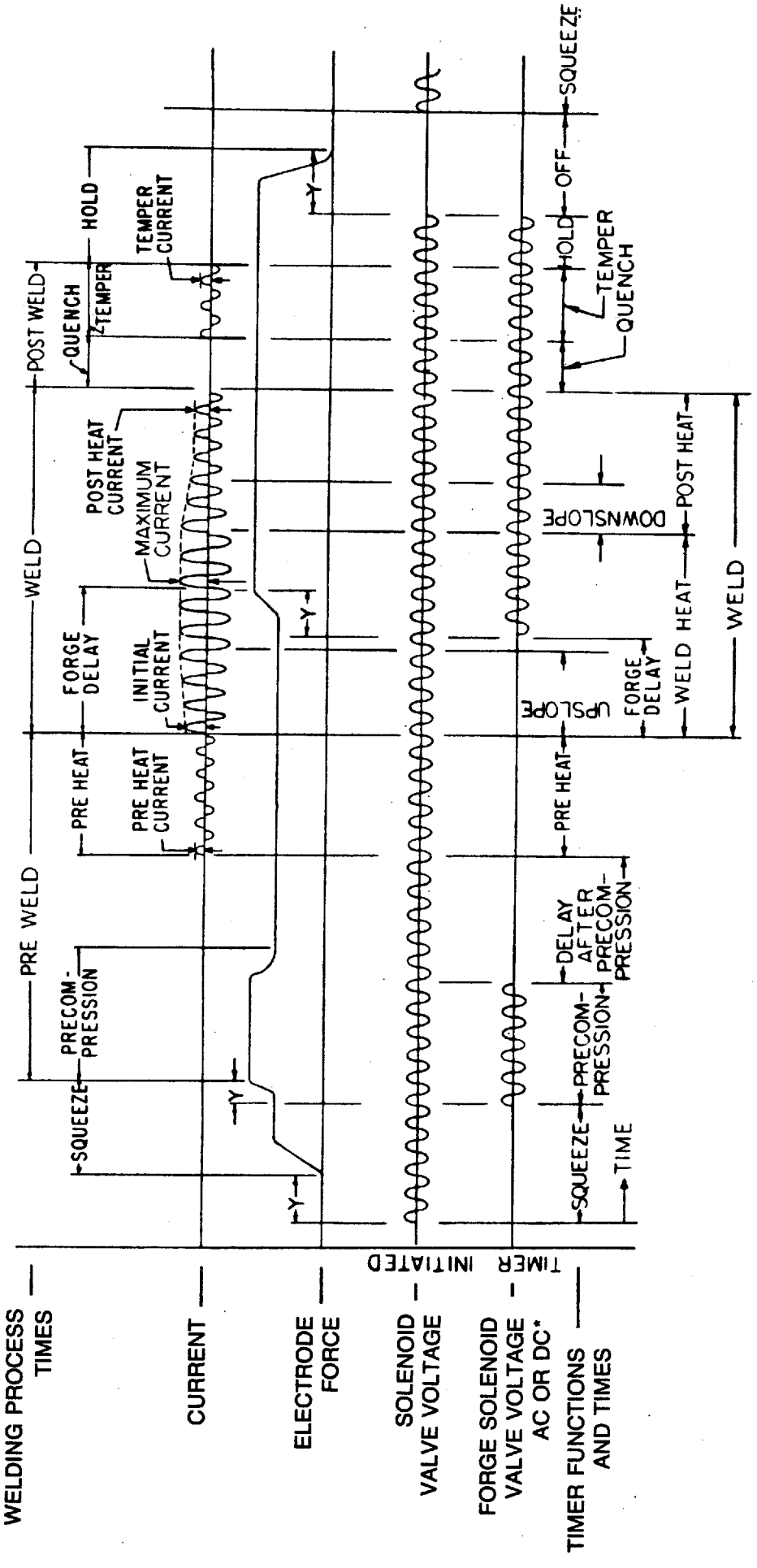


Fig. 5-001-6
WELD INTERVAL WELDING CURRENT WITH SLOPE CONTROL SIMULATES FUNCTIONS OF NEMA TYPE N1BUD

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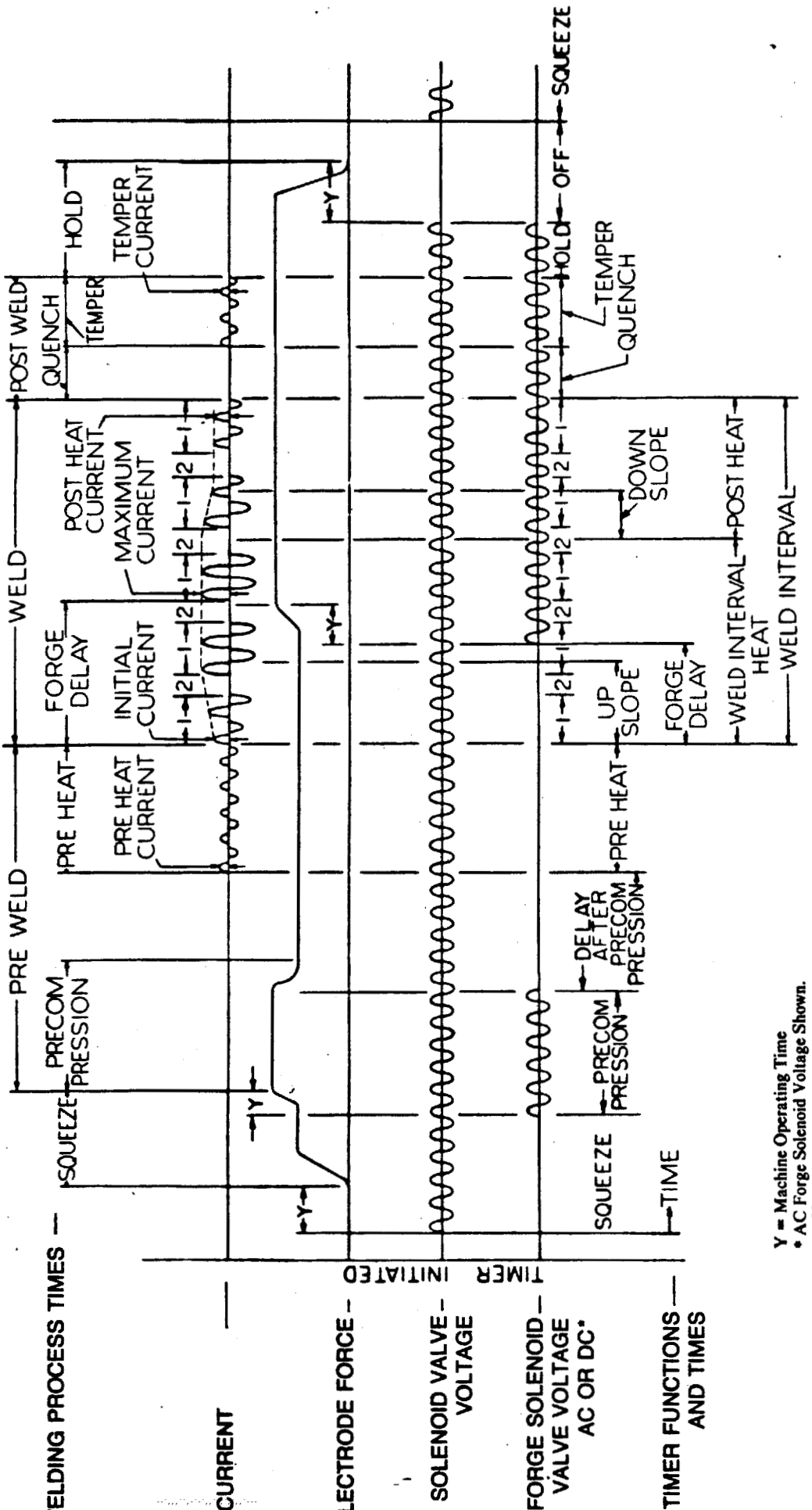


Y = Machine Operating Time
* AC Forge Solenoid Voltage Shown

NOTE—When weld delay is required, it occurs before the start of weld time; forge delay time then will be initiated at the beginning of weld delay time. Both preheat and weld delay are not used in the same sequence.

Fig. 5-001-7
COMPLEX WELD CYCLE—SINGLE IMPULSE SIMULATES FUNCTIONS OF NEMA TYPE N2UDFTPZ OR S2UDFTPZ WHERE Z DENOTES PRECOMPRESSION AND DELAY AFTER PRECOMPRESSION FUNCTIONS TO BE SPECIFIED

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Y = Machine Operating Time
* AC Forge Solenoid Voltage Shown.
1 = Heat
2 = Cool

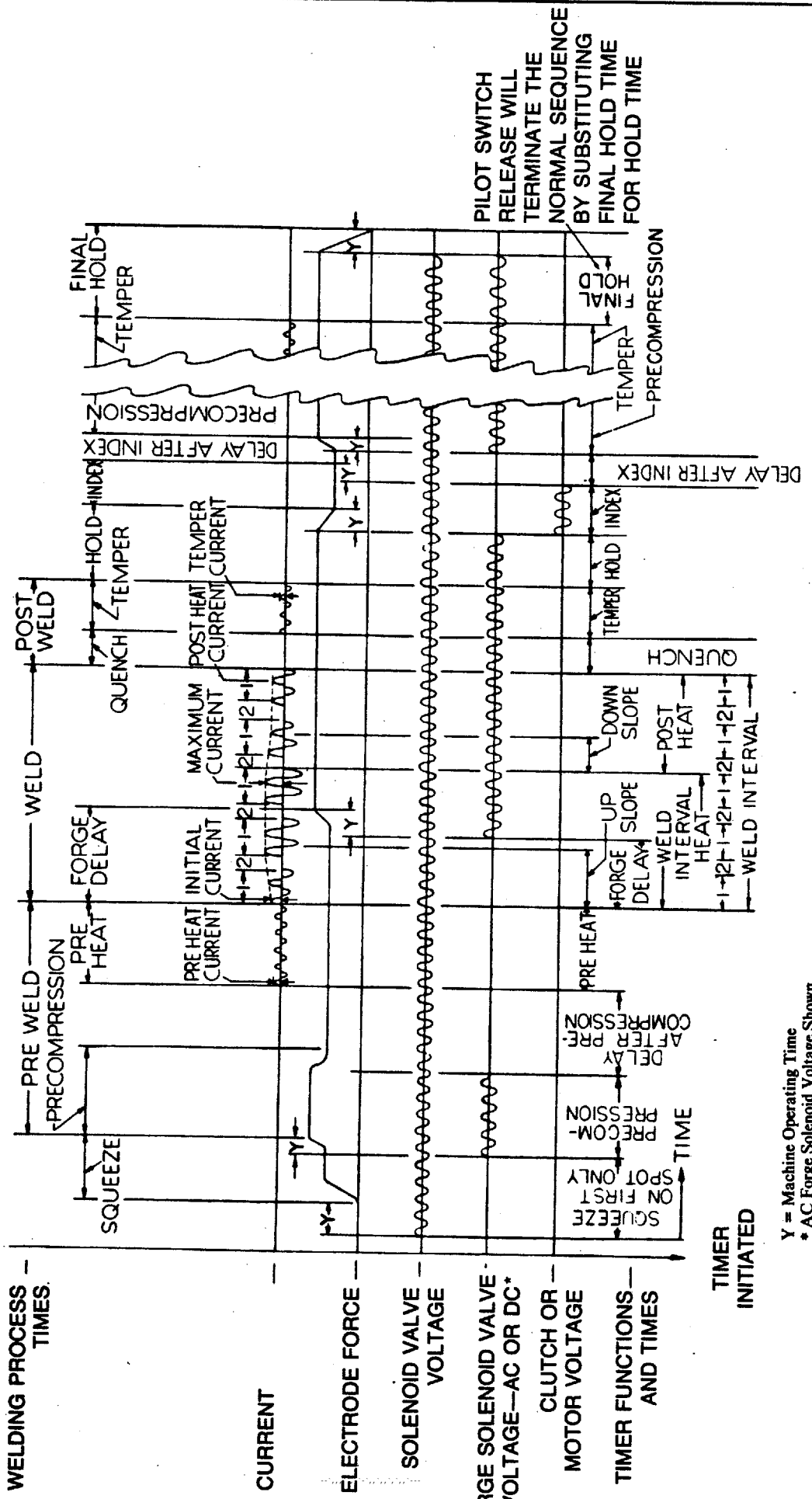
NOTE—When weld delay is required, it occurs before the start of weld time; forge delay time then will be initiated at the beginning of weld delay time. Both preheat and weld delay are not used in the same sequence.

Fig. 5-001-8
COMPLEX WELD CYCLE—MULTIPLE IMPULSE SIMULATES FUNCTIONS OF NEMA TYPE N3UDFTPZ OR S3UDFTPZ WHERE Z DENOTES PRECOMPRESSION AND DELAY AFTER PRECOMPRESSION FUNCTIONS TO BE SPECIFIED

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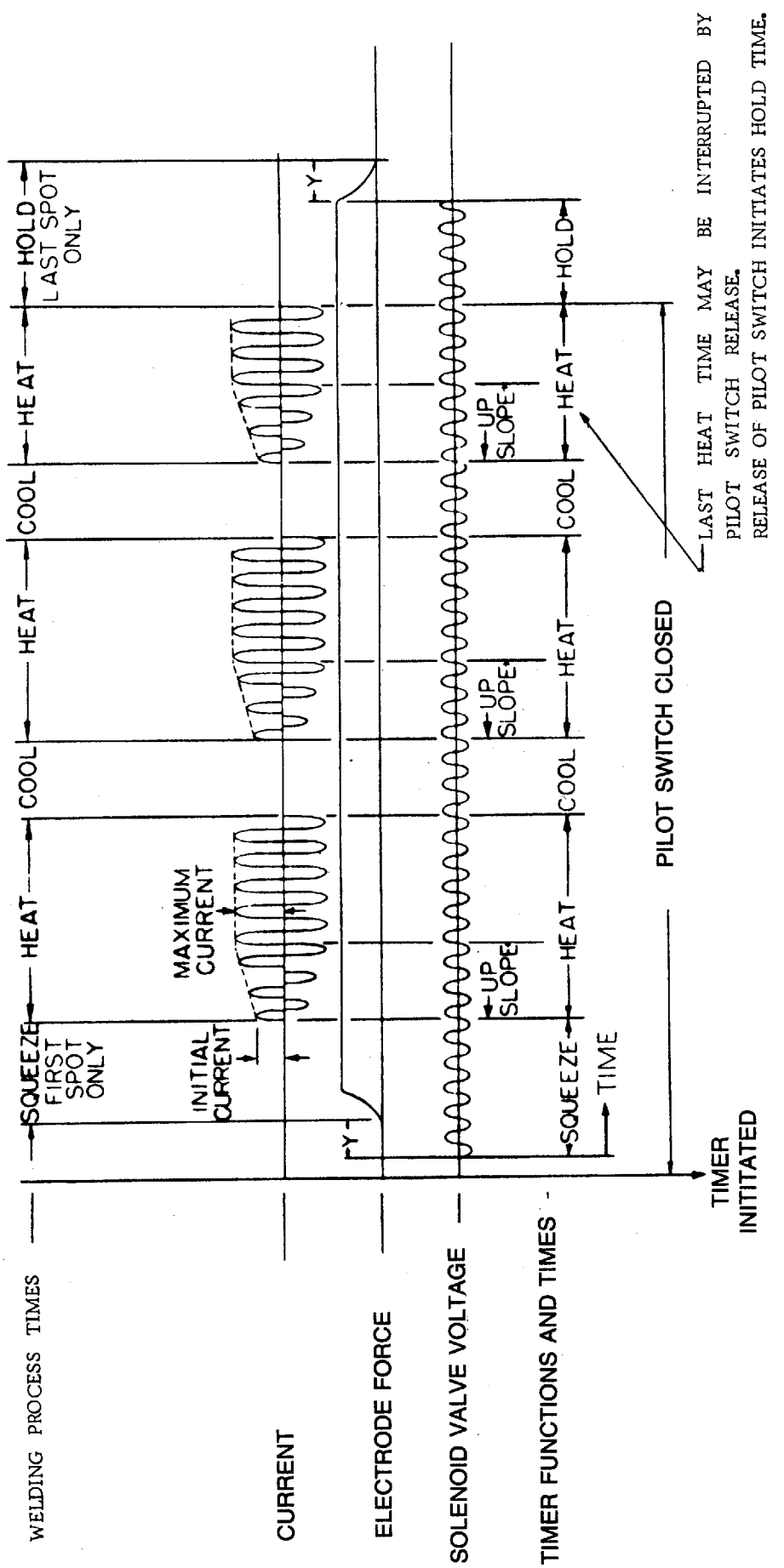
Y = Machine Operating Time
* AC Forge Solenoid Voltage Shown.
1 = Heat
2 = Cool

NOTE—When weld delay is required, it occurs before the start of weld time; forge delay time then will be initiated at the beginning of weld delay time. Both preheat and weld delay are not used in the same sequence.

Fig. 5-001-9
INTERMITTENT INDEX ROLL SPOT WITH COMPLEX WELD CYCLE SIMULATES FUNCTIONS OF NEMA TYPE S4UDFTPRZ WHERE Z DENOTES PRECOMPRESSION AND DELAY AFTER PRECOMPRESSION FUNCTIONS TO BE SPECIFIED

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Y = Machine Operating Time

Fig. 5-001-10
SEAM WELD CYCLE (WITH SLOPE CONTROL)—SINGLE IMPULSE SIMULATES FUNCTIONS OF NEMA TYPE S5UZ WHERE Z DENOTES ADDITIONAL SQUEEZE AND HOLD FUNCTIONS TO BE SPECIFIED. THE UP SLOPE SHOULD BE SPECIFIED AS SINGLE IMPULSE AS TYPIFIED BY FIGURE 5-001-5 OR AS A SERIES OF IMPULSES AS TYPIFIED BY FIGURE 5-001-6

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Part ICS 5-002

GENERAL STANDARDS

The standards in this part apply to all other parts of this Standards Publication unless otherwise specified. The definitions and standards of Part ICS 5-001 and NEMA Standards Publication ICS 1 apply to this part unless otherwise specified.

ICS 5-002.01 CONTROL CIRCUIT TRANSFORMER PRIMARY VOLTAGES AND FREQUENCY

The primary of a resistance welding control circuit transformer shall be so designed that the transformer may be connected to a supply circuit of 230 or 460 volts at 60 Hertz.

NEMA Standard 1-11-1983.

ICS 5-002.02 ALLOWABLE VOLTAGE VARIATIONS

Resistance welder control equipment shall be capable of operating on control circuit voltages which vary as much as plus or minus 10 percent from the voltage for which the equipment is adjusted.

NEMA Standard 9-17-1953.

ICS 5-002.03 EXTERNAL CONTROL CIRCUITS

.01 Nominal Voltage

When low-voltage control is not specified, a nominal voltage of 115 volts shall be provided between the terminals which are provided for circuits to the no-weld switch, pressure switch and the weld cycle initiating switch. These circuits must be isolated from the power supply.

.02 Low Voltage

When a low-voltage transformer for the pilot circuit is specified as a part of the system, the secondary voltage shall be 24 volts.

NEMA Standard 8-7-1952.

ICS 5-002.04 TIME DESIGNATIONS

When given, time shall be expressed in cycles of the power supply frequency.

NEMA Standard 8-7-1952.

ICS 5-002.05 HEAT CONTROL

.01 Adjustment

Heat control shall provide for the adjustment of the rms current through an electronic welding contactor over the ranges of:

(a) 20 to 100 percent of the maximum rms current when thyratron tube contactors are used.

(b) 20 to 100 percent of the maximum rms current for the 400-500 volt range when ignitron tube contactors are used. This applies to a maximum power factor of 85 percent at 460 volts.

(c) 40 to 100 percent of the maximum rms current for the 200-250 volt range with single-phase ignitron tube contactors. This applies to a maximum power factor of 70 percent at 230 volts.

(d) 40 to 100 percent of the maximum rms current for the 200-250 volt range when ignitron tube contactors are used in frequency converter control with three-phase power supply.

(e) 20 to 100 percent of the maximum rms current for the 200-500 volt range when thyristor switches are used.

NEMA Standard 1-11-1983.

.02 Calibration

The rms current shall be within plus or minus 10 percent of the value set by the heat control. Calibration shall be performed at a power factor of 40 percent and a constant supply voltage.

NEMA Standard 1-11-1983.

ICS 5-002.06 SOLENOID VALVE RELAY

The contacts of a relay for operating the solenoid valve shall have the following minimum ratings:

(a) 1250 voltamperes inrush.

(b) 400 voltamperes continuous.

(c) Voltage range—115 to 600 volts.

The relay for operating the solenoid valve shall be able to operate at a rate of 2000 times in any 10-minute period with an energization time of 55 percent or 300 times in any one isolated minute with an energization time of 75 percent. NEMA Standard 8-7-1952.

ICS 5-002.07 FIRING RELAYS

The contacts of a relay for operating a welder contactor shall be capable of operating a magnetic contactor, size 2W or smaller, with coil voltages of 208 volts and higher, or size 1W or smaller at voltages of 115 volts and higher.

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The firing relay for operating a welder contactor shall be able to operate at a rate of 2000 times in any 10-minute period or 300 times in any one isolated minute.

NEMA Standard 1-11-1983.

ICS 5-002.08 METHOD OF INITIATION—DELAYED FIRING

The weld current shall be initiated at 85 degrees, plus or minus 5 degrees, relative to the line voltage. These conditions shall be maintained with a plus 10 percent and minus 5 percent variation in the line voltage and with sudden line voltage changes of plus or minus 5 percent. See 5-001.

When heat control is used and firing angles greater than 85 degrees occur, then the heat control shall initiate the weld current.

NEMA Standard 1-11-1983.

ICS 5-002.09 PRESSURE SWITCH FUNCTIONS

Connections of the pressure switch terminals into a timer circuit shall be such that:

(a) The squeeze timer is initiated independently of the pressure switch.
(b) The weld timer is not initiated until both termination of squeeze time and closing of the pressure switch contact have occurred.

The pressure switch contact shall be normally open when not welding and shall close on rising pressure.

NEMA Standard 1-22-1954.

ICS 5-002.10 UNUSUAL SERVICE CONDITIONS

There are unusual conditions which, where they exist, shall be called to the manufacturer's attention. Apparatus for use in such cases may require special construction or protection.

Authorized Engineering Information 3-13-1952.

ICS 5-002.11 BASIS OF THERMAL RATINGS

The thermal ratings of resistance welding control apparatus are based on an ambient temperature of 40°C.

NEMA Standard 3-13-1952.

ICS 5-002.12 DIELECTRIC TESTS—TEST VOLTAGES

See 1-109.21 of Standards Publication No. ICS 1.

ICS 5-002.13 PROTECTION OF ELECTRON TUBES AGAINST PREMATURE APPLICATION OF ANODE POTENTIAL

Where necessary, a time-delay device shall be provided to protect tube cathodes against the premature application of anode potential during cathode heating.

NEMA Standard 3-7-1946.

ICS 5-002.14 WATER SAVER TIMER

(a) The timing period of a water saver timer is nonadjustable and is approximately 4 minutes long.
(b) The water saver timer shall be initiated from one of the following standard voltages: 115, 230 or 460 volts, alternating current, 60 cycles.
(c) The contact for operating the water valve shall be normally open and shall have a minimum rating of 5 amperes at 115 volts, alternating current.

NEMA Standard 7-27-1955.

ICS 5-002.15 SAFETY FEATURES

See Part ICS 5-015.65.

ICS 5-002.16 PREVENTION OF SPURIOUS OPERATION

See Part ICS 5-015.65.

ICS 5-002.17 SURGE TEST

See Part ICS 5-015.65.

ICS 5-002.18 AUXILIARY CIRCUIT PROTECTION

For combination controllers with ignitron contactors, a short-circuit protective device shall be connected between the power supply and the separate power supply for control $2L_1$ and $2L_2$.

NEMA Standard 1-21-1964.

ICS 5-002.19 SOLID STATE SOLENOID VALVE POWER SUPPLY AND SWITCHING MEANS

The power supply and switching means for alternating current 115-volt 60-hertz valve control shall be rated 250 voltamperes inrush and 25 voltamperes holding. ▲

The power supply and switching means for direct current valve control shall be rated 24 volts, 12 watts.

NEMA Standard 1-11-1983.

Where the operator is exposed to the machinery, such as in loading or unloading of the resistance welding machine, or where the machine cycles automatically, consideration should be given to the use of an electromechanical override or other redundant means, independent of the solenoid valve switch, for starting or interrupting the cycle.

Authorized Engineering Information 1-11-1983.

▲ Editorially revised.

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.01 Solenoid Valve Operation

A contact shall be in series with the valve contactor circuit to prevent spurious operation. This contact will be open when the control is in standby condition.

.02 Weld Firing Circuit

A contact shall be in series with the weld firing circuit to prevent spurious operation. This contact will be open when the control is in standby condition.

NEMA Standard 1-21-1964.

A damped oscillatory voltage surge, having a peak equal to 1.41 times the line voltage and a base frequency of 5000 hertz, shall be applied so that it is additive to the primary control power supply. The surge shall be applied in both positive and negative polarities of the control power supply.

NEMA Standard 9-19-1962.

The above is a design test for component failure, timing accuracy and detection of spurious operation.

Authorized Engineering Information 9-19-1962.

ICS 5-002.20 VOLTAGE REGULATOR

A voltage regulator as used in connection with resistance welding control shall have the following characteristics:

.01 Accuracy

A voltage regulator shall hold the welding transformer primary rms voltage within ±2 percent of the preset value under line voltage variations of ±10 percent. This device is not required to operate beyond the limits of the heat control.

.02 Response Time

The regulator shall cause the voltage to be corrected at least 50 percent at the second cycle, 80 percent at the third cycle, and 97 percent at the fourth cycle, after the line voltage disturbance.

.03 Cut Off Means

A means shall be provided to disable the voltage regulator.

NEMA Standard 3-6-1985.

ICS 5-002.21 CURRENT REGULATOR

A current regulator as used in connection with resistance welding control shall have the following characteristics:

.01 Accuracy

The current regulator shall hold the rms primary welding current within ±3 percent under the same conditions which would cause the unregulated welding current to vary ±20 percent, providing the regulator is not required to operate beyond the limits of the heat control. The foregoing will hold true if the line voltage variations do not exceed ±10 percent.

.02 Response Time

The regulator shall return the current value to within 5 percent of the desired value in 3 cycles or less under conditions which cause up to a 20 percent disturbance of the current.

.03 Cut Off Means

A means shall be provided to disable the current regulator.

NEMA Standard 3-6-1985.

ICS 5-002.22 VOLTAGE COMPENSATOR

A voltage compensator shall respond to a ±10 percent change in line voltage within two line cycles and shall maintain the rms primary welding current within ±2 percent of that at nominal line voltage.

A means shall be provided to indicate those instances when the compensator is no longer able to compensate for existing line conditions.

NEMA Standard 3-6-1985.

ICS 5-002.23 SLOPE CONTROL AS USED IN RESISTANCE WELDING

.01 Calibration Accuracy of Up-Slope Controls

When the up-slope time is set for a given time, the current at that time shall be 90 percent plus or minus 5 percent. The following test conditions shall apply:

a. The final current shall be set for maximum.

b. The initial current shall be set for an rms value of 20 percent of maximum.

c. The load power factor shall be set for 40 percent.

d. The line voltage shall be constant.

e. The determination of slope accuracy shall be in terms of peak primary load current with reference to a straight line between initial current and the current line at time setting. In the eleven cycle slope time, the sixth cycle current shall not deviate from the straight line by more than plus or minus 10 percent of the maximum. The peak primary load current shall be measured with an oscilloscope or equivalent instrument.

.02 Calibration Accuracy for Down-Slope Control

When the down-slope time is set for a given time, the current at that time shall be 30 percent plus or minus 5 percent. The following test conditions apply:

a. The final postheat current shall be set for an rms current of 20 percent.

b. The maximum welding current shall be set for 100 percent.

c. The load power factor shall be set for 40 percent.

d. The line voltage shall be constant.

e. The determination of slope accuracy shall be in terms of peak primary load current with reference to a straight line between maximum current and the current line at time setting. In the eleven cycle slope time, the sixth cycle current shall not deviate from the straight line by more than plus or minus 10 percent of the maximum. The peak primary load current shall be measured with an oscilloscope or equivalent instrument.

.03 Timing Function for Slope Controls

A means shall be provided to completely remove the timing function from the control sequence.

.04 Accuracy of Precision Current Slope Controls

Precision current slope controls shall slope the rms current such that the current does not deviate by more than 5 percent from that of a straight line originating at the starting heat value and extending to the ending heat value.

NEMA Standard 3-6-1985.

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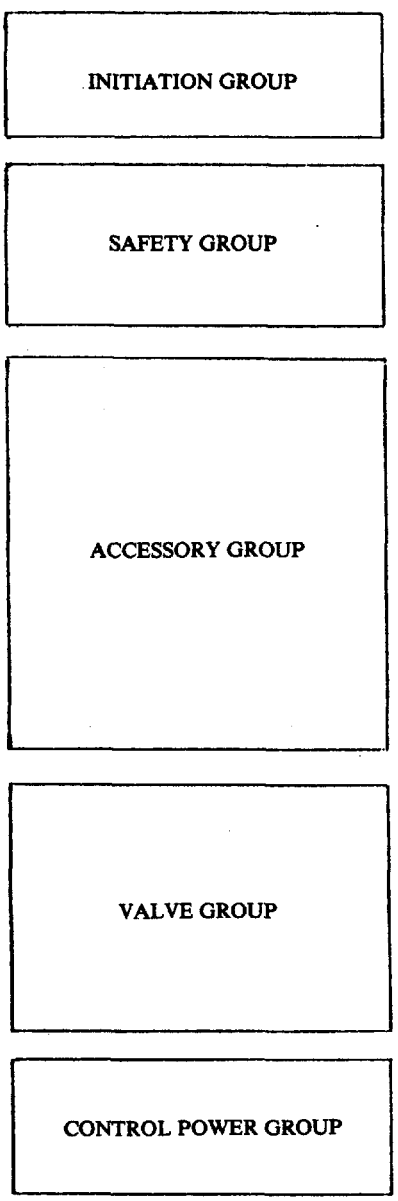
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Part ICS 5-003

TERMINAL MARKINGS AND CONNECTIONS

The standards in this part apply to all other parts of this Standards Publication unless otherwise specified. The definitions and standards of NEMA Standards Publication ICS 1 apply to this part unless otherwise specified.

ICS 5-003.01 TERMINAL BLOCK—SEQUENCE OF TERMINALS FROM TOP TO BOTTOM OR LEFT TO RIGHT*



NEMA Standard 5-12-1969.

* See ICS 5-003.02 for group terminal markings.

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ICS 5-003.02 CONTROL GROUP TERMINAL MARKINGS

The following tabulation includes the order in which terminals should appear (from left to right or from top to bottom) when their use is required by a particular application.

Function	Marking	Description	Reference
Initiation Group	FS_1, FS_2	115-volt foot switch terminals (single stage)	Note I and definition in ICS 5-001.04
	FS_3, FS_4, FS_5, FS_6, Etc.	Second-stage switch terminals of two-stage foot switch, initiation circuits	Note II and definition in ICS 5-001.04
Safety Group	PS_1, PS_2	Pressure switch terminals	ICS 5-002.09 and ICS 5-003.08
	NW_1, NW_2	External-weld no-weld switch terminals	ICS 5-003.07
	SR_1, SR_2	External sequence reset switch terminals	ICS 5-015.65.04
	TS_1, TS_2, Etc.	Ignitron thermal switch terminals	Note III and definition in ICS 5-001.04
Valve Group	VL_1, VL_2	Valve power supply terminals	ICS 5-003.04, ICS 5-003.05 and ICS 5-003.06
	SV_1, SV_2	Solenoid valve terminals	ICS 5-002.16 and ICS 5-003.04
	RV_1, RV_2	Retraction valve terminals	ICS 5-003.06 and definition in ICS 5.001.04
	FV_1, FV_2	Forge valve terminals	ICS 5.003.05 and definition in ICS 5-001.03
Control Power Group	L_1, L_2	Power fuse load terminals	ICS 5-003.03
	$1L_1$, $1L_2$	Control panel power input terminals	
	$2L_1$, $2L_2$	Control panel fuse load terminals	

NOTE I—FS_1 and FS_2 terminals utilized for the first stage of two-stage foot switch.
NOTE II—FS_1 and FS_4 terminals may be a single terminal common to both stages.
NOTE III—The ignitron thermal switch shall be wired to isolated terminals and normally connected into the NWCR (no-weld control relay) relay circuit.

NEMA Standard 6-21-1979.

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ICS 5-003.03 CONTROL AND WELDER POWER SCHEMATIC DIAGRAMS

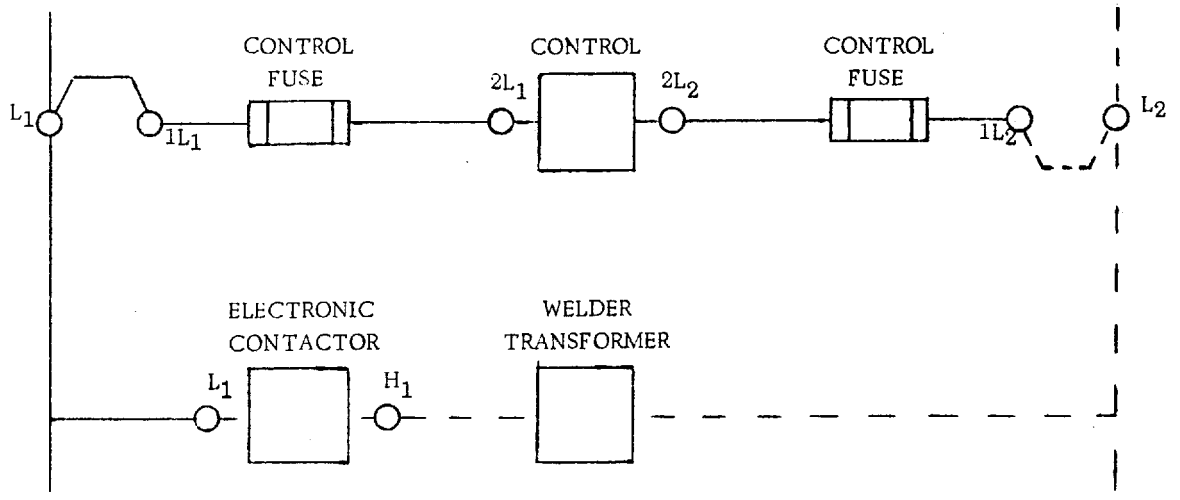


Fig. 5-003-1
TERMINAL MARKINGS FOR POWER AND CONTROL CONNECTIONS

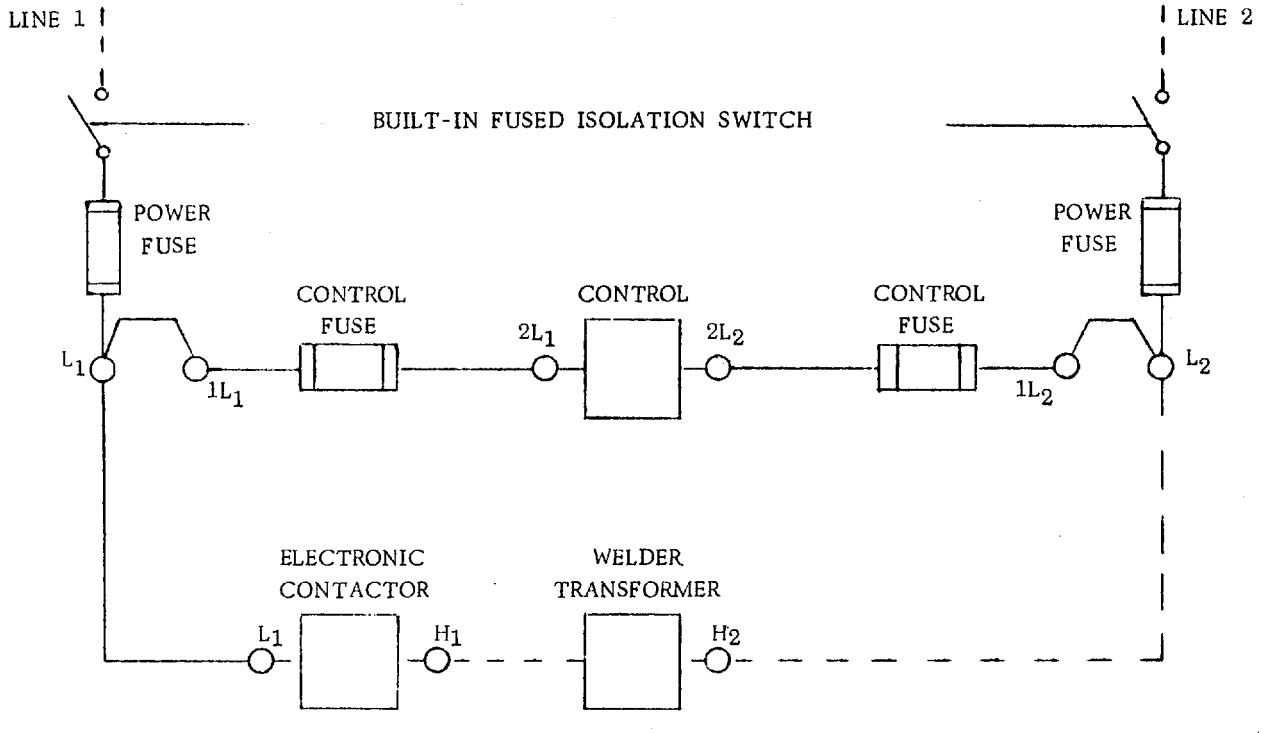


Fig. 5-003-2
TERMINAL MARKINGS FOR POWER AND CONTROL CONNECTIONS WITH BUILT-IN FUSED ISOLATION SWITCH

NOTE—Dash lines represent connections made by the welder manufacturer or the user.

NEMA Standard 1-21-1964.

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ICS 5-003.04 SOLENOID VALVE SCHEMATIC DIAGRAMS

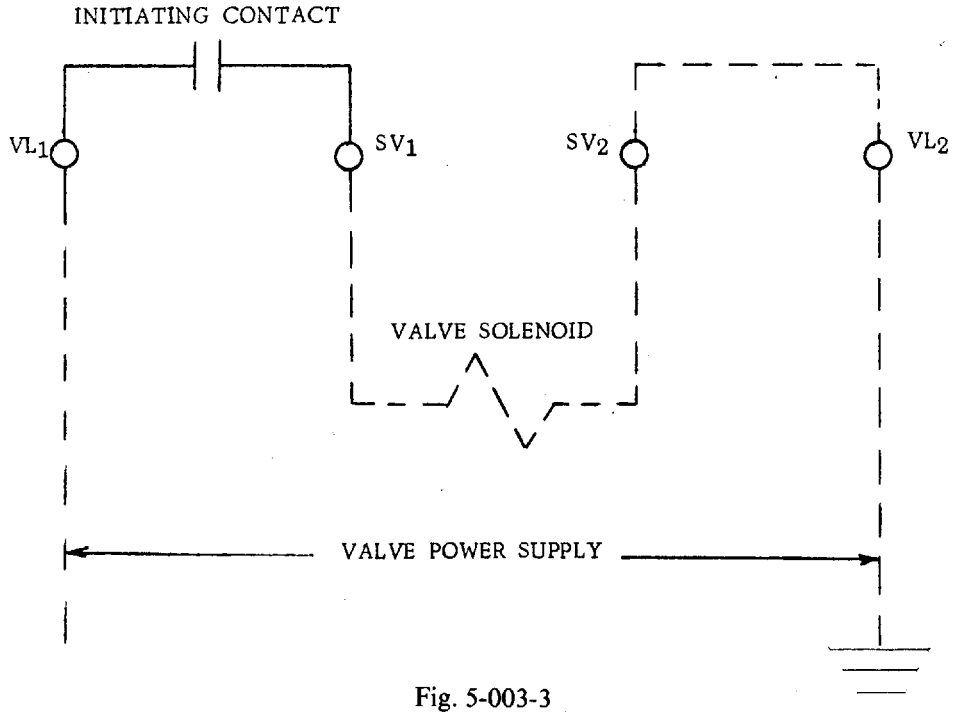


Fig. 5-003-3
CONNECTIONS UTILIZED WITH ONE INITIATING CONTACT

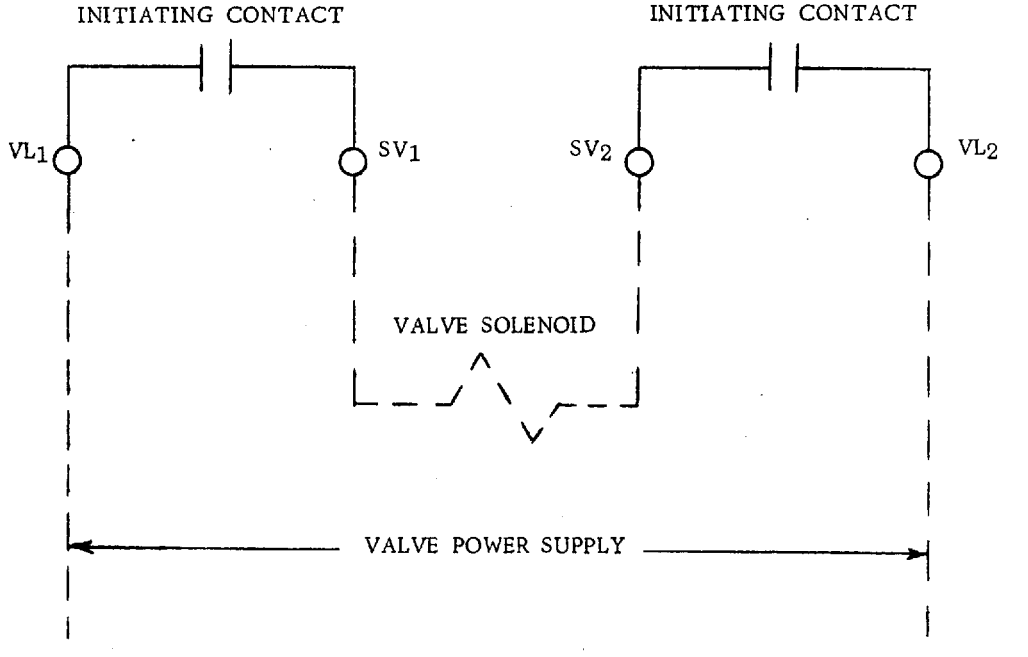


Fig. 5-003-4
CONNECTIONS UTILIZED WITH TWO INITIATING CONTACTS

NOTE—Dash lines represent connections made by the welder manufacturer or the user.

▲NEMA Standard 6-21-1979.

▲ Editorially revised.

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ICS 5-003.05 FORGE VALVE SCHEMATIC DIAGRAMS

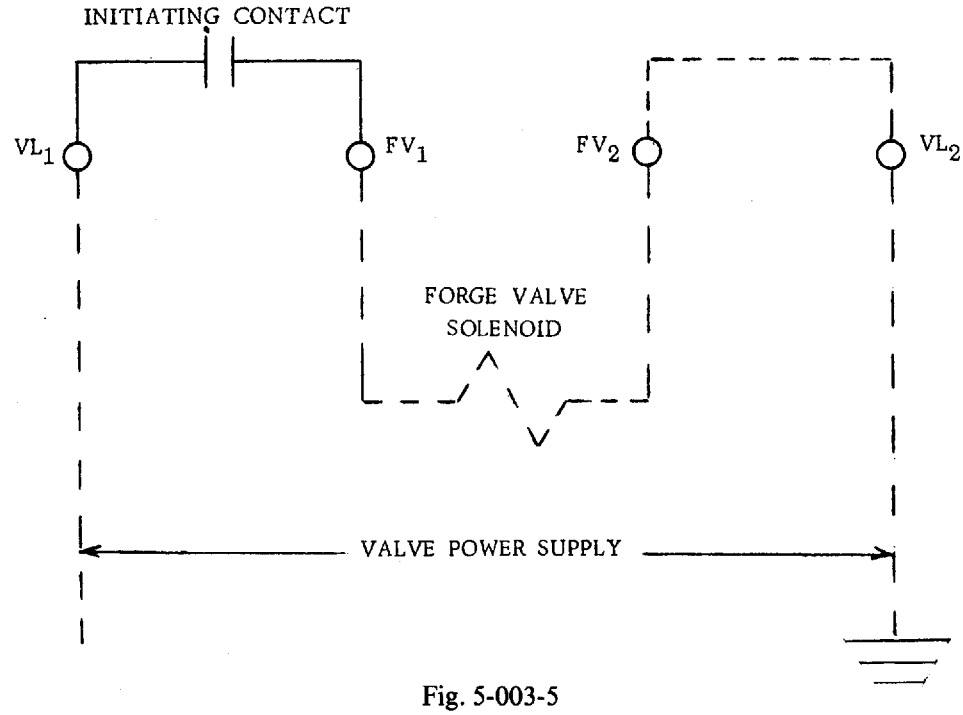


Fig. 5-003-5
CONNECTIONS UTILIZED WITH ONE INITIATING CONTACT

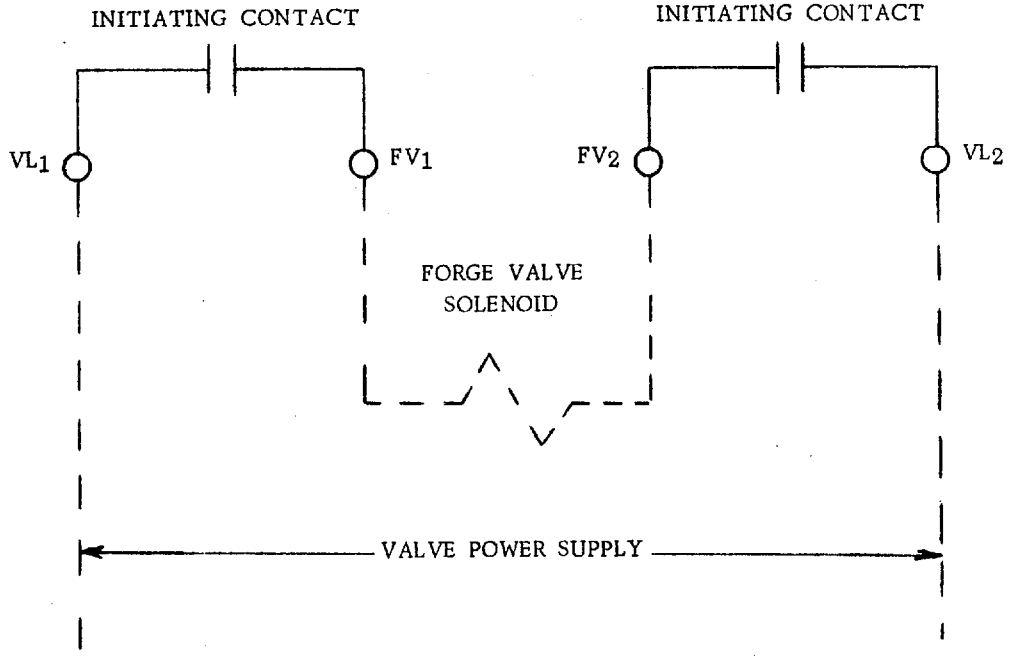


Fig. 5-003-6
CONNECTIONS UTILIZED WITH TWO INITIATING CONTACTS

NOTE—Dash lines represent connections made by the welder manufacturer or the user.

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▲ Editorially revised.

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ICS 5-003.06 RETRACTION VALVE SCHEMATIC DIAGRAMS

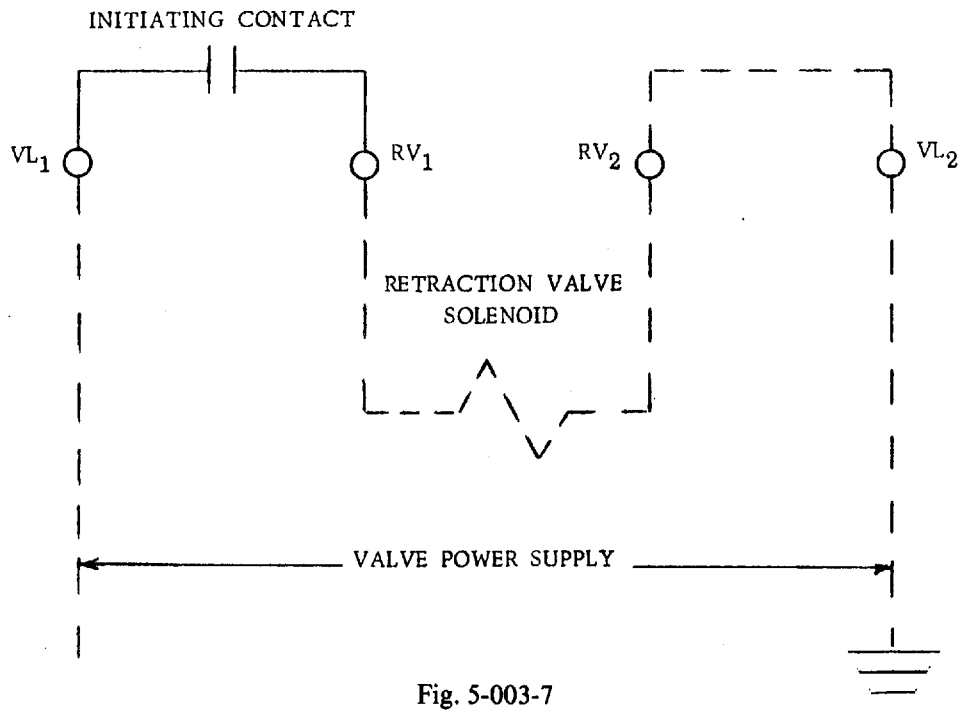


Fig. 5-003-7
CONNECTIONS USED WITH ONE INITIATING CONTACT

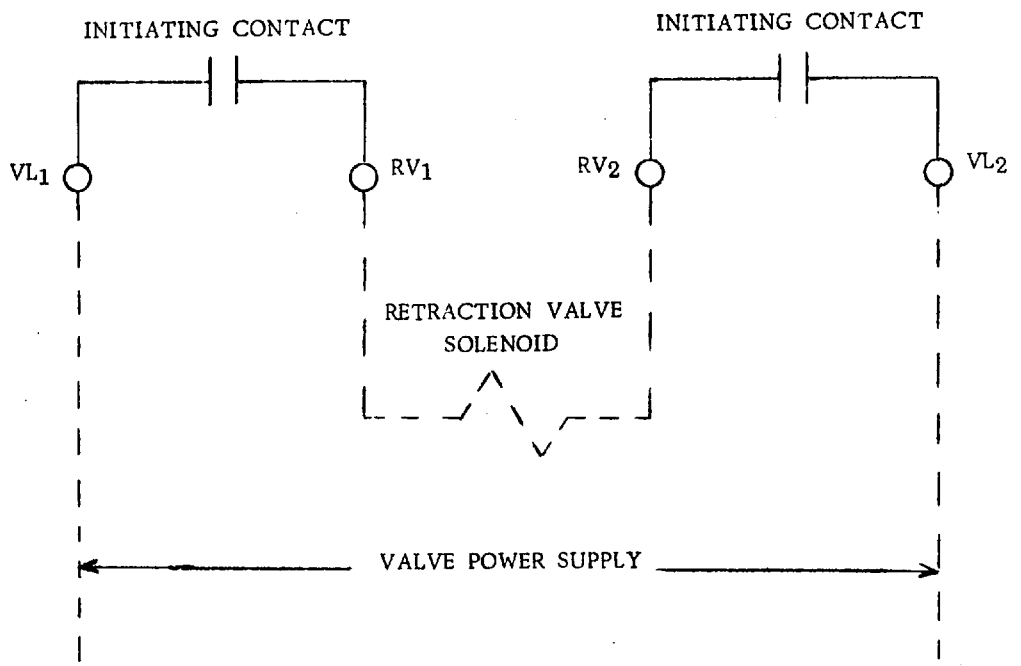


Fig. 5-003-8
CONNECTIONS USED WITH TWO INITIATING CONTACTS

NOTE—Dash lines represent connections made by the welder manufacturer or the user.

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▲ Editorially revised.

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ICS 5-003.07 CONNECTIONS FOR NO-WELD SWITCH

Terminals shall be provided for an externally connected no-weld switch and shall be connected and marked in accordance with the following diagram.

When a no-weld switch is provided on the welding timer, it shall be connected in accordance with Fig. 5-003-9.

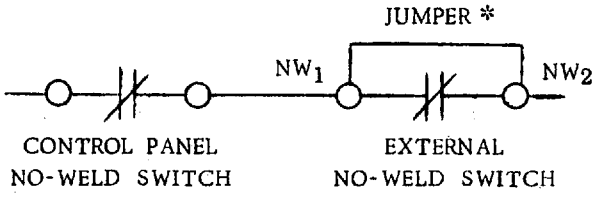


Fig. 5-003-9
NO-WELD SWITCH CONNECTIONS

* When using an external no-weld switch, remove jumper and connect external switch leads between NW_1 and NW_2 terminals. (Both no-weld switches must be closed for weld to occur.)

NEMA Standard 9-17-1953.

ICS 5-003.08 PRESSURE SWITCH CONNECTIONS

Terminals shall be provided for connections of the pressure switch (PS_1 and PS_2). A jumper shall be connected between these terminals. When utilizing the pressure switch, remove the jumper and connect the pressure switch leads between these terminals. (See ICS 5-002.09, Pressure Switch Functions.)

NEMA Standard 3-18-1964.

ICS 5-003.09 TERMINAL MARKINGS FOR PRIMARY BUS ON FREQUENCY CONVERTER CONTROL

On frequency converter control, the terminals on the contactors to be connected to the power supply shall be marked L_1, L_2 and L_3, respectively, and those terminals to be connected to the load circuit shall be marked H_1, H_2 and H_3, respectively.

NEMA Standard 7-13-1960.

ICS 5-003.10 POWER CIRCUIT CONNECTIONS

If only one side of the power supply to the welding transformer is interrupted, L_1 shall be interrupted.

NEMA Standard 9-17-1953.

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Part ICS 5-004

ENCLOSURE FEATURES FOR RESISTANCE WELDING CONTROLS

The standards in this part apply to all other parts of this Standards Publication unless otherwise specified. The definitions and standards of Standards Publication No. ICS 1 apply to this part unless otherwise specified. For enclosure definitions, general information, types, design tests, construction, and related information, see Standards Publication Nos. ICS 6 and 250.▲

ICS 5-004.80 ENCLOSURES FOR SINGLE-PHASE NONSYNCHRONOUS AND SYNCHRONOUS PRECISION TIMER COMBINATIONS (SEE FIG. 5-004-1)

.01 Type of Enclosure

NEMA Type 1 shall be provided. Combination units shall be mechanically joined and electrically interconnected. Main enclosure door(s) shall be located on surface "O." (See Fig. 5-004-1.)

.02 Location of Adjustments

On nonsynchronous controls the adjustments shall be mounted on surface "O."

On synchronous controls the adjustments shall be mounted on either surface "P" or "O" as required by the particular installation.

Operating adjustments shall be covered by an access door with locking means.

.03 Securing Means

Parts of enclosures such as doors, covers, tanks, etc., shall be provided with means for firmly securing them in place.

Doors and access panels shall have provisions for locking or shall be interlocked. A door or access panel shall be considered locked if a key, wrench or other instrument is required to open it.

Doors shall swing a minimum of 90 degrees. All parts of door fasteners shall remain captive when the door is opened.

.04 Power and Water Connections

One-half-inch female pipe threads shall be provided for water connections for contactors of the 600 frame size.

Water fittings shall be of noncorrosive material.

Space for water connections and a 4-inch diameter bushing shall be provided somewhere within two areas (10 inches wide and 8 inches high) located on surfaces "M" and "N." The areas on surfaces "M" and "N" shall begin 2 inches from the bottom and not less than 2 inches from the adjoining side walls of the enclosure.

.05 Enclosure Dimensions for Control Combinations—600 Volts or Less

The dimensions of enclosures, exclusive of fittings, shall not exceed the values shown in the following Table 5-004-1.

Table 5-004-1
MAXIMUM ENCLOSURE DIMENSIONS

Contactor Frame Size	O-M Depth, Inches	P-N Width, Inches
600	15	26
1200	15	30
2400	24	48

.06 Provision for Drainage

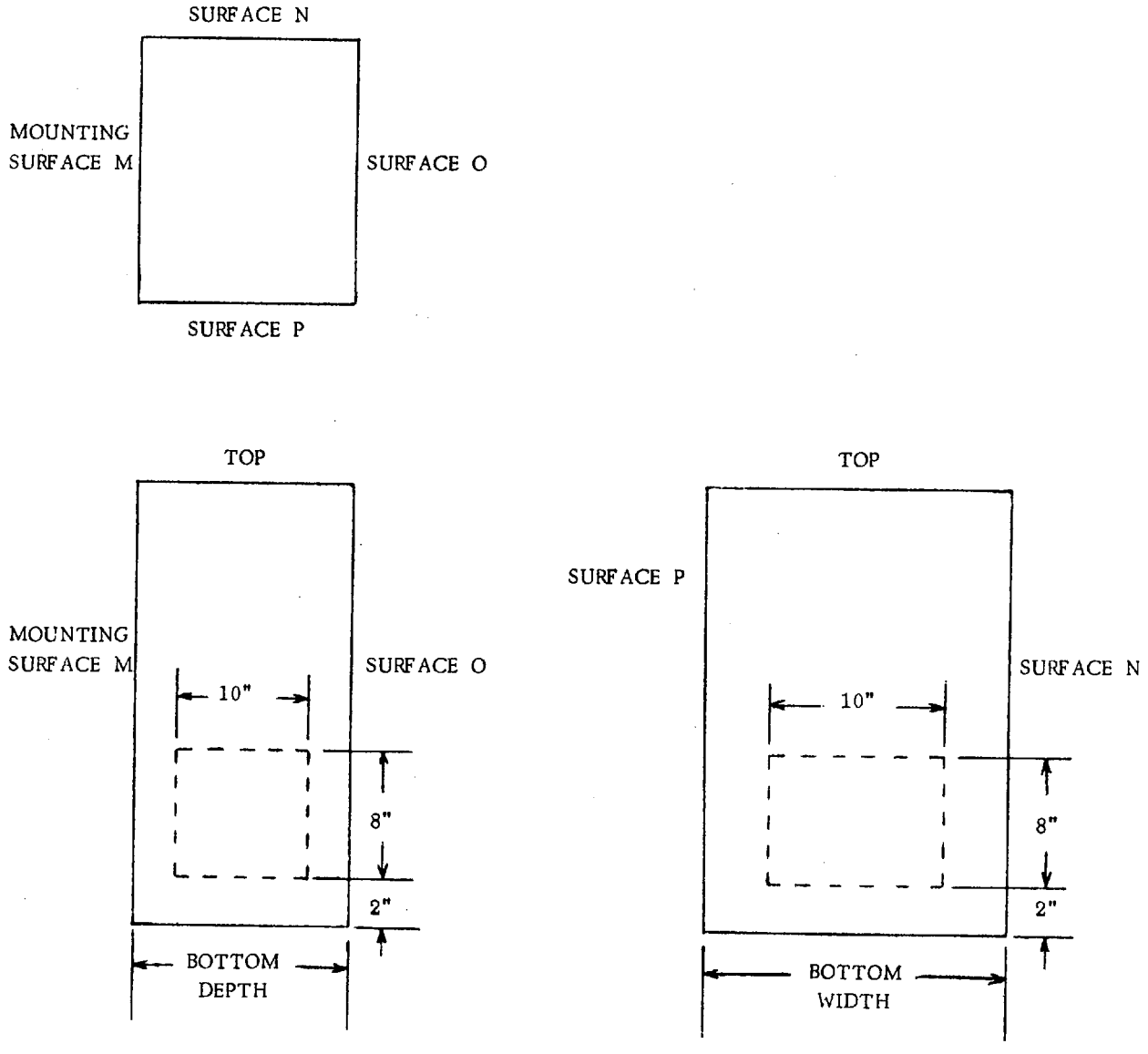
Drainage holes shall provide a total area of at least 1-square-inch opening in the bottom of the contactor section.

.07 Mechanical Barrier

A mechanical barrier shall be provided between the timer and the contactor portion of a combination control. NEMA Standard 6-21-1979.

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For power and water connections, see ICS 5-004.80.04.
For enclosure dimensions, see ICS 5-004.80.05.

Fig. 5-004-1
ENCLOSURE SURFACES

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Part ICS 5-005

WELDING CONTACTORS

The standards in this part apply to all other parts of this Standards Publication unless otherwise specified. The definitions and standards of NEMA Standards Publication No. ICS 1 apply to this part unless otherwise specified.

ICS 5-005.01 MAGNETIC WELDING CONTACTORS

.01 Rating in Amperes

The ampere ratings of single- and double-pole magnetic welder contactors used for resistance welding duty are shown in Table 5-005-1.

Table 5-005-1
AMPERE RATINGS

Size Number	Nominal Rating, Amperes
0W	50
1W	100
2W	150
3W	300
4W	600
5W	900

Where two single-pole contactors are used to break the circuit in two places, the ratings of these single-pole contactors shall be the same as the rating of a double-pole contactor.

The ampere rating for each size of contactor depends upon the following:

(a) Voltage of the circuit controlled.
(b) Alternating-current frequency of the circuit controlled.
(c) Number of poles of the contactors.
(d) Frequency of operation of the contactor.
(e) Weld time.

The ratings for the 50/60-hertz contactors shall be based upon the following formula:

$$\frac{I_0}{T} = \left[\frac{0.0077EN}{P} + \sqrt{\left(\frac{0.0077EN}{P}\right)^2 + 77NC}\right] 10^{-3}$$

The ratings for the 25-hertz contactors shall be based upon the following formula:

$$\frac{I_0}{T} = \left[\frac{0.0185EN}{P} + \sqrt{\left(\frac{0.0185EN}{P}\right)^2 + 185NC}\right] 10^{-3}$$

Where:
I_0 = Nominal rating required.
I = Primary welding amperes.
N = Average welds per minute (10-minute averaging period).
E = RMS line voltage.
P = Number of poles.
C = Welding time in cycles of current frequency.

The maximum amperes or highest rating shall not exceed 400 percent of the nominal rating of the contactor.

NEMA Standard 7-13-1960.

The minimum amperes depend upon the number of operations per minute and upon the time-on period. The curves should be cut-off at a point where the number of operations per minute will not overheat the coil.

The following formula may be used as a safe guide in determining the cut-off point:

$$\frac{C}{F} = \frac{41}{N} - 0.084$$

Where:
C = Weld time in current frequency.
F = Current frequency.
N = Number of operations per minute (10-minute period).

▲ Authorized Engineering Information 7-13-1960.

.02 Isolation Contactor (Magnetic)

An isolation contactor is a device used to open both sides of the line to the primary of the welding transformer.

NEMA Standard 6-21-1979.

The following formula should be used to select the proper size of isolation contactor for spot welding service when the contactor is not called upon to make or break the welding current.▲

$$I_2 = I_1 \sqrt{\text{Duty Cycle}}$$

Where:
I_1—maximum intermittent current.
I_2—equivalent continuous rms current flowing through the contactor.

Maximum current I_2 should not exceed 6 times the normal current rating of the isolation contactor.

Authorized Engineering Information 7-13-1960.

ICS 5-005.02 ELECTRONIC WELDING CONTACTORS (TUBE TYPE)

.01 Single-phase Electronic Welding Contactors (Tube Type)—600 Volts or Less

(a) An electronic welding contactor used to make and break one line of a single-phase welding system shall consist of the following:
(1) Two inversely connected tubes with suitable mounting provisions. When viewing the contactor from the front, the left cathode connection shall be marked L_1 and the right cathode connection shall be marked H_1.

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(2) Control circuit and components provided to permit control of initiation and termination of current conduction by an external pilot device or equivalent external electronic device.
(3) An internally mounted surge suppressing means.
(4) Ignitron contactors shall include means for protection in case of excessive ignitron tube temperature.

(b) Single-phase tube-type electronic welding contactors shall be sized per Table 5-005-2.

NEMA Standard 9-20-1978.

.02 Ratings for Single-phase Electronic Welding Contactors, 600 Volts and Less (Thyratron Tubes)

Fig. 5-005-1 shall be used to determine the proper size of thyratron tubes for single-phase electronic welding contactors for any given welding current and duty cycle.

NEMA Standard 7-13-1960.

.03 Ratings for Single-phase Electronic Welding Contactors (Ignitron Tubes)

Fig. 5-005-2 to 5-005-6, inclusive, shall be used to determine the proper size of ignitron tubes for single-phase electronic welding contactors for any given line voltage, welding current and duty cycle.

NEMA Standard 1-21-1964.

ICS 5-005.03 ELECTRONIC WELDING CONTACTORS (THYRISTOR TYPE)

.01 Single-phase Electronic Welding Contactors (Thyristor Type)

A thyristor-type welding contactor used to make and break one line of a single-phase welding system shall consist of the following:

(a) A switch consisting of two inversely connected thyristors with suitable mounting and cooling provisions.
(b) Control circuit and components provided to permit control of initiation and termination of current conduction by an external pilot device or equivalent external electronic device.
(c) A surge suppressing means.

.02 Ratings, Dimensions, and Markings for Single-phase Electronic Switches (Thyristor Type)

Ratings, dimensions, and markings for thyristor switches shall be in accordance with Table 5-005-3.

NEMA Standard 9-20-1978.

Electronic Switches (Thyristor type) similar to JEDEC Type Numbers 3N221 and 3N222 may be specified with hose-type water cooling but are otherwise electrically and physically similar.

Authorized Engineering Information 1-11-1983.

Table 5-005-2
SINGLE-PHASE TUBE-TYPE ELECTRONIC WELDING CONTACTORS

Frame Size	Tubes Accommodated	External Connection Bus Drilling
10	2.5 Amperes Average (Thyratron)	...
25	6.4 Amperes Average (Thyratron)	...
75	16 Amperes Average (Thyratron)	...
150	Size A (Ignitron)	One 3/8-inch-diameter bolt
600	Size B or C* (Ignitron)	Two 1/2-inch-diameter bolts
1200	Size B, C or D (Ignitron)	Two 5/8-inch-diameter bolts
2400	Size E (Ignitron)	Four 1/2-inch-diameter bolts

* Frame size 600 shall accommodate Size A tube if a suitable adapter is used.

Table 5-005-3
RATINGS, DIMENSIONS, AND MARKINGS FOR THYRISTOR SWITCHES

JEDEC Type No.	Continuous Current RMS (A)	Repetitive Peak Off-state Voltage DRM (V)	Repetitive Peak Reverse Voltage RRM (V)	Nonrepetitive Peak Reverse Voltage RSM (V)	Maximum Peak Off-state and Reverse Current I_{DM} & I_{RM} (mA)	Current Versus Percent Duty Cycle	General Arrangement, Dimensions, and Marking	Schematic Diagram	Minimum Cooling Water Flow Rate GPM	Cooling Water Inlet Temperature Range Degrees C
3N221	1200	1700	1700	1800	50	Fig. 5-005-7	Fig. 5-005-8 & Table 5-005-4	Fig. 5-005-9	1.2	5-40
3N222	1200	2600	2600	2700	60	Fig. 5-005-7	Fig. 5-005-8 & Table 5-005-4	Fig. 5-005-9	1.2	5-40

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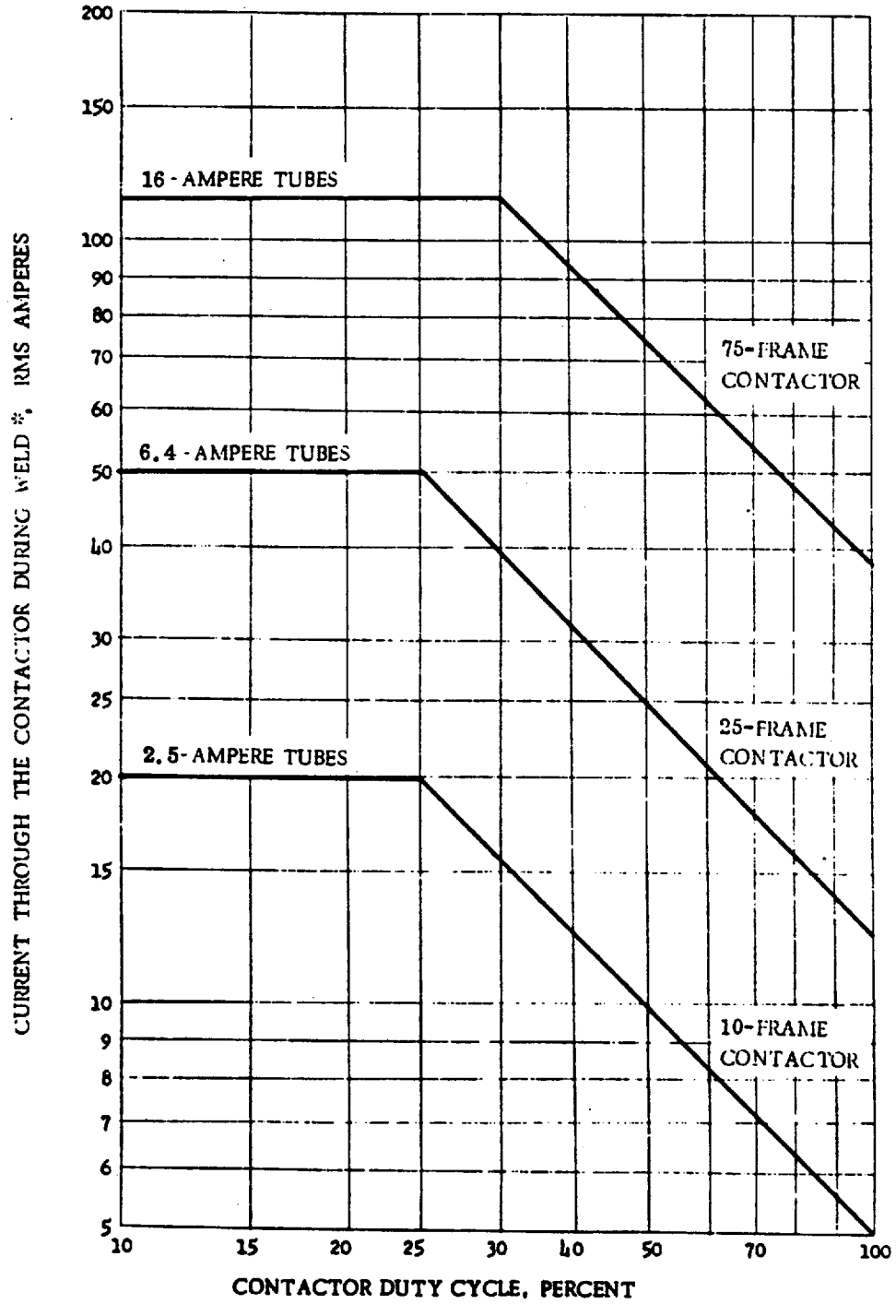
Table 5-005-4
DIMENSIONS FOR JEDEC TYPES 3N221 AND 3N222 THYRISTOR SWITCHES

Symbol	Inches		Millimeters	
	Minimum	Maximum	Minimum	Maximum
A	6.965	7.045	176.92	178.94
B	6.835	6.915	173.61	175.64
C	1.56	1.69	39.63	42.92
D	3.19	3.31	81.03	84.07
E	8.46	8.54	214.89	216.91
F	2.36	2.52	59.95	64.00
G	...	0.300	...	7.62
H*	2.49	2.65	63.25	67.31
J	...	4.50	...	114.30
K	0.98	1.02	24.90	25.90
L	6.48	6.52	164.60	165.60
M	0.24	0.26	6.10	6.60
N	1.97	2.03	50.04	51.56
P	0.96	1.04	24.39	26.41
ØQ	0.553	0.573	14.05	14.55
R	0.65	0.81	16.51	20.57
S	0.365	0.400	9.28	10.16
T	0.470	0.655	11.94	16.63
U	7.00	9.00	177.80	228.60
V	2.87	3.13	72.90	79.50
ØW	0.255	0.275	6.48	6.98
ØX†	...	...	...	...
Y	0.520	0.685	13.21	17.39
Z	1.440	1.560	36.58	39.62

* To centerline of bus bars only.
† Female ¼—18 NPT.

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THYRATRON CONTACTOR RATINGS
TWO TUBES CONNECTED IN INVERSE PARALLEL
AVERAGING TIME 5 SECONDS



$$\text{Percent Duty Cycle} = \frac{\text{Cycles per weld} \times \text{number of welds during averaging time (in seconds)}}{\text{Line frequency (hertz)} \times \text{averaging time (in seconds)}} \times 100$$

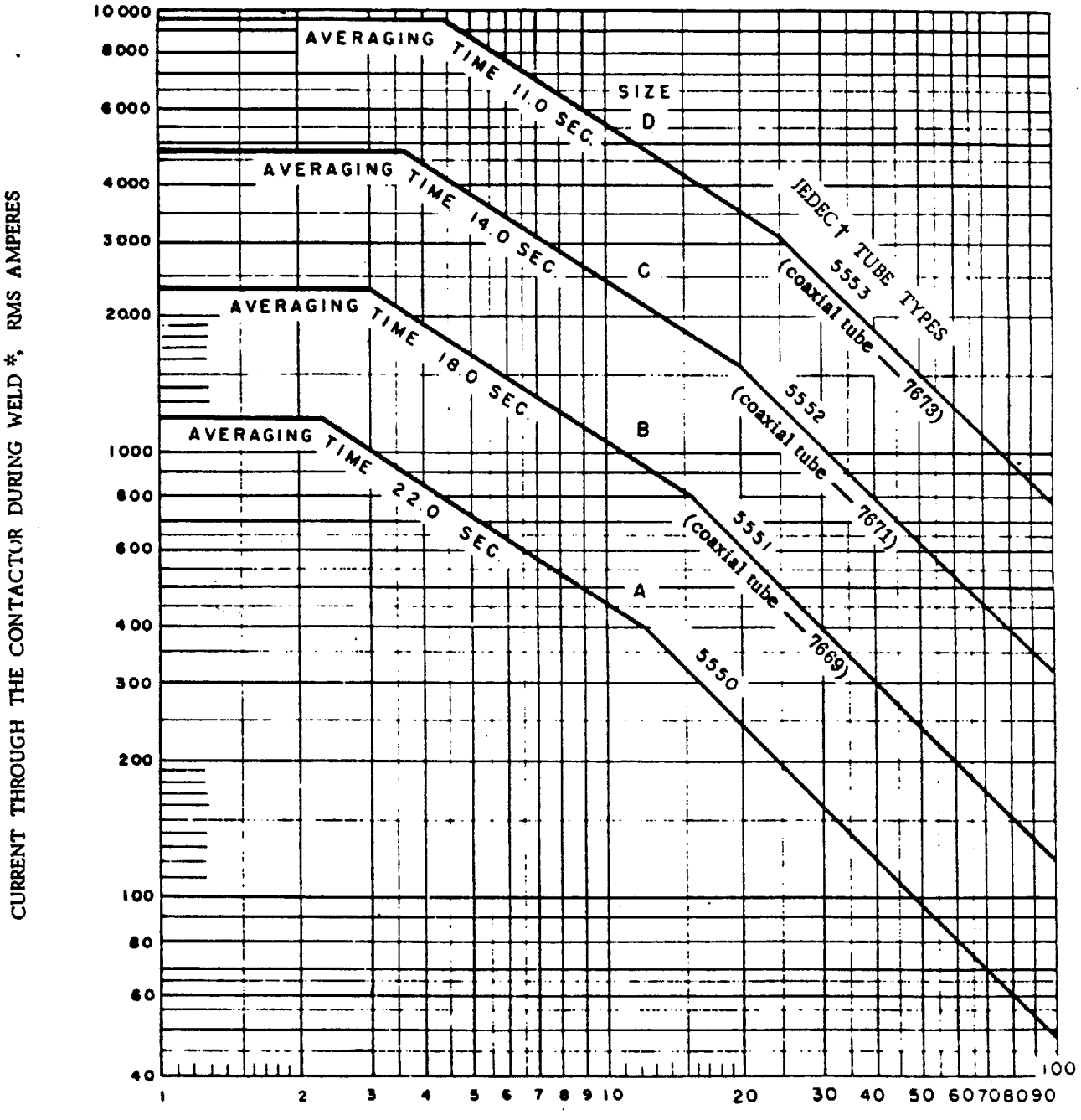
* Measured with full conduction during each half cycle.

Fig. 5-005-1
RATINGS FOR LINE VOLTAGES OF 200 TO 600 VOLTS, INCLUSIVE, 25 TO 60 HERTZ

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IGNITRON CONTACTOR RATINGS



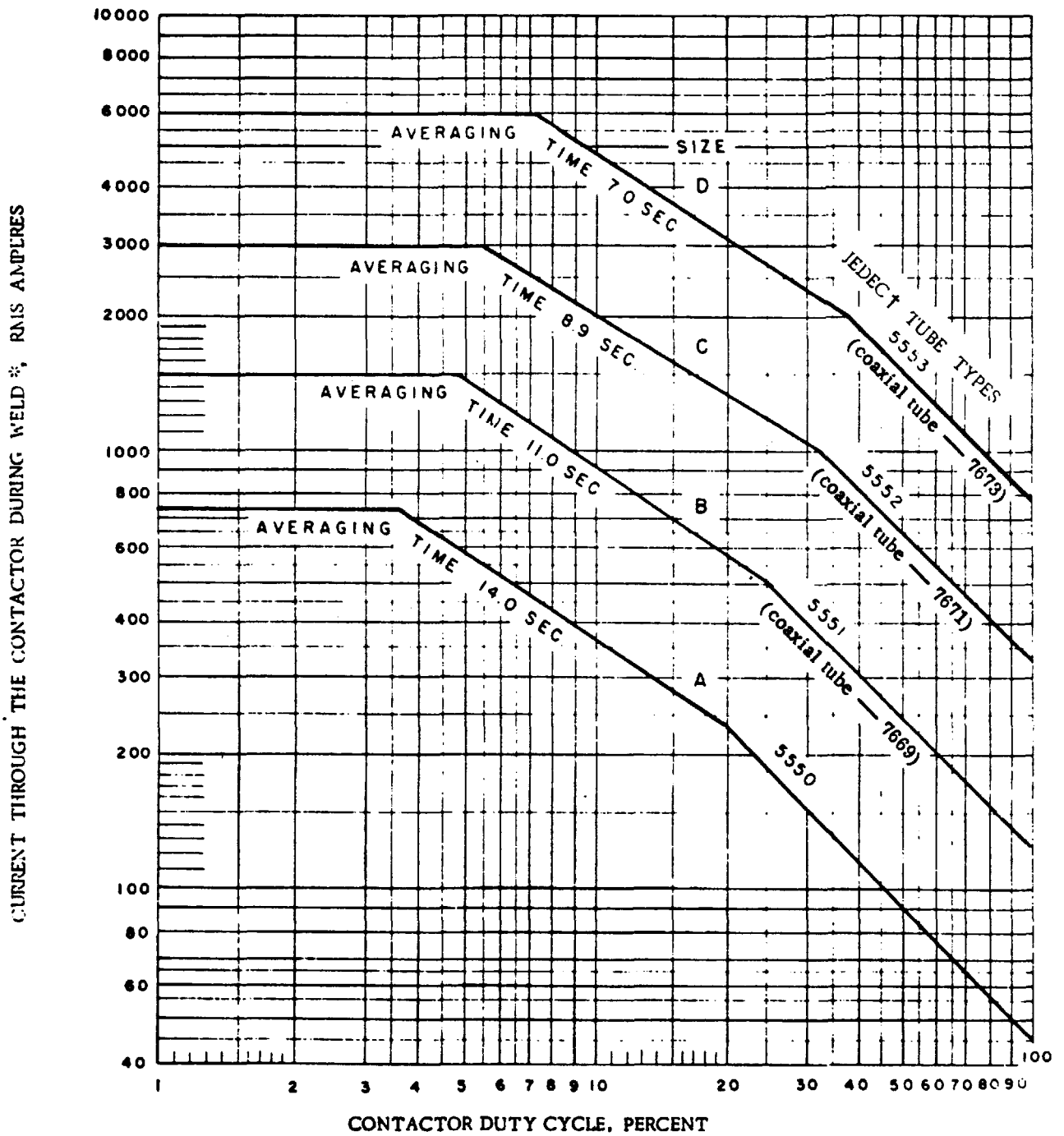
$$\text{Percent Duty Cycle} = \frac{\text{Cycles per weld} \times \text{number of welds during averaging time (in seconds)}}{\text{Line frequency (hertz)} \times \text{averaging time (in seconds)}} \times 100$$

* Measured with full conduction during each half cycle.
† JEDEC is the Joint Electron Device Engineering Council.

Fig. 5-005-2
RATINGS FOR LINE VOLTAGES OF 200 TO 250 VOLTS, INCLUSIVE, 25 TO 60 HERTZ

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IGNITRON CONTACTOR RATINGS



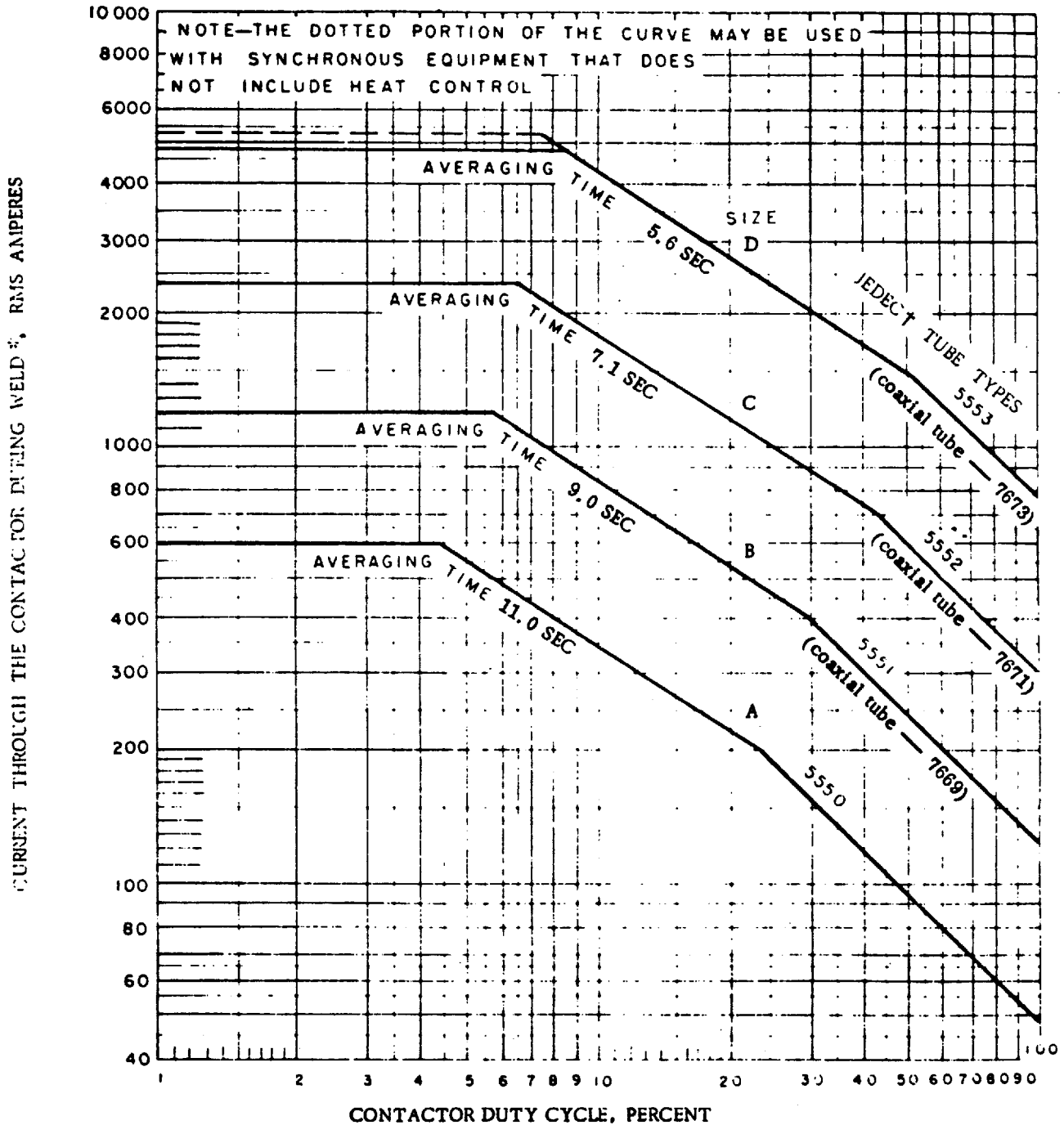
$$\text{Percent Duty Cycle} = \frac{\text{Cycles per weld} \times \text{number of welds during averaging time (in seconds)}}{\text{Line frequency (hertz)} \times \text{averaging time (in seconds)}} \times 100$$

* Measured with full conduction during each half cycle.
† JEDEC is the Joint Electron Device Engineering Council.

Fig. 5-005-3
RATINGS FOR LINE VOLTAGES OF 250 TO 400 VOLTS, INCLUSIVE, 25 TO 60 HERTZ

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IGNITRON CONTACTOR RATINGS



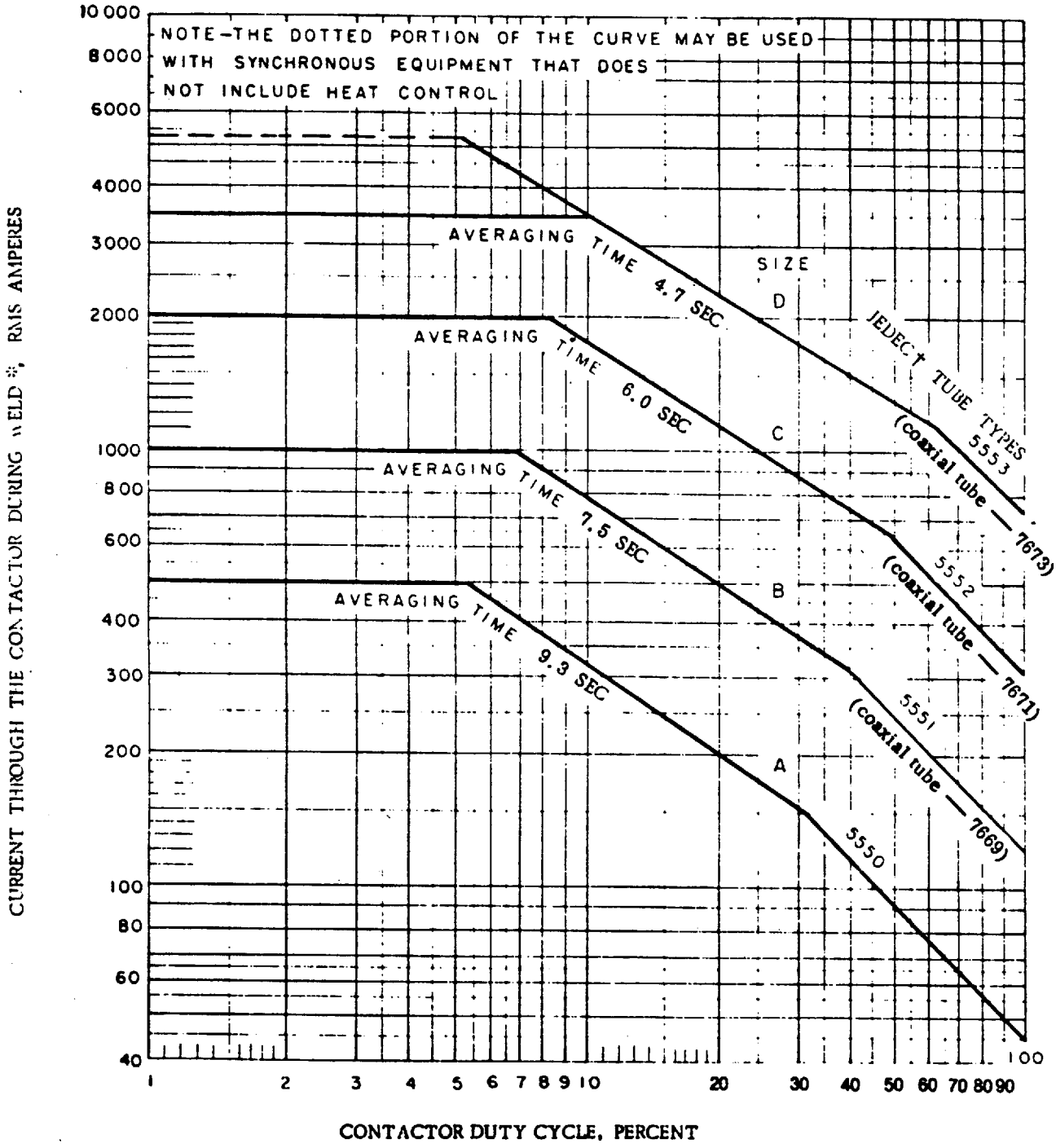
$$\text{Percent Duty Cycle} = \frac{\text{Cycles per weld} \times \text{number of welds during averaging time (in seconds)}}{\text{Line frequency (hertz)} \times \text{averaging time (in seconds)}} \times 100$$

* Measured with full conduction during each half cycle.
† JEDEC is the Joint Electron Device Engineering Council.

Fig. 5-005-4
RATINGS FOR LINE VOLTAGES OF 400 TO 500 VOLTS, INCLUSIVE, 25 TO 60 HERTZ

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IGNITRON CONTACTOR RATINGS



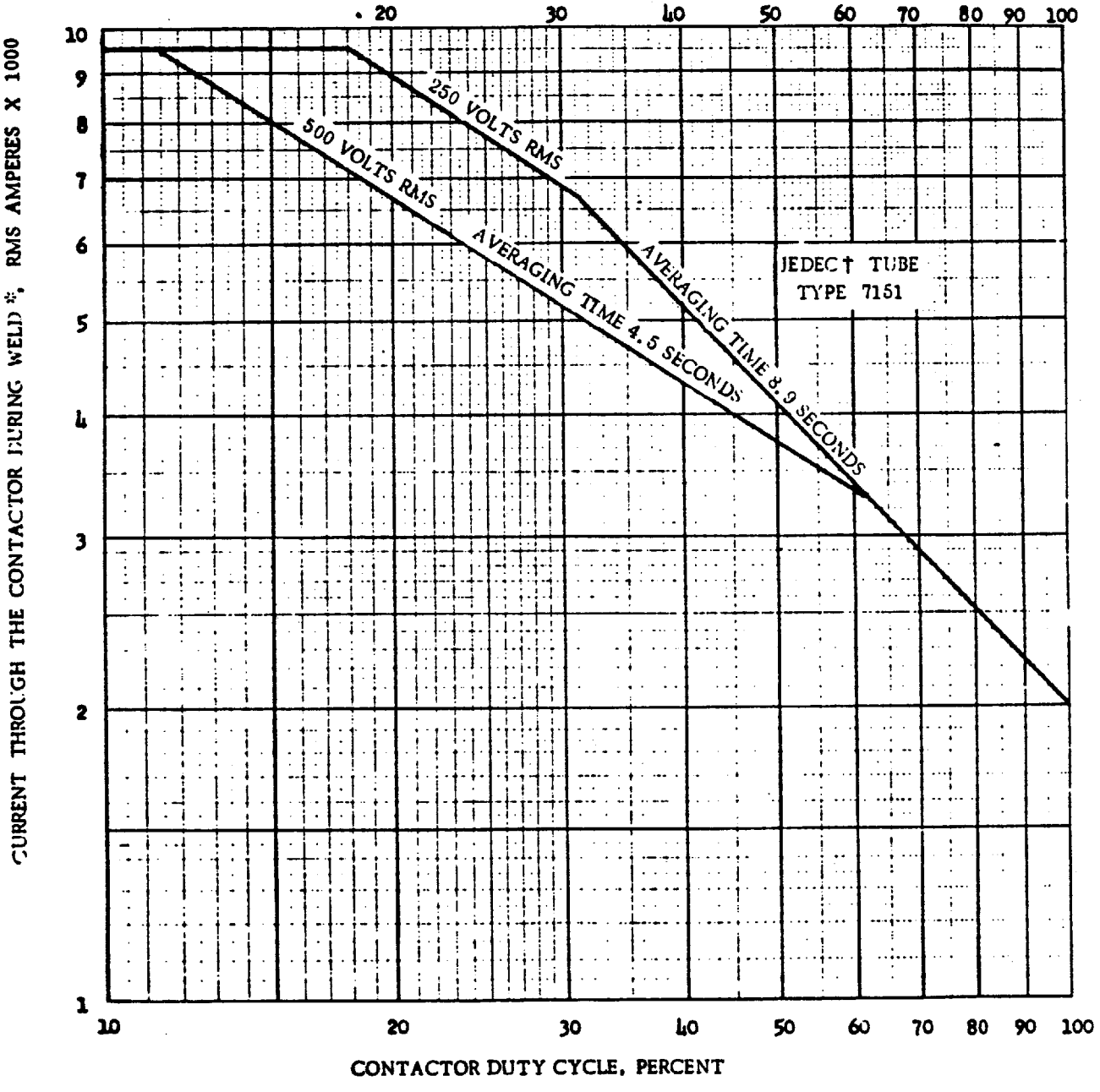
$$\text{Percent Duty Cycle} = \frac{\text{Cycles per weld} \times \text{number of welds during averaging time (in seconds)}}{\text{Line frequency (hertz)} \times \text{averaging time (in seconds)}} \times 100$$

• Measured with full conduction during each half cycle.
† JEDEC is the Joint Electron Device Engineering Council.

Fig. 5-005-5
RATINGS FOR LINE VOLTAGES OF 500 TO 600 VOLTS, INCLUSIVE, 25 TO 60 HERTZ

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SIZE E IGNITRON CONTACTOR RATINGS
TWO TUBES CONNECTED IN INVERSE PARALLEL



$$\text{Percent Duty Cycle} = \frac{\text{Cycles per weld} \times \text{number of welds during averaging time (in seconds)}}{\text{Line frequency (hertz)} \times \text{averaging time (in seconds)}} \times 100$$

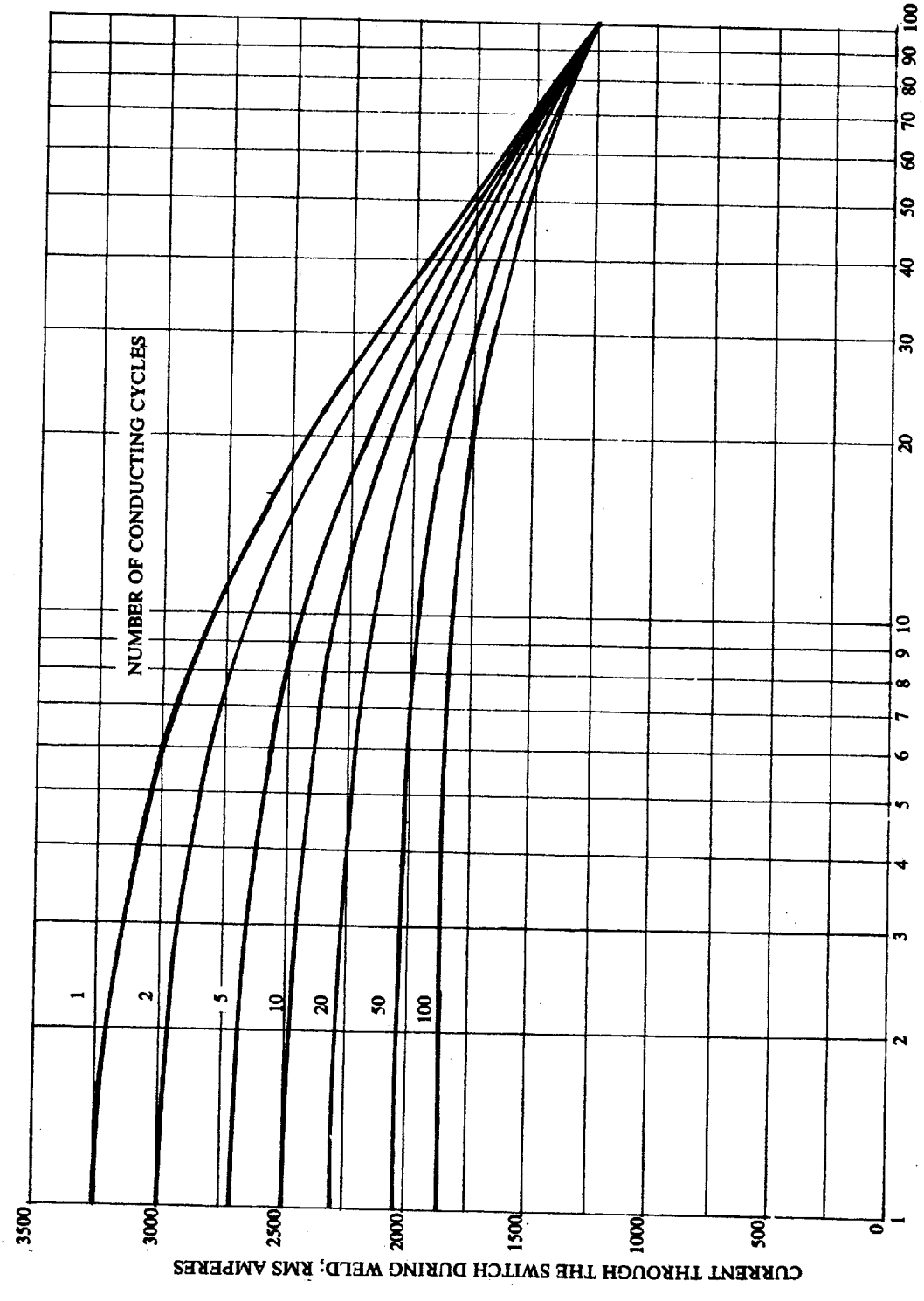
* Measured with full conduction during each half cycle.
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Fig. 5-005-6
RATINGS FOR 25 TO 60 HERTZ

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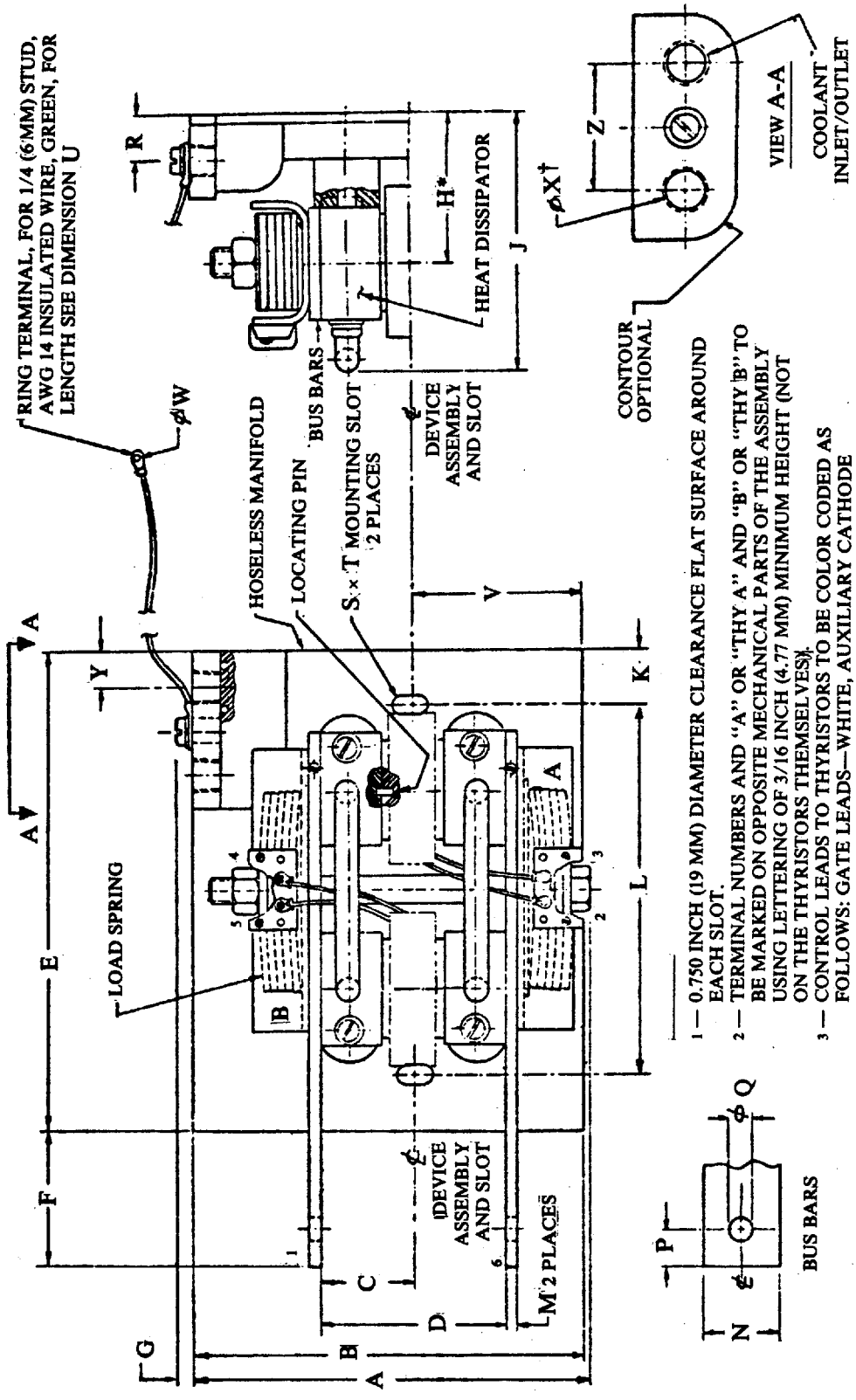


$$\text{PERCENT DUTY CYCLE} = \frac{\text{TIME ON}}{\text{TIME ON + TIME OFF}} \times 100$$

FOR ANY NUMBER OF CONDUCTING CYCLES GREATER THAN 100, THE MAXIMUM RMS DEMAND CURRENT SHALL BE 1200 AMPERES.

Fig. 5-005-7
RATINGS OF THYRISTOR SWITCHES
JEDEC TYPES 3N221 AND 3N222

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1 — 0.750 INCH (19 MM) DIAMETER CLEARANCE FLAT SURFACE AROUND EACH SLOT.
2 — TERMINAL NUMBERS AND "A" OR "THY A" AND "B" OR "THY B" TO BE MARKED ON OPPOSITE MECHANICAL PARTS OF THE ASSEMBLY USING LETTERING OF 3/16 INCH (4.77 MM) MINIMUM HEIGHT (NOT ON THE THYRISTORS THEMSELVES).
3 — CONTROL LEADS TO THYRISTORS TO BE COLOR CODED AS FOLLOWS: GATE LEADS—WHITE, AUXILIARY CATHODE LEADS—RED.
4 — JEDEC IDENTIFICATION 3N221 OR 3N222, AS APPLICABLE, SHALL APPEAR IN A PROMINENT PLACE ON THE THYRISTOR HEAT SINK ASSEMBLY.
5 — SEE TABLE 5-005-4 FOR DIMENSIONS.
6 — SEE FIG. 5-005-9 FOR SCHEMATIC DIAGRAM AND IDENTIFICATION OF TERMINAL NUMBERS.
* — SEE * FOOTNOTE TO TABLE 5-005-4.
† — SEE † FOOTNOTE TO TABLE 5-005-4.

Fig. 5-005-8
OUTLINE JEDEC TYPES
3N221 AND 3N222 THYRISTOR SWITCHES

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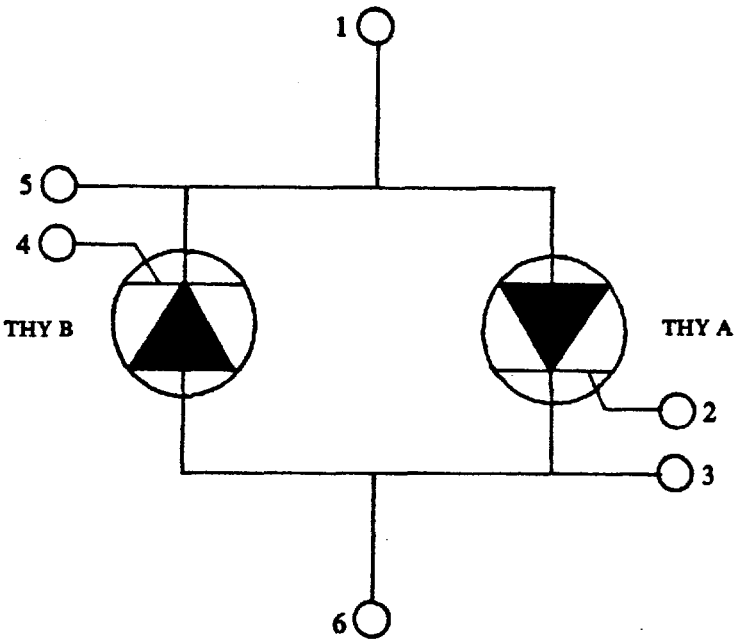


Fig. 5-005-9
SCHEMATIC DIAGRAM
JEDEC TYPES 3N221 AND 3N222 THYRISTOR SWITCHES

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WELDING CONTROL TYPES

Part ICS 5-006

The standards in this part apply to all other parts of this Standards Publication unless otherwise specified. The definitions and standards of NEMA Standards Publication No. ICS 1 apply to this part unless otherwise specified.

ICS 5-006.01 TIMER TYPES AND TIME RANGES

Table 5-006-1
TIMER TYPES AND TIME RANGES

Description I Timer Function II Control Features	Reference	Nonsynchronous Timer Range (1) NEMA Type No. (3)									Synchronous Precision Timer Range (1) NEMA Type No. (3)			Absolute Cycle Timer Range (7)			
		1A	1B	1D(‡)A	1D(‡)B	3B	3C(4)	5B	7B	9B	1AS	1BS	1CS	A1A	A3B	A3C	A5B
I Squeeze		...	...	...	...	3–120	3–30	3–120	3–120	3–120	...	...	...	...	1–99	1–59	1–99
Squeeze Delay		...	...	...	...	...	3–30*	...	...	...	...	...	...	...	...	1–59	...
Initial Squeeze		...	...	...	...	...	3–60*	...	...	...	...	...	...	...	...	...	...
Weld		3–120	...	...	...	3–120	2–30	...	(5)	...	1–60	...	1–10	1–99	1–99	1–59	...
Weld Interval		...	9–360	...	...	...	...*	9–360	...	9–360	...	...	...	...	...	...	1–8
	ICS 5-001.03																Heat Times
Heat		...	3–30	...	...	...	...	3–30	...	(6)	...	1–30	...	...	...	...	1–99
Cool		...	3–30	...	...	...	...	3–30	...	(6)	...	1–30	...	...	...	...	1–29
Hold		...	...	...	...	3–60	2–30	3–60	3–60	3–60	...	...	...	...	1–99	1–29	1–99
Off		...	...	...	...	3–60	3–30	3–60	3–60	3–60	...	...	...	...	1–99	1–29	1–99
Function	ICS 5-010.03	...	...	3–60	3–360	...	...	...	...	...	...	...	...	...	...	...	...
II Repeat		...	...	...	...	†	†	†	†	†	...	...	...	...	†	†	†
Nonrepeat	ICS 5-001.04	†	†	...	...	†	†	†	†	†	...	...	...	...	†	†	†
Nonbeat		...	...	...	...	†	†	†	†	†	(2)	...	(2)	...	†	†	†
Pressure Switch	ICS 5-002.09	...	...	...	...	†	...	†	†	†	...	...	...	...	†	...	†
Two Stage Pilot Switch		...	...	...	...	(2)	...	(2)	(2)	(2)	...	...	...	...	(2)	...	(2)
Dual Gun Dual Sequence	ICS 5-001.04	...	...	...	...	...	(2)	...	...	...	...	...	...	...	...	(2)	...
Weld Safe		...	...	†	...	...	†	...	...	...	...	...	...	...	...	...	...
Delayed Firing	ICS 5-001.04 and ICS 5-002.08	...	...	...	...	(2)	†	...	...	...	...	...	...	...	(2)	†	...

* Select only one function marked with an asterisk.
† Indicates control feature provided by timer.
‡ Select the complete NEMA type number from ICS 5-010.03, e.g., the complete NEMA type might be 1D-3B.
(1) Timer ranges in cycles, based on 60-hertz power supply. For 50-hertz power supply, multiply the ranges shown by the factor 50/60; for 25-hertz power supply, multiply by 25/60. Calibration and repetitive accuracies shall be in accordance with Part ICS 5-007 except when noted.
(2) Provision shall be included for this control feature.
(3) When a sequence timer or sequence weld timer does not conform in every particular to any NEMA type designation, it shall be designated by adding the suffix "X" to the nearest NEMA type designation.
(4) Calibration and repetitive accuracies shall be in accordance with par. ICS 5-010.02.04.
(5) Requires external weld timer type 1AS.
(6) Requires external seam weld timer type 1BS.
(7) Timer ranges are in cycles based on system power supply. When required, extended time ranges may be provided by accessory means. For definition of repetitive and calibration accuracy, refer to Part ICS 5-007.

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ICS 5-006.02 AUXILIARY CONTROL FUNCTIONS

See Note (3) below and definition in ICS 5-001.06.

Table 5-006-2
AUXILIARY CONTROL FUNCTIONS

Description Timer Function	Nonsynchronous Timer Range(2) NEMA Suffix No. (1)							Synchronous Precision Timer Range (2) NEMA Suffix No. (1)						Absolute Cycle Timer Range (7)						
	U	D	T	F	P	R	(4)	U	D	F	(4)	T	P	U	UD	T	F	P	R	(4)
Up Slope	3-30	...	...	...	...	...	...	1-10* (9)	...	...	...	...	...	1-9* (9)	1-9* (9)	...	...	...	...	...
Up Slope	...	...	...	...	...	...	...	1-30* (9)	...	...	...	...	...	1-29* (9)	1-29* (9)	...	...	...	...	...
Weld Heat ...	...	3-60	...	...	...	...	...	...	1-60	...	...	...	...	...	1-99	...	...	...	...	...
Weld Interval Heat	...	3-180	...	...	...	...	...	...	3-180 (5)	...	...	...	...	...	1-8 Heat Times	...	...	...	...	...
Down Slope ..	...	3-30	...	...	...	...	...	...	1-10* (8)(9)	...	...	...	...	...	1-9 (8)(9)	...	...	...	...	...
Down Slope ..	...	...	...	...	...	...	...	...	1-30* (8)(9)	...	...	...	...	...	1-29 (8)(9)	...	...	...	...	...
Quench	...	...	9-360	...	...	...	...	...	...	...	...	9-360 (5)	...	...	...	1-99	...	...	...	...
Temper	...	...	3-120	...	...	...	...	...	...	...	...	1-120	...	...	...	1-99	...	...	...	...
Forge Delay ..	...	...	...	3-360	...	...	...	...	...	1-360*	...	...	...	...	...	...	1-99*	...	...	...
Forge Delay ..	...	...	...	...	...	...	...	...	...	0.1-59.9* (6)	...	...	...	...	...	...	0.1-99.9* (6)	...	...	...
Precompression	...	...	...	...	...	...	3-10	...	...	...	...	...	...	...	...	...	...	...	...	1-9
Delay After Precompression	...	...	...	...	...	...	3-10	...	...	...	...	...	...	...	...	...	...	...	...	1-9
Preheat	...	...	...	...	3-120	...	...	...	...	...	...	...	1-120	...	...	...	...	1-99	...	...
Weld Delay ..	...	...	...	...	...	...	...	...	...	...	1-3	...	...	...	...	...	...	...	...	1-9
Final Hold ...	...	...	...	...	...	1-180	...	...	...	...	...	...	...	...	...	...	...	...	1-99	...
Index	...	...	...	...	...	3-360	...	...	...	...	...	...	...	...	...	...	...	...	1-99	...
Delay After Index	...	...	...	...	...	1-10	...	...	...	...	...	...	...	...	...	...	...	...	1-9	...
Delay After Forge	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1-9	...

* Select only one range marked with an asterisk.

(1) Auxiliary control functions are indicated by a suffix letter. When a control does not conform in every particular to any NEMA designation, it shall be designated by adding the suffix "X" to the nearest NEMA type designation.

(Continued)

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(2) Timer ranges in cycles, based on 60-hertz power supply. For 50-hertz power supply, multiply the ranges shown by the factor 50/60; for 25-hertz power supply, multiply by 25/60. Calibration and repetitive accuracies shall be in accordance with Part ICS 5-007 except where noted.
(3) Includes means to by-pass auxiliary control function.
(4) Where a letter designation does not exist, the auxiliary control function shall be described.
(5) Refer to ICS 5-007.01 and ICS 5-007.02 for timer accuracies.
(6) 0.1 through 0.9 fine adjustment is in 0.1 cycle markings. Refer to Part ICS 5-007 for timing accuracy (ICS 5-007.01 and ICS 5-007.02).
(7) Timer ranges are in cycles based on system power supply. When required, extended time ranges may be provided by accessory means. For definitions of repetitive and calibration accuracy refer to Part ICS 5-007.
(8) Down-slope range will be the same as Up-slope time range.
(9) Refer to ICS 5-009.01 for calibration accuracy.

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ICS 5-006.03 COMBINATION CONTROLS—600 VOLTS OR LESS

The weld diagrams shown in Part 1 of this Standards Publication are illustrative of types of controls designated from standard NEMA types with the auxiliary controls.

Table 5-006-3
TYPES OF COMBINATION CONTROLS

Description I Timers (See ICS 5-006.01) II Auxiliary Control Functions (See ICS 5-006.02) III Contactors	Suffix	Reference or Example	Nonsynchronous NEMA Type No. (1)						Synchronous Precision NEMA Type No. (1)				
			N1A	N1B	N1H	N2	N3	N6	S1H	S2H	S3H	S4H (3) (4)	S5H (4)
I													
Type 1A Weld Timer	...	ICS 5-006.01	‡	...	...	...	...	...	...	...	...	...	...
Type 1B Pulsation Weld Timer	...		...	‡	...	...	...	...	...	...	...	...	...
Type 3B Sequence Weld Timer	...		...	...	...	‡	...	...	...	...	...	...	...
Type 3C Sequence Weld Timer	...		...	...	...	...	...	‡	...	...	...	...	...
Type 5B Sequence Weld Timer	...		...	...	...	...	‡	...	...	...	...	...	...
Type 7B Sequence Timer	...		...	...	...	...	...	...	...	‡	...	...	...
Type 9B Sequence Timer	...		...	...	...	...	...	...	...	...	‡	‡	...
Type 1AS Synchronous Precision Weld Timer	...		...	...	...	...	...	...	*	‡	...	...	...
Type 1BS Synchronous Precision Seam Weld Timer	...		...	...	...	...	...	...	...	...	‡	‡	‡
Type 1CS Synchronous Precision Weld Timer	...		...	...	...	...	...	...	*	...	...	...	...
II													
Heat Control	H(2)	ICS 5-002.05	†	†	‡	†	†	†	‡	‡	‡	‡	‡
Electronic Current Regulator	C	ICS 5-009.02	*	*	*	*	*	*	*	*	*	*	...
Electronic Voltage Regulator	V	ICS 5-009.03	*	*	*	*	*	*	*	*	*	*	...
Up Slope Control	U	ICS 5-006.02 and ICS 5-009.01	†	†	...	†	†	...	†	†	†	†	†
Down Slope Control	D	ICS 5-006.02 and ICS 5-009.01	†	†	...	†	†	...	†	†	†	†	...
Quench Temper Control	T	ICS 5-006.02	...	...	...	†	†	...	...	†	†	†	...
Preheat Control	P	ICS 5-006.02	...	...	...	†	†	...	...	†	†	†	...
Hold-index Control	R	ICS 5-006.02	...	...	...	...	...	...	...	...	...	†	...
Forge Delay Control	F	ICS 5-006.02	...	...	...	†	†	...	...	†	†	†	...

(*Continued*)

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Table 5-006-3
(CONTINUED)

Description I Timers (See ICS 5-006.01) II Auxiliary Control Functions (See ICS 5-006.02) III Contactors	Suffix	Reference or Example	Nonsynchronous NEMA Type No. (1) N1A	N1B	N1H	N2	N3	N6	Synchronous Precision NEMA Type No. (1) S1H	S2H	S3H	S4H (3) (4)	S5H (4)
III—MAGNETIC													
Magnetic Welding Contactor 50 Amperes	0W	ICS 5-005.01	*	*	...	*	*	...	...	...	...	...	...
Magnetic Welding Contactor 100 Amperes ...	1W		*	*	...	*	*	...	...	...	...	...	...
Magnetic Welding Contactor 150 Amperes ...	2W		*	*	...	*	*	...	...	...	...	...	...
Magnetic Welding Contactor 300 Amperes ...	3W		*	*	...	*	*	...	...	...	...	...	...
Magnetic Welding Contactor 600 Amperes ...	4W		*	*	...	*	*	...	...	...	...	...	...
Magnetic Welding Contactor 900 Amperes ...	5W		*	*	...	*	*	...	...	...	...	...	...
III—THYRATRON													
Electronic Welding Contactor 10 Amperes	10	ICS 5-005.04	*	*	*	*	*	...	*	*	*	*	*
Electronic Welding Contactor 25 Amperes	25		*	*	*	*	*	...	*	*	*	*	*
Electronic Welding Contactor 75 Amperes	75		*	*	*	*	*	...	*	*	*	*	*
III—IGNITRON													
Electronic Welding Contactor 150 Amperes ...	150	ICS 5-005.05	*	*	*	*	*	...	*	*	*	*	*
Electronic Welding Contactor 600 Amperes ...	600		*	*	*	*	*	*	*	*	*	*	*
Electronic Welding Contactor 1200 Amperes ..	1200		*	*	*	*	*	*	*	*	*	*	*
Electronic Welding Contactor 2400 Amperes ..	2400		*	*	*	*	*	*	*	*	*	*	*

(1) When auxiliary control functions are added, a suffix letter after the numeral shall be used to describe these controls. When a combination control does not conform in every particular to any NEMA designation, it shall be designated by adding the suffix "X" to the nearest NEMA type designation.
(2) When an auxiliary control function requires heat control, the suffix denoting that auxiliary control function shall replace suffix "H". Examples are "C", "V", "U" and "D". For example N6U-600.
(3) Includes means to change from seam to multiple impulse welding.
(4) Includes means to change from intermittent to continuous seam welding.
* In Section I under S1H, select either 1AS or 1CS timer.
In Section II, when a regulator is required, select either current or voltage type.
In Section III, select contactor required. (Magnetic contactors cannot be used with auxiliaries which involve heat control.)
† Provision shall be included for these auxiliary control functions. The auxiliary control function shall be specified when required.
‡ Indicates timer types and auxiliary control functions provided in combination control.

NEMA Standard 7-13-1960.

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Part ICS 5-007

WELDING TIMER ACCURACIES

The standards in this part apply to all other parts of this Standards Publication unless otherwise specified. The definitions and standards of NEMA Standards Publication No. ICS 1 apply to this part unless otherwise specified.

ICS 5-007.01 NONSYNCHRONOUS TIMERS

.01 Repetitive Accuracy

When a gradual variation in control-circuit voltage at any time does not exceed plus or minus 10 percent from the value for which the timer is adjusted, each timer will perform its specified timing function in such a way that during any 1-hour test period the maximum observed time to perform each such specified timing function and the minimum observed time to perform the same specified timing function shall not vary from the average of such maximum and minimum by more than plus or minus one-half cycle up to 5 cycles, and plus or minus 1 cycle from 6 to 10 cycles, and plus or minus 10 percent for 11 cycles and above.

NEMA Standard 7-13-1960.

.02 Calibration Accuracy of Nonsynchronous Control

When a gradual variation in control-circuit voltage at any time does not exceed plus or minus 10 percent, the calibration accuracy at the minimum calibrated setting point is equal to plus or minus one cycle, at the mechanical mid-position of the adjuster plus or minus 20 percent of the setting, and at the maximum position of the adjuster plus or minus 20 percent of the maximum setting.

NEMA Standard 11-12-1953.

.03 Nonsynchronous Timing

Nonsynchronous timing is applied to various timing periods as indicated in Part ICS 5-006. When applied to a timing period controlling welding transformer primary current, the initiation and termination of such current is at a random time with respect to the primary voltage.

NEMA Standard 9-28-1961.

ICS 5-007.02 SYNCHRONOUS PRECISION TIMERS

.01 Steps of Timing Adjustment

Synchronous precision timers shall be provided with steps of one cycle up to 30 cycles. For the time range between 30 and 60 cycles on a 60-hertz power supply, and between 30 and 50 cycles on a 50-hertz power supply, the adjustment shall be in one- or two-cycle steps. For a time range between 13 and 25 cycles on a 25-hertz power supply, the adjustment shall be in one-cycle steps.

NEMA Standard 9-17-1953.

.02 Timing Accuracy

The accuracy of a synchronous precision timer, when operating on a circuit where the gradual variation in control-circuit voltage at any time does not exceed plus or minus 10 percent from the value for which the timer is adjusted, shall be such that the variations from the calibrated values will not exceed those listed in Table 5-007-1.

Table 5-007-1
ALLOWABLE ACCURACY OF SYNCHRONOUS TIMERS

60-hertz Power Supply		50-hertz Power Supply		25-hertz Power Supply	
Timing Range Setting, Cycles	Allowable Variation, Plus or Minus, Cycles	Timing Range Setting, Cycles	Allowable Variation, Plus or Minus, Cycles	Timing Range Setting, Cycles	Allowable Variation, Plus or Minus, Cycles
1–15	0	1–15	0	1–13	0
16–30	1	16–30	1	14–25	1
31–40	2	31–40	2	...	...
41–60	3	41–50	3	...	...

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For multiple-impulse welding, there shall be no variation in the number of heat times from the calibrated values over the range of from 1 to 15 impulses.

For times in excess of those shown in the foregoing table, no calibration accuracy is stated, but the repetitive accuracy shall be the same as for nonsynchronous timers as covered by ICS 5-007.01.01.

Within the range of 0–1 cycle, the calibration accuracy shall be plus or minus 0.1 cycle, and the repetitive accuracy shall be plus or minus 0.03 cycle at timer constant supply voltage.

The maximum allowable time between closure of the initiating circuit on an S1H control and the initiation of weld current is 1-1/2 cycles. The operating time of any associated control or safety device which must be closed prior to the initiation of weld current is not included in the maximum allowable time specified for the control.

NEMA Standard 5-12-1969.

The initiating device should be open for a maximum of 3 cycles to assure proper operation of the control.

Authorized Engineering Information 9-23-1964.

.03 Synchronous Precision Timing

Synchronous precision timing is applied to various timing periods as indicated in Part ICS 5-006. When applied to a timing period controlling welding transformer primary current, the initiation and termination of each half cycle of such current is the same whether in the same or succeeding welds. The timing period shall consist of an equal number of positive and negative half cycles. Auxiliary functions controlling welding transformer primary current, such as delayed firing and slope control, will modify the initiation of half cycles of welding transformer primary current.

NEMA Standard 9-28-1961.

ICS 5-007.03 ABSOLUTE CYCLE TIMERS

.01 Steps of Timing Adjustment

Absolute cycle timers shall be in steps of one cycle in the 1–99 cycle range. For longer time ranges, the incremental adjustment may be in steps greater than one cycle.

NEMA Standard 11-17-1966.

.02 Timing Accuracy

The accuracy of absolute cycle timers, when operating on a circuit where the gradual variation in control-circuit voltage at any time does not exceed plus or minus 10 percent from the value for which the timer is adjusted, shall be plus or minus 0 cycles.

For multiple-impulse welding, there shall be no variation in the number of heat times for the calibrated values.

When the fine adjustment is 0.1 through 0.9 cycle and is part of an absolute cycle timing control, the calibration accuracy shall be plus or minus 0.1 cycle, and the repetitive accuracy shall be plus or minus 0.03 cycle.

NEMA Standard 11-17-1966.

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Part ICS 5-008

FREQUENCY CONVERTER WELDING CONTROLS

The definitions and standards of NEMA Standards Publication No. ICS 1 apply to this part unless otherwise specified.

ICS 5-008.01 TERMINAL MARKINGS

See ICS 5-003.09.

ICS 5-008.02 FREQUENCY CONVERTER CONTROL FEATURES

Frequency converter controls shall have the following features:

(a) Indicating lights shall indicate an ignitor fuse failure.

(b) Means shall be provided for balancing positive and negative half cycles of low frequency.

NEMA Standard 7-13-1960.

ICS 5-008.03 NOTES FOR ICS 5-008.04, ICS 5-008.05 AND ICS 5-008.06

\# — Indicates control feature provided in combination control.

† — Provision shall be included for these auxiliary control functions. The auxiliary control function shall be specified when required.

* — Select contactor required.

a — Synchronous precision timing.

b — Maximum time fixed at 2, 3, 4 or 5 cycles.

c — Includes means to bypass the auxiliary control function.

d — Includes mode selection means.

e — Does not include additional fraction of a cycle required for operation.

f — Counts impulses.

g — Counts pulses.

h — 0–1 vernier in 0.1-cycle increments, Resistance-Capacitance (RC) timing.

j — Applies to single operation only.

k — Provision for this auxiliary control function.

l — Includes indicating lights for: (a) Warm-up period elapsed. (b) Water flow adequate. (c) Power on. (d) Direction of next welding pulse.

m — Cycles at line frequency unless otherwise indicated.

n — When an auxiliary control function requires heat control, the suffix denoting that auxiliary function shall replace suffix "H." Examples are: "C," "V," "P" and "T." For example, F2-PT600.

p — Extended range for CF7H.

r — Where an auxiliary control function designation does not exist, the auxiliary control function shall be described.

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ICS 5-008.04 FREQUENCY CONVERTER CONTROL FUNCTIONS

Table 5-008-1
CONTROL FUNCTIONS

Description	Timing Range	
	R/C Timing p	Digital Counting Time a
Squeeze	3–120	1–100
Preheat	...	1–100g
Weld Interval	9–360	1–100f
Cool	1–30	1–100
Weld Time	3–360, 1–30	1–100g
Post Heat	...	1–10e
Forge Delay	...	1–100, 0–1000h, p
Quench	...	1–1000
Temper	...	1–100g
Hold	3–60	1–100
Final Hold	...	1–100
Off	3–60	1–100
Pulse	1–5a, b, e	1–10
Interpulse	0–3a, e	0–9e
Index	...	1–1000
Delay After Index	...	1–10

See Par. ICS 5-008.03.

NEMA Standard 7-13-1960.

ICS 5-008.05 FREQUENCY CONVERTER AUXILIARY CONTROL FUNCTIONS

Table 5-008-2
AUXILIARY CONTROL FUNCTIONS

Description	Reference or Example	R/C Timing m NEMA Suffix No.				Digital Counting Timing a NEMA Suffix No.			
		T	F	P	r	T	F	P	r
Precompression	Fig. 5-008-6	...	...	...	3–10	...	...	...	1–10
Delay After Precompression	Fig. 5-008-6	...	...	...	3–10	...	...	...	1–10
Quench	Fig. 5-008-6	9–360	...	...	...	1–1000	...	...	...
Temper	Fig. 5-008-6	3–120	...	...	...	1–100g	...	...	...
Forge Delay	Fig. 5-008-6	...	3–360	...	...	...	1–1000, 0–1000p	...	...
Preheat	Fig. 5-008-6	...	...	3–120	...	...	...	1–100g	...
Postheat	Fig. 5-008-6	...	...	...	1–10e	...	...	...	1–10e
Weld Time	Fig. 5-008-4	...	...	...	1–30	...	...	...	1–100g
Cool Time	Fig. 5-008-5	...	...	...	1–30	...	...	...	1–100
Weld Delay	Fig. 5-008-6	...	...	...	0–3a, h	...	...	...	0–10h
Weld Interval	Fig. 5-008-5	...	...	...	9–360	...	...	...	1–100f
Off	Fig. 5-008-4	...	...	...	...	...	...	...	1–1000p
Squeeze	Fig. 5-008-4	...	...	...	...	...	...	...	1–1000p
Hold	Fig. 5-008-4	...	...	...	...	...	...	...	1–1000p

See Par. ICS 5-008.03.

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ICS 5-008.06 FREQUENCY CONVERTER CONTROL COMBINATIONS

The cycle diagram figures in Part ICS 5-001 of this publication are illustrative of types of control designated from standard NEMA types with auxiliary control functions.

Table 5-008-3
CONTROL COMBINATIONS

	Description			R/C Timing NEMA Type No.			Digital Timing NEMA Type No.				
I	Standard Combinations (See par. ICS 5-008.04)										
II	Auxiliary Control Functions (See par. ICS 5-008.05)	Suffix								CF7H	CF8H
III	Contactors	n	Reference	F2H	F3H	F5H	CF2H	CF3H	CF5H	e, l	d, e, l
I	Squeeze	...		#	#	...	#	#	...	#	#
	Preheat c	...		...	...	...	...	...	...	#	...
	Weld Interval	...		...	#	...	...	#	...	...	#
	Cool c	...		...	#	...	...	#	...	...	#
	Weld Time	...		#	#	...	#	#	...	#	...
	Post Heat	...		...	...	...	...	...	...	#	#
	Forge Delay	...		...	...	...	...	...	...	#	#
	Quench c	...		...	...	...	...	...	...	#	...
	Temper c	...		...	...	...	...	...	...	#	...
	Hold	...	ICS 5-008.04	#	#	...	#	#	...	#	#
	Final Hold	...		...	...	...	...	...	...	...	#
	Off	...		#	#	...	#	#	...	#	...
	Pulse	...		#	#	#	#	#	#	#	#
	Interpulse	...		#	#	#	#	#	#	#	#
	Index	...		...	...	...	...	...	...	...	#
	Delay After Index	...		...	...	...	...	...	...	...	#
	Unipolarity	...	ICS 5-001.02	...	...	...	...	...	...	#	#
	Alternate Polarity	...		...	...	...	...	...	...	#	#
	Inversion	...	ICS 5-001.04	...	...	...	...	...	...	#	#
	Vernier (Electronic Heat)	...	ICS 5-002.05	...	...	...	...	...	...	#	#
II	Quench	T		†	†	...	†	†	...	...	†k
	Temper c	T		†	†	...	†	†	...	...	†k
	Forge Delay c	F		†	†	...	†	†	...	†	...
	Post Heat c	r		†	...	...	†	...	...	...	...
	Weld Time	r		...	...	†	...	...	†	†	...
	Cool Time	r		...	...	†	...	...	†	†	...
	Weld Delay	r	ICS 5-008.05	†	†	...	†	†	...	†	†
	Weld Interval	r		...	...	...	...	...	...	†	...
	Squeeze	r		...	...	†	...	...	†	†p	...
	Preheat c	p		†	...	...	†	†	...	...	†
	Hold	r		...	...	†	...	...	†	†p	...
	Precompression	r		†	†	...	†	†	...	†	†
	Delay After Precompression	r		†	†	...	†	†	...	†	†
	Off	r		...	...	...	...	...	...	†p	...
	Unipolarity	...	ICS 5-001.02	†	†	†	†	†	†	...	...
	Alternate Polarity	...	ICS 5-001.02	†	†	†	†	†	†	...	...
	Inversion	...	ICS 5-001.04	†	†	†	†	†	†	...	...
	Vernier (Electronic Heat)	...	ICS 5-002.05	†	†	†	†	†	†	...	...
III	Electronic 600	600		*	*	*	*	*	*	*	*
	Electronic 1200	1200	ICS 5-008.07	*	*	*	*	*	*	*	*
	Electronic 2400	2400		*	*	*	*	*	*	*	*

See par. ICS 5-008.03.

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ICS 5-008.07 ELECTRONIC WELDING CONTACTORS, THREE PHASE

A three-phase electronic welding contactor used to make and break three lines of a three-phase welding system shall consist of the following:

(a) Three pairs of inversely connected tubes with suitable mounting provisions.
(b) Control circuit and components to permit control of initiation and termination of current conduction by an external pilot or equivalent external electronic device.
(c) Three internally mounted surge suppressing means.
(d) Ignitron contactors with means for protection in case of excessive ignitron tube temperature.

NEMA Standard 7-13-1960.

ICS 5-008.08 RATING FOR THREE-PHASE ELECTRONIC WELDING CONTACTORS

Figs. 5-008-1 through 5-008-3 shall be used to determine the proper size of ignitron tubes for a three-phase electronic welding contactor controlling a frequency converter or a rectifier at any given line voltage, welding current and duty cycle.

NEMA Standard 7-13-1960.

ICS 5-008.09 DUTY CYCLE OF THREE-PHASE ELECTRONIC WELDING CONTACTORS (MACHINE)

The duty cycle of three-phase electronic welding contactors shall be in accordance with the following:

$$\text{Machine duty cycle in percent} = \frac{\text{Contactor ``on'' time}}{\text{Averaging time}} = \frac{\text{Contactor ``on'' time}}{\text{``On'' time + ``off'' time}}$$

NEMA Standard 7-13-1960.

ICS 5-008.10 WELD CYCLE DIAGRAMS FOR FREQUENCY CONVERTER CONTROLS

Single-phase weld cycle diagrams are shown in par. ICS 5-001.06 and Figs. 5-001-1 through 5-001-9.

For weld cycle diagrams for frequency converter controls, see Figs. 5-008-4 through 5-008-10.

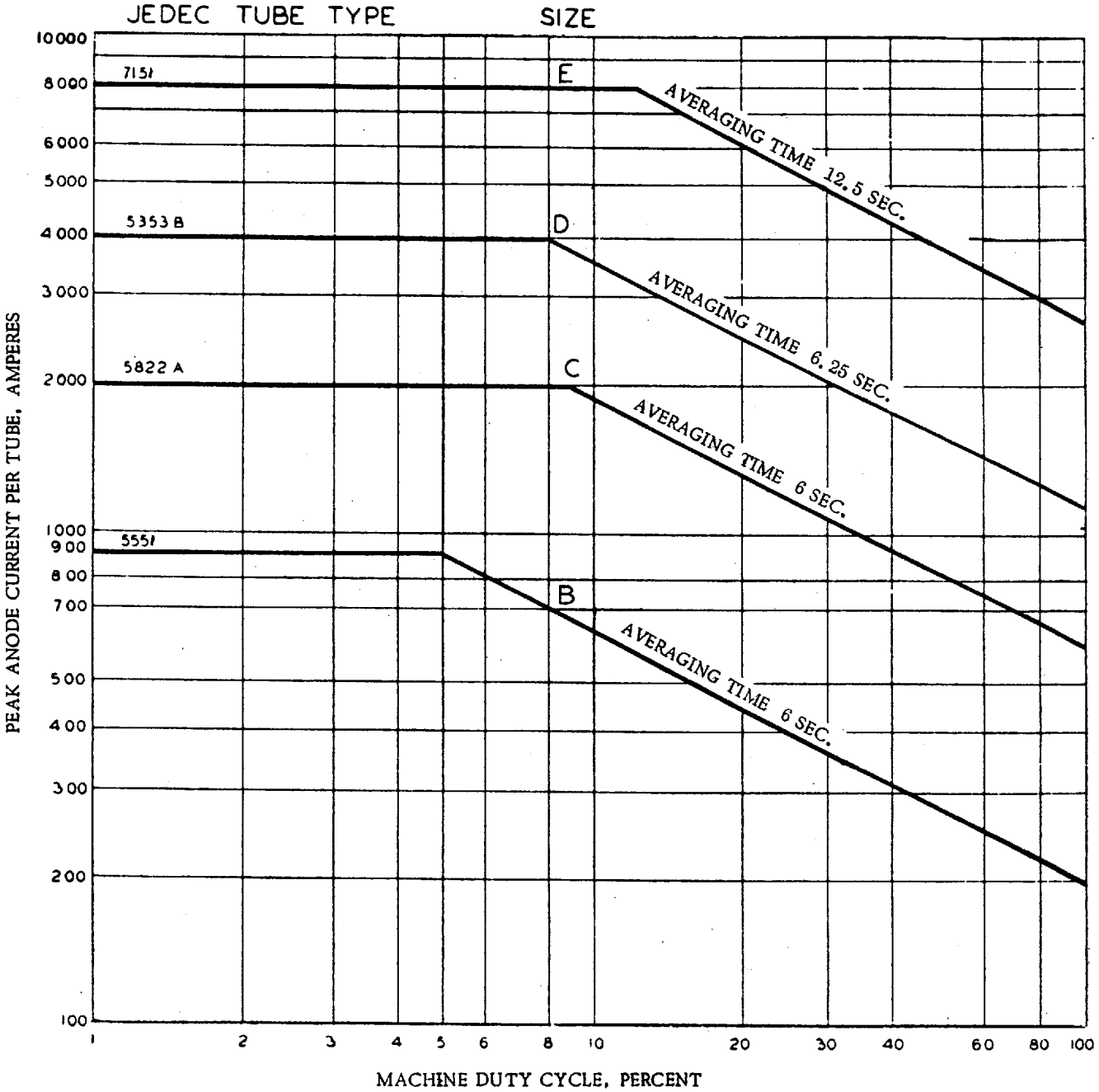
NEMA Standard 7-13-1960.

Table 5-008-4
THREE-PHASE ELECTRONIC WELDING CONTACTORS

Frame Size	Tubes Accommodated	External Connection Bus Drilling
600	Size B or C (Ignitron)	Two 1/2-inch-diameter bolts
1200	Size B, C or D (Ignitron)	Two 5/8-inch-diameter bolts
2400	Size E (Ignitron)	Four 1/2-inch-diameter bolts

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IGNITRON CONTACTOR RATINGS
3-PHASE 1/2-WAVE POWER RECTIFIER OR LOW-FREQUENCY CONVERTER (6 TUBES)



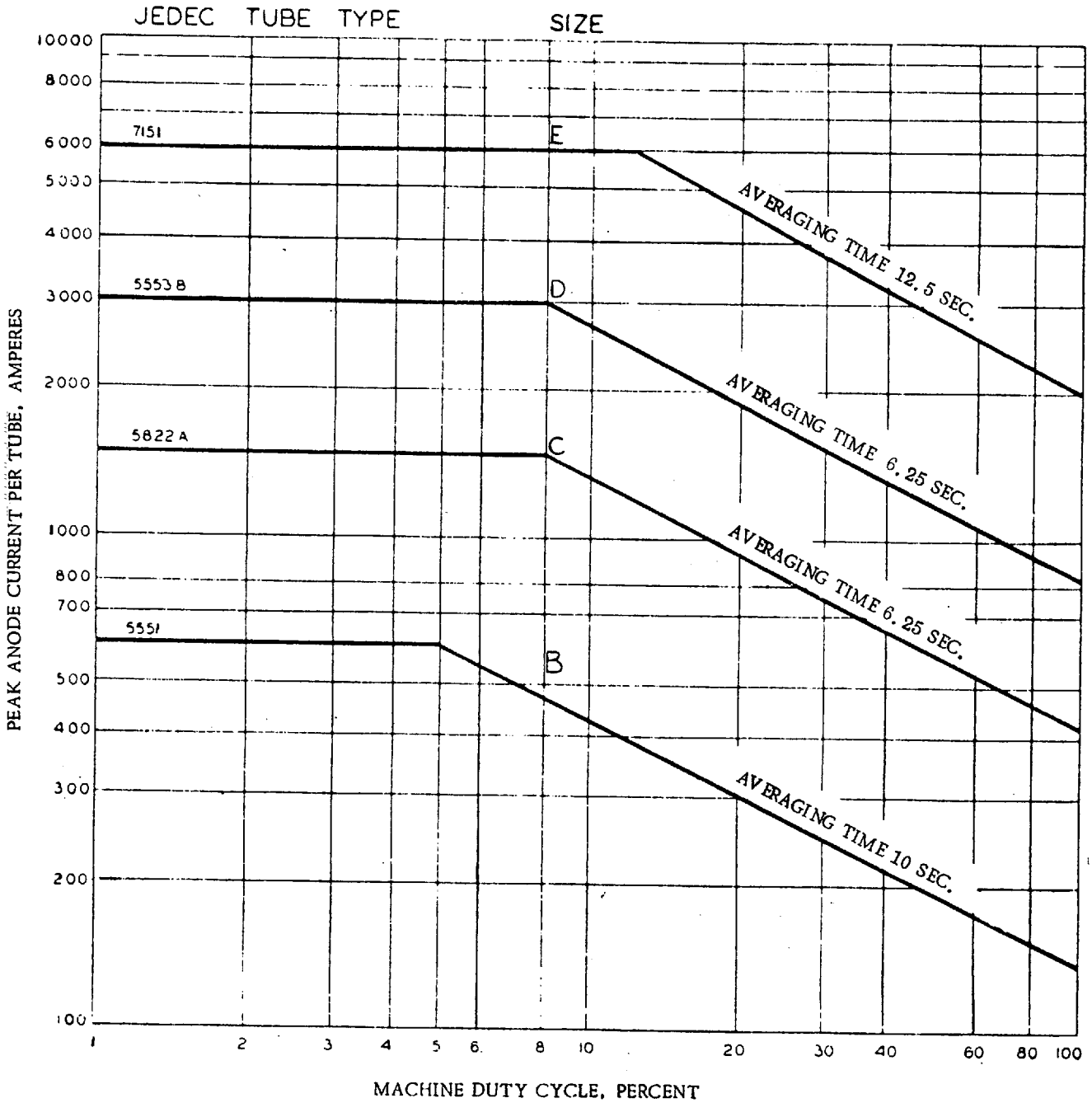
(PEAK $E_{INV} = E_{FD} = 600$ Volts)

E_{INV} = Inverse Voltage
E_{FD} = Forward Voltage

Fig. 5-008-1
RATINGS FOR LINE VOLTAGE OF 230 VOLTS RMS

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IGNITRON CONTACTOR RATINGS
3-PHASE 1/2-WAVE POWER RECTIFIER OR LOW-FREQUENCY CONVERTER (6 TUBES)



(PEAK E_{INV} = E_{FD} = 1200 Volts)

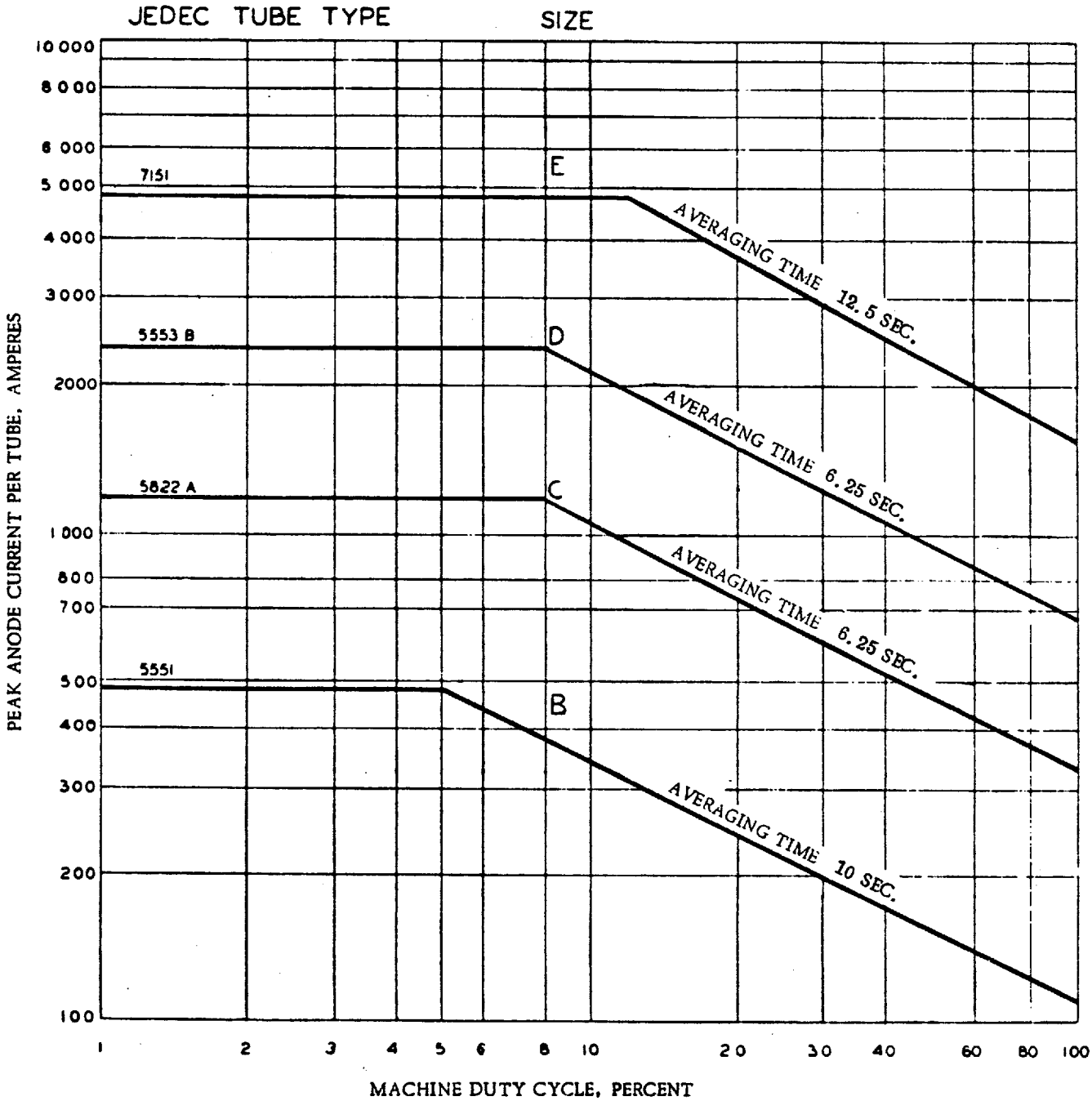
E_{INV} = Inverse Voltage
E_{FD} = Forward Voltage

Fig. 5-008-2
RATINGS FOR LINE VOLTAGE OF 460 VOLTS RMS

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IGNITRON CONTACTOR RATINGS
3-PHASE 1/2-WAVE POWER RECTIFIER OR LOW-FREQUENCY CONVERTER (6 TUBES)



(PEAK $E_{INV} = E_{FD} = 1500$ Volts)

E_{INV} = Inverse Voltage
E_{FD} = Forward Voltage

Fig. 5-008-3
RATINGS FOR LINE VOLTAGE OF 575 VOLTS RMS

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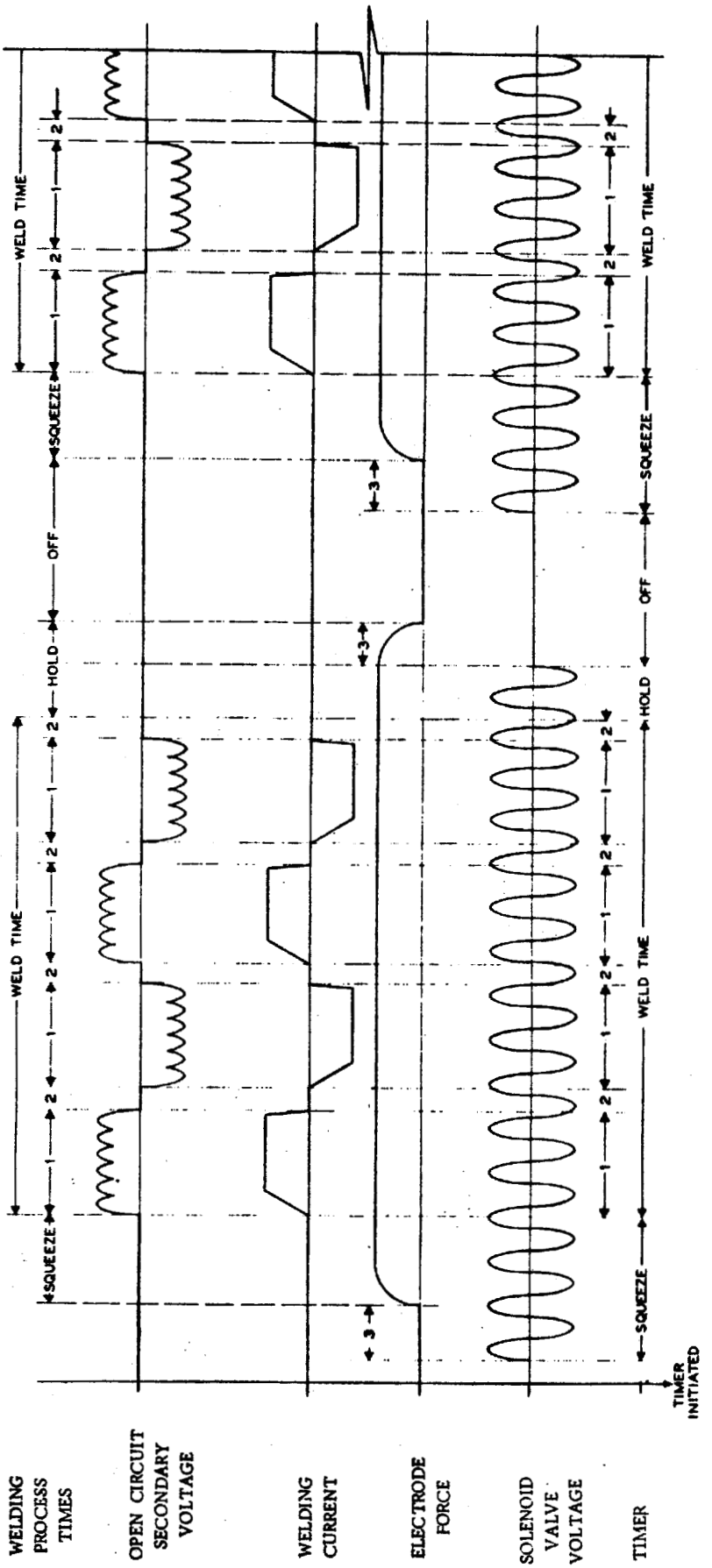


Fig. 5-008-4
FREQUENCY CONVERTER—SIMPLE WELD CYCLE (REPEAT) SIMULATES FUNCTIONS OF NEMA TYPES F2H AND CF2H

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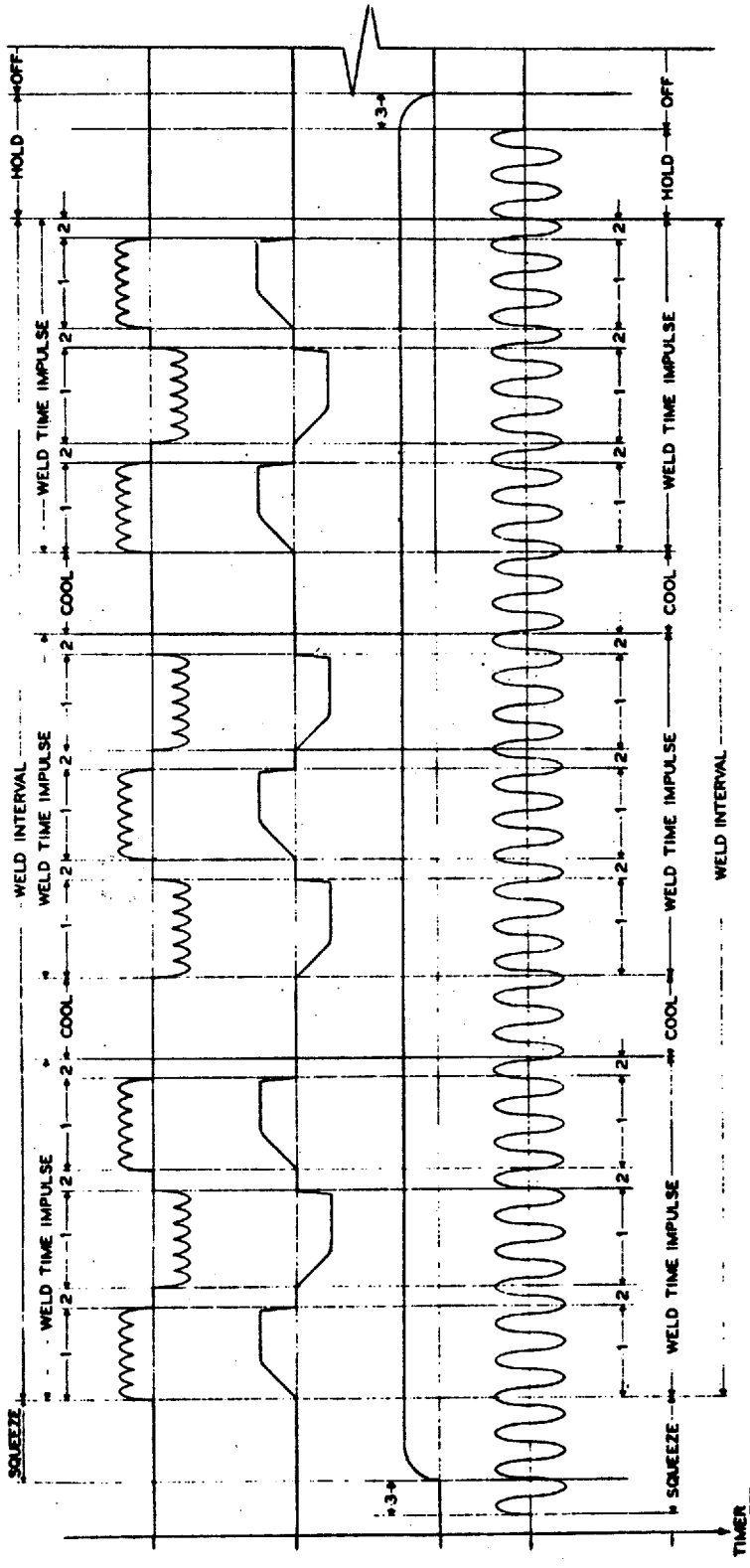
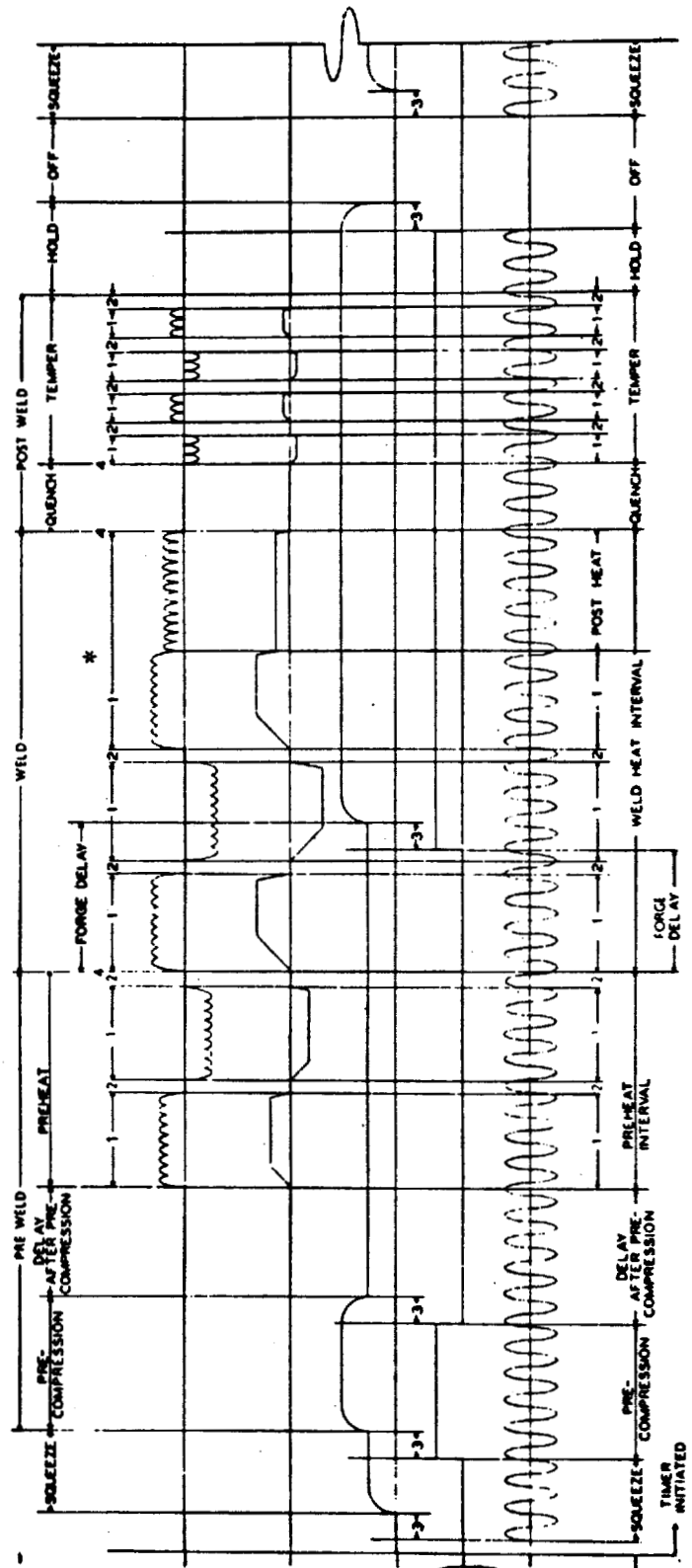


Fig. 5-008-5
FREQUENCY CONVERTER—SIMPLE WELD CYCLE WITH WELD INTERVAL SIMULATES FUNCTIONS OF NEMA TYPES F3H AND CF3H

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1 = Pulse Time
2 = Interpulse Time
3 = Machine Operating Time
4 = DC Forge Shown
Forge delay may be started
a. Beginning of quench
b. End of quench

* Pulse time includes post heat time.
NOTE—When weld delay is required, it occurs before the start of weld time; forge delay time then will be initiated at the beginning of weld delay time. Both preheat and weld delay are not used in the same sequence.

Fig. 5-008-6
FREQUENCY CONVERTER—COMPLEX WELD CYCLE SIMULATES FUNCTIONS OF NEMA TYPES F2PFTZ AND CF2PFTZ WHERE Z DENOTES WELD DELAY, POST HEAT, PRECOMPRESSION, AND DELAY AFTER PRECOMPRESSION TO BE SPECIFIED

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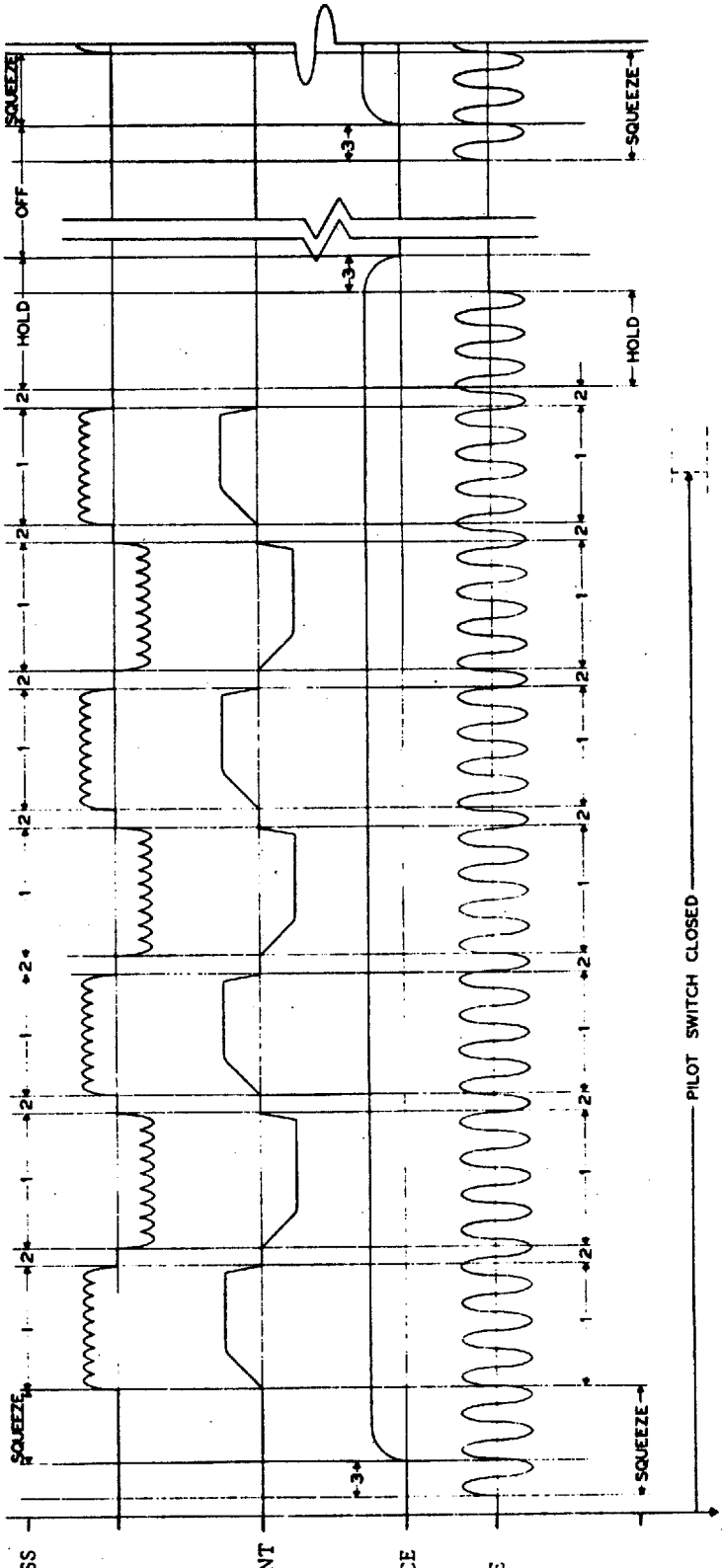


Fig. 5-008-7
FREQUENCY CONVERTER—SIMPLE SEAM WELD CYCLE SIMULATES FUNCTIONS OF NEMA TYPES F5HZ AND CF5HZ WHERE Z DENOTES ADDITIONAL SQUEEZE AND HOLD FUNCTIONS TO BE SPECIFIED

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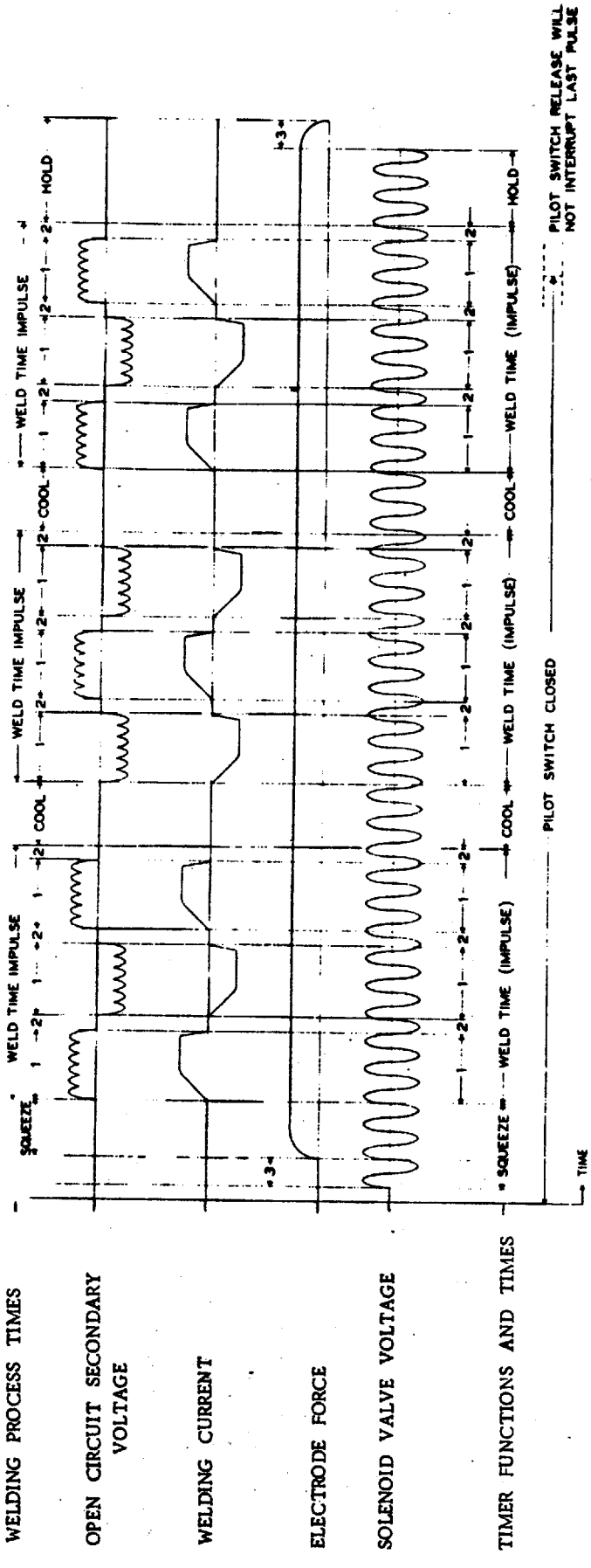


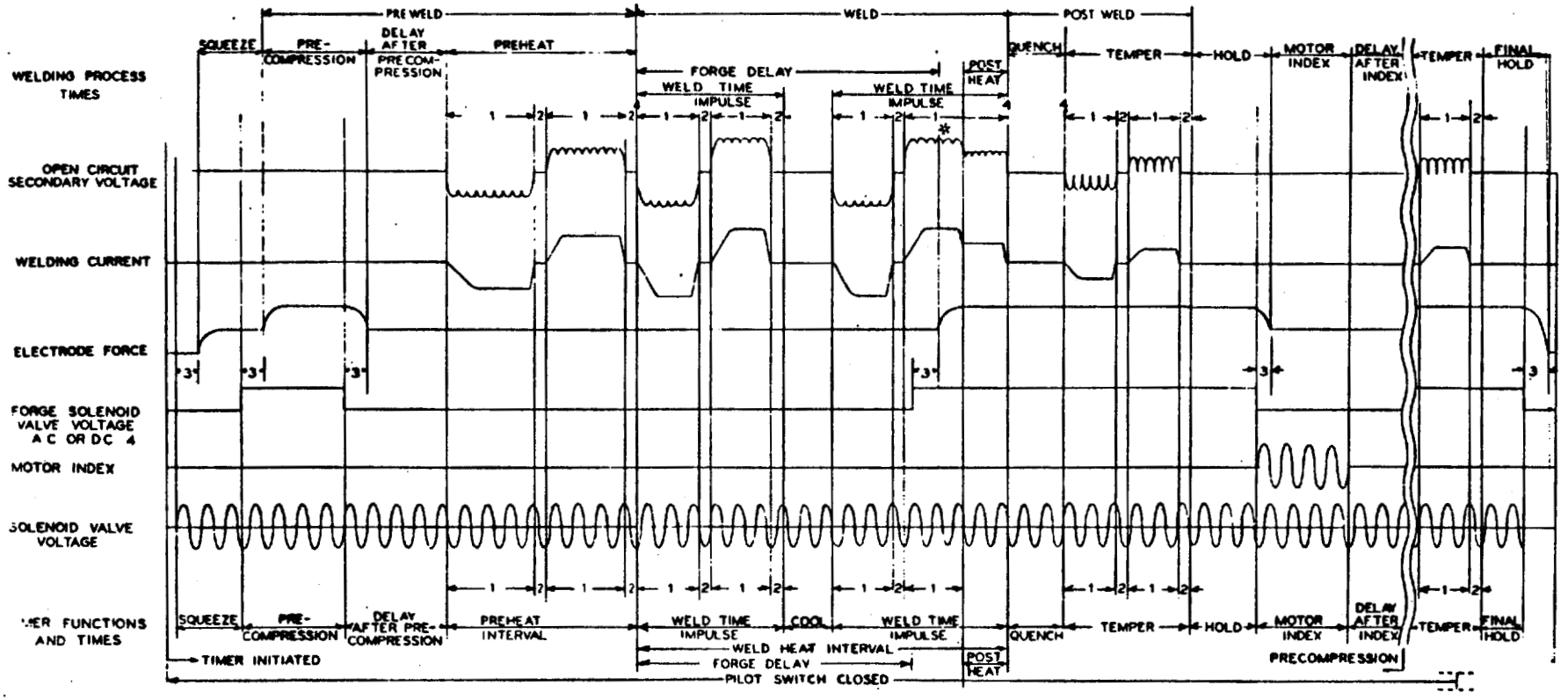
Fig. 5-008-8
FREQUENCY CONVERTER—COMPLEX SEAM WELD CYCLE SIMULATES FUNCTIONS OF NEMA TYPES F5HZ AND CF5HZ WHERE Z DENOTES ADDITIONAL SQUEEZE, HOLD, AND COOL FUNCTIONS TO BE SPECIFIED

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1 = Pulse Time
2 = Interpulse Time
3 = Machine Operating Time

4 = DC Forge Shown
Forge delay may be started
(a) Beginning of quench
(b) End of quench

* Pulse time includes post heat time.
NOTE—When weld delay is required, it occurs before the start of weld time; forge delay time then will be initiated at the beginning of weld delay time. Both preheat and weld delay are not used in the same sequence.

Pilot switch release will terminate the normal sequence by substituting "final hold" for "hold time."

Fig. 5-008-10
FREQUENCY CONVERTER INTERMITTENT INDEX ROLL SPOT WITH COMPLEX WELD CYCLE AND WELD INTERVAL SIMULATES FUNCTIONS OF NEMA TYPE CF8PTZ WHERE Z DENOTES ADDITIONAL FUNCTIONS OF WELD DELAY, PRECOMPRESSION AND DELAY AFTER PRECOMPRESSION TO BE SPECIFIED

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Part ICS 5-009

WELDING CONTROL ACCESSORIES

The standards in this part apply only to Resistance Welder Control. The definitions and standards of NEMA Standards Publication No. ICS 1 apply to this part unless otherwise specified.

ICS 5-009.01 SLOPE CONTROL AS USED IN RESISTANCE WELDING

.01 Calibration Accuracy of Up-slope Controls

When the up-slope time is set for a given time, the current at that time shall be 90 percent plus or minus 5 percent. The following test conditions shall apply:

(a) The final current shall be set for maximum.
(b) The initial current shall be set for an rms value of 20 percent of maximum.
(c) The load power factor shall be set for 40 percent.
(d) The line voltage shall be constant.
(e) The determination of slope accuracy shall be in terms of peak primary load current with reference to a straight line between initial current and the current line at time setting. In an eleven cycle slope time, the sixth cycle current shall not deviate from the straight line by more than plus or minus 10 percent of the maximum. The peak primary load current shall be measured with an oscilloscope or equivalent instrument. See Fig. 5-009-1. (This item is approved as a Suggested Standard for Future Design.)

On nonsynchronous controls, the calibration accuracy for nonsynchronous controls as covered by ICS 5-007.01.02 shall apply.

On precision controls, the calibration accuracy for synchronous controls as covered by ICS 5-007.02.02 shall apply.

.02 Timing Function for Up-slope Control

When used on multi-impulse timers, the slope function shall apply to the weld interval time. A switch shall be provided to completely remove the timing function from the circuit.

.03 Calibration Accuracy for Down-slope Control

When the down-slope time is set for a given time, the current at that time shall be 30 percent plus or minus 5 percent. The following test conditions shall apply:

(a) The final postheat current shall be set for an rms current of 20 percent.
(b) The maximum welding current shall be set for 100 percent.
(c) The load power factor shall be set for 40 percent.
(d) The line voltage shall be constant.
(e) The determination of slope accuracy shall be in terms of peak primary load current with reference to a straight line between maximum current and the current line at time setting. In the eleven cycle slope time, the sixth cycle current shall not deviate from the straight line by more than plus or minus 10 percent of the maximum. The peak primary load current shall be measured with an oscilloscope or equivalent instrument. See Fig. 5-009-1. (This item is approved as a Suggested Standard for Future Design.)

On nonsynchronous controls, the calibration accuracy for nonsynchronous controls as covered by ICS 5-007.01.02 shall apply.

On precision controls, the calibration accuracy for synchronous controls as covered by ICS 5-007.02.02 shall apply.

.04 Timing Function for Down-slope Control

When used with multi-impulse timers, the slope function shall apply to the weld interval time. A switch shall be provided to completely remove the timing function from the circuit.

NEMA Standard 1-25-1972.

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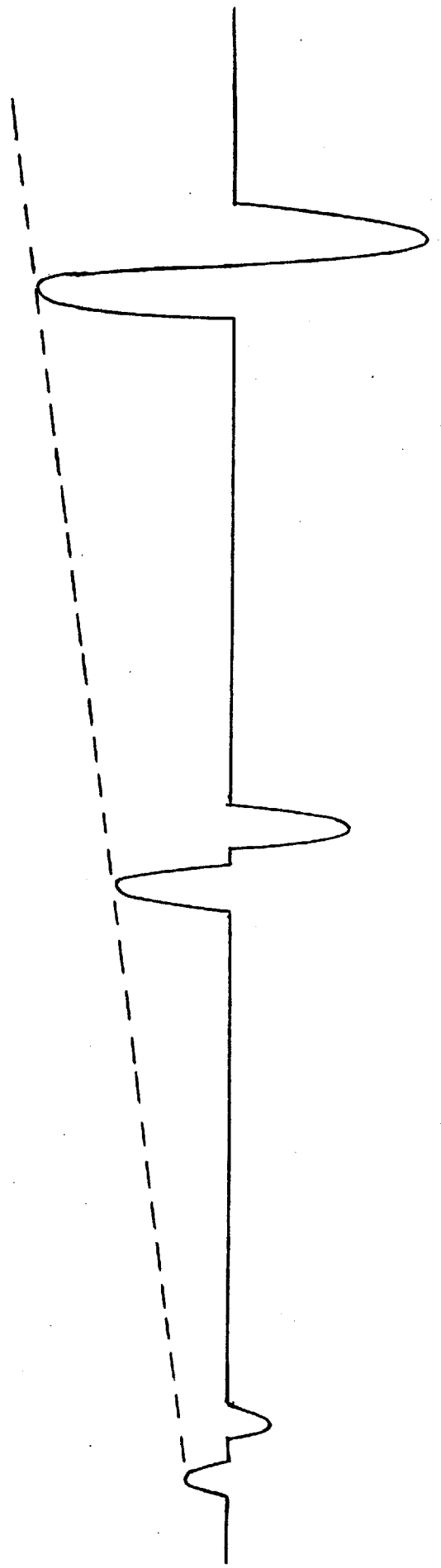


Fig. 5-009-1
DETERMINATION OF UP-SLOPE CONTROL LINEARITY BY RMS CURRENT AMPLITUDE MEANS

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ICS 5-009.02 ELECTRONIC CURRENT REGULATOR

An electronic current regulator as used in connection with resistance welding control shall have the following characteristics:

.01 Accuracy

The electronic current regulator shall hold the rms primary welding current within ± 3 percent under the same conditions which would cause the unregulated welding current to vary ± 20 percent, providing the regulator is not required to operate beyond the limits of electronic heat control. The foregoing will hold true if the line voltage variations do not exceed ± 10 percent.

.02 Response Time

The regulator shall return the current value to within 5 percent of the desired value in 3 cycles or less under conditions which cause up to a 20 percent disturbance of the current, providing the cool time or the time between welds is greater than one cycle.

.03 Cut-off Switch

An "on" and "off" switch shall be provided to remove the electronic current regulator from the circuit.

NEMA Standard 9-28-1961.

ICS 5-009.03 ELECTRONIC VOLTAGE REGULATOR

An electronic voltage regulator as used in connection with resistance welding control shall have the following characteristics:

.01 Accuracy

An electronic voltage regulator shall hold the welding transformer primary rms voltage within ± 2 percent of the preset value under line voltage variations of ± 10 percent. This device is not required to operate beyond the limits of electronic heat control.

.02 Response Time

The regulator shall cause the voltage to be corrected at least 50 percent at the second cycle, 80 percent at the third cycle, and 100 percent at the fourth cycle, after the line voltage disturbance.

.03 Cut-off Switch

An "on" and "off" switch shall be provided to remove the electronic voltage regulator from the circuit.

NEMA Standard 5-12-1969.

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Part ICS 5-010

DEFINITE APPLICATIONS OF WELDING CONTROL

The standards in this part apply only to Resistance Welder Control. The definitions and standards of NEMA Standards Publication No. ICS 1 apply to this part unless otherwise specified.

ICS 5-010.01 AIRCRAFT SPOT WELDER

This standard covers aircraft spot welder type of control known as NEMA Type S2UDF(T). Time ranges shall be as shown in ICS 5-006.01 and ICS 5-006.02.

The following control features shall be provided: indicating lights to signify (1) that contactor temperature is below maximum operating temperature, and (2) when control circuit power is applied.

NEMA Standard 7-13-1960.

ICS 5-010.02 GUN WELDER TYPE OF CONTROL FOR RESISTANCE SPOT WELDING

.01 General

This standard covers gun welder type of control for resistance spot welding which is suitable for application on high-speed (in excess of 180 spots per minute) portable gun welders. These are NEMA Types N6-600 and N6H-600.

.02 Enclosure

The combination control shall contain a timer portion, a contactor and a disconnect means.

The timer portion shall be NEMA Type 12. The contactor and disconnect means shall be NEMA Type 1.

Enclosure doors and disconnect device shall be mechanically interlocked.

Operating adjustments shall be mounted on surface "O."

Space shall be provided for a 4-inch-diameter bushing to allow entry of power leads into the top and bottom of the enclosure. Space shall be provided on surface "M" of the contactor section of the enclosure in accordance with Part ICS 5-004.

Space for mounting water saver means shall be provided.

.03 Disconnecting Means

A fusible two-pole disconnect device having a rating of either 200 amperes or 400 amperes at 600 volts shall be provided.

.04 Accuracies and Control Features

Time ranges shall be as shown in ICS 5-006.01 and ICS 5-006.02.

Calibration accuracy shall be as shown in the Table 5-010-1 when a gradual variation in the control circuit voltage at any time does not exceed plus 10 percent or minus 5 percent of the nominal control circuit voltage.

Table 5-010-1
CALIBRATION ACCURACY

Dial Setting, Cycles	Calibration Accuracy— Permissible Cycles Variation, Plus or Minus: Squeeze Delay	Squeeze	Weld	Hold	Off
−2 to zero	...	...	...	0	...
1 to 2	...	...	0	0	...
3 to 5	1	1	0	1	1
6 to 10	1	1	1	1	1
11 to 20	2	2	2	2	2
21 to 30	3	3	3	3	3

The repetitive accuracy shall be permitted to vary plus or minus 5 percent or plus or minus one cycle, whichever is greater, on all timers and all ranges. These conditions shall be maintained with a plus 10 percent, minus 5 percent, gradual variation in line voltage and with sudden line voltage variation of plus or minus 5 percent.

The timer shall be capable of completing its sequence during a sudden line voltage drop of 15 percent.

Low-voltage control shall be provided.

Separate fuses shall be provided in the primary circuit of the control transformer.

The sequence weld timer shall be so designed that its major panel subassembly can be quickly removed for servicing.

NEMA Standard 7-13-1960.

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ICS 5-010.03 FUNCTION PLUG-IN PROGRAM TIMER

This standard covers plug-in program timers suitable for machine sequencing and weld timing applications. These are NEMA Type 1D ( ). Time ranges shall be as shown in ICS 5-006.01. Terminal arrangements and control features shall be as shown in the Table 5-010-2.

Table 5-010-2
TIMER FEATURES

Terminal Numbers	Types 1	2	3	4	5	6	7*	8*	
1	x	x	x	x	x	x	x	x	115 Volt, 60 hertz
2	x	x	x	x	x	x	x	x	
3	x	x	x	x	x	x	x	x	Initiation
4	x	x	x	x	x	x	x	x	
5	...	...	x	x	x	x	x	x	
6	...	x	x	x	x	x	x	x	Operates on initiation, may or may not open after time delay†
7	...	x	x	x	x	x	x	x	
8	...	x	x	x	x	x	x	x	
9	...	...	...	x	...	x	x	...	
10	...	...	...	x	...	x	x	x	
11	...	...	...	x	...	x	x	x	
12	x	...	x	x	x	x	...	...	Operates after time delay
13	x	...	x	x	x	x	...	...	
14	x	...	x	x	x	x	...	...	
15	...	...	...	...	x	x	...	...	
16	...	...	...	...	x	x	...	...	
17	...	...	...	...	x	x	...	...	
18	...	...	...	...	...	...	x	...	1/2-Wave direct-current output
19	...	...	...	...	...	...	x	x	
20	...	...	...	...	...	...	...	x	

* Types 1D-7 and 1D-8 electronic type.
Type 1D-7 tube fires at end of timing period.
Type 1D-8 tube fires at start of timing period.
† Types 1D-7 and 1D-8 do not open.

There are two sub-types of each of the above controls, A and B:

The A timer shall have the electronic tube conduct during the timing period.

The B timer shall have the electronic tube conduct at the end of the timing period.

Timers shall be designated in accordance with the following:

Type A timer—1D-1A, 1D-2A, 1D-3A, etc.

Type B timer—1D-1B, 1D-2B, 1D-3B, etc.

Each sub-type shall provide an initiating signal light which will light when a signal is applied to the timer.

Relay contacts shall be rated 5 amperes at 115 volts, 60 hertz alternating current non-inductive.

NEMA Standard 1-21-1964.

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Part ICS 5-011

GRAPHIC SYMBOLS FOR WELDING CONTROLS

ICS 5-011.01 ELECTRICAL AND ELECTRONIC SYMBOLS

Refer to ICS 1-101A.

NEMA Standard 10-16-1985.

ICS 5-011.02 LOGIC DIAGRAM SYMBOLS

Refer to ICS 1-101A.

NEMA Standard 10-16-1985.

ICS 5-011.03 REFERENCE DESIGNATIONS

Refer to ICS 1-101A.

NEMA Standard 10-16-1985.

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ICS 5-011.04 LOGIC SYMBOLS

In the following list of logic symbols, explanations accompany the graphic representations.

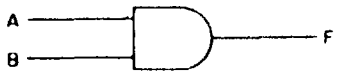
Inputs should be shown from the top, left or bottom and outputs from the top, right or bottom, but inputs and outputs should not be shown on the same side.

.01 AND

The following symbol represents the AND function:



The output of an AND assumes the 1-state if and only if all of the inputs assume the 1-state.



Inputs		Output
A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

.02 OR

The following symbol represents the INCLUSIVE OR function:



The output of an OR assumes the 1-state if one or more of the inputs assume the 1-state.



Inputs		Output
A	B	F
0	0	0
0	1	1
1	0	1
1	1	1

.03 EXCLUSIVE OR

The following symbol represents the EXCLUSIVE OR function:



The following symbol represents the EXCLUSIVE OR function with high output. The output of an EXCLUSIVE OR with two inputs assumes the 1-state if one and only one input assumes the 1-state.



Inputs		Output
A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

.04 LOGIC NEGATION

The symbol o represents LOGIC NEGATION.

The output of LOGIC NEGATION operation takes on the 1-state if and only if the input does not take on the 1-state.

It is an auxiliary symbol to be used only with one of the regular symbols to indicate LOGIC NEGATION. A small circle drawn at the point where a signal line joins a logic symbol indicates LOGIC NEGATION.

.05 NAND

The following symbol represents the NAND function. The output of a NAND assumes the 0-state if and only if all inputs assume the 1-state.



Inputs			Output
A	B	C	F
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

* Not part of symbol.

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.06 NOR

The following symbol represents the NOR function. The output of a NOR assumes the 1-state if and only if all inputs assume the 0-state.



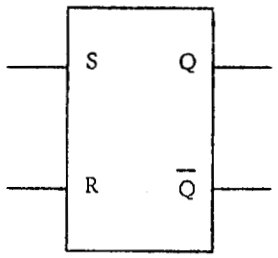
Inputs			Output
A	B	C	F
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

.07 FLIP-FLOP

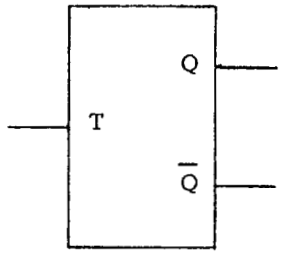
The FLIP-FLOP is a binary sequential logic element with two stable states. One of these is called the set state (also called 1-state); the other is the reset state (also called 0-state).

(a) *Polarity*—The two outputs are normally of opposite polarity. A "1" is stored in the FLIP-FLOP when the Q output level is active and the $\overline{Q}$ level is inactive. A "0" is stored in the FLIP-FLOP when the above condition is reversed.

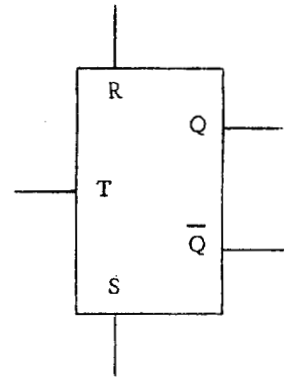
(b) *Examples of FLIP-FLOP Symbols*



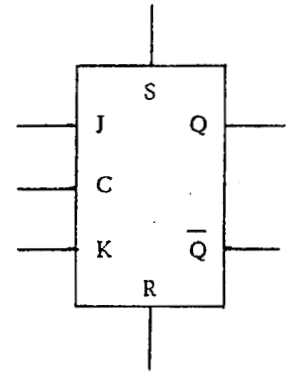
Configuration (a)



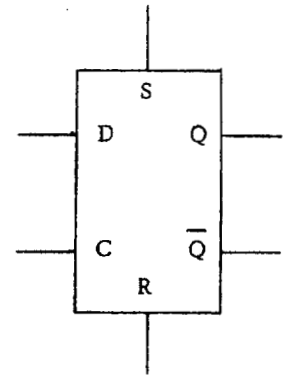
Configuration (b)



Configuration (c)



Configuration (d)



Configuration (e)

(c) *Inputs*

(1) Static R (Reset) Input—An input of the indicated 1-state will reset the FLIP-FLOP. The return of this input to its 0-state produces no further action. See step .07(c) (2) of par. ICS 5-011.04.

(2) Static S (Set) Input—An input of the indicated 1-state will set the FLIP-FLOP.

(Continued)

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The return of this input to its 0-state produces no action.

The state of the FLIP-FLOP is undefined (for purposes of this standard) under the following conditions: when both the R and the S inputs, including the effect of dependency notation if present, stand at their indicated 1-states concurrently; and, thereafter, if both inputs return to their 0-state simultaneously.

(3) T (Toggle) Input—Each time the T input level changes to its indicated 1-state, it changes the state of the FLIP-FLOP. The return of this input to its 0-state produces no further action.

(4) J, K and C (Clock) Inputs

I. As applied to the configuration number (d) shown in par. ICS 5-011.04, operation of the J, K and C inputs is described by the following truth table:

C*	J	K	Q	$\overline{Q}$
⎍⎍	0	0	Qo†	$\overline{Q}$o†
⎍⎍	1	0	1	0
⎍⎍	0	1	0	1
⎍⎍	1	1	‡	‡

* This input is sometimes marked T.
† Qo = No change of state. $\overline{Q}$o = No Change of state.
‡ Each time the C input level changes to its indicated 1-state, it changes the state of the FLIP-FLOP. The return of this input to its 0-state produces no further action.

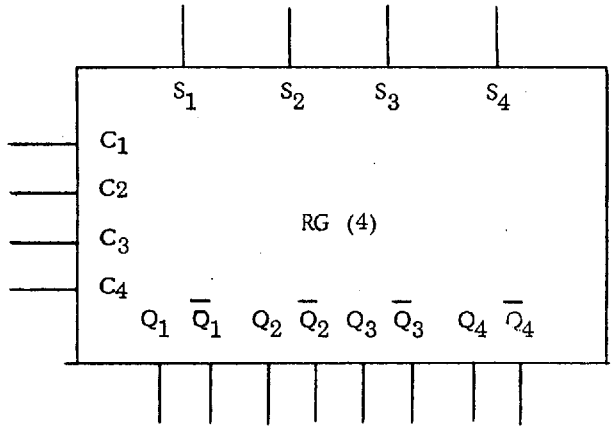
II. As applied to the configuration number (e) shown in par. ICS 5-011.04, if the C input level changes to its indicated 1-state, then the FLIP-FLOP assumes the logic state of its D input. The return of the C input to its 0-state produces no action.

An input designated C always gates a D input only.

(5) D Input (Data)—An input designated D shall always be shown further dependent upon another input, generally a C input. See step .07(c)(4).II of par. ICS 5-011.04. When this associated input level (the C input) changes to its indicated 1-state, a D input which stands at its indicated 1-state will cause the FLIP-FLOP to set, and a D input standing at its 0-state will cause the FLIP-FLOP to reset. At any such time that the C input returns to its 0-state, the FLIP-FLOP will remain in the state (set or reset) which exists at that moment in time.

.08 BINARY REGISTER

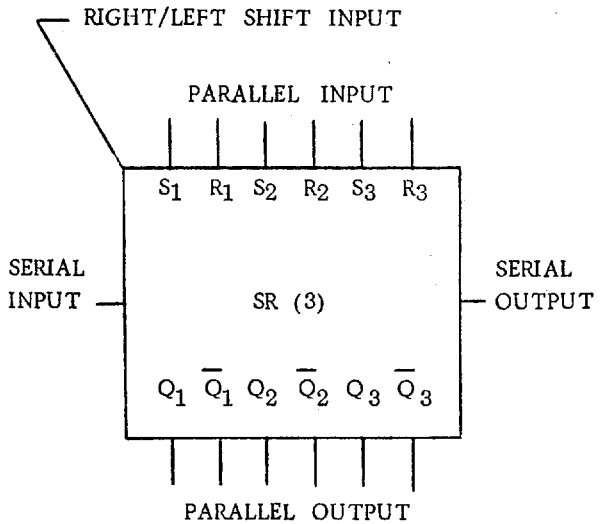
The BINARY REGISTER symbol represents a group of flip-flops used in parallel to constitute a single register (as to store four bits of a character). It is necessary to indicate the number of "bits" or individual flip-flops in the register. The following example shows four S inputs and four each Q and $\overline{Q}$ output lines.



.09 SHIFT REGISTER

The SHIFT REGISTER symbol represents a binary register with provision for displacing or shifting the content of the register one stage at a time to the right or left by means of the "shift" input.

The following is an example of the SHIFT REGISTER symbol:

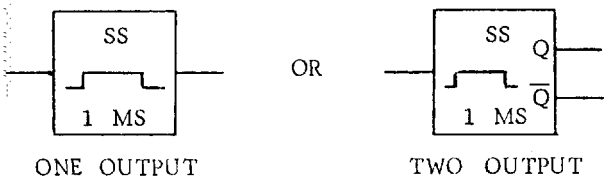


.10 SINGLE-SHOT FUNCTIONS

The following symbols are used to represent SINGLE-SHOT (SS) FUNCTIONS. Output signal shape, amplitude, duration, and polarity are determined by the circuit characteristics of the SS (not by the input

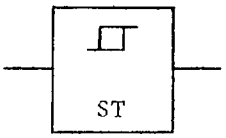
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signal) and may be shown inside or outside the symbol. The unactuated state of the SS is either zero or one. When actuated, it changes to the opposite state and remains in the opposite state for the duration of the active time of the device. The aspect ratio of the symbol shall be 1:1.



.11 SCHMITT TRIGGER

The output will assume its indicated 1-state if and only if the input reaches and exceeds a specific threshold value as it changes from the 0-state towards its indicated 1-state. The output will remain at its indicated 1-state until such time as the input returns past a specific level (not necessarily the same as above) towards its 0-state.



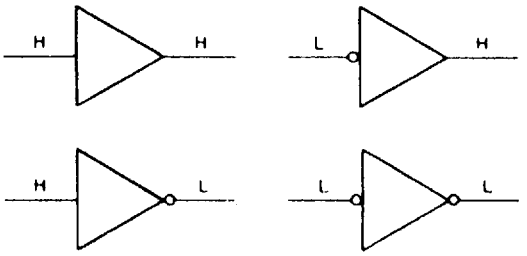
.12 GENERAL LOGIC SYMBOL

The following symbol is the GENERAL LOGIC SYMBOL for functions not elsewhere specified. The symbol shall be adequately labeled to identify the function performed. It is not intended that this symbol be used for functions which can be logically expressed by a single symbol established in this standard. The aspect ratio shall be 2:1 or greater.



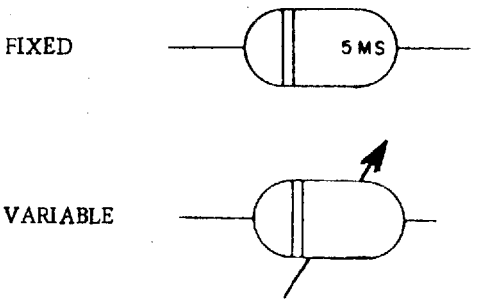
.13 AMPLIFIER

This symbol represents a linear or nonlinear current or voltage amplifier. This AMPLIFIER may have one or more stages and may or may not produce gain or inversion. Level changes and inverters, pulse amplifiers, emitter followers, cathode followers, relay pullers, lamp drivers, and shift register drivers are examples of devices for which this symbol is applicable.



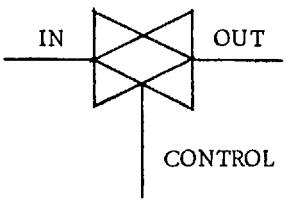
.14 TIME DELAY SYMBOL

The duration of the delay is included with the symbol. If the delay device is tapped, the delay time with respect to the input shall be included adjacent to the tap output. Twin vertical lines indicate the input side.



.15 TRANSMISSION GATE

The input to output path changes from high impedance to low impedance on application of the control signal.



NEMA Standard 5-12-1975.

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MANUFACTURING

ICS 5-015.60 CONSTRUCTION

The following construction details contribute to safety and are intended to assist the electrical manufacturer to design and build equipment with features which will reduce hazards, and also, to assist the user and the manufacturer of the equipment in the selection of electrical equipment which has been designed and built to include features that contribute to safety.

Authorized Engineering Information 6-21-1979.

ICS 5-015.61 CONTROL EQUIPMENT RATING AND IDENTIFICATION PLATES

.01 Control Equipment Nameplates

A legible, durable nameplate shall be attached to the control equipment and shall, as a minimum, include the data required by items (a) and (b).

(a) Manufacturer's name or identification number.
(b) Control equipment identification (model number, serial number, etc.).
(c) Supply voltage, phase (if polyphase), and frequency (if alternating current).

NEMA Standard 6-21-1979.

(d) Maximum permissible available symmetrical rms short-circuit current of incoming power source.

Suggested Standard for Future Design 6-21-1979.

.02 Device Identification

(a) If control and power devices are identified, the same identification as shown on the elementary diagram shall be used.
(b) All control circuit fuses shall be identified by their rating and by class or type on the panel immediately adjacent to the fuse.

Exception—Where space does not permit, the fuse may be indicated by a device symbol provided that it is clearly referenced as to its rating and class or type on the appropriate documentation.

NEMA Standard 6-21-1979.

.03 Warning Labels

It is recommended that warning label markings be in accordance with 1-112.67 of Standards Publication No. ICS 1.

Authorized Engineering Information 6-21-1979.

ICS 5-015.62 OPERATING AND MAINTENANCE DATA

Instruction documents should be furnished and should include at least the following:

(a) Information necessary for calibrating components, devices, and subassemblies which are intended to be adjusted by the user.
(b) Operating instructions, including all information necessary to operate the welding control.
(c) Maintenance instructions, including information for locating and replacing components or subassemblies.
(d) Appropriate warning notices where safety considerations exist.

Documents should be of such a size and quality as to be clearly legible. The format and symbols for diagrams should be in accordance with Part 1-101, 1-102, or 1-103 of Standards Publication No. ICS 1, as applicable.

Authorized Engineering Information 6-21-1979.

ICS 5-015.63 SUPPLY CIRCUIT DISCONNECTING MEANS

.01 General

If provided, the disconnecting means shall consist of a device(s) capable of manually interrupting specified operating overloads and automatically interrupting specified high level fault currents.

A disconnect means having a short circuit withstandability rating greater than 10,000 amperes shall be used. The short circuit rating shall not be greater than that of the specified overcurrent device.

The disconnecting means shall indicate whether it is open or closed. Devices which are normally power operated shall include means for manual opening and shall indicate when they have been opened manually. The devices need not indicate that they are in the tripped position when this position differs from the manually opened position.

If the main power disconnecting means is mounted in a control equipment enclosure, the indication shall be visible outside of the enclosure.

All ungrounded conductors of the welder and control power supply circuits shall be disconnected by a disconnecting means or by an immediately adjacent disconnecting means.

Exception—On equipment which is designed or applied so as to require more than one power source, a warning label shall be provided adjacent to the operating handle of the main power disconnecting means if this disconnecting means does not deenergize all exposed live parts when it is in the "OFF" position.

The line terminals of all disconnecting means shall be guarded to remove the likelihood of accidental contact.

When the main power disconnecting means is mounted within the control equipment enclosure, its operating handle shall be externally operable.

If locking means are provided, the operating handle shall be so arranged that it can be locked only in the "OFF" position.

NEMA Standard 1-11-1983.

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Part ICS 5-015

SAFETY STANDARDS FOR CONSTRUCTION AND GUIDE FOR HANDLING, INSTALLATION, AND OPERATION

These standards apply to all industrial electrical components and wiring which are part of the resistance welding control commencing at the point of connection of input power to these components. They apply to open or enclosed electrical equipment for use on circuits which operate from an alternating-current supply voltage of 600 volts or less.

These standards are intended for industrial equipment which will be installed in accordance with the National Electrical Code *and the manufacturer's instructions. They are not considered adequate for industrial equipment intended for use in locations which are designated as hazardous by the* National Electrical Code

These standards are generally applicable, but there may be situations where a conflict with other safety measures or operational requirements will necessitate that these standards be modified. Excluded from the scope of this part are (1) equipment built to military specifications which conflict with or override the provisions of this publication, and (2) additional specific features required for use under unusual service conditions, in locations involving hazardous atmospheres and hazardous projects.

The standards in this part apply to all other parts of this Standards Publication unless otherwise specified. The definitions and standards of Standards Publication Nos. ICS 1 and ICS 6 apply to this part unless otherwise specified.

DEFINITIONS

ICS 5-015.01 DEFINITIONS

Control Equipment

Control equipment, as used throughout Part ICS 5-015, means an assembly which is installed as a separate part of a resistance welder system. The control equipment consists of only one device, such as a contactor, or a number of devices and associated wiring, such as a sequence timer and contactor. The control equipment is assembled at the factory or consists of a number of control panels, enclosures and other components which are to be assembled into a single control equipment at the installation site.

NEMA Standard 6-21-1979.

GENERAL INFORMATION AND FEATURES

ICS 5-015.05 GENERAL

Part ICS 5-015 defines the construction and test requirements for resistance welding controls and provides recommendations for their selection, installation and operation in such a manner as to provide for the practical safeguarding of persons. This part will be found useful by electrical engineers, electrical contractors, electricians, maintenance engineers, and others.

It is general knowledge that the misuse of electricity is potentially hazardous and may create risks to personnel and property. In addition to shocks or burns from direct contact with live parts, the risks may also include (1) fire resulting from overloads, faulty wiring, or faulty equipment, and (2) injuries resulting from erratic machine operation. The degree of hazard can be greatly reduced by proper design, construction, selection, installation and use, but hazards cannot be completely eliminated. The reduction of hazard should be the joint responsibility of the user and the manufacturer of (1) the welding machine, and (2) the electrical equipment for supplying and controlling the power for the system.

Since any electrical equipment can be installed or operated in such a manner that hazardous conditions can occur, compliance with Part ICS 5-015 of this publication does not by itself assure a safe installation. However, when equipment complying with Part ICS 5-015 is properly selected with respect to the load and environment and is installed in accordance with the *National Electrical Code*, the potential hazards to persons and property will be reduced.

The importance of communication between manufacturer and user cannot be overemphasized. The chances for preventing hazardous incidents and limiting their consequences are greatly improved when both user and manufacturer are correctly and fully informed with respect to the intended use and all environmental and operating conditions.

Authorized Engineering Information 6-21-1979.

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.02 Ratings

Since most resistance welder installations are operating on a duty-cycle basis and hence overload type service, the disconnecting means shall be selected to interrupt the maximum expected currents and voltages within its ratings. Line to line and line to ground fault currents will not be interrupted by the manual operation of the disconnect means. Automatic disconnect means such as fuses, circuit breakers or instantaneous trip devices will interrupt fault currents.

Authorized Engineering Information 1-11-1983.

.03 Supply Circuit Isolating Means

If manually operated isolation means are provided and the load current exceeds the interrupting capability of the isolating means, a warning label shall state "WARNING - DO NOT OPERATE UNDER LOAD."

The isolating means shall indicate whether it is open or closed. If the main power isolating means is mounted in a control equipment enclosure, the indication shall be visible outside of the enclosure.

All ungrounded conductors of the welder and control power supply circuits shall be disconnected by one isolating means or by immediately adjacent isolating means.

Exception—On equipment which is designed or applied so as to require more than one power source, and the main power isolating means does not energize all exposed live parts when it is in the "OFF" position, a warning label shall be provided adjacent to the operating handle of the main power isolating means.

The line terminals of all isolating means shall be guarded to remove the likelihood of accidental contact.

When the main power isolating means is mounted within the control equipment enclosure, its operating handle shall be externally operable.

If locking means are provided, the operating handle shall be so arranged that it can be locked only in the "OFF" position.

NEMA Standard 1-11-1983.

ICS 5-015.64 PROTECTION

.01 Interrupting Capacity

Devices which are intended to break short-circuit current shall have an interrupting capacity sufficient for the voltage used and for the current that must be interrupted when the control equipment system is connected to a power supply having the capacity to apply maximum voltage and maximum available short-circuit current within the limits specified for the equipment. (See ICS 5-015.61.01(d).)

NEMA Standard 6-21-1979.

.02 Control Circuit

(a) *Transformer*—The control circuit transformer shall be protected against overloads and short circuits by an overcurrent protection device in the primary or secondary circuit. Where the secondary circuit is grounded, the overcurrent protective devices shall be located only in the ungrounded conductors. The overcurrent devices shall interrupt when the sustained current exceeds 125 percent of the rated current of the control transformer and shall interrupt short circuits without damage to the control transformer or conductors.

Exception 1—When 125 percent of the rated current of the control transformer does not correspond to a standard rating of the overcurrent device, the next higher standard rated device is permitted to be used.

Exception 2—Dry-type transformers that constitute a component part of the apparatus and comply with requirements for such apparatus do not require overcurrent protection.

Exception 3—Overcurrent devices are not required for transformers for limited energy circuits which, in accordance with Section 725 of the *National Electrical Code,* do not require overcurrent protection.

(b) *Conductors*—Where a control circuit transformer is used to supply a control circuit that extends beyond the control equipment, an overcurrent device shall protect the control circuit conductors .

Exception—Overcurrent devices are not required for conductors for limited energy circuits which, in accordance with Article 725 of the *National Electrical Code,* do not require overcurrent protection.

NEMA Standard 5-19-1986.

For the requirements applicable to conductors between the control equipment and the resistance welding equipment, reference should be made to Section 310 of the *National Electrical Code.*

Authorized Engineering Information 6-21-1979.

.03 Short-circuit Withstandability of Equipment

(To be developed.)

ICS 5-015.65 CONTROL CIRCUITS

.01 Source of Control Power

The control circuit shall be connected to a power source on the load side of the main disconnecting means, or a separate disconnecting means shall be provided for the control power adjacent to the main disconnecting means.

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.02 Control Voltage

All external weld-initiating control circuits shall be isolated from the welder power supply by a separate transformer, winding, or other suitable means. The nominal operating control circuit voltage shall be not over 120 volts rms for stationary equipment and not over 36 volts for portable equipment.

.03 Prevention of Spurious Operation

(a) *Solenoid Forge and Retraction Valve Operation (See ICS 5-003.04, ICS 5-003.05, and ICS 5-003.06)*—Contacts shall be in series with the valve contactor circuit to prevent spurious operation. Contacts shall be open when the control is in standby condition. If a single contact is used, the unswitched supply line shall be grounded.

(b) *Weld Firing Circuit*—When ignitrons are used as welding contactors, a contact(s) shall be used to disconnect the weld firing circuit from the igniter(s) to prevent spurious operation. This contact(s) shall be open when the control is in standby condition.

When thyristors are used as welding contactors, a contact(s) shall be used to disconnect the gate(s) from the gate power source to prevent spurious operation. This contact(s) shall be open when the control is in standby condition.

NEMA Standard 6-21-1979.

(c) *Surge Test*—A damped oscillatory voltage surge, having a peak equal to 1.41 times the line voltage and a base frequency of 5000 hertz, shall be applied so that it is additive to the primary control power supply. The surge shall be applied in both positive and negative polarities of the control power supply.

NEMA Standard 9-19-1962.

The above is a design test for component failure, timing accuracy, and detection of spurious operation.

Authorized Engineering Information 9-19-1962.

.04 Safety Features

(a) *Provision for Stopping and Resetting a Sequence*—Welding controls shall include terminal connections for sequence reset. When the sequence reset circuit is momentarily interrrupted, the controls shall stop at any point in the cycle and reset to the original starting point. Under these conditions, the initiating circuit shall be open.

NEMA Standard 6-21-1979.

(b) *Anti-tiedown Control*—Anti-tiedown control is a control which provides that the closing of two pilot switches must be made within a specific maximum time to energize the electrode actuating means.

When anti-tiedown control is utilized, the pilot switch closing shall be maintained until the welding electrodes are closed in order to start the weld time. When operating in a repeat sequence mode, the control shall be nonrepeat if any pilot switch is opened during off time. The maximum time between closing of the pilot switches to enable operation shall be 1.0 second.

NEMA Standard 7-14-1976.

This standard applies to equipment requiring a single operator only. For applications requiring more than one operator, the manufacturer should be consulted.

Authorized Engineering Information 7-14-1976.

(c) For controls employing an internal pilot power supply, the following conditions shall be met:

1. Pilot or weld sequence initiation circuits shall be designed to not cause the welder control to begin a welding sequence when a leakage current of 3 mA rms or less is present at the pilot terminals. Grounding of either of the pilot terminals will not result in welder control initiation.
2. In the event that any pilot circuit is closed at the time that sequence reset is closed from a previously open condition, the welder control will not be capable of initiation until all pilot circuits have been opened.
3. In the event that any pilot circuit is closed at the time that power is applied to the welder control, the welder control will not be capable of initiation until all pilot circuits have been opened.

Suggested Standard for Future Design 8-20-1986.

ICS 5-015.66 CONDUCTORS

.01 General

The internal wiring shall consist of material which is suitable for the particular application with respect to temperature, voltage, and condition of service.

NEMA Standard 7-14-1976.

.02 Size

Conductors for panel wiring shall be no smaller than No. 18 AWG except those used in and between electronic and solid state control assemblies, which shall be no smaller than No. 30 AWG.

.03 Ampacity

The maximum continuous current of panel wiring conductors in control equipment shall not exceed the ampacity given in Table 5-015-1.

NEMA Standard 6-21-1979.

ICS 5-015.67 WIRING METHODS AND PRACTICES

.01 Identification

Terminals on terminal blocks for connection to wires outside of the control equipment shall be marked to correspond with the markings on the diagrams.

Where white is used to identify wire at any incoming or outgoing terminal of a control equipment, it shall be

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used only for terminals which can be connected to a grounded conductor. Where green (or green with one or more yellow stripes) is used to identify wire at any incoming or outgoing terminal of a control equipment, it shall be used only for an equipment grounding or bonding conductor.

Exception—White and green shall be permitted for internal wiring if outgoing connections are permanently identified as other than ground connections and are not used as incoming power connections. Where color coding is used, only the terminations of the conductor need be identified.

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.02 Terminals

User terminals, if provided, shall be selected on the basis of the 75°C temperature ampacity rating of conductors given in Table 310-16 of the *National Electrical Code.*

Terminals for power circuits shall be grouped separately from control circuits.

.03 Enclosure Wiring

The surface of wiring channels, if used, shall be of a flame-retardant material.

Wire routings shall avoid sharp edges, burrs, moving parts, etc., which may cause abrasion of the insulation and conductors. Holes in walls or barriers through which insulated wires pass and on the edges of which they may bear shall be provided with smoothly rounded bushings or grommets or shall have smooth, well rounded surfaces upon which the wires may bear, to prevent abrasion of the insulation.

Wireways shall be smooth and entirely free from burrs.

.04 Spacings

Spacing requirements shall be in accordance with Part I-III of Standards Publication No. ICS 1.

NEMA Standard 6-21-1979.

Table 5-015-1
AMPACITIES OF COPPER CONDUCTORS WITH AN INSULATION RATING OF 90°C AT AN AMBIENT TEMPERATURE OF 55°C

Conductor Size, AWG	Ampacity	Conductor Size, AWG or MCM	Ampacity
30	0.5	2/0	225
28	0.8	3/0	260
26	1	4/0	300
24	2	250	340
22	3	300	375
20	5	350	420
18	7	400	455
16	10	500	515
14	20	600	575
12	25	700	630
10	40	750	655
8	55	800	680
6	80	900	730
4	105	1000	780
3	120	...	...
2	140	...	...
1	165	...	...
1/0	195	...	...

NEMA Standard 6-21-1979.

NOTE I—The ampacities of insulated copper conductors with insulation ratings of 110°C, 125°C, and 200°C can be considered as being 125 percent, 140 percent, and 170 percent, respectively, of the ampacities given in the above table for the same conductor size..

NOTE II—The ampacities of aluminum conductors with an insulation rating of 90°C can be obtained by multiplying the ampacity given in the table for the same size of copper conductors by 0.78.

The ampacities of insulated aluminum conductors with insulation ratings of 100°C, 125°C, and 200°C can be considered as being 116 percent, 124 percent, and 134 percent, respectively, of the ampacities calculated for the same size of aluminum conductor with an insulation rating of 90°C.

NOTE III—The ampacities listed in the table and determined in accordance with NOTES I and II apply to wireways or bundles greater than 5 feet in length. They include an allowance (1) for wireways for conductor sizes 12 AWG and smaller and (2) for bundles of one through six conductors larger than 12 AWG.

NOTE IV—Ampacities for conditions other than those covered in the table will differ and can be determined by interpolation or extrapolation. For example, for conductors having an insulation rating of 90°C, the ampacities at an ambient temperature of 40°C will be 120 percent of those at 55°C.

NOTE V—The ampacities given in the table can be exceeded if the routing and operating conditions of the conductor are known and controlled so as to limit the conductor temperature to the rated temperature of the insulation.

Authorized Engineering Information 6-21-1979.

ICS 5-015.68 GROUNDED CIRCUITS AND EQUIPMENT GROUNDING

.01 Methods of Grounding

Noncurrent-carrying metal parts which are exposed under normal operating conditions shall be electrically bonded to the enclosure or to a ground bus or ground terminal. Moving enclosure parts which have metal-to-metal bearing surfaces shall be considered as being adequately bonded. Sliding parts separated by oil or by air under pressure shall not be considered to be bonded together.

Portable, pendent, and resilient mounted equipment shall be bonded or provided with grounding screws to allow bonding.

.02 Equipment Grounding Conductors

Grounding conductors shall be in accordance with the *National Electrical Code,* Article 250, Part J.

.03 Equipment Grounds

(a) *Machine*—The welding transformer secondary shall be grounded by one of the methods in (1) or (2) below, or equivalent protection shall be provided as in (3) below:

(1) Permanently grounding the welding secondary circuit.

(2) Connecting a grounding reactor across the secondary winding with a reactor tap(s) to ground.

(3) As an alternative, on nonportable machines, arranging for an isolation contactor to open both sides of the line to the primary of the welding transformer.

NEMA Standard 6-21-1979.

NOTE—The grounding of one side of the secondary windings on multi-spot machines can cause un-

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desirable transient currents to flow between transformers if multiphase primary supplies or different secondary voltages, or both, are used for the several guns. A similar condition can also exist with portable spot welding machines, when several units are used on the same fixture or assembly, or on one that is nearby. Such situations would require use of a grounding reactor or isolation contactor.

Authorized Engineering Information 6-21-1979.

(b) *Control*—The control shall be grounded according to the general requirements for grounding and bonding of electrical insulation as set forth in Article 250 of the *National Electrical Code.*

NEMA Standard 6-21-1979.

ICS 5-015.69 DIELECTRIC TESTS

Resistance welding control equipment shall be capable of withstanding the high-potential tests described in 1-109.21 of Standards Publication No. ICS 1.

NEMA Standard 6-21-1979.

APPLICATION

ICS 5-015.80 GUIDE FOR SAFETY IN HANDLING, INSTALLATION, AND OPERATION OF RESISTANCE WELDING CONTROL

The following information is intended to guide the user and the manufacturer in the proper handling, installation and operation of resistance welder control systems. Since the reduction of hazards depends greatly on how equipment is selected, installed and used, this section points out possible hazards and suggests ways and means to reduce them.

Authorized Engineering Information 6-21-1979.

ICS 5-015.81 HANDLING

These guidelines are provided to minimize the possibility of personal injury and equipment damage during handling, as well as to facilitate moving large pieces of control equipment at the job site. Professional machinery movers should be consulted if the user has any doubt about safe handling means.

(a) Handling instructions, when furnished with specific equipment, should be followed.
(b) The equipment should be handled with care to avoid damage to components and to the frame or its finish.
(c) The equipment should be kept in an upright position unless otherwise indicated. In particular, care should be exercised to mount ignitrons in an upright position and to maintain them upright after mounting.
(d) The capabilities of the moving means available to handle the weight of the equipment should be known.
(e) When the equipment is received, it should be unpacked sufficiently to inspect it for concealed damage and to determine that the shipment is complete and correct.
(f) If the equipment is to be stored for any length of time prior to installation, the packing should be restored for protection during that period. Where conditions permit, the packing should be left intact until the equipment is at its final installation position. If packing is removed, the top and openings of the equipment should be covered during the construction period to protect against dust and debris. Equipment not installed and energized immediately should be stored in a clean, dry space having a uniform temperature to prevent condensation and in an atmosphere free of corrosive fumes. Preferably, it should be stored in a heated building having adequate air circulation and protected from dirt and water.
(g) The equipment should remain secured to the shipping skid, if provided, to prevent distortion of the bottom of the frame during moving.
(h) Rod or pipe rollers, with the aid of pinch bars, provide a simple method of moving the equipment on one floor level if there is little or no incline. The load should be steadied to prevent tipping.
(i) A forklift truck may offer a more convenient method of handling the equipment and has the added advantage of permitting lifting between levels. The load should be balanced carefully, and a topheavy piece of control equipment should be steadied as necessary while moving.
(j) When it is necessary to move the equipment between elevations without a suitable platform elevator or lift truck, overhead hoisting may be required. Lifting plates and eyebolts (Fig. 5-015-1) or channels, angles, or bars with lift holes (Fig. 5-015-2) may be provided as a permanent or removable part of the equipment. If they are not, cable, chair, or band slings (Figs. 5-015-3) may be rigged around the equipment.

(1) Spreaders (Fig. 5-015-1) or spanner bars (Fig. 5-015-3) should be used to provide the vertical lift on eyebolts and lifting slings to avoid crushing or otherwise damaging the enclosure or its finish. On

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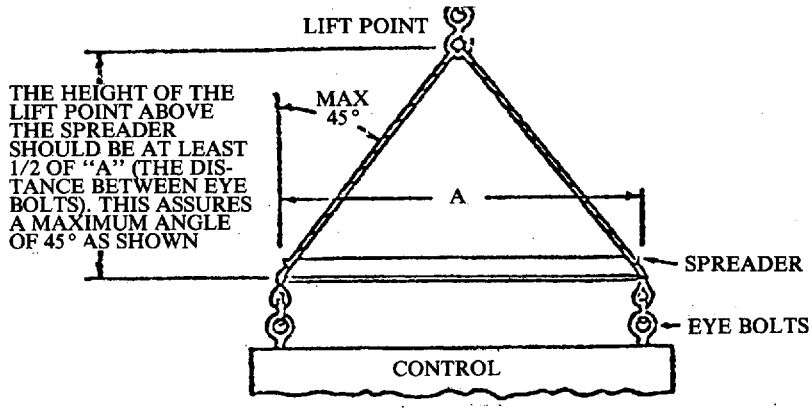


Fig. 5-015-1
LIFTING WITH EYE BOLTS

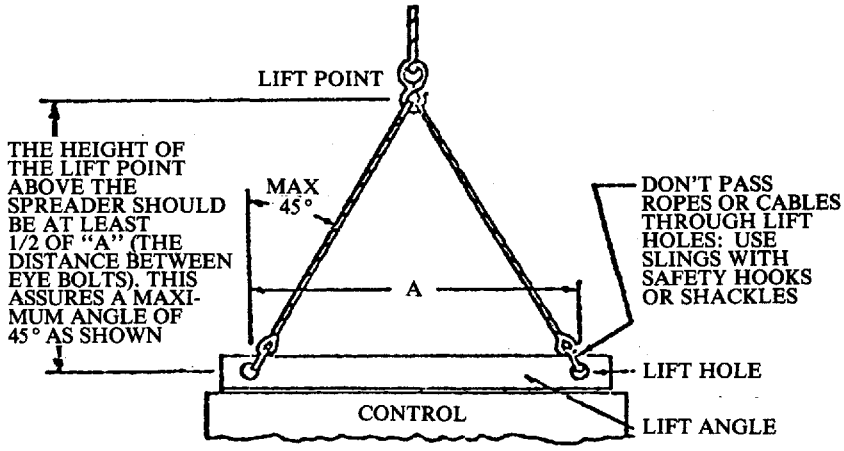


Fig. 5-015-2
LIFTING WITH INTEGRAL LIFT ANGLE

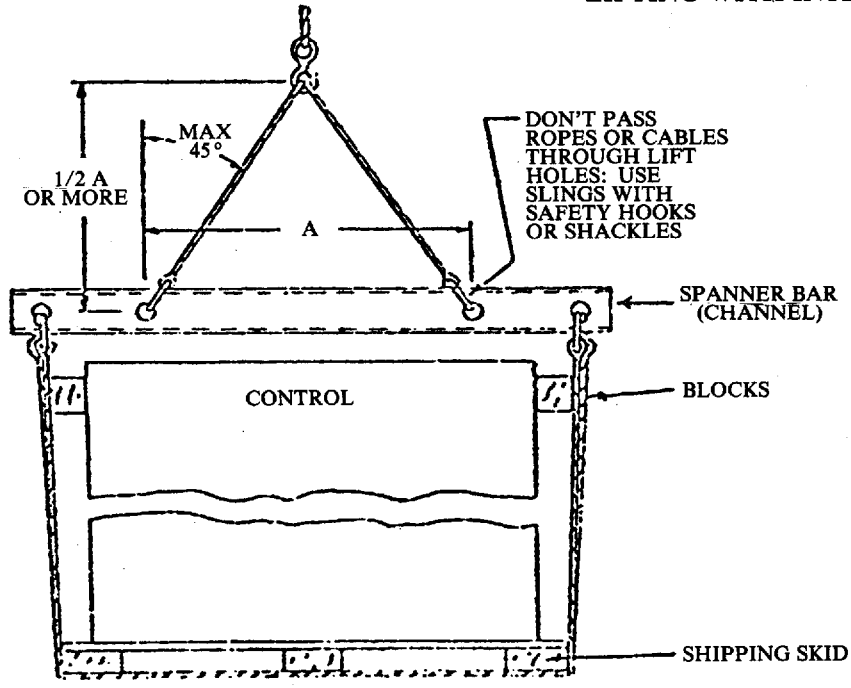


Fig. 5-015-3
LIFTING WITH SLING RIGGING

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long line-ups, lifting bars may require additional spreaders to reduce the horizontal compressive load.

(2) The rigging length should be selected or adjusted to compensate for any unequal weight distribution of load and to maintain the equipment in an upright position.

(3) The angle between the lifting cables and vertical should not be allowed to exceed 45 degrees in order to reduce the tension on the rigging and the compressive load on the lifting spanner bars and spreaders.

(4) Ropes or cables should not be passed through the lift holes in bars, angles, or channels. Slings with safety hooks or shackles should be used.

(5) The area below the lifting zone should be kept clear of personnel and property that could be injured or damaged if the load is dropped.

Authorized Engineering Information 6-21-1979.

ICS 5-015.82 INSTALLATION

The control equipment should be installed in a neat and workmanlike manner.

.01 Location

The following considerations should be observed whenever equipment is mounted, installed, or relocated:

(a) The equipment should be located so that it is readily accessible and not exposed to physical damage.

(b) The equipment should be located well away from flammable material.

(c) The equipment should not be located where it will be exposed to ambient temperatures above 40°C (104°F), corrosive or explosive fumes, dust, vapors, abnormal vibration, shock or tilting, or unusual operation conditions, unless the cabinet has been designed for these conditions.

(d) Control enclosures should be specifically approved for wet location; i.e., they should be rainproof and sleet (ice) resistant if used outdoors, and dripproof if used indoors. The enclosure should be mounted so there is at least 1/4 inch of air space between the enclosure and the wall or other supporting surface.

(e) The control should not be located against a ceiling that will support combustion. A space of 3 feet should be allowed between the ceiling and enclosure unless an adequate fire shield is provided.

(f) Adequate working space should be provided for adjustment, inspection, and maintenance.

(g) Operators' control stations should be convenient to permit observation of machine operation when necessary. The location should be such that the operator is free of hazard from moving parts of the machine or work in process and such that the control station is not subject to accidental operation or damage.

(h) Operator's devices, such as emergency-stop pushbuttons, which are installed to provide safety, should be located so that they can be operated conveniently by the operator, or in an emergency, by other personnel in the event that the condition for which they were selected occurs.

(i) The main electrical disconnecting means should be easily accessible and have provisions for applying multiple padlock lockouts.

.02 Installation

(a) *Mounting of Cabinet*—The enclosure should be reliably secured to the mounting surface. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials should not be depended upon.

(b) *Unused openings in enclosure*—Unused openings in the enclosure should be closed effectively to provide protection which is substantially equivalent to that afforded by the wall of the enclosure.

(c) *Grounding*—Equipment should be grounded in accordance with the *National Electrical Code.*

(d) Installation of controllers should be made in conformance with the *National Electrical Code,* regulations of the Occupational Safety and Health Administration, and other national, regional, or local industry codes and standards.

(e) Conduits, cables, and other conductors should be installed so as to prevent moisture or water from entering and accumulating in the enclosure. All bolted connections of thyristor switches and ignitron tubes should be properly tightened.

(f) Care should be exercised to assure that the wiring connection points which have been provided are suitable for use with the wire being installed in the control equipment.

(g) Care should be exercised in stripping insulation from the conductors so as not to nick or ring the conductor. All wiring connection points should be properly tightened. Recommended tightening torque values should be used when they are furnished with the equipment.

(h) Provisions should be made to locate the wires in the control equipment so that they will be free from physical damage. Care should be taken that the wire will not interfere with any moving parts.

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(i) All incoming and outgoing control connections should be made in accordance with the schematic and wiring diagrams furnished with the control.

(j) Fuses of the proper class and rating should be installed in all fuseholders. If circuit breakers are provided, trip ratings should be checked with load requirements to assure compliance with prevailing codes and regulations. Maximum ratings, when specified by the manufacturer, should not be exceeded.

(k) Debris should be cleaned out of the cabinet after installation. A vacuum cleaner fitted with an insulated nozzle or brush which has no exposed metal should be used. Cleaning with a compressed air gun is not recommended.

(l) A safe and reliable installation requires careful attention to the installation of conduit and other raceways, pulling of all wire, connections, etc., so as to avoid damage to conductor insulation and nicked wire terminations, as well as to assure continuity of the conduit and equipment enclosure grounding system. Unskilled personnel may be unaware of the requirements or hazards involved. It is recommended that only properly trained, skilled personnel be employed for installing electrical equipment.

Authorized Engineering Information 6-21-1979.

ICS 5-015.83 START-UP AND TEST

Prior to releasing electrical control equipment for regular operation after installation, the system should be given a start-up test by competent personnel to assure correct operation of the equipment for reasons of reliable and safe performance. It is important that arrangements for such a check be made and that enough time be allowed to perform complete and satisfactory testing.

Before operational tests are performed, all blocks or other temporary holding means used for shipment should be removed from all component devices.

Precautions should be taken to assure that the completed system is free from all short circuits and grounds except those grounds installed per the *National Electrical Code.*

Start-up tests may be simple or complex, depending on the nature of the installation. A simple case may require only a check that a certain push-button initiates the welder. Other cases may involve the checking out of many devices and the proper operation of the overall system including its regulators, logic functions, and protective devices.

The variety involved precludes a detailed listing of checks. However, attention should be directed to the need for such start-up tests in order to detect and correct possible serious hazards for personnel and equipment.

Authorized Engineering Information 6-21-1979.

ICS 5-015.84 OPERATION

Regardless of the care exercised in the design and manufacture of control equipment or in the selection and rating of components, there are hazards which can be encountered if such equipment is improperly operated.

It is sometimes possible to misadjust the equipment and thus produce unsatisfactory or unsafe operations. The instructions furnished with the equipment should always be used as a guide for functional adjustments. Personnel who are to have access to these adjustments should be familiar with both the instructions for the control and the equipment being controlled.

Authorized Engineering Information 6-21-1979.

ICS 5-015.85 CARE AND MAINTENANCE

A well planned and executed maintenance schedule is essential to satisfactory operation of electrical equipment. The type and frequency of maintenance operation will vary with the type and size of the equipment, as well as the nature of the operating conditions.

It is not possible to establish a single maintenance program to serve all classes of equipment within the scope of this publication. A maintenance program should be established giving due consideration to the operating and service conditions, the application of the equipment, as well as the maintenance instructions and recommendations received with the equipment.

The following factors should be considered when formulating a maintenance program:

(a) Maintenance should be performed by qualified personnel.

(b) The equipment should be located so as to permit the performance of all maintenance operations without hazard to the worker.

(c) Maintenance should be performed only when the equipment is disconnected from the electrical power lines and not in operation. Each maintenance person should use his own individual padlock to lock power supply disconnect devices in the open position while at work on the equipment.

(d) A grounding device(s) of suitable size should be attached to the power busses after they have been disconnected.

(e) A general inspection of mechanical integrity, i.e., fracture, loose bolts, missing parts, etc., should be made.

(f) Ventilation passages should be kept open. If the equipment depends on auxiliary cooling, periodic inspection (with filter replacement when necessary) should be made.

(g) Means employed for grounding or insulating the equipment from ground should be checked to assure its integrity.

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(h) Flexible cord and connectors should be examined to determine that the cords are free from abrasion, cracks, and exposed strands, and that the connectors have unbroken bodies so that live parts are not exposed.

(i) If a breaker has tripped or a fuse has blown, a short circuit or ground may be indicated which may also have damaged the electrical equipment. The short circuit or ground should be located and repaired. The contacts in the control should be replaced if necessary, and other damage should be repaired before restoring power to the circuit.

(j) Accumulations of dust and dirt should be cleaned out with a vacuum cleaner fitted with an insulated nozzle or brush which has no exposed metal. Blowing out dust with a compressed air gun is not recommended.

(k) Moving parts should be inspected to assure that they move freely without binding or sticking and are not badly worn. They should be replaced or the entire device should be replaced if any doubtful performance is observed.

(l) Contacts should be inspected for excessive wear or burning and, if necessary, replaced in accordance with instructions. Contact springs should be checked and replaced if the spring force has been reduced or if there is evidence of burning or overheating. Devices having concealed or inaccessible contacts should be given an operational check to determine if the contacts are opening and closing as required. The entire contact switching assembly should be replaced if any doubtful performance is observed.

(m) Arc chambers and other insulating parts should be inspected and replaced if they are broken or badly eroded; easily dislodged metal dust or granules, if any, should be removed. Insulating surfaces should not be scraped.

(n) Terminals, fuse clips, and connections should be inspected for evidence of loosening or overheating. As necessary, contact surfaces should be cleaned and loose terminations tightened or replaced.

(o) Fuses and circuit breakers should be checked to assure that they have the proper ampere rating and interrupting rating. Noncurrent-limiting fuses should never be used for replacements for current-limiting fuses. No attempt should be made to defeat rejection mechanisms which are provided to prevent the installation of the wrong type of fuses.

(p) Enclosures should be inspected for evidence of deterioration. Accumulated dust and dirt should be removed from the tops of enclosures before opening doors or removing covers.

(q) Water leaks or dripping inside the equipment enclosure should be looked for. If necessary, the source of wetness or dripping should be eliminated. Any insulation material which is damp or wet or shows any accumulation of deposited material from previous wettings should be replaced or thoroughly cleaned and dried.

(r) After inspection, maintenance, or repair operations, the grounding device should be removed from the power busses before the grounding device is removed from the ground bus; and steps should be taken to assure that no hazard will occur to personnel before power is applied.

(s) When equipment is repaired, it is important that every replacement part be in accordance with the recommendations received with the equipment. Care should be taken to avoid tne use of parts which are no longer compatible with other changes in the equipment. Also, replacement parts should be inspected for deterioration due to shelf life and for signs of rework or wear which may involve factors critical to safety.

(t) A written record of both scheduled inspection and service problems encountered should be made. Entries of parts replaced and service problems encountered will often alert personnel to future potential problems before they occur. Adequate records of inspection and repairs will not only enhance the safety of the equipment but will also demonstrate that a planned program for safe operation and maintenance has been established.

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Appendix A

REFERENCED STANDARDS

In this publication reference is made to the following standards listed below. Copies are available from the indicated sources.

I

American National Standards Institute
1430 Broadway
New York, NY 10018

ANSI/IEEE Std 315-1975 (ANSI Y32.2)	*Graphic Symbols for Electrical and Electronics Diagrams*
ANSI/NFPA 70-84 (ANSI C1)	*National Electrical Code*

II

Institute of Electrical and Electronics Engineers
345 East 47th Street
New York, NY 10017

ANSI/IEEE Std 315-1975 (ANSI Y32.2)	*Graphic Symbols for Electrical and Electronics Diagrams*

III

National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 20037

ICS 1-1983	*General Standards for Industrial Control and Systems*
ICS 2-1983	*Industrial Control Devices, Controllers and Assemblies*
ICS 3-1983	*Industrial Systems*
*ICS 4-1983	*Terminal Blocks for Industrial Control Equipment and Systems*
ICS 6-1983	*Enclosures for Industrial Controls and Systems*
250-1979	*Enclosures for Electrical Equipment (1000 Volts Maximum)*

IV

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

ANSI/NFPA 70-84 (ANSI C1)	*National Electrical Code*

* Approved by the American National Standards Institute.

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PARTICIPANTS IN THE DEVELOPMENT OF PUBLICATION NO. ICS 5

National Electrical Manufacturers Association

Square D Company
Milwaukee, WI 53212

Technitron, Inc.
Carol Stream, IL 60187

Weltronic Co.
Novi,MI 48050

Resistance Welder Manufacturer's Association

Anderson Automation Inc.
Grandville, MI 49418

Banner Welder, Inc.
Milwaukee, WI 53209

Entron Controls, Inc.
Carol Stream, IL 60187

Goodrich Division
Conrac Corp.
Hudsonville, MI 49426

Kirkhof Transformer Division
FLX Corp.
Troy, MI 48083

Medar, Inc.
Farmington Hill, MI 48018

Midland Ross Corp.
Robotron Division
Southfield, MI 48086

Newcor, Inc.
Bay City, MI 48707

Roman Manufacturing Company
Grand Rapids, MI 49508

Sciaky Brothers, Inc.
Chicago, IL 60638

Taylor-Windfield Corp.
Warren, OH 44482

Technitron, Inc.
Carol Stream, IL 60187

Teledyne Peer
Benton Harbor, MI 49022

Weldaloy Products Co.
Warren, MI 48090

Weltronics Co.
Novi, MI 48050

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NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA Bylaws, which are quoted below:

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for its particular need. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

(Bylaw—Art. V, Sec. 1)

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Bylaw—Art. V, Sec. 2, Subsection A)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the standards publication may be capable of otherwise equivalent performance.

(NEMA Policy Memorandum 84-2, dated June 7, 1984)

Classes of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Bylaw—Art. V, Sec. 2, Subsection B)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design.

(Bylaw—Art. V, Sec. 6, 1st Sentence)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment and/or approval.

(Bylaw—Art. V, Sec. 4, Subsection A)

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

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INDUSTRIAL CONTROL AND SYSTEMS SECTION
OF THE
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
MEMBER COMPANIES

Allan Bradley Company
Milwaukee, WI 53201

Amerace Corp.
Hackettstown, NJ 07840

Asea, Inc.
White Plaines, NY 10604

Automatic Switch Co.
Florham Park, NJ 07932

Balluff Inc.
Florence, KY 41042

Cleveland Machine Controls, Inc.
Cleveland, OH 44125

Cogenel Inc.
Entrelec Div.
Spring Valley, NY 10977

Copper Industries, Inc.
Arrow-Hart Div.
Hartford, CT 06101

Curtis Industries, Inc.
Milwaukee, WI 53223

Cutler-Hammer Products
Eaton Corp.
Milwaukee, WI 53216

Cyberex, Inc.
Mentor, OH 44060

Electric Machinery Industrial
Controls Group
Macon, GA 31206

Electro Switch Corp.
Weymouth, MA 02188

Elliott Control Co.
Hollister, CA 95024-1329

Emerson Electric Co.
Grand Island, NY 14072

Federal Pacific Electric Co.
Raleigh, NC 27607

Furnas Electric Co.
Batavia, IL 60510

General Electric Co.
Bloomington, IL 61701

General Signal Corp.
Nelson Electric Unit
Tulsa, OK 74101

Harnischfeger Corp.
Milwaukee, WI 53201

Harvey Hubbell, Inc.
Industrial Controls Division
Madison, OH 44057

Industrial Engineering & Equipment Co.
Solitech Div.
St. Louis, MO 63132

Industrial Solid State Controls, Inc.
York, PA 17405

Integrated Power Systems Corp.
Sugarland, TX 77478

Johnson Controls Inc.
Goshen, IN 46526

Joslyn Clark Controls Inc.
Lancaster, SC 29720

Klockner-Moeller Corp.
Natick, MA 01760

Kohler Company
Kohler, WI 53044

Kulka Smith, Inc.
Manasquan, NJ 08736

Lake Shore Electric Corp.
Bedford, OH 44146

McGill Manufacturing Co., Inc.
Valparaiso, IN 46383

Micro Switch
Division of Honeywell, Inc.
Freeport, IL 61032

Namco Controls
An Acme Cleveland Co.
Mentor, OH 44060

Onan Corporation
A. Subs. of McGraw-Edison Co.
Minneapolis, MN 55432

Parametrics
A Unit of Barry Wright
Orange, CT 06477

Pass & Seymour, Inc.
Syracuse, NY 13221

Pertron Controls Corp.
Canoga Park, CA 91304

Reliance Electric Co.
Athens, GA 30613-1299

Rise America, Inc.
Parlin, NJ 08859

Russelectric Inc.
Hingham, MA 02043

Siemens Energy & Automation, Inc.
Wichita Falls, TX 76307

Sprecher & Schuh, Inc.
S&S Controls Division
Port Chester, NY 10573

Square D Company
Palatine, IL 60067

Technitron, Inc.
Carol Stream, IL 60187

Teledyne Penn-Union
Edinboro, PA 16412

Telemecanique Inc.
Arlington Heights, IL 60005

Texas Instruments, Inc.
Attleboro, MA 02703

Toshiba International Corp.
Houston, TX 77041

Turck Multiprox, Inc.
Plymouth, MN 55441

Underwriters Safety Device
An Allied Company
Chicago, IL 60656

Unico, Inc.
Franksville, WI 53126

Ward Leonard Electric Co., Inc.
Mount Vernon, NY 10550

Weidmuller Terminations, Inc.
Richmond, VA 23236

Weltronic Co.
Subs. of Ransburgh Corp.
Novi, MI 48050

Westinghouse Electric Corp.
Asheville, NC 28813

Zenith Controls, Inc.
Chicago, IL 60609

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