

ENGINEERING REFERENCE DATA

**RELAYS
AND
CIRCUIT ARRANGEMENTS
FOR
TIME DELAY**

BELL TELEPHONE LABORATORIES

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INTRODUCTION

This is one of a series of Engineering Reference Data Bulletins containing information on apparatus designed by the Bell Telephone Laboratories, Incorporated, for other than military applications, and manufactured by the Western Electric Company or by other suppliers in accordance with specifications prepared by the Laboratories. It is intended primarily for use by engineers of the Laboratories, and contains information on apparatus which may be rated AT&TCo Standard, A&M Only, Component Part, or Special; codes classified ML; or codes designated for nonassociate use. Codes rated Manufacture Discontinued are not included.

It is planned to bring this bulletin up to date periodically; however, the information contained herein may not be complete and ratings of the items are not shown. The final selection of apparatus should, therefore, be made on the basis of the usual sources of information, such as the Western Electric Apparatus Card Catalog, the manufacturing specifications, and price data. For information regarding the output of apparatus refer to the Western Electric Report A-822.1.

The bulletin may include some codes of apparatus for which catalog cards will not be found in the Western Electric Apparatus Card Catalog. Such codes are in general rated "Component Part." This rating is applied to apparatus where it is believed that the associated telephone companies will have no need for apparatus card catalog information and orders for the apparatus from the field are not expected.

When apparatus which is not listed on a white card in the Western Electric Apparatus Card Catalog is selected for use in new applications, the Standards Engineer, Department 5241, Bell Telephone Laboratories, Incorporated, 463 West Street, New York, should be notified of the new use and probable demand so that consideration can be given to re-rating the apparatus. When such new applications are made within the Laboratories, the selection should first be discussed with the department responsible for the design of the apparatus.

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SECTION I

GENERAL

In many circuit applications delay times are required which are greater than can be provided with the conventional types of slow acting relays, such as the Y or AG relays. The conventional relays are not capable of minimum operate times much greater than 35 milliseconds, or release times in excess of a minimum of approximately 300 milliseconds. To meet the longer time delays, several types of slow acting relays are available. Some of them are manufactured by the Western Electric Company, and others by outside suppliers, usually under KS specifications.

KS specifications are usually assigned to relays of outside manufacture used in Telephone Systems. This provides a means of control to prevent the outside supplier from making changes in his product that might result in affecting the performance of relays that had previously been tested and approved. New KS specifications should be requested through the relay requirements group.

Information regarding the time-delay relays available, the times that can be obtained with the various relays, the advantages and the disadvantages of the various types of relays is scattered through many KS specifications, the manufacturers catalogs and pamphlets, etc. Centralized information of the different types of slow acting relays is thus not readily available to the design engineers. This bulletin attempts to make available a comparative list of the time-delay relays that are most commonly used, the limitations and the advantages of the various designs. Table I-1 contains a summary of the various relays.

In general, the slow acting relays can be grouped into three classes, (1) thermal delay relays, (2) those using other means of obtaining time delay, such as solenoid operation and synchronous motor timers, and (3) circuit arrangements, such as condenser-timed relays and cold-cathode tubes.

The thermal delay relays generally make use of the principle that different metals have a different degree of expansion with changes in temperature, although some of the relays utilize the expansion of a single member.

Where the relay may be subject to a train of pulses, the thermal relays may not be satisfactory since the relay will gradually heat up and may eventually operate on the pulses because these relays require an open interval several times that of the operate delay time to cool off before the full-operate time delay can be obtained on a circuit reclosure.

The delay relays that are usually used in Telephone Systems are described in the following sections. They by no means cover the entire field of manufacturers of delay relays but do cover the major proportion of manufacturers whose product has been approved for Bell System use.

Because the relays covered in this bulletin are used for special circuit conditions, no codes are indicated as preferred.

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TABLE I-1

RELAY	SECT	PAGE	TIME RANGE	RECYCLE TIME	SLOW OPER RELS		CONTACTS	VOLTAGE	SIZE	APROX COST	COVER	SEALED RELAY	TIME ADJUSTABLE	
					✓	✓							YES	NO
235	II	1	2 to 25 sec	2 min	✓		M or B	20-50	Same as E Relay	\$ 1.75	Optional		✓	
236	II	3	1 ipm		✓		M	48	Same as E Relay		Optional		✓	
271	II	4	2 to 25 sec	5 min	✓		M or B	20-50	Same as U Relay	\$ 2.80	Optional		✓	
282	II	5	2 to 25 sec	5 min	✓		M or B	20-50	Same as Y Relay	\$ 3.25	Optional		✓	
Edison	III	1	5 to 300 sec	3 to 12 min	✓		M or B	6-130	1-1/4 x 3-3/4	\$ 4.00		✓		✓
Amperite	III	4	2 to 120 sec	3 to 12 min	✓		M or B	6-115	1-1/4 x 3-3/4	\$ 2.00		✓		✓
Livingston	III	7	5 to 300 sec	3 to 12 min	✓		M or B	6-115	1-1/4 x 3-3/4	\$ 2.00		✓		✓
G-V Controls	III	8												
Type R			3 sec to 5 min	12 sec to 20 min	✓	✓	M or B	6-220	1-5/16 x 3 or 3/4 x 2-3/4	\$ 9.50		✓		✓
Type H			0.25 to 8 sec	0.5 to 12 sec	✓	✓	M or B	6-28		\$14.00		✓		✓
Type T			2 to 20 sec	1.5 to 12 sec	✓	✓	M or B	6-125		\$12.00		✓		✓
Red Line			2 to 180 sec	12 sec to 10 min*	✓	✓	M or B	6-230		\$ 4.00		✓		✓
Adlake	III	11	0.5 sec to 20 min	0.3 to 180 sec	✓	✓	M or B	6-115	3-1/4 x 5-3/4 or 3-1/4 x 6-1/4	\$25.00		✓		✓
Oil Dashpot	III	18	5 sec to 1.5 min	10 msec	✓	✓	6 Springs	6-230	1-3/4 x 6-3/4				✓	
Agastat	III	19	0.1 to 200 sec 200 sec to 5 min	10 msec 10 msec	✓ ✓	✓ ✓	2 BM 2 BM	6-550ac 6-230dc	2-1/2 x 4-7/8	\$21.00		✓ ✓		✓ ✓
Vibrating Reed	III	23	1 to 15 sec		✓		4 Springs		1-1/4 x 4-3/8	\$ 8.75			✓	
Condenser Timed	IV	1	0 to 0.75 sec	5 msec	✓	✓	EM	20-50		\$10.00	✓		✓	
Thermistor	IV	2	0.1 to 10 sec	6-60 sec	✓		*	20-50		\$ 3.50	Optional			✓
Cold-cathode Tube	IV	4	0 to 1 min	10 msec	✓		*	+130		\$ 5.00	Optional		✓	
Motor-driven Timers	V	1	0 to 48 hrs	10 msec	✓		5 BM	20-115		\$25.00	✓			✓

*Recycle time of red line relays per KS-16615 is about 30 milliseconds.

SECTION II

WESTERN ELECTRIC DELAY RELAYS

235-type Relay

The 235 relays consist of one or two thermal units mounted in place of one or both of the spring units on an E relay structure as shown in Fig. II-1. Each thermal unit consists of two bimetal springs equipped with standard bar-type contacts. A heater winding wound on a flat mica form is attached to one of the bimetal springs. When the heater winding is energized, the heat causes the bimetal spring to which the heater winding is attached to bend, due to the unequal expansion of the two metals, and make contact with the other spring if it is a normally open contact, and break with the other spring if it is a normally closed contact.

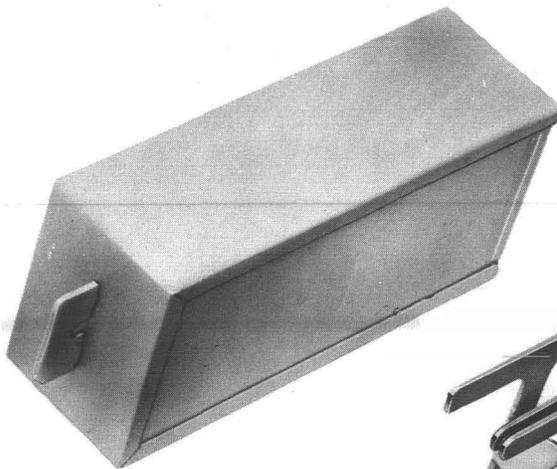
Both springs are bimetal so that the effect of ambient temperature changes is to cause both springs to bend in the same direction and by the same amount, thus maintaining the same relative position of the

springs with respect to each other. The delay times therefore will not be changed by ambient temperature changes.

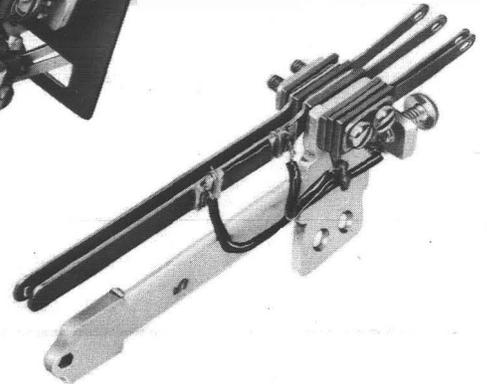
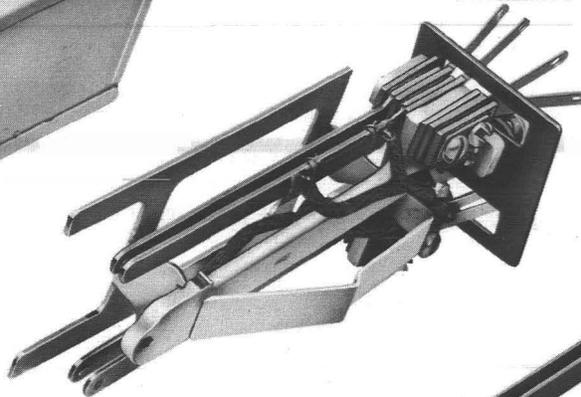
The magnitude of the time delay on a relay with normally open contacts depends on the wattage applied to the heater winding and the spacing between the contacts on the bimetal springs at the room temperature. The delay times can be adjusted by changing the contact spacing. On the normally closed contacts, the time delay depends on the force with which one spring rests against the other and the time is varied by changing this force.

Since the bimetal springs do not cool off immediately after the current is removed from the heater winding, an interval sufficient to allow the springs to cool to the room temperature must be allowed between successive operations if the full-operate time is to be obtained on each circuit closure. The time required to cool to a point

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235D RELAY



235E RELAY

Fig. II-1 - 235 Relay

where the full-operate time is obtained is called the recycle time. The recycle time for the 235 relay is 2 minutes.

Some contact chatter can be expected at the initial contact closure since the two contacts close with a very low-contact pressure until the springs have deflected sufficiently to build up contact pressure.

Since the rate of travel of the contacts is relatively slow, the chatter period may last several milliseconds until the contact has traveled far enough to build up to a higher contact pressure.

Table II-1 lists the 235 relays that are available. Some relays are equipped with a cover as indicated in the table.

TABLE II-1

235 RELAYS

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CODE	SPRING COMB.	OPERATE TIME - SECONDS				COVER	HEATER RES	VOLTAGES
		READJUST		SUB. INSP				
		MIN	MAX	MIN	MAX			
235D	Top M	16	25	15	27	√	1000	48.5-50
	Bot M	2.2	4.3	2.1	4.6		1000	48.5-50
235E	M	16	25	15	27		1000	48.5-50
235G	M	8	13	7	14	√	1000	48.5-50
235H	Top M	12	18	11	19		1000	26-26.5
	Bot M	12	18	11	19		1000	26-26.5
235J	Top B	14	18	13	19	√	1000	48-48.5
235K	Top M	12	17	11	18	√	1000	39-39.5
	Bot M	2.6	4.7	2.5	5		470	39-39.5
235L	Top M	13	20	12	21		470	26-26.5
	Bot M	13	20	12	21		470	26-26.5

A 2-minute cooling interval must be allowed between successive time checks.

236-type Relay

The 236 relay is designed to operate on the thermal principle and was developed for use in connection with a cable leak alarm. It is made of standard E relay parts, except the core which is that of the F relay in order to obtain an adjustable stop disc.

A single-bimetal spring with a heater coil consisting of a few turns of high-resistance wire wound around it is mounted in place of the top spring combination. This spring rests against a stud fastened to the armature.

Only one relay (236A) has been coded. This relay has a standard 2000-ohm coil on the core and a BM spring combination in the bottom spring position.

When current is applied to the coil winding, the relay operates. Current is then applied to the heater winding on the bimetal spring through a make contact on the relay. The spring is heated up and tries to bend toward the armature due to the unequal expansion of the elements of the bimetal spring. The tendency of the spring to bend is opposed by the force with which the operating winding is holding the armature against the core. As the force exerted against the armature by the bimetal spring becomes great enough to overcome the magnetizing force of the operating winding the armature is released, causing the heater

winding to be opened. As soon as the heater winding is opened, the bimetal spring begins to cool and tends to return to its normal position, gradually reducing the pressure tending to hold armature in the unoperated position. When the pressure against the armature drops low enough, it reoperates and starts a new cycle. The cycle is repeated as long as the current is kept on the operating coil and alternately closed and opened on the heater winding.

The rate of pulsing can be varied by changing the initial tension of the bimetal spring against the armature and by varying the height of the adjustable stop discs. The 236A relay is adjusted to meet the following requirements. With the cover on, with 0.012 ampere through the relay coil and 0.240 ampere through the heater winding, and after being operated for 10 minutes, the relay will periodically open and close the transfer contacts at intervals of 60 seconds ± 15 seconds, the open period being 16 seconds ± 2 seconds.

Since only one bimetal spring is used on this relay, the time is subject to variations due to ambient temperature changes.

This relay has been used in only one circuit. Its use in other circuits is not recommended due to its high cost and the fact that by a slight change in the circuit wiring the 271A relay can do the same jobs as the 236A.

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271-type Relay

The 271 relay is composed of a standard U relay except that a pair of bimetal thermal springs is added to the bottom spring unit. The U relay merely serves as a support for the thermal springs which have no effect on the normal operation of the U relay. This relay looks very much like the 282 relay shown in Fig. II-2.

The bimetal thermal springs function the same as those on the 235 relay. They are not subject to time variations with ambient temperature changes since both springs are bimetal. They have the same chatter characteristics as the 235 relay.

Only one 271 relay (271A) has been coded. This relay has a winding resistance of 500 ohms ± 5 per cent and a heater winding of 112 ohms ± 5 per cent. One set of break-make contacts is furnished in the top spring position and a pair of normally closed thermal springs in the bottom spring position. The break-make spring combination operates on a current of 0.0155 ampere through the 500-ohm winding. The thermal springs open in minimum 20 seconds readjust, and minimum 23 seconds on subsequent inspection with 26 to 26.5 volts across the heater winding. A 5-minute interval must be allowed for cooling between successive time checks.

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282-type Relay

This relay is like the 271 relay in construction except that a Y relay structure is used instead of the U relay. This relay is shown in Fig. II-2.

Only one relay (282A) has been coded at this time. This relay has a 1/2-inch copper sleeve over the core, a primary winding of 255 ohms ± 10 per cent, a secondary winding of 340 ohms ± 10 per cent, and a heater winding of 112 ohms ± 5 per cent. A set of one make and one break springs is furnished in the top spring position and a pair of normally closed thermal springs in the bottom spring position. The make and the break springs are adjusted to operate on 0.039 ampere, hold on 0.0032 ampere, and release on 0.0021 ampere, each after a soak of 0.080 ampere, all on the primary winding. The relay is adjusted to release in minimum 0.265 second, maximum 0.415 second after a soak of 0.80 ampere through the primary winding. The thermal springs open in minimum

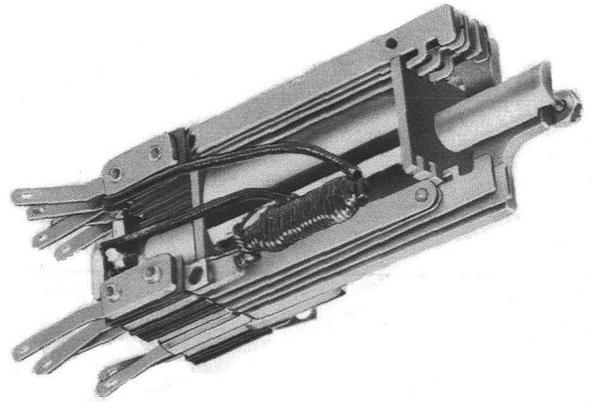


Fig. II-2 - 282 Relay

20 seconds readjust and minimum 23 seconds on subsequent inspection, both with 26 to 26.5 volts across the heater winding. A 5-minute interval must be allowed for cooling between successive time checks.

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OUTSIDE SUPPLIERS

SECTION III

RELAYS MANUFACTURED BY OUTSIDE SUPPLIERS

Edison Thermal Relay - Models 501 and 250
Thomas A. Edison, Inc.
West Orange, New Jersey

The mechanism of the Edison Model 501 thermal relay consists essentially of two bimetallic strips, each supported rigidly at one end and carrying a contact at the other. Only a single make or a single break is available. A heater winding is wound around one of the bimetal strips. Application of current to this heater winding causes the bimetal strip to bend so that the relay contacts either make or break depending on whether the contact is normally open or normally closed. The entire mechanism is sealed in a standard T9 glass radio tube envelope, and consequently is nonadjustable in the field (see Fig. III-1).

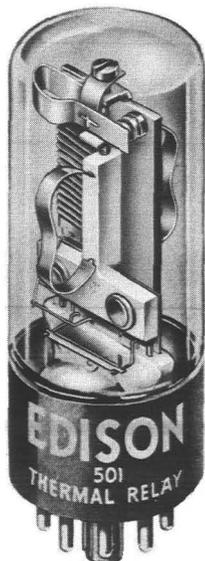


Fig. III-1 - Edison Relay

Full-contact pressure of 50 grams is applied to the make contacts almost as soon as they close. The moving contact is supported on the bimetal strip by a spring which is restrained so that the entire structure acts as a unit until the contact is made. As the bimetal strip moves further, the restraining member is moved away from the spring, and the spring then applies full force to hold the contacts together.

The use of similar bimetal strips to support both of the contacts provides compensation for ambient temperature changes. As the ambient temperature changes, both bimetal strips are affected in the same manner, and by the same amount. Thus the spacing between the contacts remains unchanged, and the amount of travel of the heated bimetal strip required to operate the contacts, which determines the timing, is unaffected through a range of -30 to $+150^{\circ}\text{F}$. The factors controlling the deflection of the bimetal strip are stable, so that consistency of operation is obtained.

The ability of the relay contacts to make and break comparatively heavy currents at substantial voltages results from the arc-quenching atmosphere in which they are sealed. For some characteristics, gases such as hydrogen or nitrogen are introduced before sealing. In all cases, the atmosphere is arc-quenching and eliminates contact burning or fouling. With the entire mechanism hermetically sealed in glass, its operation is independent of atmospheric pressure, humidity, or the presence of corrosive or hazardous fumes or dust.

The relay can be operated continuously. Due to the spring-mounting of the contacts, the bimetal strip cannot be overstressed. Thermal coupling between the heater and the compensating bimetal strip has been held to a low value to avoid contact reopening after long heating. The heaters operate at low temperatures to provide maximum life. It is advisable to open the heater winding as soon as the contacts have functioned in order to obtain a faster recycle time.

The relay can be provided in a variety of mountings but only the standard octal base has been used in the systems applications. The connections to the terminals and the size of the relay are shown in Fig. III-2.

The following table shows the operate times available on standard relays and the adjusting tolerance based on the nominal voltage. These times can be obtained on voltages from 6 to 130 volts ac or dc. Delay times other than those shown can be obtained but usually at a higher cost since they will be made specially, whereas the standard time-delay relays will be made in quantity lots and stocked. As with most temperature operated devices, the delay time will vary with a variation from the nominal voltage, the time varying approximately inversely as the square of the voltage change.

OPERATING TIME - SECONDS		CONTACT RATING
NOMINAL	TOLERANCE	
5	±1	3 amp 150V dc or 250V ac
10	±2	3 amp 150V dc or 250V ac
20	±3	3 amp 150V dc or 250V ac
30	±5	3 amp 150V dc or 250V ac
45	±7	3 amp 150V dc or 250V ac
60	±9	3 amp 150V dc or 250V ac
75	±12	3 amp 150V dc or 250V ac
105	±16	3 amp 450V dc or ac
120	±18	3 amp 450V dc or ac
150	±23	3 amp 450V dc or ac
180	±27	3 amp 450V dc or ac
210	±32	3 amp 450V dc or ac
300	±45	3 amp 450V dc or ac

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The power handling capacity of the contacts is affected by the atmosphere used in the sealed tube. Hydrogen and nitrogen will ionize and arc at high voltages. The relays which operate times up to 100 seconds use these gases and consequently the contacts are limited to 150 volts dc or 250 volts ac. Evacuated relays can be obtained for times in excess of 100 seconds and hence their contacts are capable of handling 450 volts ac or dc.

The heater winding ordinarily operates at 4 watts, but will withstand 5 watts continuous heating at any voltage up to 130 volts ac or dc.

Table III-1 shows the thermal delay relays of this type that have been assigned KS specifications. The same KS specifications may be manufactured by several different companies and the table indicates which manufacturers have been approved for each code. The recycle or cooling time varies with the delay times as shown in the table.

The Edison Model 250 is a sealed miniature relay that was developed to meet military shock and vibration requirements. It can be obtained with a single break or make contact and either hooked terminals for solder connections or pins for mounting in a 7-pin miniature socket. The terminals

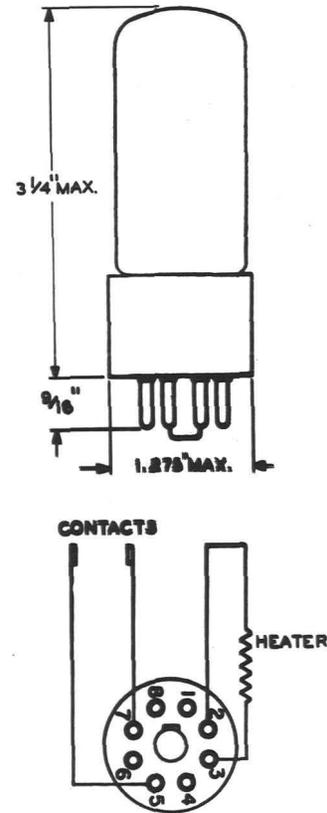


Fig. III-2 - Edison Relay - Terminal Arrangement

are brought out to the same pins as the octal base relay in Fig. III-2.

The relay operates on the principle of differential expansion multiplied by a system that produces an exceptionally high rate of contact closure. As the heater causes the expansion member to elongate, a lever pivots on a hinge and compresses a bowed spring in the direction to close the contacts.

Ambient temperature compensation is obtained by a matching expansion member that compensates for external changes in temperature between -50°F and +200°F. Heaters are available for either continuous or intermittent duty. The contacts are rated at 1 ampere at 27 volts dc or 3 amperes at 115 volts ac. The seated height is 2 inches and the diameter 3/4 inch.

Delay times ranging from 5 to 180 seconds ±10 per cent with heater voltages from 6.3 to 115 volts are obtainable.

TABLE III-1

TIME DELAY RELAYS

Relays listed below are enclosed in a glass envelope, have a standard intermediate octal base.

CODE	CONTACT	VOLTAGE			OPERATE TIME SECONDS		COOLING TIME (MINUTES) BETWEEN OPERATIONS	APPROVED** MANUFACTURER
		MIN	RATED	MAX	MIN	MAX		
KS-13542	M	45		50	13	32	4	A,E,L
KS-13543	M	45		50	2	6	3	A,E,L
KS-13782	B		6.3		50	70	10	L
KS-13977	M	10.8		11.2	60	100	6	A,E,L
KS-13991	M	20		26	90	250	12	A,E,L
KS-14082	M		6.3+		40	120*	5	A,E,L
KS-14233	M		6.3+		51	69	6	E,L
				6.5+	40			
KS-14392	M	47		53	90	180	12	A,E,L
KS-14400	M	20		26	15	45	4	A,E,L
KS-14404	M	19		28	9	27	5	A,E,L
X-75519 KS-14454	B		115+		6	10	15	Af
KS-14506	M	20		28	2.5	12	4	A,L
KS-14566	B		115+		3	7	3	A
KS-14683	M		115		95	250	12	A
KS-14695	M	20		26	7	22	4	A,E,L
KS-16084	B		6.3		105	180	10	A
KS-16479Ø	M	20		26	90	180	10	A
KS-16578	M		115 ±1		6	10	4	E
KS-16579	M		115 ±1		13	23	4	E
KS-16582	M		115 ±1		30	50	5	E

ØOpening heater circuit after it has been closed for minimum 3 minutes, the contacts shall reclose in a maximum of 10 seconds.

+AC voltage.

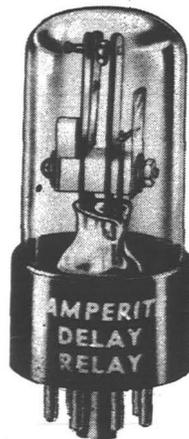
*In series with 1.1 ohms ±5 per cent at 6 volts.

**A - Amperite
E - Edison
L - Livingston

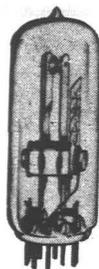
ØMiniature 9-pin base.

Amperite Thermostatic Delay Relay
Amperite Company
561 Broadway, New York, New York

The Amperite relay consists of two bimetallic strips rigidly fastened at one end and carrying a pair of silver contacts. Only a single-make or a single-break contact is available. A heater winding is located near one of the bimetal strips. When the heater winding is energized, the heat causes the adjacent bimetal strip to bend so that the relay contacts either make or break depending on whether they are normally open or normally closed. The entire mechanism is sealed in a glass tube and consequently is nonadjustable after assembly. The glass tube may be evacuated, or filled with hydrogen or nitrogen gas depending on the time delay required, the recycle time, the operating voltage, etc. Fig. III-3 shows a photograph of the relay.



STANDARD



MINIATURE

Fig. III-3 - Amperite Relay

Since both the strips that carry the contacts are bimetal, compensation is provided for ambient temperature changes from -30 to +160F.

The relays are not affected by altitude, moisture, corrosive fumes, dust, etc., since they are hermetically sealed, but the times have been found to vary some with the position of the relay. In the Amperite relay, the heater element may be wound on a mica strip which is positioned parallel to and approximately 1/8 inch from one of the bimetal strips or on a round bobbin which is positioned adjacent to one of the bimetal strips. Some of the heat energy transfer is by convection and this accounts for the operate time variation with different positions of the mounting socket. It is therefore important that all equipment drawings show the socket mounted with the key slot in the same position. As viewed from the front, the socket shall be positioned with the keyway of the centering hole pointing 40 degrees clockwise from the extreme downward position.

Heater coils for operation on 26 volts or less have a built-in compensation for voltage variations. Fig. III-4 shows how the time varies with the voltage. Without this regulation, the time will vary approximately inversely as the square of the supply voltage variation.

One caution must be observed in the use of relays with the voltage regulator. Ordinarily, a low-voltage relay can be used on a higher voltage by connecting a series resistance in the circuit so that the voltage drop across the relay is equal to its rated voltage. This arrangement does not adequately protect the voltage regulated relays and the heater windings may be damaged if low-voltage relays are used on high circuit voltage. The circuit voltage where a series resistor is used should not be more than 30 per cent higher than the rated voltage of the relay. The voltage regulation is based on a change in the resistance of the coil as the voltage changes. With a zero temperature coefficient resistance in series with the heater winding, the per cent of the voltage that is across the heater winding increases as the heater winding resistance increases and excess voltage on the heater winding may result.

The heater windings require about 2.0 watts and can be operated continuously on this wattage. They will withstand a 50 per cent overload for a short duration of time.

The relays are hermetically sealed in a standard T9 radio tube envelope with an octal base. Fig. III-5 shows the terminal connections and the size of the relay. The relay is also available in a miniature size as shown in Figs. III-3 and III-5.

The following table shows the delay times available on standard relays and the adjusting tolerance, both in seconds. These times are based on the nominal voltage which ranges from 6 to 120 volts ac or dc.

x-75519

<u>DELAY TIME</u>	<u>TOLERANCE</u>
2	±1
3	±1
5	±2
10	±3
20	±4
25	±5
30	±8
45	±10
60	±12
75	±15
120	±30

The contacts will make or break 1.5 amperes at 50 volts dc with no protection. When the contacts control a dc voltage above 50 volts, a protective network must be connected across the contacts in accordance with the following table.

<u>CURRENT (AMPERES)</u>	<u>PROTECTION</u>		
	<u>50V DC</u>	<u>115V DC</u>	<u>230V DC</u>
0 - 0.5	None	0.1 µf	0.25 µf
0.5 - 1.5	None	0.25 µf	0.25 µf
1.5 - 3	0.25 µf	1 µf	0.5 µf

When breaking an inductive ac load, a condenser of 0.01 to 0.1 microfarad must be connected across the contacts.

The Amperite relay is also available in what is called a flasher relay. The heater input is carried through the normally closed thermal springs. After a predetermined interval, the contacts open and open the heater winding. The thermal springs then cool and after an interval reclose, starting a new operating cycle. Flashing rates from 15 to 125 flashes per minute can be obtained.

Table III-1 shows a list of the thermal delay relays of this type that have been assigned KS specifications and the delay times. The recycle time varies with the delay times as shown in the table. The table also indicates those relays that have been approved for manufacture by the Amperite Company.

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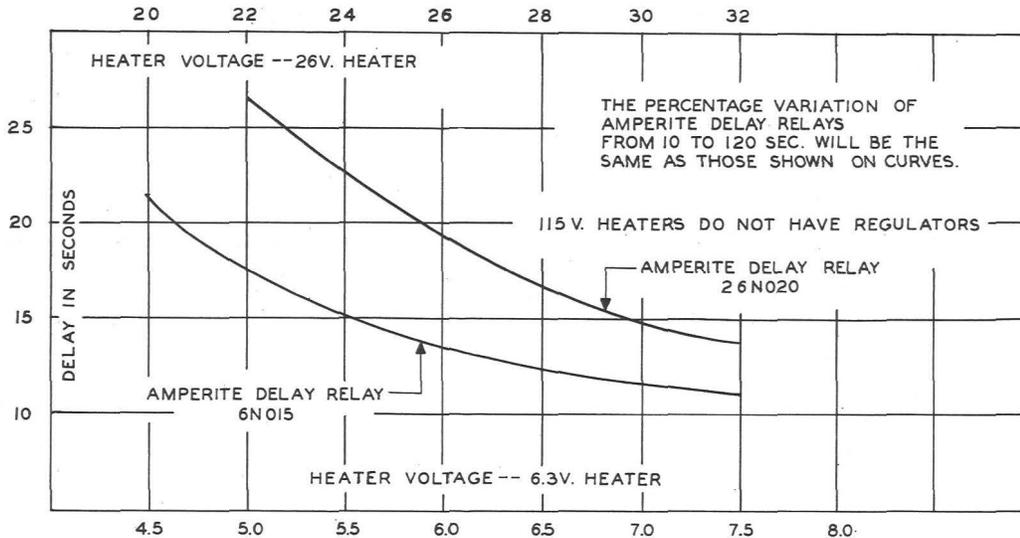


Fig. III-4 - Amperite Relay Time Change With Voltage Changes

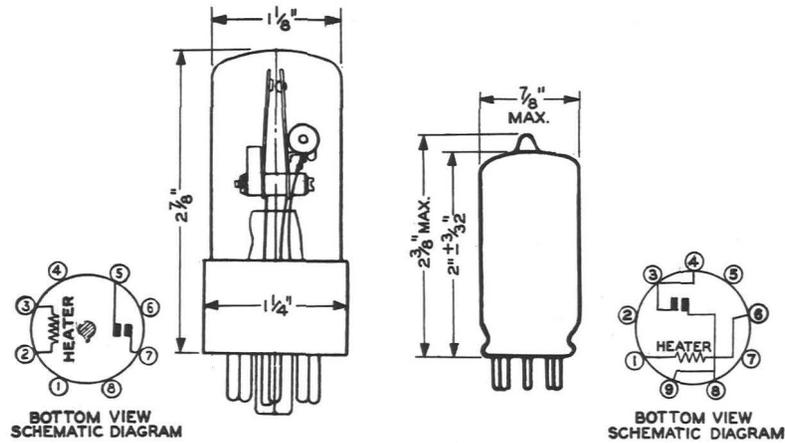


Fig. III-5 - Amperite Relay - Terminal Arrangement

TABLE III-1 - TIME-DELAY RELAYS

Relays listed below are enclosed in a glass envelope, have a standard intermediate octal base.

CODE	CONTACT	VOLTAGE			OPERATE TIME SECONDS		COOLING TIME (MINUTES) BETWEEN OPERATIONS	APPROVED** MANUFACTURER
		MIN	RATED	MAX	MIN	MAX		
KS-13542	M	45		50	13	32	4	A,E,L
KS-13543	M	45		50	2	6	3	A,E,L
KS-13782	B		6.3		50	70	10	L
KS-13977	M	10.8		11.2	60	100	6	A,E,L
KS-13991	M	20		26	90	250	12	A,E,L
KS-14082	M		6.3+		40	120*	5	A,E,L
KS-14233	M		6.3+		51	69	6	E,L
				6.5+	40			
KS-14392	M	47		53	90	180	12	A,E,L
KS-14400	M	20		26	15	45	4	A,E,L
KS-14404	M	19		28	9	27	5	A,E,L
KS-14454	B		115+		6	10	15	A f
KS-14506	M	20		28	2.5	12	4	A,L
KS-14566	B		115+		3	7	3	A
KS-14683	M		115		95	250	12	A
KS-14695	M	20		26	7	22	4	A,E,L
KS-16084	B		6.3		105	180	10	A
KS-16479 \emptyset	M	20		26	90	180	10	A
KS-16578	M		115 \pm 1		6	10	4	E
KS-16579	M		115 \pm 1		13	23	4	E
KS-16582	M		115 \pm 1		30	50	5	E

\emptyset Opening heater circuit after it has been closed for minimum 3 minutes, the contacts shall reclose in a maximum of 10 seconds.

+AC voltage.

*In series with 1.1 ohms \pm 5 per cent at 6 volts.

**A - Amperite
E - Edison
L - Livingston

\emptyset Miniature 9-pin base.

May, 1961

Livingston Thermal Relay
 Livingston Electronics Co.
 Essex Falls, New Jersey

This relay is very similar to the Edison thermal relay in both appearance and performance. Table III-1 indicates those uses for which the Livingston relay has been approved.

TABLE III-1

Relays listed below are enclosed in a glass envelope, have a standard intermediate octal base.

x-75519

CODE	CONTACT	VOLTAGE			OPERATE TIME SECONDS		COOLING TIME (MINUTES) BETWEEN OPERATIONS	APPROVED** MANUFACTURER
		MIN	RATED	MAX	MIN	MAX		
KS-13542	M	45		50	13	32	4	A,E,L
KS-13543	M	45		50	2	6	3	A,E,L
KS-13782	B		6.3		50	70	10	L
KS-13977	M	10.8		11.2	60	100	6	A,E,L
KS-13991	M	20		26	90	250	12	A,E,L
KS-14082	M		6.3+		40	120*	5	A,E,L
KS-14233	M		6.3+		51	69	6	E,L
				6.5+	40			
KS-14392	M	47		53	90	180	12	A,E,L
KS-14400	M	20		26	15	45	4	A,E,L
KS-14404	M	19		28	9	27	5	A,E,L
KS-14454	B		115+		6	10	15	A ^F
KS-14506	M	20		28	2.5	12	4	A,L
KS-14566	B		115+		3	7	3	A
KS-14683	M		115		95	250	12	A
KS-14695	M	20		26	7	22	4	A,E,L
KS-16084	B		6.3		105	180	10	A
KS-16479 \emptyset	M	20		26	90	180	10	A
KS-16578	M		115 \pm 1		6	10	4	E
KS-16579	M		115 \pm 1		13	23	4	E
KS-16582	M		115 \pm 1		30	50	5	E

\emptyset Opening heater circuit after it has been closed for minimum 3 minutes, the contacts shall reclose in a maximum of 10 seconds.

+AC voltage.

*In series with 1.1 ohms \pm 5 per cent of 6 volts.

**A - Amperite

E - Edison

L - Livingston

\emptyset Miniature 9-pin base.

May, 1961

G-V Thermal Delay Relays
 G-V Controls, Inc.
 28 Hollywood Plaza
 East Orange, N. J.

The G-V controls offer a line of sealed adjustable thermal relays that differ from the thermal relays discussed previously in that they do not depend on the expansion of members composed of two dissimilar metals. These relays depend on the expansion of steel members, ribbon tapes, or wires. Fig. III-6 shows the general appearance of the relays. The relays are equipped with a single-make (NO) or a single-break (NC) contact.

There is also a nonadjustable relay equipped with an octal base which can be obtained with two makes or a make and a break.

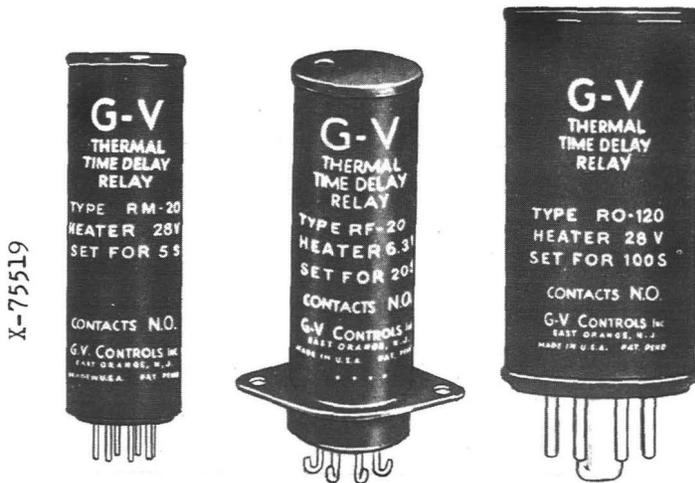


Fig. III-6 - G-V Thermal Relays

The miniature plug-in relays can be equipped with an XA-1 retainer or an XA-2 clamp to hold the relay firmly in the socket.

The Table on page III-9 shows the KS specifications that have been assigned to G-V Controls relays.

Type R and KR Relays

The mechanism of the R relay consists essentially of two rigid stainless-steel members of equal length which expand longitudinally with a temperature rise. Fig. III-7 shows this arrangement. A heater winding is embedded in one of the steel members (A) causing it to expand when the winding is energized, but the second member (B) has no heater and therefore does not expand as much. A simple but rugged and precise mechanism (C) multiplies any difference in expansion of the two members to move a

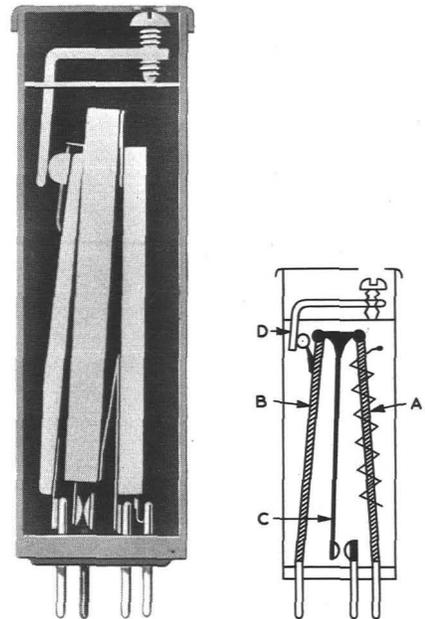


Fig. III-7 - G-V Thermal Relays - Operating Mechanism

contact arm. Ambient temperature changes expand both members the same amount and no contact movement results.

An adjusting arm (D) is fastened to a diaphragm which forms the top of a hermetically sealed space enclosing the operating mechanism. The inner end of the arm rests against the relay structure and when moved by changing the position of an adjusting screw, varies the size of the contact gap and thus changes the time required to operate the contacts.

The contact pressure is about 30 grams and there is a slight contact wiping action.

For short times, thin members are used to heat up quickly to a given temperature differential. For the longer times, thicker and more massive elements are employed so that a longer period of time is required to reach the same temperature differential. Elements of seven different masses are made and they have overlapping time ranges. This permits desired combinations of heating and cooling characteristics to be chosen for any particular application.

These relays are hermetically sealed in dry atmosphere in a metal case. The R relays are available in either the standard

octal base (RO type), a 7-pin miniature plug-in base (RM type), or a miniature form with soldered terminals and a flange base (RF type). The KR relays are furnished only with the flanged base.

Fig. III-8 shows the relative sizes of the octal base and the miniature base relays and Fig. III-9 the terminal connections. In the miniature relays of type R, pins 1, 4, 6, and 7 are connected together by the internal structure of the relay. These socket points, therefore, cannot be used in the circuit as multiple or tie points for circuit wiring other than for wiring to the relay itself.

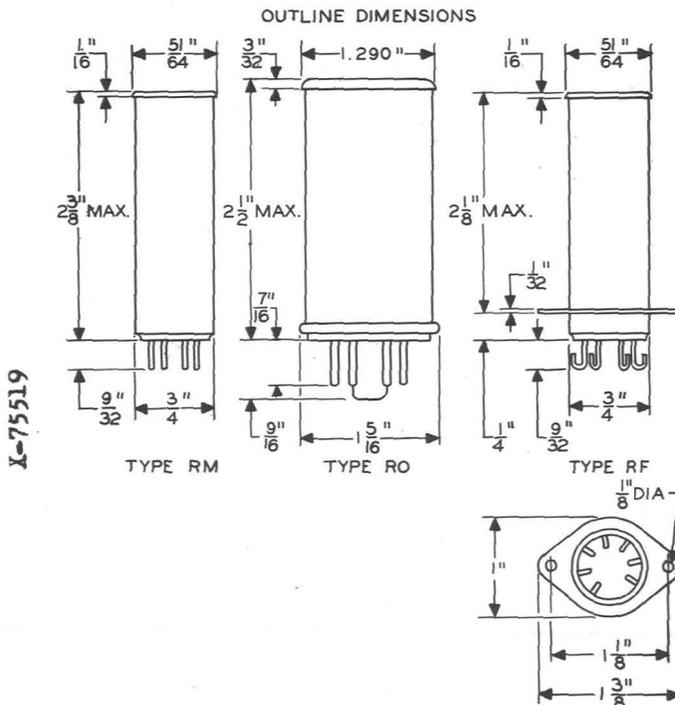


Fig. III-8 - G-V Terminal Relays - Size of Relays

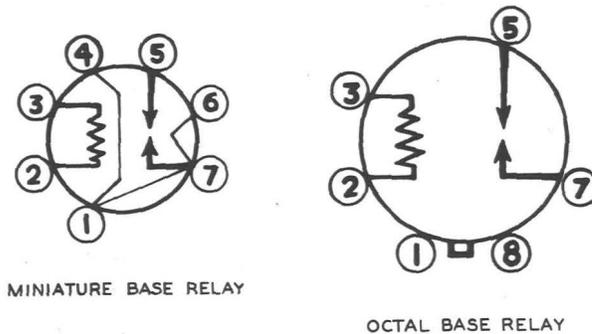


Fig. III-9 - G-V Terminal Relays - Terminal Arrangement

The relays require approximately 4 watts and may be operated on this wattage continuously. Less than 4 watts can be used under some conditions.

The contacts on all relays are silver-palladium and are rated at 3 amperes 250 volts on ac with a noninductive load and 25 volt-amperes up to 250 volts on inductive loads. A 1-ampere limit applies below 25 volts. The dc rating is 1 ampere up to 32 volts with a noninductive load and 1/8 amperes with an inductive load. The dc limit can be raised to 3 amperes if a 0.5 microfarad condenser is wired across the thermal relay contacts. If the dc loads are inductive, contact protection should be provided. There is very little contact chatter on this relay compared to most thermal relays. Tests have indicated that the chatter lasts for only 5 or 6 milliseconds.

The relay is quite stable under vibration conditions and shock, the time settings remaining stable under shock and accelerations up to 30g for the R relay and 50g for the KR relay. The relays are compensated for temperature variations from -30 to +210F. The position of the relay has practically no effect on the delay times.

The type R relays require an appreciable interval from the time the heater circuit is opened until it can be reclosed if the full-re-operate time is to be obtained on the reclosure. If cut off at the end of the time-delay period, the type R relays will recover in a given time a fixed percentage of the time it is set for. The following table shows the percentage of the operate time that will be recovered with cooling times expressed as a multiple of the basic operating time T_b . If allowed to heat to saturation, longer recovery times than shown in the table must be allowed.

COOLING TIME	PER CENT OF OPERATING TIME
$1 \times T_b$	50
$2 \times T_b$	75
$3 \times T_b$	85
$4 \times T_b$	95

The following table shows the times that can be obtained with the R and KR relays. The KR relay characteristics are like those of the R relays except that the KR relays will stand greater shock and vibration.

"R" & "KR" Series 12 to 180 Seconds

SERIES AND NOMINAL BASIC TIME	BASIC TIME	RECOMMENDED TIME RANGE	FACTORY SETTING TOLERANCE ON NORMAL OPERATE TIME (at Rated Input Voltage and Room Temperature)
RF-20 RM-20 & RO-20	20 secs	12 to 22 secs	±2 seconds
KRF-20	20 secs	12 to 22 secs	±3 seconds
RF-30, RM-30 & RO-30	30 secs	22 to 33 secs	±3 seconds
KRF-30	30 secs	22 to 33 secs	±4.5 seconds
RF-40, RM-40 & RO-40	40 secs	33 to 45 secs	±4 seconds
KRF-40	40 secs	33 to 45 secs	±6 seconds
RF-60, RM-60 & RO-60	60 secs	45 to 65 secs	±10% but not less than 5 secs
KRF-60	60 secs	45 to 65 secs	±15% but not less than 7 secs
RF-80, RM-80 & RO-80	80 secs	65 to 90 secs	±10% but not less than 7 secs
KRF-80	80 secs	65 to 90 secs	±15% but not less than 10 secs
RF-120, RM-120 & RO-120	120 secs	90 to 125 secs	±10% but not less than 11 secs
KRF-120	120 secs	10 to 125 secs	±15% but not less than 15 secs
RF-160, RM-160 & RO-160	160 secs	125 to 180 secs (Note A)	±10% but not less than 15 secs
KRF-160	160 secs	125 to 180 secs	±15% but not less than 20 secs

NOTE: (A) Range may be extended to 240 secs with tolerance of ±15%. Consult G-V Engineers.

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Type H Relays

The H-type relay is like the R type except that the steel expanding member with the internal heater is replaced by a group of resistance alloy wires under tension through which the heater current passes so that the relay is actually operated by the expansion of the hot wires. The wires are normally kept under tension by the other members of the relay. The change in length of the wire as it becomes heated causes the contacts to open or close. With this type of construction, the heater voltage is presently limited to a maximum of 28 volts, whereas the R-type relay can be used on heater voltages as high as 220 volts ac or dc. The expanding wires are not heated to incandescence so that continuous energization will not limit the life of the relay. The heaters require about 4 watts.

An unheated member having the same length and expansion coefficient as the hot wire element compensates for variations in ambient temperature from -30 F to +210 F.

The H relay is hermetically sealed in a metal case in dry atmosphere. It is

available with the 7-pin miniature plug-in base (HM type) or in the miniature flanged base (HF type). The relay size and terminal connections are shown in Fig. III-8 and III-9. Pins 1, 4, 6, and 7 are connected together in the miniature base relay.

Adjustment of the relay-operate time is made by means of a screw which operates a lever mounted on a flexible diaphragm similar to the method used on the R-type relay. The position of the relay has practically no effect on the delay times.

The H-type relays may be used for time intervals down to 0.1 second by applying up to twice the normal voltage to the heaters. When a voltage more than 15 per cent above normal is used, a self-protecting circuit which removes the heater voltage, when the contacts operate, must be used. Doubling the heater voltage reduces the time delay to about one quarter of that at nominal voltage.

If the heater circuit of an H-type relay is opened as soon as the contacts

operate cooling starts instantly and the contacts release in about 0.1 second. The table below shows the time required for the relays to recover various percentages of the delay for which the relays are set. This characteristic differs slightly between relays of different nominal heater voltages.

Per Cent of Operating Time	Cooling Time	
	HM01 & HF01	HMO4 & HFO4
50	1 sec	5 sec
75	2.5 sec	18 sec
85	5.0 sec	30 sec
95	10.0 sec	40 sec

If the relay is allowed to heat to saturation, longer recovery times will be required.

The contact ratings are the same as for the type R relay.

There are two nominal time ranges as shown in the following table.

"H", Series 1/2 to 4 Seconds					
SERIES AND NOMINAL BASIC TIME	NOMINAL HEATER VOLTAGE	ACTUAL BASIC TIME	RECOMMENDED TIME RANGE	FACTORY SETTING TOLERANCE ON NORMAL OPERATE TIME (at rated input voltage and room temperature)	
	28 volts	1 sec	0.5 to 1.25 sec		
HF-01 & HM-01	20 volts	0.75 sec	0.5 to 1 sec	±25% for setting below 1 sec ±20% for setting 1 sec & up	
	12 & 6.3 volts	0.55 sec	0.5 to 0.75 sec		
			(See note)		
	28 volts	3 sec	1.25 to 3 sec		
HF-04 & HM-04	20 volts	2.6 sec	1.25 to 2.75 sec		±20%
	12 & 6.3 volts	2 sec	1.25 to 2.5 sec		

Note: Range may be extended to 4 seconds when quick recovery time is required at this setting. Consult G-V Engineers.

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Type T Relays

The type T relay is like the R relay except that it uses a stainless-steel ribbon expanding element which is indirectly heated by a resistance element wound around it. This construction permits the use of heater voltages up to 125 volts.

Adjustment of the relay-operate time is made by means of a screw which operates a lever mounted on a flexible diaphragm forming one end of the sealed chamber. The movement of the lever controls the contact separation in a manner similar to the adjusting action of the type R relay.

This relay can be furnished with the octal base (TO type), the 7-pin miniature plug-in base (TM type), the miniature flanged base (TF type), or the KTF type for military shock requirements. The relay sizes and terminal arrangements are shown in Fig. III-8 and III-9.

The contact rating and shock limits are the same as for the type R relay. The position of the relay has practically no effect on the delay times.

The relays are available in two time ranges as shown below. The recovery time is one half and one third that of the R relay.

the operating times listed in the tables for the R, H, and T relays can be obtained. If a relay is to be set for "Holdover" service, this must be specified in the orders. Normal setting tolerances can be held on either operate or release time, but not on both.

Current- or Voltage-Sensing Relays

These relays are structurally the same as the R, H, and T relays described previously. Current-sensing relays are designed to operate their contacts when the current passing through the heater exceeds a set value. Voltage-sensing relays operate their contacts when the voltage across the heater exceeds a set value. When the current or voltage drops below the set value, the contacts return to the unoperated condition.

Relays can be provided for current settings from 0.015 to 5 amperes, and voltage settings from 2 to 230 volts. The setting for each relay is adjustable over a fairly wide range. The relays are available in the 7-pin miniature plug-in base or the flanged base.

Red Line Relays

These relays are similar to the type R relays but are not adjustable, do not meet

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"T" & "KT", Series 2 to 12 Seconds

SERIES AND NOMINAL BASIC TIME	NOMINAL HEATER VOLTAGE	ACTUAL BASIC TIME	RECOMMENDED TIME RANGE	FACTORY SETTING TOLERANCE ON NORMAL OPERATE TIME (at rated input voltage and room temperature)
TF-06, TM-06, & TO-06	6.3 to 125	6 sec	3 to 8 sec (Note A)	±10% but not less than 0.4 sec
KTF-06 (Note B)	6.3 to 125	6 sec	2 to 8 sec	±15% but not less than 0.5 sec
TF-10, TM-10, & TO-19	6.3 to 125	10 sec	8 to 12 sec	±10%
KTF-10 (Note B)	6.3 to 125	10 sec	8 to 12 sec	±15%

Notes:

- A. Range may be extended to 2 seconds if 115-volt heater is required, or if vibration and shock superior to "H" series is needed. Consult G-V Engineers.
- B. "KT" series relay withstands higher vibration and shock than "T" series.

Holdover Time

The R, H, or T relays may be used in what is designated as "Holdover" service in which the contacts hold their operated condition for a specific time interval after the heater is de-energized. The delay time will vary with the different relays and their adjustments. If the relays are energized long enough to reach the saturation point, a release time about the same as

shock and vibration requirements, and are not hermetically sealed. They are furnished in the octal base only, and have either a normally open or a normally closed contact. They can be operated on 6.3 to 230 volts with time delays ranging from 2 seconds ±1/2 second to 180 seconds ±27 seconds. These are low cost relays in a price range comparable to the Edison relays.

When used as described in the following paragraph for rapid reset, they are

equipped with either two make, or one make and one break, contacts.

Rapid Reset Thermal Delay Circuit

Thermal relays ordinarily cannot be used where a fast reoperation is required or where the relay may be subjected to intermittent closures and opens, since a thermal relay must be allowed to cool before it can again be re-energized.

A thermal and a magnetic relay can be wired together as shown in Fig. III-9A to produce a timer which has rapid reset characteristics. The basic principle involved is the use of a cycle composed of both the heating and the cooling cycle of the thermal unit. The heating interval is about 25 per cent of the total interval and the cooling interval about 75 per cent.

When contact SW is closed, the heater winding heats up through a break contact on M relay of Fig. III-9A. The T1 contact closes first and opens the output lead in another place in the case of the normally open output, or places a short on the output leads in parallel with the M relay contact in the case of the normally closed output. A short time later T2 contact closes and operates M relay which locks under control of the starting SW contact. M relay opens the heater winding and the thermal unit starts to cool. As the thermal unit nears the room temperature, T1 contact restores to normal and completes the output circuit for the normally open circuit, or opens the output circuit for the normally closed output circuit.

When the heating-cooling sequence has been completed, the equipment is ready for reoperation, since the cooling period has already taken place. If the cycle is interrupted, by opening contact SW before the thermal relay of Fig. III-9A has cooled to a point where the contacts restore to the unoperated position, a part of the heating cycle and all of the cooling cycle will be repeated on an immediate reclosure of SW. The shortest delay period would occur if SW were opened momentarily just as the thermal unit heated up to point B where the magnetic relay had just operated. Under this condition, a delay equal to the cooling time will be obtained.

There is no cumulative effect of successive energizing pulses as long as such pulses allow sufficient time for the magnetic relay to release and are not longer than the minimum cooling time.

The red line relay equipped with two contacts has usually been used for this arrangement. Types R, H, and T thermal relays can also be used in this circuit by using two relays operating in parallel to obtain the two thermal contacts required. Type H relays are limited to 28 volts and the two relays must be operated in series if the voltage exceeds this value. Time delays from 2 seconds to 4 minutes can be obtained.

Thermal relays used in this arrangement are subject to position and orientation effects since the majority of the delay time comes from the cooling period and the cooling rate is dependant on the relative position of the thermal contacts and the heater winding. The time requirements specified for the rapid reset relay are based on the relay mounted in a horizontal plane with the tube socket oriented so that the keyway of the centering hole is pointed 40 degrees clockwise from the downward position.

KS specifications have been assigned to the following G-V controls relays.

- KS-16022 - Adjustable relay with octal base
- KS-16195 - Adjustable relay with miniature base
- KS-16388 - Voltage-sensing relay
- KS-16615 - Rapid recycle relay
- KS-16856 - Red line relay
- KS-16988 - *Holdover time after short heating time
- KS-19072 - Voltage-sensing relay

*Mounted horizontally with the keyway of the mounting socket pointing directly up.

The individual list numbers are shown in the following tabulations.

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KS	TYPE	CONTACT	VOLTAGE	TIME (SECONDS)		MIN WAITING TIME BETWEEN TESTS (MINUTES)
				MIN	MAX	
KS-16022, L1	RO-20	NO	24 +.5, -0	7	9	4
16022, L2	TO-10	NO	48 +.5, -0	2.5	3.5	3
16022, L3	TO-10	NO	48 +.5, -0	9	11	4
KS-16195, L1	HM-04	NO	28 +.5, -0	2	3	2
16195, L2	HM-04	NC	28 +.5, -0	2	3	2
16195, L3	RM-20	NO	230	*	*	-
16195, L4	HM-01	NO	24 +.5, -0	0.73	0.77	1

*Hold for 13 ±3 seconds after being energized for 3 minutes on 230 volts.

KS-16388, L1 HFV-01 NO 28 (See Note)

Note: With a minimum of 27 volts applied for minimum of 2 minutes, the relay shall not operate. Increase the voltage to 33 ±1 volts and the relay shall operate in 1 second maximum. After being de-energized for at least 20 minutes, the relay shall operate in maximum 3 seconds on 33 volts maximum.

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KS	CONTACT	VOLTAGE	TOTAL TIME DELAY (SECONDS)		COOLING PERIOD (SECONDS)	MIN WAITING TIME BETWEEN TESTS (SECONDS)
			MIN	MAX		
KS-16615, L1	NO	24 +.5, -0	115	155	95	120
16615, L2	NO	48 +.5, -0	5	7	3.5	60
16615, L3	NO	24 +.5, -0	200	280	150	240
16615, L4	NO	48 +.5, -0	200	280	150	240
16615, L5	NC	24 +.5, -0	200	280	150	240
16615, L6	NC	48 +.5, -0	200	280	150	240
16615, L7	NC	48 +.5, -0	15	20	10	90
16615, L8	NO	48 +.5, -0	20	30	15	90
16615, L9	NO	48 +.5, -0	90	150	75	120
16615, L10	NO	48 +.5, -0	40	60	30	90
16615, L11	NO	48 +.5, -0	3	4	1.7	60
16615, L12	NO	48 +.5, -0	30	40	22	90

<u>KS</u>	<u>CONTACT</u>	<u>VOLTAGE</u>	<u>TIME (SECONDS)</u>		<u>MIN WAITING TIME BETWEEN TESTS (MINUTES)</u>
			<u>MIN</u>	<u>MAX</u>	
KS-16856, L1	NO	115 +.5, -0	1.5	3	2
16856, L2	NO	26 +.5, -0	30	40	5
16856, L3	NC	26 +.5, -0	*	*	-

*Set for minimum 68, maximum 92 seconds holdover after being energized for 10 minutes.

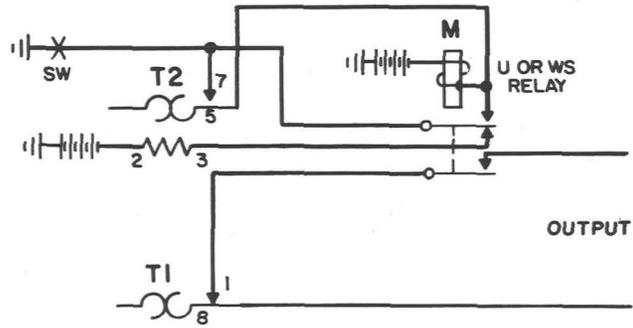
KS-16988, L1	NC	26 +.5, -0	**	**	-
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**Set for minimum 80, maximum 100 seconds after being energized for 20 minutes. After 1 minute energization, the holdover time is minimum 50 seconds.

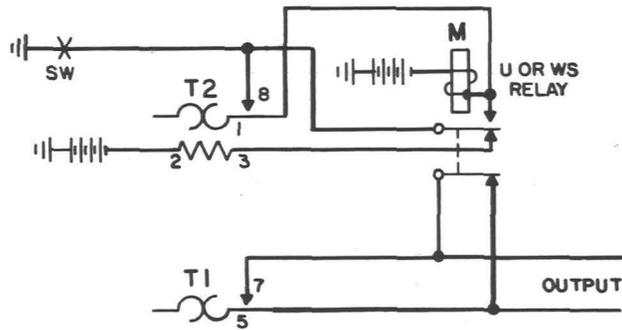
<u>KS</u>	<u>CONTACT</u>	<u>VOLTAGE SETTING</u>	
KS-19072, L1	NO	28 ±1.1 volts	Mounted vertically
19072, L2	NO	56 ±2.2 volts	Mounted vertically
19072, L3	NO	100 ±4 volts	

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NORMALLY OPEN OUTPUT



NORMALLY CLOSED OUTPUT

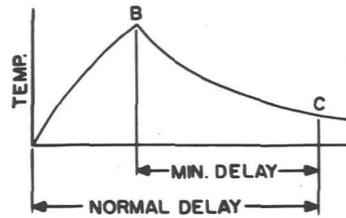


Fig. III-9A - Time Delay Relay for Immediate Recycle

Adlake Relay
 Adams Westlake Company
 Elkhart, Indiana

The Adlake relay consists essentially of a solenoid plunger floating in a pool of mercury within a glass or metal tube. Fig. III-10 is a cutout view showing the elements of the relay.

Fig. III-11 shows a general view of the two types of relays normally used. The two types of relays are alike except that a slightly rounded top is required on some relays, thus necessitating about 1/2 inch more vertical mounting space. Whether the flat or rounded top is required depends on the location of the tube inside the coil, which in turn depends on the voltage and time requirements.

The method of obtaining the operate time delay may best be understood from Fig. III-12 which shows how a normally open slow make contact functions. In Fig. III-12A the plunger (P) is floating in a pool of mercury (M). The space (S) is filled with an inert gas. When the coil (C) is energized (Fig. III-12B), the plunger (P) is pulled down into the mercury (M). The mercury thus displaced enters the thimble (T) through the opening (O). The mercury is prevented from immediately rising in the thimble by the pressure of the gas inside.

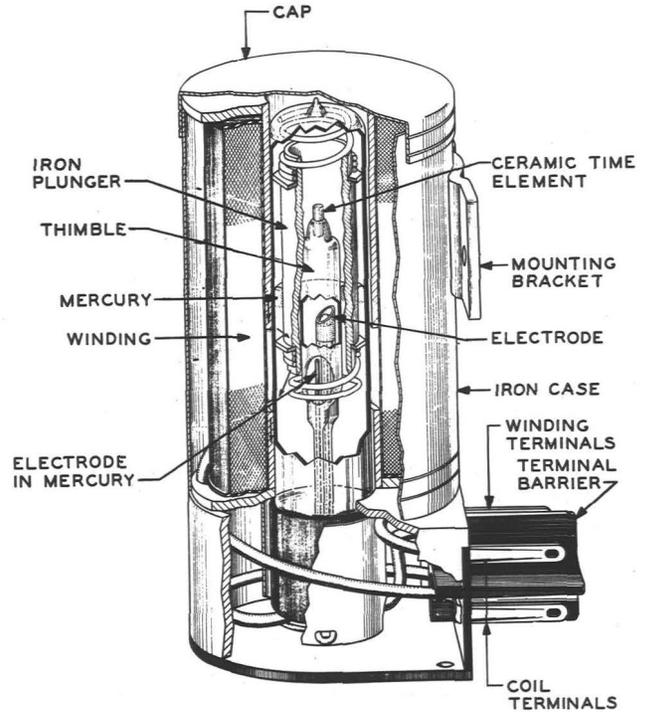


Fig. III-10 - Adlake Relay Sectional View

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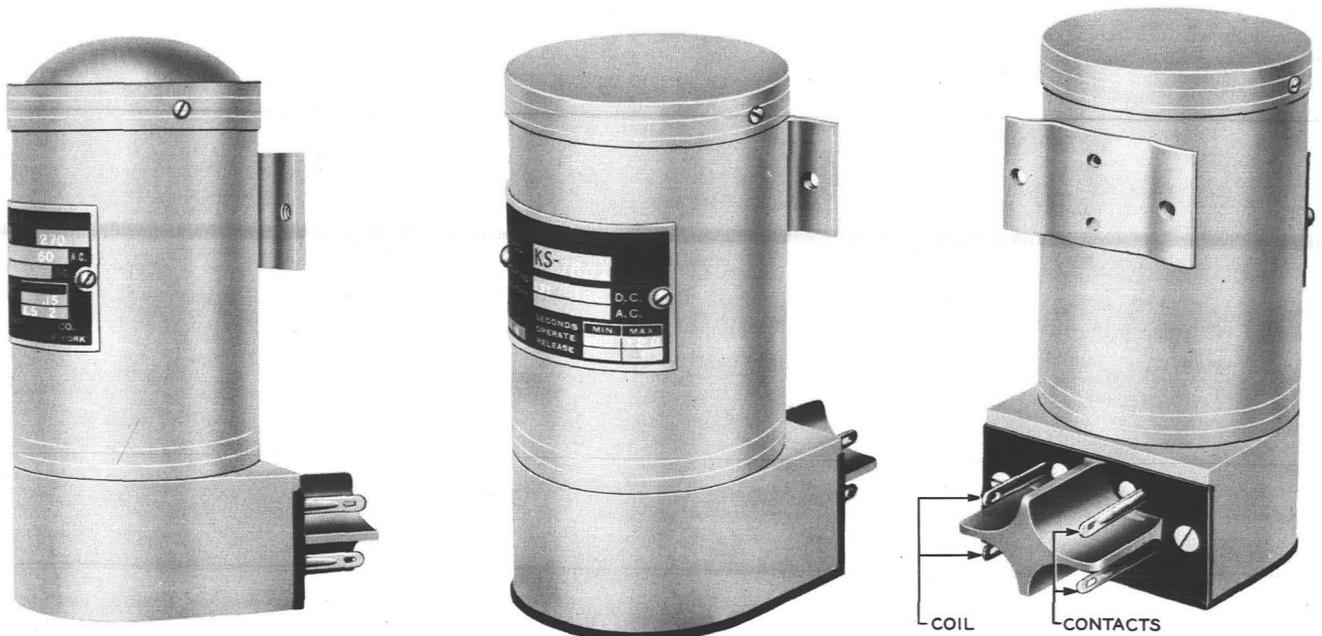


Fig. III-11 - Adlake Relay

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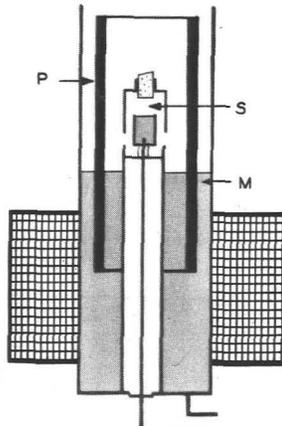


FIG. III-12A

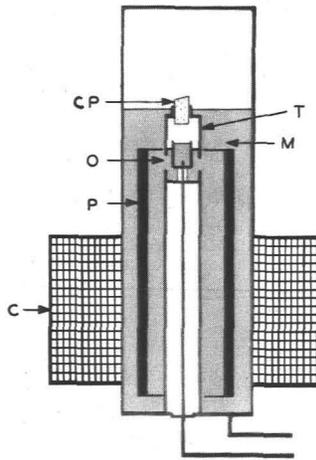


FIG. III-12B

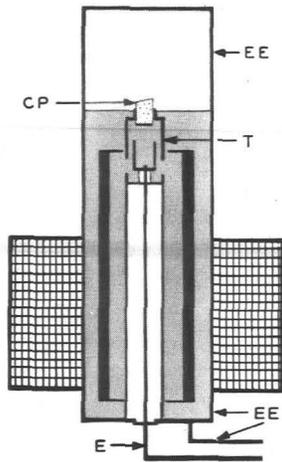


FIG. III-12C

Fig. III-12 - Adlake Relay - Method of Operation of Slow Operate Relay

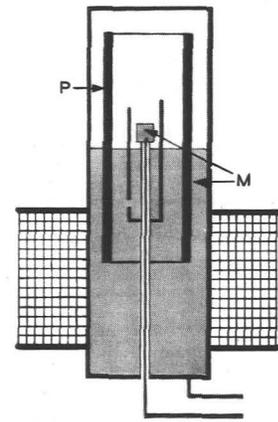


FIG. III-13A

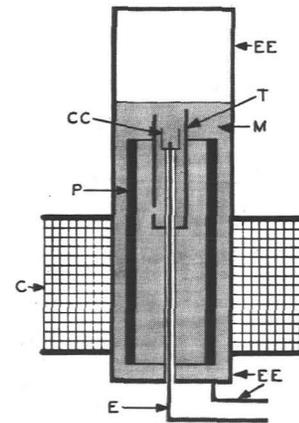


FIG. III-13B

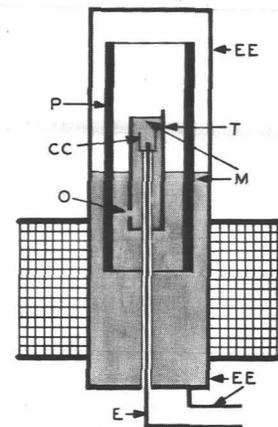


FIG. III-13C

Fig. III-13 - Adlake Relay - Method of Operation of Slow Release Relay

the thimble. The pressure of the mercury forces the gas out through the porous ceramic plug (CP) and allows the mercury to rise in the thimble. When the mercury rises high enough in the thimble (Fig. III-12C) a mercury-to-mercury contact is established between the electrodes (E) and (EE). The size and porosity of the ceramic plug governs the rate at which the gas escapes from the thimble and thus controls the delay time.

The slow release time is obtained as shown in Fig. III-13. When the coil is de-energized, plunger (P) (Fig. III-13A) is floating in a pool of mercury. When the coil is energized, the plunger is pulled down into the mercury pool (M) (Fig. III-13B). The mercury thus displaced fills the thimble (T) and overflows the lips of the ceramic cup (CC). This establishes a mercury-to-mercury contact between electrodes (E) and (EE). When the coil is de-energized (Fig. III-13C), the thimble, full of mercury, lifts out of the mercury pool but the electrical contact is maintained by the mercury surrounding the contact and bridging the gap between the contact and the cup. When the thimble (T) is lifted out of the mercury pool (M), the mercury in the thimble slowly drains out through a small opening (O). When the mercury level inside the thimble drops below the lips of the ceramic cup (CC), the mercury-to-mercury contact between electrodes (E) and (EE) is broken. The magnitude of the time delay depends on the size of the opening (O) through which the mercury drains.

By combining these features, the relay may be made slow operate and slow release.

Only a single-make or a single-break contact is available.

The tube within which the functioning elements are sealed is usually metal in order to reduce the possibility of breakage. There are cases, however, where the times cannot be obtained with the metal tube. In these cases, a glass tube is used.

The relay can be obtained with time delays ranging from a fraction of a second to 1200 seconds on 6 to 120 volts ac or dc. Table III-2 lists the relays that have been used and their operating characteristics. These relays will function on a temperature range from -38F to 125F and are unaffected by vibration or humidity.

In view of the operating characteristics of this relay, it is permissible for the relay to exceed its maximum operating time on the initial operation after having been mounted in the operating position. Hence when checking the initial operation after the relay has been mounted, the initial time measurements should be disregarded.

The contact electrodes are made of molybdenum, which is characterized by high conductivity, high-melting point, and ability to withstand the chemical reactions with mercury. The contacts are hermetically sealed and consequently are free from troubles due to dirt and oxidation. With mercury-to-mercury contacts there is no chatter and no contact pitting. The following table gives the contact capability under different load conditions.

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CONTACT RATING OF RELAYS

TIME DELAY CONTACT NORMALLY OPEN		110 VOLTS		220 VOLTS		440 VOLTS
		AC AMP	DC AMP	AC AMP	DC AMP	AC ONLY AMP
Slow Operate	Noninductive	15	5	10	2	2
Quick Release	Inductive	10	1	6	0.5	2
Slow Operate	Noninductive	10	3	5	1.5	2.5
Slow Release	Inductive	5	0.6	8.5	0.4	1
Quick Operate	Noninductive	10	3	5	1.5	2.5
Slow Release	Inductive	5	0.6	2.5	0.4	1
TIME DELAY CONTACT NORMALLY CLOSED						
Slow Operate	Noninductive	10	3	5	1.5	2.5
Quick Release	Inductive	5	0.6	2.5	0.4	1
Slow Operate	Noninductive	10	3	5	1.5	2.5
Slow Release	Inductive	5	0.6	2.5	0.4	1
Quick Operate	Noninductive	15	5	10	2	5
Slow Release	Inductive	10	1	6	0.5	2

WHEN TIME DELAYS ARE:

0.5 to 10 seconds	Loads as above
11 to 60 seconds	50 per cent of above loads
61 to 120 seconds	25 per cent of above loads
Over 120 seconds	10 per cent of above loads

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TABLE III-2

CODE	CONT.	OPERATE TIME SECONDS		RELEASE TIME SECONDS		RECYCLE TIME SECONDS	HEATER RES	VOLTAGE		MTG CTRS	CONTACT CAPABILITY
		MIN	MAX	MIN	MAX	MAX		MIN	MAX		
KS-7801	B	25	45	1	10	-	5250±5%	131dc	160dc	H.3-1/4 V.5-3/4	0.4 amp at 160V dc
KS-7802	M	540	720	-	0.3	2	5250±5%	131dc	160dc	H.3-1/4 V.5-3/4	0.4 amp at 160V dc
KS-7803	M	120	180	-	1	-	200±5%	20dc	28dc	H.3-1/4 V.5-3/4	0.070 amp at 28V dc
KS-7804	M	120	180	-	1	-	5250±10%	125dc	160dc	H.3-1/4 V.5-3/4	0.045 amp at 160V dc
KS-7805	M	4	7	-	0.5	-	300±10%	105 60~ or dc 1sw 625w	130 60~ or dc 1sw 625w	H.3-1/4 V.6-1/4	0.114 amp at 130V ac or dc
KS-7806	M	-	1	5	8	-	800±5%	190 60~	240 60~	H.3-1/4 V.6-1/4	1 amp at 200V 60
KS-7807	M	180	240	-	0.5	1.5	800±5%	190 60~	240 60~	H.3-1/4 V.6-1/4	1 amp at 230V 60
KS-7808	M	1.5	2.5	-	0.3	0.8	800±5%	190 60~	240 60~	H.3-1/4 V.6-1/4	1 amp at 230V 60
KS-7809	M	2	4	-	1	-	5250±10%	131dc	160dc	H.3-1/4 V.5-3/4	0.1 amp at 160V dc
KS-7810	M	600	1200	-	0.3	0.3	150±5%	18dc	28dc	H.3-1/4 V.5-3/4	0.5 amp at 65V dc
KS-7811	M	3.	5.	0.18	0.5	See E	300±5%	18dc	28dc	H.3-1/4 V.6-1/4	2 amp at 28V dc
KS-7812	M	-	0.5	2.5*	5.	-	450±5%	18dc	28dc	H.3-1/4 V.5-3/4	0.10 amp at 28V dc
KS-7813	M	20	28	-	0.5	-	300±5%	18dc	28dc	H.3-1/4 V.5-3/4	0.05 amp at 28V dc
KS-7814	M	600	1200	-	-	0.3	700±5%	32dc	46dc	H.3-1/4 V.5-3/4	0.5 amp at 65V dc
KS-7815	M	600	1200	-	-	0.3	200±5%	14dc	21dc	H.3-1/4 V.5-3/4	0.5 amp at 65V dc
KS-7816	M	4	5.5	-	-	0.5	300±5%	18dc	28dc	H.3-1/4 V.6-1/4	0.07 amp at 28V dc
KS-7817	M	67	81	-	-	5.	275±5%	20dc	28dc	H.3-1/4 V.5-3/4	0.07 amp at 28V dc

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TABLE III-2 (Contd)

CODE	CONT.	OPERATE TIME SECONDS		RELEASE TIME SECONDS		RECYCLE TIME SECONDS	HEATER RES	VOLTAGE		MTG CTRS	CONTACT CAPABILITY
		MIN	MAX	MIN	MAX	MAX		MIN	MAX		
KS-7818	M	107	126	-	-	5.	275±5%	20dc	28dc	H.3-1/4 V.5-3/4	0.070 amp at 28V dc
KS-7819	M	120	240	0.1	-	0.5	700±10%	45dc	50dc	H.3-1/4 V.5-3/4	0.060 amp at 50V dc
KS-7820	M	15	30	-	-	0.5	700±5%	44dc	50dc	H.3-1/4 V.6-1/4	0.021 amp at 50V dc
KS-7821	B	1200	1800	-	-	60	5250±5%	131dc	160dc	H.3-1/4 V.6-1/4	0.040 amp at 160V dc
KS-7822	B	6	9	-	-	180	350±5%	20dc	28dc	H.3-1/4 V.6-1/4	Break 0.045 amp at 28V dc makes 147 amp at 28V dc
KS-7823	M	1.5	2.5	-	-	0.350	1500±10%	45dc	50dc	H.3-1/4 V.6-1/4	0.023 amp at 56V dc
KS-7824	M	30	60	-	0.250	0.5	700±5%	44dc	50dc	H.3-1/4 V.6-1/4	0.1 amp at 50V dc
KS-7826	B	160	200	0.050	1.	15	5250±10%	120dc	160dc	H.3-1/4 V.6-1/4	0.015 amp at 160V dc
KS-7827	M	-	1.0	35	65	-	5250±5%	120dc	160dc	H.3-1/4 V.6-1/4	0.015 amp at 160V dc
KS-7828	M	1200 (See F)	1800	-	-	0.5	700±10%	45dc	50dc	H.3-1/4 V.6-1/4	0.044 amp at 50V dc
KS-7829	M	-	1.0	3	4	5	700±10%	45dc	50dc	H.3-1/4 V.6-1/4	0.021 amp at 50V dc
KS-7830	M	180	300	-	10	15	700±10%	44dc	50dc	H.3-1/4 V.6-1/4	0.025 amp at 50V dc
KS-7831	M	180	300	-	10	15	300±5%	20dc	28dc	H.3-1/4 V.6-1/4	0.025 amp at 50V dc
KS-7832	M	160	200	-	15	15	250±5%	18dc	28dc	H.3-1/4 V.6-1/4	0.028 amp at 28V dc
KS-7833	M	360	800	-	1	30	300±5%	20dc	28dc	H.3-1/4 V.6-1/4	0.030 amp at 28V dc
KS-7835	M	60	120	-	-	0.5	250±5%	20dc	28dc	H.3-1/4 V.6-1/4	0.14 amp at 28V dc

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TABLE III-2 (Contd)

CODE	CONT.	OPERATE TIME SECONDS		RELEASE TIME SECONDS		RECYCLE TIME SECONDS	HEATER RES	VOLTAGE		MTG CTRS	CONTACT CAPABILITY
		MIN	MAX	MIN	MAX	MAX		MIN	MAX		
KS-7836	B	20	20	1	10	60	5250±5%	131dc	160dc	H.3-1/4 V.5-3/4	0.4 amp at 160V dc
KS-7837	M	90	150	-	0.3	2	5250±10%	131dc	160dc	H.3-1/4 V.5-3/4	0.4 amp at 160V dc
KS-8171	B	13	20	-	0.3	-	15±10%	4.5	10	H.3-1/2 V.6	5 amp at 18V dc
KS-8280	B	0.12	0.25	-	0.2	-	210±5%	13dc	20dc	-	100 amp at 50V dc
KS-8331	B	4	10	-	0.5	2	370±5%	16dc	50dc	-	0.1 amp at 50V dc

Notes

- A. All time values are in seconds.
- B. Definition of Operate Time: The operate time is the period between the closure of the electrical circuit through the relay winding and the making or breaking (as required) of the relay contact.
- C. Definition of Release Time: The release time is the period between the opening of the electrical circuit through the relay winding and the breaking or making (as required) of the relay contact.
- D. Definition of Recycling Time: The recycling time is the period between the opening and the reclosing of the electrical circuit through the relay winding in which the relay must restore sufficiently to give the specified operate time.
- E. The relay shall also give the operate time specified if after it has been operated, its contact is opened (by opening the winding circuit) for a period between 0.10 and 0.20 second and the relay winding is again energized. The relay shall also give the release time specified upon opening of the winding circuit, after the relay has been operated for a period between 0.02 and 0.3 second.
- F. The operating time shall be measured after at least one preconditioning cycle of operate and release. The operating circuit shall be opened not later than 3 seconds after the relay contact has closed.

Oil Dashpot Relay
Automatic Electric, Inc.
Chicago, Illinois

The oil dashpot relay consists of a piston in an oil-filled brass chamber, which is enclosed in an oil tight outer brass chamber. The piston is flexibly joined to a magnetic iron plunger which fits closely into the core of a solenoid. A heelpiece of magnetic iron encloses the solenoid on three sides and the iron spoolhead completes the magnetic circuit. A picture of the relay is shown in Fig. III-14.

When the solenoid is energized, the plunger pulls the piston up through the oil-filled cylinder forcing the oil out through a small opening in the cylinder. When the plunger is pulled all the way up, a small lever operates the contact springs. The time delay is governed by the size of the opening in the cylinder, which can be adjusted for delay times ranging from 5 seconds to 1.5 minutes by turning the outer cylinder. The relay releases in about 10 milliseconds and cannot be made slow release. A ball valve in the piston opens and permits the plunger to drop immediately when the energizing current is cut off. Dropping the plunger allows the oil to return to the inner cylinder.

Relays can be furnished for operation on 6 to 115 volts dc or 100 to 120 volts 60 cycles ac. Operation on voltages up to 230 volts dc or ac can be obtained by using the 115-volt relay with a series resistor.

Make, break, transfer, or continuity springs may be obtained. The dc relay is limited to a total of six springs and the ac relay to four springs. The contacts are single palladium with a load limit of one ampere.

The relay is normally arranged to mount vertically on the front of a panel,

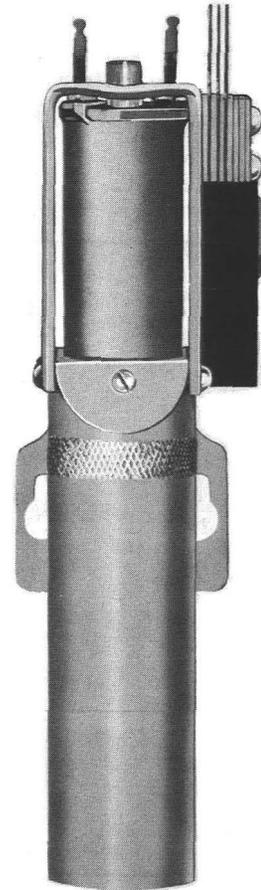


Fig. III-14 - Automatic Electric Company Dashpot Relay

although mounting for the rear of the panel can be provided. The relay is 6-3/4 inches high, 1-3/4 inches wide, and projects 1-5/8 inches from the mounting plate.

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Agastat Relay
 Division of Elastic Stop Nut Corporation
 Elizabeth, New Jersey

The Agastat relay is a solenoid actuated pneumatically timed delay relay. The relay has comparatively few moving parts, being composed of a pneumatic timing head, a solenoid assembly, a switch and a contact terminal block. A special diaphragm and cap encases the head in which the air used for timing is recirculated, making the timing chamber dustproof. The time delay is adjustable and two different means of adjusting are available; a slotted hex head screw and a dial head. Fig. III-15 shows the hex head screw model and Fig. III-16 the dial head model with the cover removed to show the snap action contact switch mounted on the terminal block.

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Fig. III-15 - Agastat Relay Hex Screw Adjusting Head

These relays are made for continuous ac duty and for continuous or intermittent dc service. They can be obtained for ac operation on 6 to 550 volts, 25 or 60 cycles, and from 6 to 230 volts dc. The relays require a power input of approximately 6 watts.

A terminal block is located on the bottom of the relay. Fig. III-17 is a bottom view of the relay showing the arrangement of the terminals on the block. The terminal block is readily replaceable for switch maintenance. A front terminal arrangement or terminal extensions are available at a slight increase in cost.

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Fig. III-16 - Agastat Relay Dial Adjusting Head

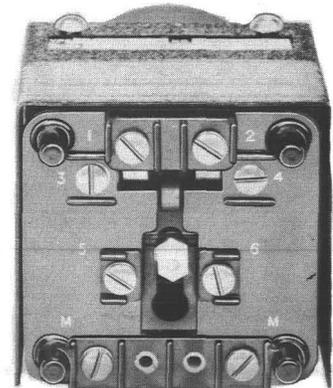


Fig. III-17 - Agastat Relay Terminal Arrangement

Agastat relays are normally supplied for mounting in a vertical position by means of four tapped holes in the back of the relay, but can be furnished to mount in a horizontal position. Relays intended for vertical mounting should not be mounted horizontally and vice versa.

The ac and intermittent duty dc relays weigh about 1-1/2 pounds and are about 4-7/8 inches high by 2-1/2 inches square. The dc relays for continuous duty weigh about 2-1/2 pounds and are about 5-5/16 inches high by 2-1/2 inches square.

The Agastat relay is furnished in two basic types; slow operate or slow release. The recycle time with either type is about 40 milliseconds. Momentary de-energization of the coil during the timing period returns the relay to the normal condition and again starts the timing period from the beginning. The timing delay is adjustable in several ranges as shown in the following table. Repetitive relay operations are accurate to within ± 10 per cent of the set adjustment. The relays are unaffected by voltage variations or temperature within a range of -65 to $+165^{\circ}\text{F}$.

Relay Adjusting Ranges

DIAL HEAD RELAYS

0.08 to	3 Seconds	- Green Dial Head
0.15 to	10 Seconds	- White Dial Head
0.2 to	30 Seconds	- Yellow Dial Head
10 to	200 Seconds	- Red Dial Head
30 Seconds to	15 Minutes	- Blue Dial Head

Hex Head Screw Relays

0.1 to 15 Minutes

In selecting dial head relays for circuit use, the relay with the lowest maximum range that will provide the required time should be used since the ease of adjustment varies with the magnitude of the adjusting range. This is because the entire adjusting range is obtained in one revolution of the dial head.

There are two contact terminal arrangements identified as type 1 and type 2. The type 1 contact arrangement is used on the slow operate relays and the type 2 arrangement on the slow release relays. Either type of contact arrangement can be provided with two transfers with a common armature or with a split armature which gives two independent transfer contacts. Fig. III-18 shows the schematic arrangement for the two types of contact arrangements.

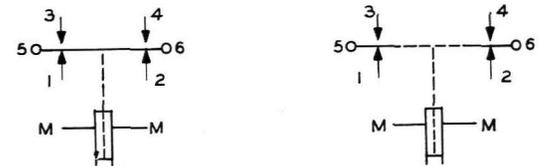
The contacts are silver and have the following load capabilities:

	CONTACT LOAD IN AMPERES	
	SINGLE CONTACT	TWO CONTACTS IN SERIES
0-32V DC	5	10
110-220V DC	0.1	0.2
115V 60 Cycle	5	15
230V 60 Cycle	3.3	10
440-550V 60 Cycle	1.6	5

Contacts 1, 2, 3, and 4 of Fig. III-18 are rigid contacts but flexible contacts can be furnished at a slight extra cost.



TYPE 1 CONTACT ARRANGEMENT
(SLOW OPERATE)



TYPE 2 CONTACT ARRANGEMENT
(SLOW RELEASE)

Fig. III-18 - Agastat Relay Schematic Arrangement

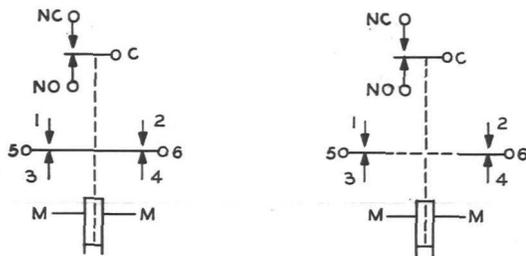
The Agastat relay is also available with a double time interval (Fig. III-19). The double time interval is obtained by means of an auxiliary switch fastened to the bottom of the terminal block of the standard relay. In the de-energized condition, the pressure of the Agastat relay spindle holds the auxiliary switch in the open position. When the relay coil is energized, the spindle is drawn slowly upward. After a pre-set time delay, it removes pressure from the auxiliary switch lever permitting this switch to operate. The spindle continues its upward movement until it finally trips the Agastat switch, ending the over-all time delay. Both switches remain in the operated position as long as the coil is energized and immediately return to their normal positions as soon as the coil is de-energized. This switch thus provides a sequence of two time delays or gives a momentary circuit closure to an electromagnet. Fig. III-20 shows the schematic arrangement and terminal numbering for the double time interval relay.

The over-all time delay, which is the elapsed time between energizing the coil and the Agastat contact closure is controlled by rotating the adjusting screw or dial head. A cam arrangement permits the auxiliary switch to be raised or lowered, thus controlling the point at which this switch functions and thus regulating the interval between the closure of the two sets of contacts. The auxiliary switch delay period can be adjusted from 0 to 15 seconds and the Agastat switch contacts from 0.1 second to 15 minutes.

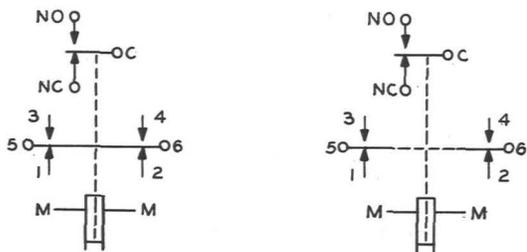
The relay can also be obtained with an auxiliary switch which is nonadjustable. In this case, the auxiliary switch contacts



Fig. III-19 - Agastat Relay With Double Time Delay



TYPE 1 CONTACT ARRANGEMENT (SLOW OPERATE)



TYPE 2 CONTACT ARRANGEMENT (SLOW RELEASE)

Fig. III-20 - Agastat Relay With Double Time-delay Schematic Arrangement

function as soon as the relay is energized and the spindle starts to move.

The foregoing description covers the operation of the slow operate (type 1) relay. The same features are also available in the slow release (type 2) relay. In this case the contacts function as soon as the coil is energized and the delay time starts when the coil is de-energized. At the expiration of a preset time delay the auxiliary contacts release and later the Agastat switch contacts restore to their normal position.

This model of the Agastat relay is 2-1/2 inches square and 6 inches high. Four tapped holes are provided in the rear for mounting with the relay in a vertical position, but a relay designed for horizontal mounting can be furnished. The standard relay has a terminal block located on the bottom of the relay. A special terminal block to mount on the front of the relay can be provided where the terminal block on the bottom of the relay is not satisfactory.

The Agastat relay is also available with an upper and a lower timing head to provide both slow operate and slow release. The upper portion of the relay is a standard type 1 time-delay head and the time delay starts when the coil is energized. At the end of the time delay period, the switch contacts operate. The switch remains in the operated position as long as the coil is energized. When the coil is de-energized, the relay recycles slowly due to the time delay setting of the lower timing head.

The contacts are brought out to the terminals as shown for the type 1 contact arrangement of Fig. III-18. A terminal block is provided on the side of the relay as shown in Fig. III-21.

The code symbols used on the Agastat relay have the following significance:

1. Letters indicate the relay types:

A. The first letter indicates the type of relay adjustment.

N - Screw adjusting head.
D - Dial adjusting head.

B. The second letter indicates the type of operating current.

D and F - Direct current.
E - Alternating current.

C. A third letter indicates an additional timing step.

H - Standard relay with nonadjustable auxiliary switch.

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- T - Standard relay with adjustable auxiliary switch.
- D - Relay with two timing heads for slow operate and slow release.

2. Numbers indicate the operating sequence and the switching arrangement.

A. The first digit indicates the operating sequence.

- 1 - Slow operate - time delay start when the coil is energized.
- 2 - Slow release - time delay starts when the coil is de-energized.

B. The second digit indicates the switching arrangement.

- 1 - Two transfers with a common armature.
- 2 - Two transfers with the split armature.

The code DDT11 would thus indicate a dial head relay for operation on direct current, equipped with the auxiliary adjustable switch, arranged for slow operation and equipped with a common armature contact arrangement.

Preliminary tests on some samples of the Agastat relay, especially the horizontal mounted relay, have indicated a tendency for the delay times to increase with a number of operations after exposure to a high humidity cycle. Pending further information on the performance of the relay, prospective users of the Agastat relay should discuss the use of the relay with the Relay Requirements Group before specifying them for circuit use.

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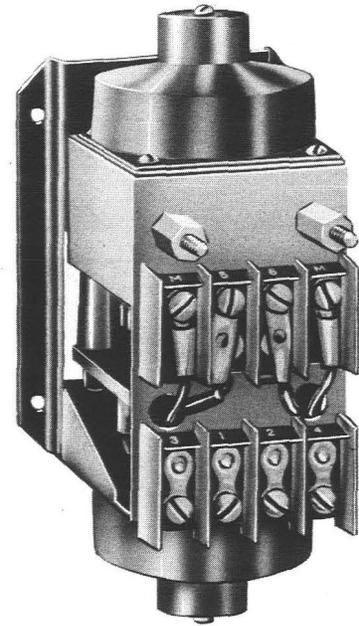


Fig. III-21 - Agastat Relay With Two Timing Heads

KS specifications have been assigned to the following relays.

- KS-16064, L2 - Model DER12 - 210 volts ± 8 per cent 60-cycle ac - Vertical mounting - Adjustable from 10 to 200 seconds operate time
- KS-16624, L1 - Model DEY21 - 230 volts ± 5 per cent 60-cycle ac - Horizontal mounting - Adjustable from 0.2 to 30 seconds release time
- KS-16624, L2 - Model DFG22I - 24 volts dc - Vertical mounting - Adjustable from 0.08 to 3 seconds release time - Cover over the dial adjusting head.

Vibrating Reed Relay
Automatic Electric Company
Chicago, Illinois

The vibrating reed relay shown in Fig. III-22 consists of a coil wound on a magnetic iron core with a spring assembly mounted along the side of the coil. One of the springs has a weight on the end of the spring which is attracted toward the core when the coil is energized. When the coil is de-energized, the weighted spring vibrates for a predetermined interval, alternately opening and closing its contacts.

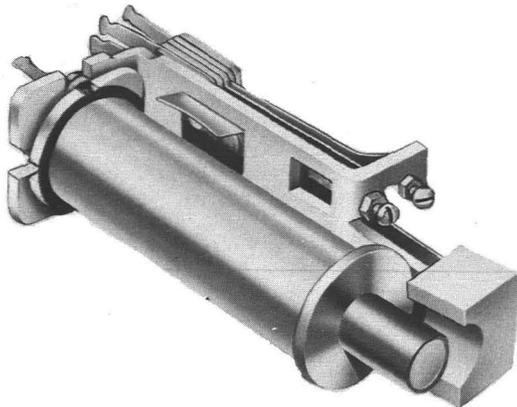


Fig. III-22 - Vibrating Reed Time-delay Relay

This relay is used in conjunction with an auxiliary switching relay which is made slow acting by means of a copper sleeve over the core. This arrangement is shown in Fig. III-23. On operation, the vibrating reed (VR) relay operates quickly (about 25 milliseconds) followed by the slow releasing (SR) relay. When the (VR) relay is released by opening the control circuit, the weighted spring vibrates alternately closing ground to the front and back contact springs, sending pulses to the slow releasing relay and holding it operated. When the vibrations dampen to a point where the amplitude is too small to close the contacts, the armature circuit stands open and the slow releasing relay releases.

The relay is equipped with a set of four springs as shown in Fig. III-23. The contacts are palladium with a contact load rating of 150 watts (maximum one ampere). All inductive loads should have contact protection.

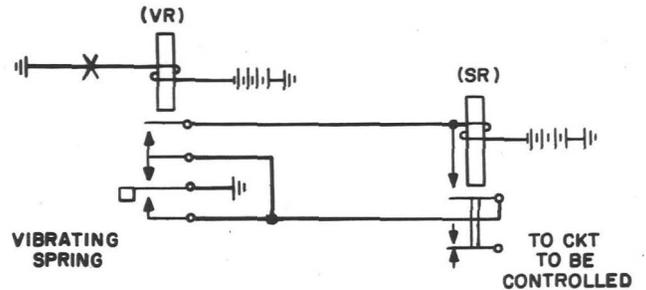


Fig. III-23 - Vibrating Reed Relay Circuit Schematic

The delay time, in conjunction with the auxiliary slow acting relay is adjustable from 1 to 15 seconds.

The relay is available in a range of voltages as shown in the following table. The relay works on dc only.

OPERATING VOLTAGE (VOLTS)	OPERATE CURRENT (MILLI-AMPERES)	RESISTANCE (OHMS)	CATALOG NO.
6 - 12	224	13.4	RF-68
12 - 20	173	35	RF-69
18 - 33	100	90	RF-70
24 - 49	60	200	RF-71
48 - 78	48	500	RF-72
115 - 200	17	3300	RF-73

The over-all length of the relay is 4-3/8 inches, the height 1-1/4 inches, and the width 1-3/4 inches. The relay should be mounted on a rigid support, not subject to vibration, and in such a position that the reed vibrates in a horizontal plane.

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Thermistor Controlled Relays

Thermistors are circuit elements made of solid semiconducting materials and are characterized by a high negative temperature coefficient of resistivity. At any fixed temperature, a thermistor is a conductor of a particular resistance. If its temperature is allowed to change, either by means of a change in the ambient temperature or because of dissipation of electric power in the thermistor, the resistance of the thermistor will change. The resistance value of a thermistor is a definite reproducible function of its temperature.

Advantage is taken of the resistance-temperature characteristics to obtain a time-delay relay by using a thermistor in series with a relay. The initial resistance of the thermistor is so high that the relay will not operate. After voltage has been applied to the series combination for a predetermined time, the thermistor resistance drops to a value that permits sufficient current to operate the relay to flow in the circuit.

By the use of a thermistor suited to the circuit operating conditions, relay time delays ranging from a few milliseconds to several seconds can be obtained. Thermistors have the advantage of small size, light weight, ruggedness, long life, and absence of contacts or moving parts. There should be no maintenance problems. Thermistors are best suited for circuit applications where close limits on the time intervals are not required. Ordinarily, there is about a six-to-one ratio between the minimum and the maximum delay times.

Since the thermistor is a temperature operated device, it is subject to variations due to ambient temperature changes and voltage variation. It also has a recycle time several times the delay time due to the necessity of cooling the thermistor to the normal temperature between operations. Thermistors should be removed from the relay operating path as soon as the relay operates to permit the thermistor to start cooling and reduce the necessary interval between the time the relay releases and when it can be reoperated. Also some thermistors have a low-current carrying capacity which is another reason for removing them from the circuit as soon as possible.

To avoid the limitations of wide timing intervals and the extended cooling period between operations, a cooling time delay method may be used. In this arrangement, two relays are employed and the thermistor is heated to a low-resistance value by passing a relatively large current through it for a short interval compared to the desired time interval. The current is then reduced automatically to a lower value and the thermistor cools until its resistance increases enough to reduce the current to a value low

enough to actuate the working relay. This part of the operating cycle accounts for the greater part of the desired time interval. With this arrangement, the thermistor is available for re-use very shortly after a completed timing interval. By the proper choice of operating currents and circuit resistance values wide variations of voltage and ambient temperature may occur with relatively little effect upon the time interval. The principle variable left is the cooling time of the thermistor itself. This is fixed in a given unit but may vary from unit to unit depending on the heat dissipation constant and thermal capacity.

Three types of thermistors have been used in time-delay circuits; the 1, 8, and 26 types. Fig. IV-2 shows the relative size of these thermistors.

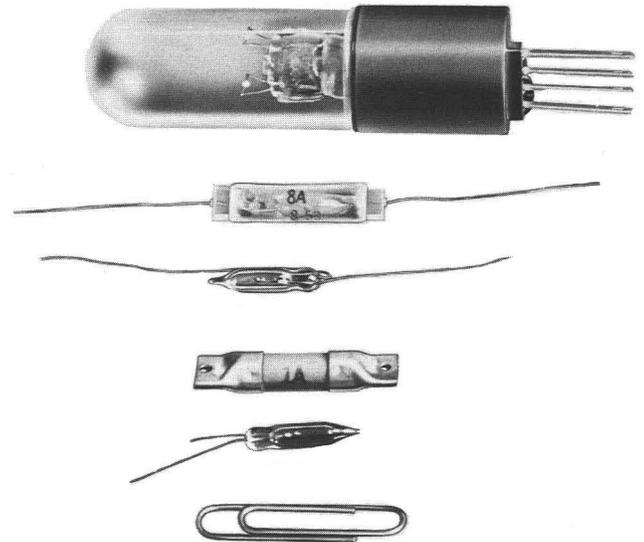


Fig. IV-2 - Nos. 1, 8, and 26 Thermistors

The 1A, 1D, and 1F thermistors consist of a directly heated bead-type unit in an evacuated glass envelope mounted in a phenol fiber casing with metal terminals. The unit is about 1-5/16 inches long and 3/8 inch wide. The 1C thermistor is the same as the 1A except that it is nitrogen filled.

The 8A thermistor consists of a directly heated bead-type unit in an evacuated glass envelope mounted in a nylon casing with two tinned wire terminals. Excluding the wire terminals, this thermistor is about 1-1/4 inches long and 9/32 inches wide. The 8C thermistor is the same except that it is nitrogen filled.

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The 26A thermistor has two directly heated bead-type units enclosed in an evacuated glass envelope. The two beads are similar but are not necessarily identical in characteristics. It has four terminals and is arranged for panel mounting like the 11-type resistance lamps. One bead is brought out on terminals 1 and 3 and the other on terminals 2 and 4. The over-all dimensions of this thermistor are approximately 15/16 inch in diameter and 4-1/4 inches long including the terminals. The

glass envelope itself with the base, less the terminals, is 3-3/8 inches long.

The characteristics of the thermistors used in relay time-delay circuits are shown in the following table. The cold resistance R_0 , is the resistance of the thermistor measured with a current small enough so as not to heat it appreciably. The ambient temperature at which the cold resistance is measured is always specified.

THERMISTOR CHARACTERISTICS

CODE	APPROXIMATE COLD RESISTANCE R_0		MAXIMUM CONTINUOUS CURRENT (MILLIAMPERES)		APPROX TIME DELAY (SECONDS)
	AT 32F (OHMS)	AT 77F (OHMS)	AC	DC	
	1A	140,000	60,000	15	
1C	155,000	50,000	25	25	0.3**
1D	310,000	100,000	20	20	1.5**
1F	97,000	27,000	20	20	1.5***
8A+	140,000	69,000	15	1	0.8
8C	155,000	50,000	25	25	0.3**
26A*	450,000	140,000	30	30	13**

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+For AC only.

*The data shown for the 26A thermistor are representative values for the two beads connected in series.

**In series with a 1500-ohm relay operating on 0.010 ampere with 48 volts applied across the relay and thermistor at 77F.

***In series with a 1500-ohm relay with 24 volts applied across the relay and thermistor at 77F.

Cold-cathode Tube Delay Circuits

These circuits employ a 3-element cold-cathode gas tube which operates from the exponentially rising capacitor voltage. The gas tube acts as a trigger device which uses two of the tube elements for the timing function and then operates a relay through the third element. These circuits require the use of a +130-volt potential.

In the usual 3-element cold-cathode tube, two of the electrodes have relatively large surfaces and are activated to serve as emitters or anodes. The third element is simply a wire with a small exposed surface which is used as the cathode. The gap between one of the anodes and the cathode serves as a control, or starter gap while the gap between the other anode and the cathode is known as the main gap. The tube characteristics are such that the main gap will not breakdown on the nominal voltages until the control gap has broken down.

A typical method of using a cold-cathode tube is to connect the anode, or main gap to a relay winding and a source of high dc potential such as +130 volts. A voltage sufficient to cause the tube to breakdown and ionize is connected across the starter or control gap. The tube then conducts on its anode gap with a voltage drop equal to the sustaining potential. The amount of current flowing in the starter gap necessary to ionize the gas to the extent necessary to fire the tube on its anode gap is called the transfer current and is usually a small fraction of a milli-ampere.

A photograph of a cold-cathode tube is shown in Fig. IV-3 and typical applications of the tube to obtain a time delay are shown in Fig. IV-4. This figure shows four arrangements of the time-delay circuits. Three of them are satisfactory for general use but the use of the fourth arrangement (Fig. IV-4D) is not recommended. This arrangement is unsatisfactory because of a severe enabling transient on the control gap of the tube due to chatter on the make contact of the C relay which may fire the tube prematurely, and also because of the susceptibility of this circuit to magnetic interference, since the relay is in the control gap circuit of the tube.

The operation of the circuit is as follows. Refer to Fig. IV-4A. When the control relay (C) is released, a +130-volt potential is connected to the terminals of the tube, the tube is de-ionized, and the timing relay (T) is released. When relay (C) operates, the discharge path is removed from the capacitor (C) which then slowly charges through resistor (R) to a voltage equal to the firing point of the control

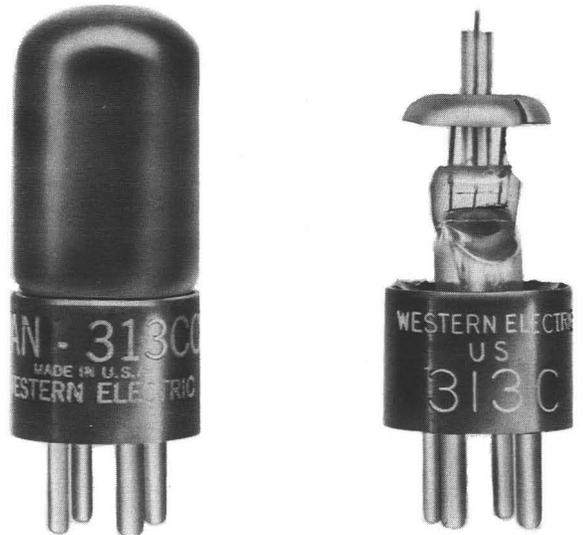


Fig. IV-3 - Cold-cathode Tube

gap, firing the tube and operating the relay. When relay (C) releases, the circuit to the timing relay is opened, a resistor is connected across the capacitor to discharge it, and the tube is extinguished.

With this arrangement there is a drain on the 130-volt battery and the tube is ionized as long as the control relay is energized. To reduce the 130-volt battery drain and conserve tube life, the arrangements in Fig. IV-4B and IV-4C should be used. The arrangement of Fig. IV-4C is preferred since it eliminates the need for the special make-before-break spring sequence and the double-wound relay. The single-wound relay circuit of Fig. IV-4C is also less affected by an undesirable enabling transient than the double-wound relay circuit.

The 313-type tube requires a current limiting resistor of 0.1 megohm connected to terminal 1 of the tube. This resistance is built into the 346B tube. The 0.001 microfarad capacitor is to prevent high-frequency pickup from falsely firing the tube.

Cold-cathode tubes are subject to false firing from transient potentials appearing on a relay spring adjacent to the tube. It has been found that by mounting the equipment of the timing circuit in a definite pattern this hazard is eliminated. The recommended mounting arrangement uses 2-inch vertical mounting centers with the relay operated by the tube mounted to the left of the tube and the timing capacitor to the right of the tube.

With the proper choice of circuit constants, delay times ranging from a few milliseconds to approximately 1 minute can be

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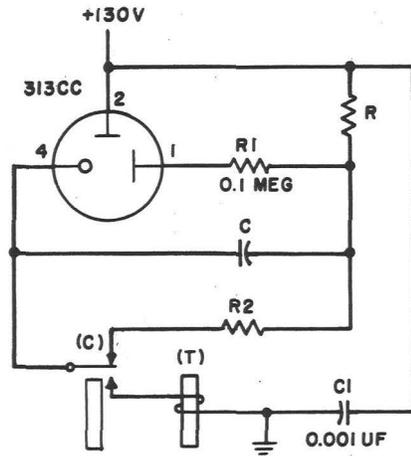


FIG. IX-4A

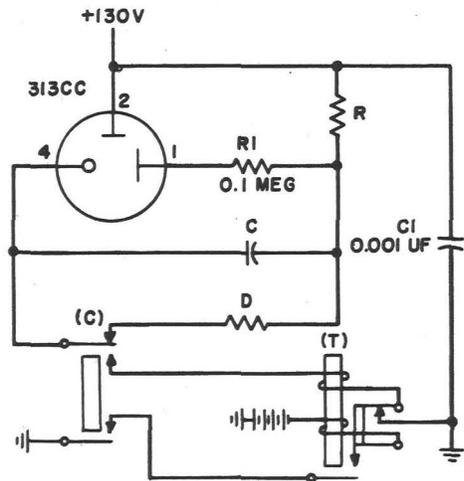


FIG. IX-4B

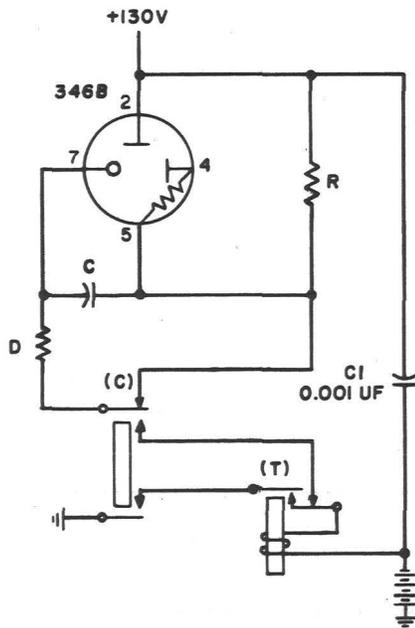


FIG. IX-4C

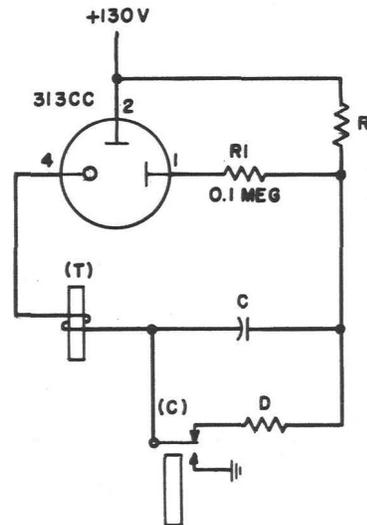


FIG. IX-4D
(NOT RECOMMENDED)

Fig. IV-4 - Cold-Cathode Tube Timing Circuit Arrangements

obtained. The recycle time for circuits using the cold-cathode tubes is very short, being in the order of 10 milliseconds. The variation in delay time varies with the tube used, the voltage, resistor, and capacitor tolerances but can be held to approximately a two to one ratio between minimum to maximum delay times.

The time delay can be computed from the equation $T = (XRC)10^{-6}$ where

T = Time for the capacitor to charge to the voltage that will fire the tube.

X = RC time constant for $\frac{E}{E_1}$, read on the curve of Fig. IV-5.

E = Breakdown voltage of tube.

E_1 = Supply voltage.

R = Resistance in charging circuit of the capacitor.

C = Charging capacitance in microfarads.

The field test voltage characteristics of the commonly used cold-cathode tubes are shown in the following table.

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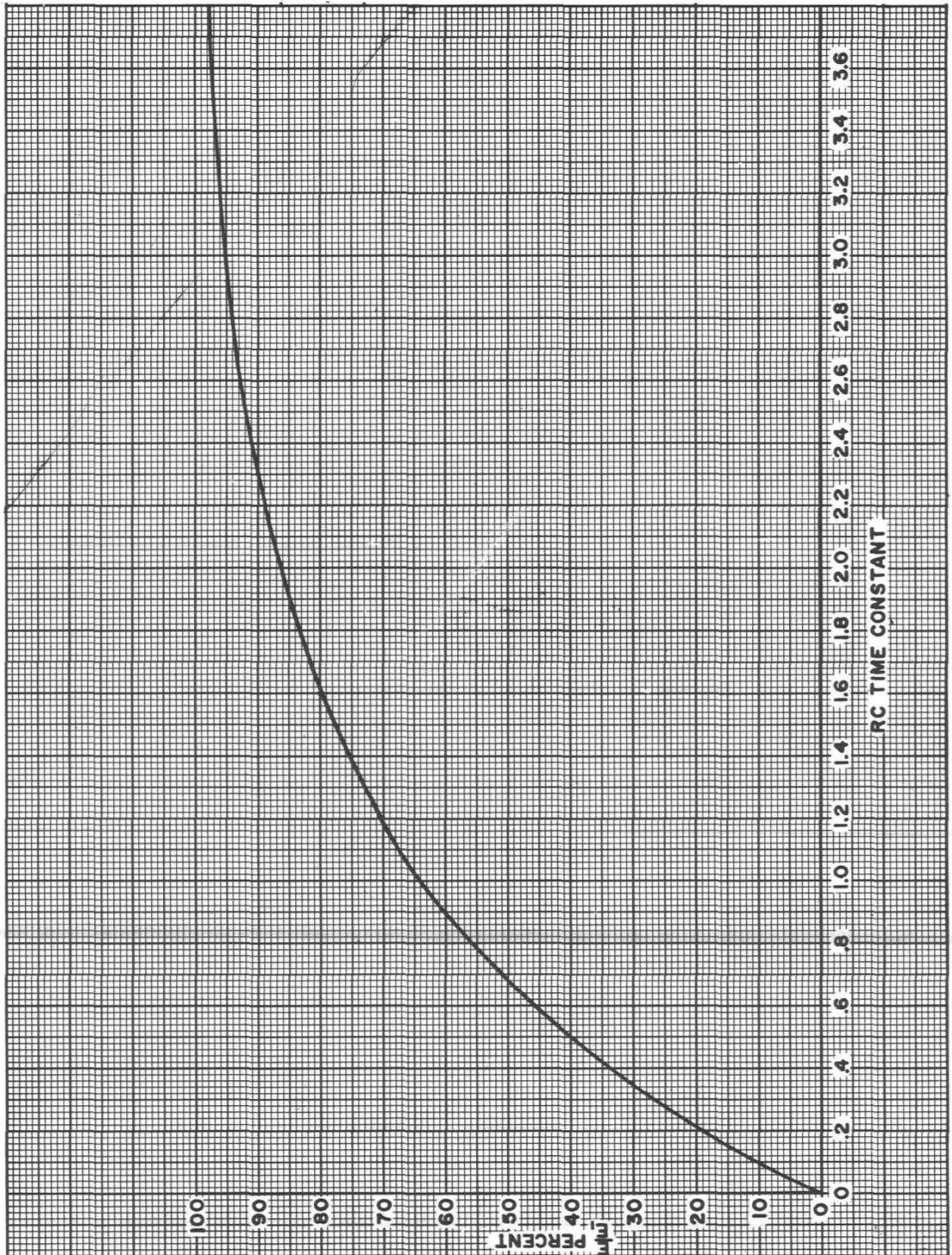


Fig. IV-5 - RC Time Constant

FIELD TEST DC VOLTAGE LIMITS
THREE ELEMENT COLD-CATHODE TUBES

CODE	STARTER GAP				ANODE GAP			
	BREAKDOWN+		DROP (AT 20MA)		FORWARD MAX	DROP (AT 20MA)		
	MIN	MAX	MIN	MAX		MIN	MAX	
313C	62	89	52	74	185	68	90	
313CA	66	78	52	74	200	68	88	
313CB	62	89	52	74	170	71	81	
313CC	66	78	52	74	150	68	88	
313CD	64	78	52	74	-	-	-	
333A	62	89	52	74	150	68	90	
346B	62	89	52	74	225	72	90	
353A	62	89	52	74	150	68	90	
359A	67	89	52*	74*	165	66*	90*	
376B	67	85	50	74	275	58**	80**	
395A	71	84	52*	74*	140	68*	85*	
426A	65	85	53***	72***	180	63*	75*	

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+These values apply just after tube has been conducting. The initial operation after a period of idleness may be as much as 3 volts higher or lower than the values shown.

*At 10 milliamperes.

**At 30 milliamperes.

***At 3 milliamperes.

The 313 tubes use a 4-pin socket mounting; the 333 and 372 tubes mount by means of a screw in the bottom of the base and the terminals are brought out on spade clips; the 346 and 353 tubes mount the same as the 333 tube but connections are made by solder-

ing to pins; the 359 and 395 tubes are small lightweight tubes that are connected directly into the wiring; the 376 tube has a standard octal base; and the 426 tube mounts on a bracket and has the terminals brought out on flexible leads terminating in spade terminals.



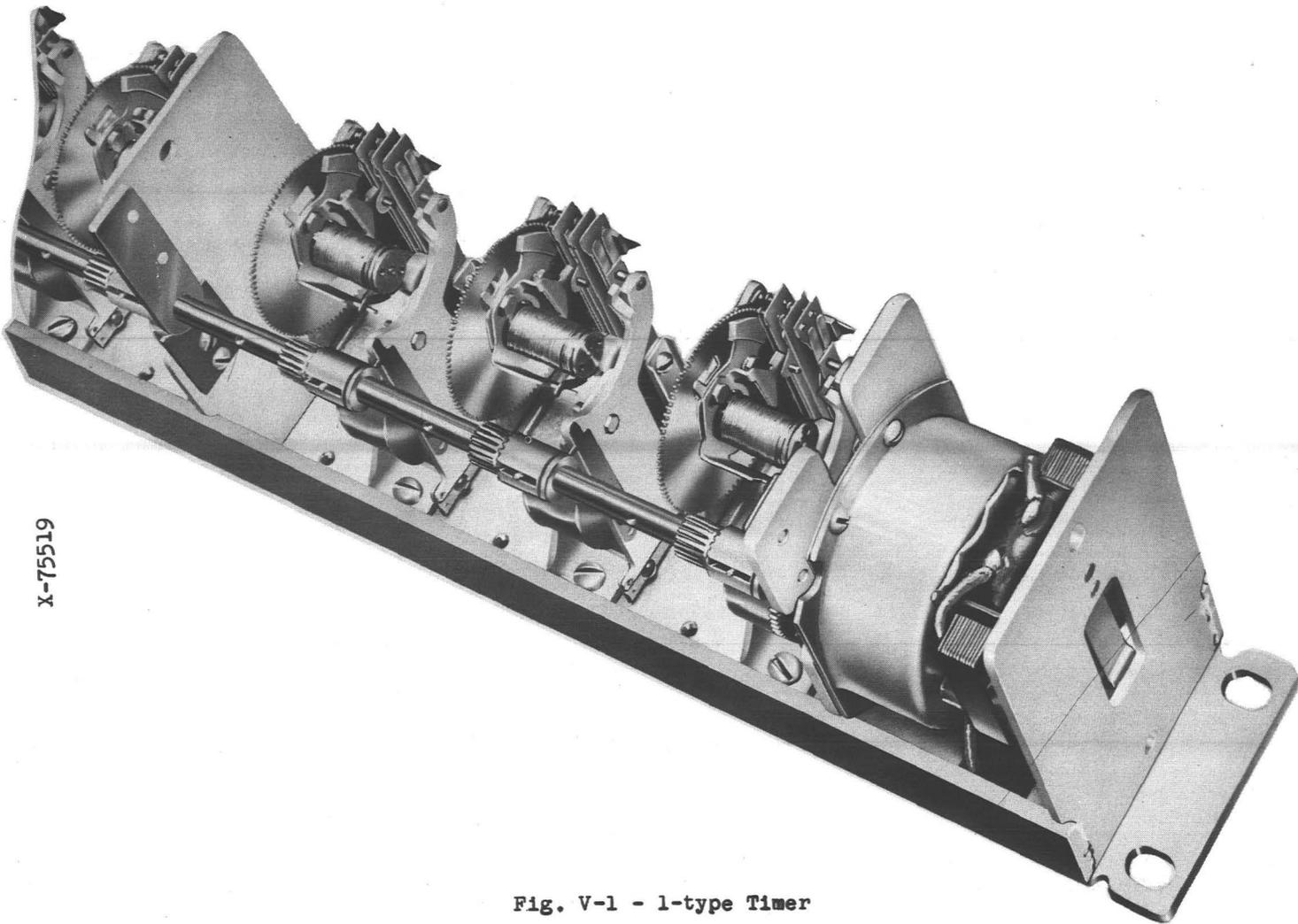
SECTION V

MOTOR-DRIVEN TIMERS

Synchronous Motor Timers
Hayden Manufacturing Company
Torrington, Conn. or
R. W. Cramer, Company
Centerbrook, Conn.

Where long delay times, extreme accuracy in delay times, and a short recycle period is required, a synchronous motor with a cam attachment to actuate one or more micro switches or contact springs can be used. These motors can be obtained for operation on ac with frequencies from 25 to 400 cycles per second and on voltages up to 230 volts, or on dc. When using a dc motor, the circuit must be arranged to cut the power off as soon as the contacts have operated or the timer may be damaged.

Fig. V-1 shows a 1-type timer used to time the length of a call in coin or message register subscriber circuits. In this application, several sets of switch contacts are mounted in a row, each associated with a gear on a constantly rotating shaft by means of a magnetic clutch. Whenever it is desired to time a call, the clutch magnet is energized and the rotating mechanism is started. At the end of a predetermined interval, a cam on the rotating mechanism closes a set of spring contacts. By the proper design of the cam, several timing intervals can be provided and the length of the contact closures can be controlled. When the clutch magnet is de-energized, the rotating mechanism is returned to normal by a spring.



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Fig. V-1 - 1-type Timer

This timer is $5\frac{23}{64}$ inches long and $2\frac{21}{64}$ inches high. The width depends on the number of units that are mounted on the common shaft. Ordinarily the shaft and motor drive occupies the full length of a 23-inch mounting plate.

The 2-type timer (Fig. V-2) is similar to the No. 1 timer except that it is individually mounted. The No. 2 timer is $5\frac{13}{32}$

inches long, $2\frac{3}{4}$ inches high, and $2\frac{1}{4}$ inches wide. It usually has a cover over the contact springs.

The 3-type timer (Fig. V-3) has several micro switches operated by cams on a shaft rotated by a telechron motor. It is a jack-mounted unit enclosed in a can $9\frac{9}{6}$ inches long, $4\frac{31}{32}$ inches deep, and $3\frac{5}{16}$ inches high.

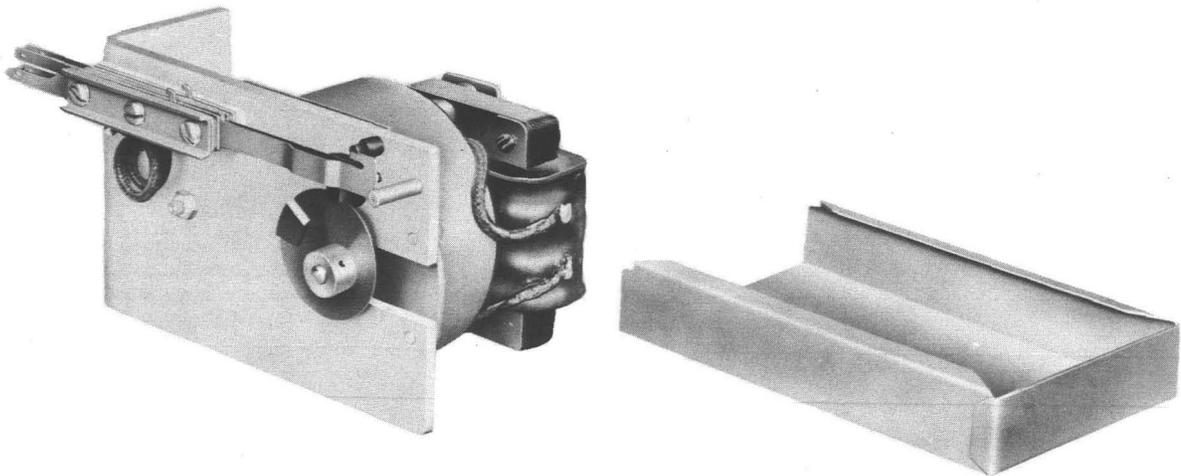


Fig. V-2 - 2-type Timer

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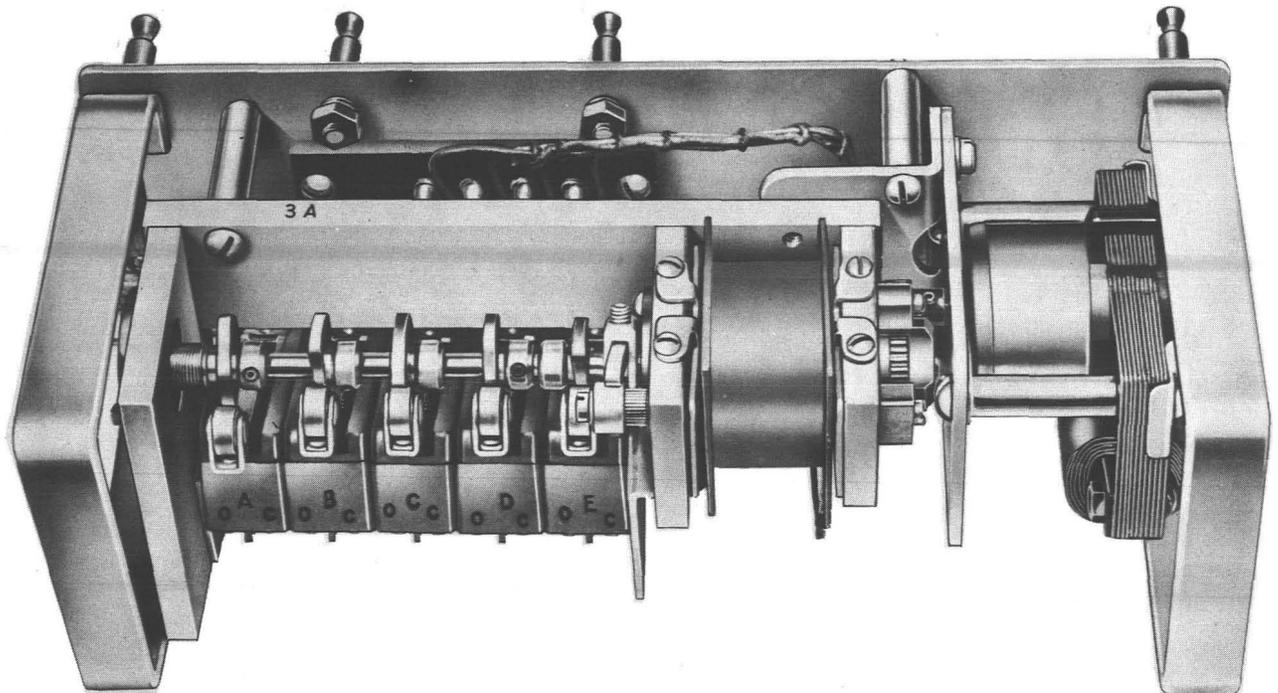


Fig. V-3 - 3-type Timer

There are many variations of the telechron motor actuating one or more micro switches. The simplest form of this is shown in Fig. V-4.

The synchronous motor timers are dependable, and can be operated in any position. They have a wide range of output shaft speeds, ranging from 60 rpm to one revolution per two weeks. Special speeds

up to several hundred rpm can also be obtained.

Several types of motors are available for various uses and it is suggested that the manufacturer's catalog be consulted for information pertaining to any desired use in order to select the type best suited for the particular use. Tables V-1 and V-2 list the coded and KS specification synchronous motor-driven timers that are available.

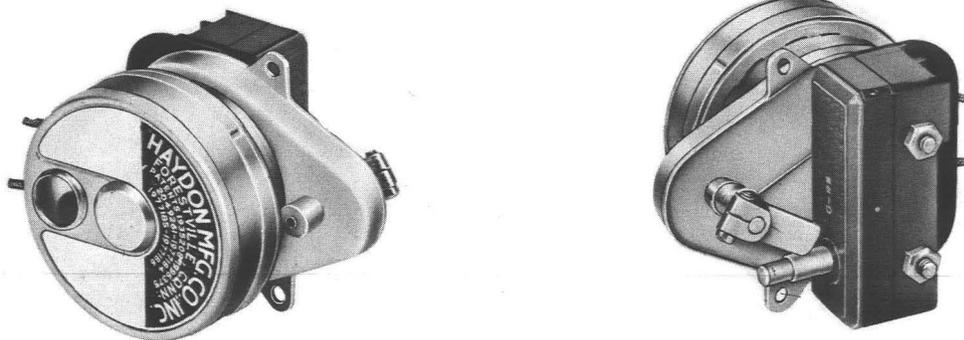


Fig. V-4 - Synchronous Motor-operated Micro Switch

TABLE V-1

CODE	OPERATE TIME		VOLTS	FREQ	CONTACTS
	MIN	MAX			
1A	See Fig. A		22	60~	1M, 1B, 1BM
1B	See Fig. A		22	60~	2M, 1B
1C	See Fig. A		22	60~	1M, 1B
1D	See Fig. A		22	60~	2M, 1B
2A	See Fig. B		22	60~	1M
2C	See Fig. B		22	60~	1M
2E	See Fig. B		22	60~	1M
3A	See Fig. C		22	60~	3M, 2B
3B	See Fig. C		22	60~	1M, 2B

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SPRING COMBINATION OPERATED BY

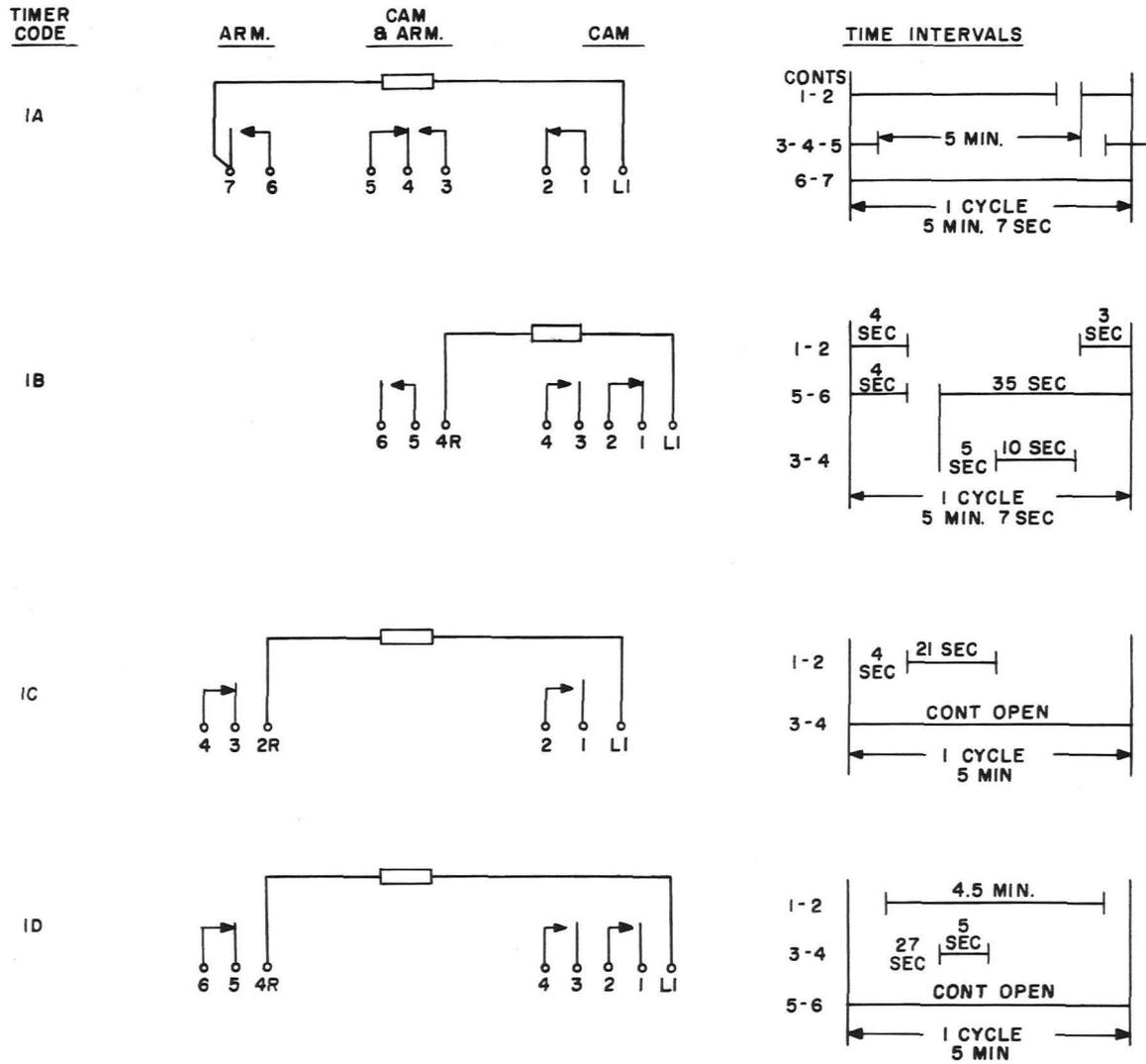


Fig. A - Timing Intervals

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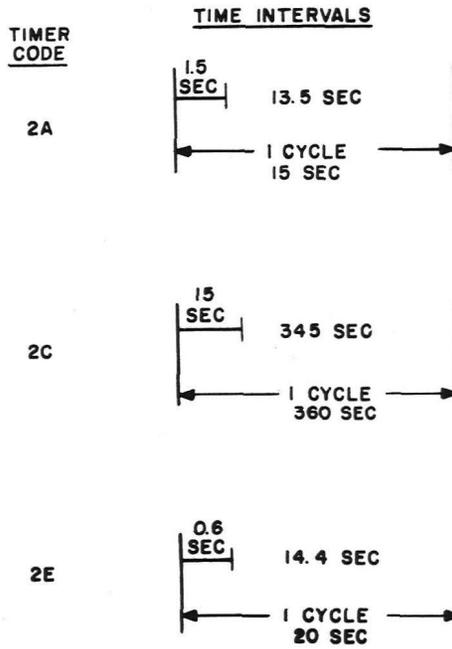


Fig. B - Timing Intervals

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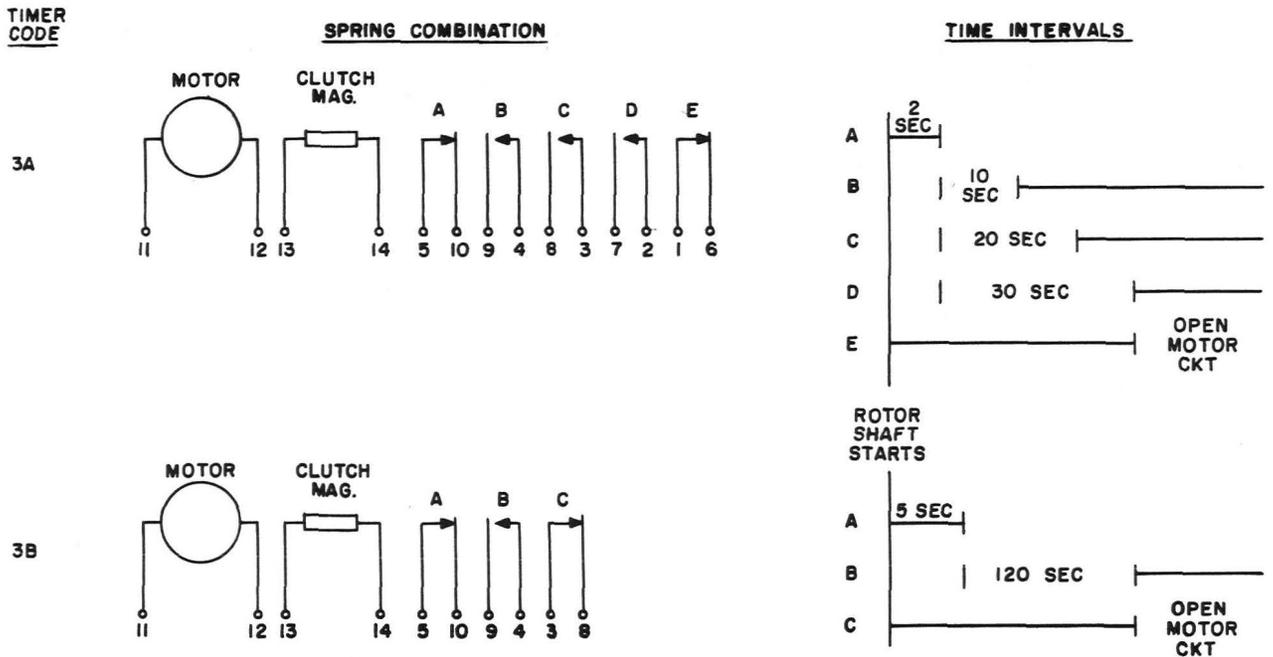


Fig. C - Timing Intervals

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TABLE V-2

CODE	OPERATE TIME		RECYCLE	VOLTS	FREQ	CONTACTS
	MIN	MAX				
KS-5839, L01	15 sec	18 sec	3 sec	20	60~	Micro Switch (1BM)
L02	15 sec	18 sec	3 sec	115	60~	Micro Switch (1BM)
L03	30 sec	36 sec	4 sec	115	60~	Micro Switch (1BM)
L04	60 sec	72 sec	4 sec	115	60~	Micro Switch (1BM)
L05	60 sec	72 sec	4 sec	20	60~	Micro Switch (1BM)
KS-8560, L1	180 sec	190 sec	4 sec	55	60~	MXT-1-2376 Unimax Sw (1BM)
L2	180 sec	190 sec	4 sec	20	60~	MXT-1-2376 Unimax Sw (1BM)
KS-8561, L2	2 hrs	±1 min		55	60~	B2RW16 Micro Switch (1BM)
L3	12 hrs	±1 min		55	60~	B2RW16 Micro Switch (1BM)
L4	2 hrs	±1 min		20	60~	B2RW16 Micro Switch (1BM)
L5	30 min	±5 sec		20	60~	B2RW16 Micro Switch (1BM)
L6	24 hrs	±2 min		20	60~	B2RW16 Micro Switch (1BM)
KS-5708, L1*	15 sec	16 sec	3 sec	110	60~	BZ-RW-9 Micro Switch (1BM)
L2*	15 sec	16 sec	3 sec	110	60~	BZ-RW-9 Micro Switch (1BM)
L3*	15 sec	16 sec	3 sec	110	60~	BZ-RW-9 Micro Switch (1BM)
L4	20 sec	21 sec	4 sec	110	60~	BZ-RW-9 Micro Switch (1BM)
L5	15 sec	16 sec	3 sec	20	60~	BZ-RW-9 Micro Switch (1BM)
KS-9194, L1	6 min	±6 sec	6 sec	20	60~	BZ-RW-10 Micro Switch (1BM)
KS-9215	60 sec			110	60~	BZ-RW-103 Micro Switch (1BM)

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TABLE V-2 (Contd)

CODE	OPERATE TIME		RECYCLE	VOLTS	FREQ	CONTACTS
	MIN	MAX				
KS-9469	60 sec	70 sec	3 sec	20	60 ~	BZ-RW-10 Micro Switch (1BM)
KS-9482	60 sec**			110	60 ~	2 BZ-RW4 Micro Switches (2BM)
KS-9718	4 min	6 min		26	dc	BZ-3RWT Micro Switch (1BM)
KS-13349, L1	4 min	6 min		20	dc	3 BM Snap Action Switches
L2	2 min	3 min				
KS-13585	6 hrs	±1/4 hr		20	60 ~	1BM Snap Action Switch
KS-14259	13 sec	17 sec		48	dc	3BM Micro Switches
KS-14260	13 sec	17 sec		230	60 ~	3BM Micro Switches
KS-14799	99 sec	101 sec		115	60 ~	2 Cam Actuated Type W Micro Switches
KS-15513, L1	***			220	60 ~	1M, 1B, 1BM Contact
L2				115	60 ~	

*These relays differ by the length of the motor leads.

**The time between the closing of the two normally open contacts shall be 30 seconds ±5 seconds.

***Time delay adjustable from 2 seconds to 50 minutes.

