UDC 621. 311. 4 : 621. 33 : 654. 93

CENTRALIZED SUPERVISORY CONTROL EQUIPMENT WITH WIRE SPRING RELAY DELIVERED TO THE CHIBA C.C. OF THE JAPANESE NATIONAL RAILWAYS

By Minoru Shijima and
Shoji Hasegawa
Technical Planning Dept.

I. INTRODUCTION

The centralized supervisory control equipment (hereafter referred to as 'control equipment') was developed from the so-called relay system, and utilizes several principles and systems established in accordance with the present progress in transistor systems. Except for the New Tokaido Line the Japanese National Railways for example always employed control equipment in which the railroad substation of existing lines all contained the former relay system, and the relays used in the equipment in heavy current areas were mostly auxiliary relays of the electromagnetic insert type. Therefore, these relays were used because their insulation withstand strength was rather good and operation frequency in heavy current areas was relatively high. The relay systems of most control equipment was of the JNR B type developed by the JNR Engineering Laboratory. However, very recently, price reductions in connection with high speed control equipment required for centralized control in railroad substation; equipment price reductions and the prudent use of signal wires were investigated carefully for over one year by the Railroad Substation Remote Control Research Committee of the Railroad Electrification Association. As a result, circuit formulae of control equipment using wire spring relays was established and an actual stage was put into operation. Around the same time Fuji Electric delivered this equipment to the Japanese National Railways Chiba Control Center for the Sobu and Narita Lines, and operation has been satisfactory so far. In order to solve the problems brought up by the committee's investigations, Fuji Electric developed test equipment with the same specifications to carry out assembly tests. This new centralized supervisory control equipment utilizing the wire spring relay is introduced below.

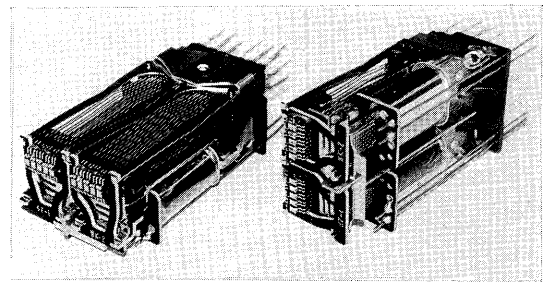
II. PROBELMS AND ADVANTAGES OF WIRE SPRING RELAYS

This system is exactly the same as that used in the previous B4–2 control equipment, except that wire spring relays are used instead of the insert type relays. Advantages and disadvantages are given below.

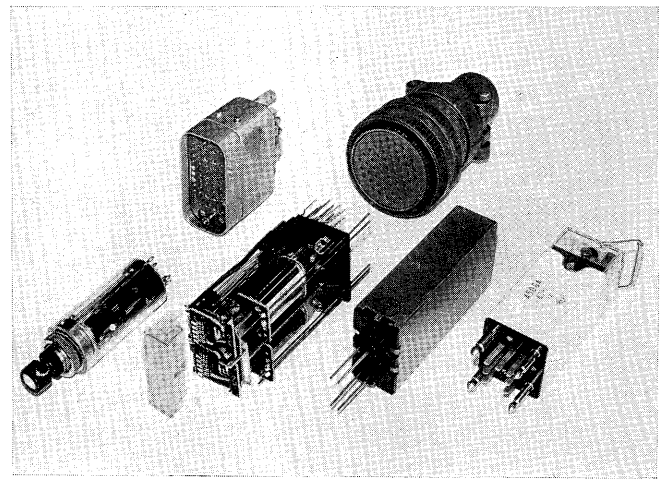
1. Application of the Single Unit Relay

The wire spring relays used at present were developed originally for use in crossbar telephone exchange equipment. They possess the following excellent features, which can provide high speed operation, high reliability, standardization and economy.

1) The main unit is a non-adjustable assembly and simple construction facilitates mass-production.
2) The number of contacts per relay is high, making power consumption per contact group low.
3) Operation and release are rapid; 1/2 to 1/3 to that of the insert type relays.
4) Contact capacity is excellent.
5) Service life is long. In comparison with the 10



(a) Wire spring relay



(b) Indivisual parts

Fig. 1 Construction of wire spring relay

million operation life of the former insert relays, the wire spring relay has a life of 100 million times.

6) Wrapping terminal connections are used. The former insert type relays were connected by soldering, but these new wire spring relays are connected by wrapping so that the number of processes are reduced and excellent performance is assured in comparison with the soldered connections.

2. Standardization of the Equipment

1) Code distribution
2) Number of controlled areas per group and number of positions
3) Code length
4) Part used
5) Circuits
6) Control panel construction
7) Relay panel construction

The above points are considered in the standardization of the equipment. Production and maintenance can be coordinated and the number of required spares can be reduced because of interchangeability. It is also relatively easy to transfer equipment, increase the number of controlled areas, and add more positions.

3. Insulation Withstand Voltage

In the previous control equipment, a high withstand voltage relay (withstand capacity: ac 2500 v for 1 min) was used in the portion where the signal wire is directly connected to the link line in the transmit-receive circuit to provide protection against abnormal voltage arising because of ground faults in extra high tension circuts, etc. The connection to the standard logical circuit also had a withstand capacity of ac 1500 v for 1 min. However, the withstand voltag of the wire spring relay is only ac 500 v for 1 min and therefore, they cannot be used as they are. Sufficient withstand voltage is provided by the system shown in *Fig. 2.*

According to *Fig. 2,* when there is an abnormal rise in the ground potential, Ar_1 and Ar_2 discharge, and the signal wire is cut when the fuse blows. Protection of the control equipment is thus assured. A high withstand voltage lead relay is used for connection between the portion directly connected to the transmit/receive circuit and the standard logical circuit. This relay provides a withstand voltage of ac 5000 v for 5 min.

In standard logical circuits of equipment used in dc substation, insulation material is placed between the unit and the installation panel to provide a withstand voltage of ac 1500 v for 1 min.

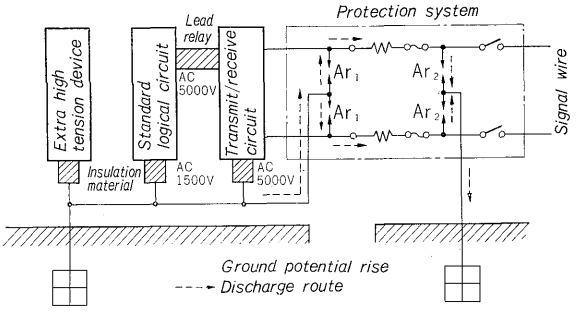


Fig. 2 Insulation system

4. Applied Voltage

Rated voltage for the wire spring relays are 24 v and 48 v. However, a series resistance connection must be used since the standard voltage of dc voltage sources used for control in JNR railroad substations is 100 v.

5. Installation and Connection Methods

Since the wire spring relays are connected by wrapping, the relays cannot be inserted separately. Depending on the application, single units of 20 to 30 relays are inserted in one case. A special connector for connections between cases and external circuits facilitates maintenance.

III. EQUIPMENT OUTLINE

1. System

As indicated in *Fig. 3,* there are 4 signal wires: LA_1, LA_2, LB_1 and LB_2, which are divided into the A circuit and B circuit. The signal is established by applying dc valtage to both the A and B circuits. Assuming that LA_1 and LA_2 are positive and negative or the reverse, eight types of signal signs result as shown in *Table 1.*

When chosing positions with control or display signals, the previously established sign combination hereafter referred to as "Code" is transmitted from

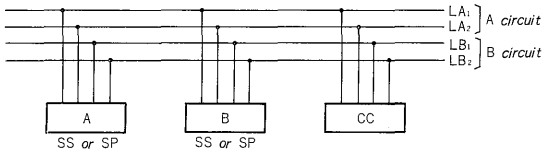


Fig. 3 Signal wire connection diagram

***Table 1* Sign Table**

Sign Mark	X	Y	R	S	T	U	V	W
A Circuit	+	+	0	−	−	0	+	−
B Circuit	+	0	+	−	0	−	−	+

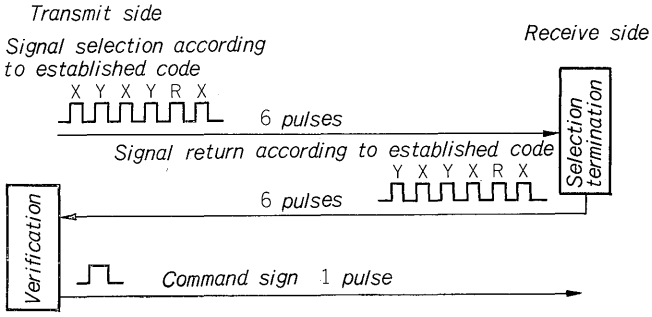


Fig. 4 Operation principle diagram

the transmit side via the signal wire to the receive side as shown in *Fig. 4*.

At the receive side, the position selected according to the code is aligned and a verifying signal is sent to the transmit side. At the transmit side, the return code and transmit code are verified. If the codes agree, a control or indication command sign is transmitted and the signal is completed. The selection and return signs are made up of 6 pulses as shown in *Fig. 4*. However, in accordance with simultaneous transmit control processing, pulses 1 to 4 are designated only by X and Y as shown in *Table 2*. Pulses 5 and 6 are designated by 8 signs between X and W.

Therefore, the codes are as follows:

Pulse 1～4 Simultaneous transmit control and controlled area selection

Pulse 5～6 Machine and indication position selection

Pulse 7～10 Return verification (controlled area selection)

Pulse 11～12 Return verification (position selection)

Pulse 13 Command sign

2. Simultaneous Transmit Control

When the "a" station is designated as XYXY and the "b" station is XYYX, and considering that both a and b commence transmission at the same time, the X sign in a and b, i.e. both the A and B circuits have their voltage increased in the positive direction in the No. 1 pulse ladder. Therefore, there is no difference in either side. There is also no difference

Table 2 **Code Table**

Priority control, display, standard control positions

Classification	Station Mark	Priority Sign	No. 6 / No. 5	X	Y	R	S	T	U	V	W	Direction
Priority Control	a	XXXX	X	SA	ST	VE	1W	2W				Control→ Controlled
	b	XXXY										
	c	XXYX										
	d	XXYY										
	e	XYXX										
Display	a	XYXY	X	SA	ST	VE						Control← Controlled
	b	XYYX	Y	1A	2A	3A	4A	5A	6A	7A	8A	Control← Controlled
	c	XYYY	R	11M	12M	13M	14M	21M	22M	23M	24M	Control← Controlled
	d	YXXX	S	31M	32M	33M	34M	41M	42M	43M	44M	Control← Controlled
	e	YXXY	T	51M	52M	53M	54M	61M	62M	63M	64M	Control← Controlled
Standard Control	a	YXYX	X									
	b	YXYY	Y	1A	2A	3A	4A	5A	6A	7A	8A	Control→ Controlled
	c	YYXX	R	11M	12M	13M	14M	21M	22M	23M	24M	Control→ Controlled
	d	YYXY	S	31M	32M	33M	34M	41M	42M	43M	44M	Control→ Controlled
	e	YYYX	T	51M	52M	53M	54M	61M	62M	63M	64M	Control→ Controlled

Special sign positions

Discharge Sequence	Position Title	Sign	
		Step No. 1	Step No. 2
1	ESS (express super search)	X	X
2	ESR (express super reset)	X	W
3	EVE (express super emergency)	X	S

Command Sign

Input command	X
Switch command	S
Special device command	W

Digital sign

Number	0	1	2	3	4	5	6	7	8	9
Sign of step No. 1, 2, 3	X	X	X	X	X	Y	Y	Y	Y	Y
Sign of step No. 4, 5, 6	X	Y	R	T	U	X	Y	R	T	U

100 position are indicated with steps No. 1 and 4
10 position are indicated with steps No. 2 and 5
1 position is indicated with steps No. 3 and 6

because both sides are designated by the Y sign. When they reach No. 3 pulse ladder, " a " station becomes X (both circuits positive) and " b " station becomes Y (A circuit : positive, B circuit : " O "). Since the X sign is applied to the signal wire by " a " station transmission, a and b stations receive the X sign and, irrespective of Y sign transmission in " b " station, subsequent transmission circuits are locked when the X sign is received and transmission is delayed until the " a " station signal is terminated.

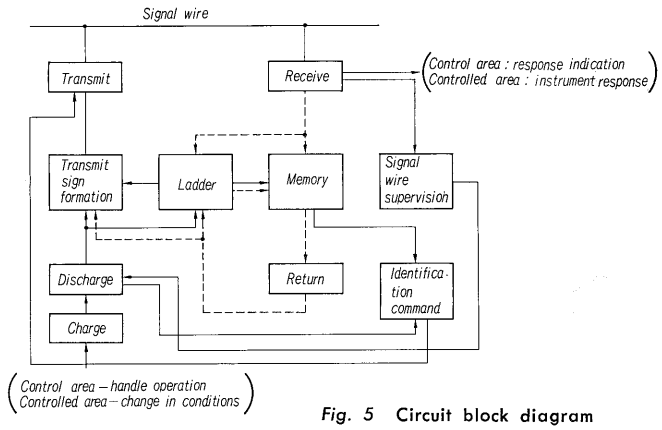


Fig. 5 **Circuit block diagram**

3. Circuit Construction

Circuit construction is as shown in *Fig. 5*.

1) Transmit/receive circuit :
   Sign formation, sign transmission/reception, sign discrimination, command sign transmit/receive
2) Supervisory (watch) dircuit :
   Signal wire supervision, simultaneous transmission processing stoppage detection, special sign transmission/reception
3) Ladder circuit : Ladder calculations, pulse length regulation

Table 3 **Relay Unit and Relay Panel**

Application	Classification	Abbreviation	Size Type	Main Circuit Used	Relay Panel Capacity (max. no. of relay units which can be connected) CC	SSA	SSB	SP
Control Area	Transmit/receive (control)	T	Large	Receive circuit, transmit aux. circuit	1			
	Ladder (control)	L	Large	Receive aux. circuit, ladder circuit, ladder aux. circuit	1			
	Supervision (control)	K	Large	Signal wire supervisory circuit, stoppage detection circuit, special sign circuit	1			
	Memory (control)	M	Small	Memory circuit	1			
	Test SS (control)	S	Small	Switching test, single emergency stop (accident indication test), measurement, spec. remote control reference circuit		1	1	1
	Test SP (control)	S	Small	Switching test, single emergency stop (accident indication test), spec. remote control reference circuit				
	Accident SS (control)	A	Small	Accident indication (8 position) reference circuit		1	1	1
	Accident SP (control)	A	Small	Acciednt indication (4 position) reference circuit				
	Instrument (control)	C	Small	Instrument (4 position) reference circuit		6	4	4
Controlled Area	Transmit/receive (controlled)	T	Large	Transmit/receive circuit, transmit aux. circuit		1	1	1
	Ladder (controlled)	L	Large	Receive aux. circuit, ladder circuit, ladder aux. circiuit		1	1	1
	Supervision (controlled)	K	Large	Signal wire supervisory circuit, stoppage detection circuit, special sign circuit		1	1	1
	Memory (controlled)	M	Small	Memory circuit		1	1	1
	Test SS (controlled)	S	Small	Switching test, single emergency stop (accident indication test), measurement, spec. remote control reference circuit		1	1	1
	Test SP (controlled)	S	Small	Switching test, single emergency stop (accident indication test), spec. remote control reference circuit				
	Accident SS (controlled)	A	Small	Accident indication (8 position) reference circuit		1	1	1
	Accident SP (controlled)	A	Small	Accident indication (4 position) reference circuit				
	Instrument (controlled)	C	Small	Instrument (4 position) reference circuit		6	4	2

4) Memory circuit: Memory for transmission/reception
5) Starting circuit: Starting of charge and discharge
6) Check circuit: Sign check, selection return
7) Display, etc.: Indication command reception, detection of condition changes, instrument and accident indication, alarm

4. Sign Distribution

An example of a code list is given in *Table 2*. The codes are divided into the following 4 groups according to the importance of the information signals, and the order of preference is established.

1) Express control position group
2) Priority control position group
3) Indication position group
4) Standard control position group

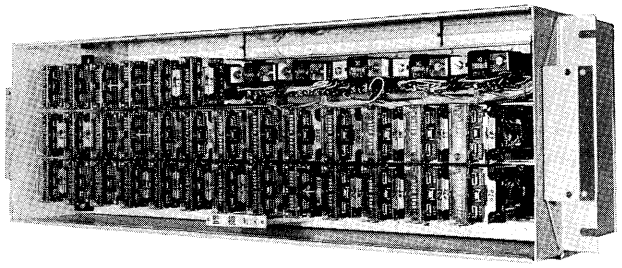
5. Number of Controlled Areas

The number of controlled areas per group is based on economy, required signal time when indication signals are received simultaneously from several controlled areas, trouble signals and their range when an accident occurs in the common control section. A distance of 100 km, 10 SS (or SP) is divided among 2 groups, and arranged mutually so that as a standard, 1 group has 5 SS.

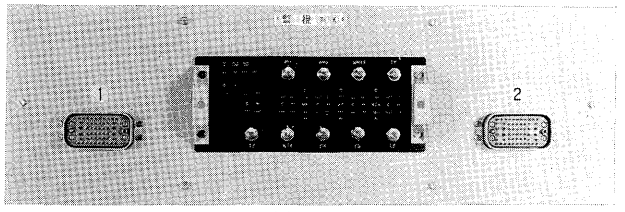
6. Relay Code Types and Position Capacity

Depending on circuit function, 20 to 30 individual relays are inserted in one case to form one unit as shown in *Fig. 6*. All connections between units or to external circuits are made with connectors. Construction of the various types of units is shown in *Table 3*.

The position capacity per controlled area is of 3 types; SSA, SSB and SP, according to the equipment used.



(a) Front



(b) Back

Fig. 6 Relay unit

7. Switches and Plugs

The selection of the controlled area priority sequence is determined by pulses 1 to 4. However, switches are installed in test SS (controlled) and test SP (controlled) units. These switches facilitate the establishment of priority sequences.

Among the units shown in *Table 3*, test SS (control, instrument (control), accident SS (controlled), accident SP (controlled), and instrument (controlled) have prime and spare plugs.

Switching between prime and spare units is accomplished by patching.

8. Test and Timing Adjustments

A test terminal is provided on the back of each unit so that sequence checking can be performed without removing the units. (Refer to *Fig. 6 (b)*)

Adjustable resistors for timing adjustments and terminals for timing measurements are installed in units which contain slow release relays for supervision, etc.

IV. EQUIPMENT DELIVERED TO CHIBA C.C.

1. Group Construction

The group construction of the Chiba C.C. is shown in *Fig. 7*. Remote supervisory control of the 77.5 km between Sobu Line Chiba Station and Koiwa is performed from the Chiba C.C. by dividing into 2 groups, A and B, with 6 SS and 1 SP installed along the line. Remote supervisory control of the 27.9 km between Narita Line Chiba Station and Shisui is performed by the 3 SS D group. A list of A, B and D group supervisory control items is given in *Table 4*.

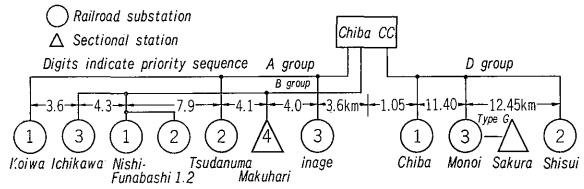


Fig. 7 Group construction of Chiba C.C.

2. Construction

1) Desk-type control panel

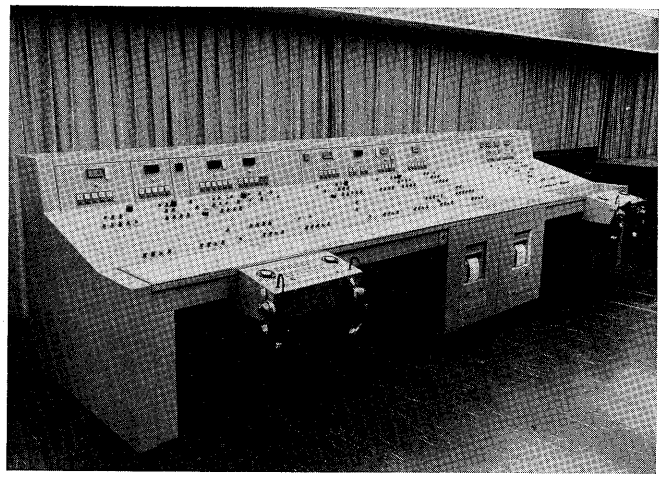
As shown in *Fig. 8 (a)* and *(b)* common parts and individual parts (controlled area units) are arranged separately and it is easy to add additional equipment or reconstruct existing equipment.

An automatic recording system is installed in the front of the panel. With this equipment, automatic recording takes place when control or indication signals occur and also when digital measurements of hourly integrated power are carried out.

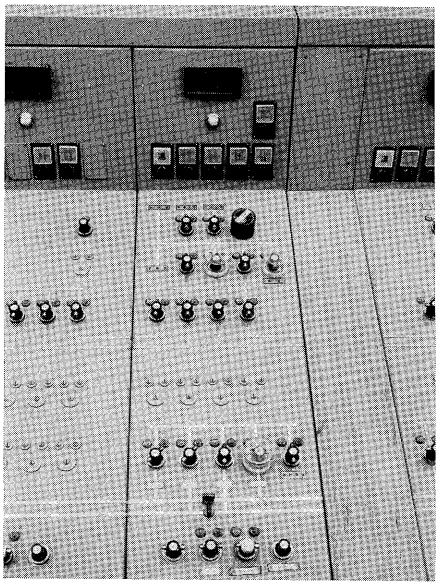
Table 4 **Control Position Table**

Classification	Item	Marking	Control Indication	A Group a Koiwa SS SSA	A Group b Tsudanuma SS SSA	A Group c Inage SS SSB	B Group a Nishi Funabashi 1SS	B Group b Nishi Funabashi 2SS	B Group c Ichikawa SS SSB	B Group d Makuhari SP SSA	D Group a Chiba SS SSA	D Group b Shisui SS SSB	D Group c Monoi SS SSB	D Group c Sakura SP SSB
Special	Express super search	ESS	1/0	○	○	○	○	○	○	○	○	○	○	
Special	Express super reset	ESR	1/0	○	○	○	○	○	○	○	○	○	○	
Special	Express super emergency	EVE	1/0	○	○	○	○	○	○	○	○	○	○	
Priority	Super accident	SA	0/2	○	○	○	○	○	○	○	○	○	○	
Priority	Super test	ST	2/2	○	○	○	○	○	○	○	○	○	○	
Priority	Emergency	VE	1/0	○	○	○	○	○	○	○	○	○	○	
Priority	Digital measurement 1	1W	1/0	○	○	○	○	○	○	○	○	○	○	
Priority	Digital measurement 2	2W	1/0				○							
Accident	Earth fire	EF	0/2	○	○	○		○	○	○	○	○	○	○
Accident	Heavy accident	HA	0/2	○	○	○	○	○	○	△	○	○	○	
Accident	Light accident 1						○							
Accident	Light accident 2						○							
Accident	Light accident	LA	0/2	○	○	○	○	○	○	○	○	○	○	○
Accident	Light accident (common)	LA (common)	0/2	○	○	○		○	○	○	○	○	○	
Accident	Distribution line (H.T.) accident	DA	0/2	△				○		△	○			○
Instrument	Receive circuit breaker 1	$52R_1$	2/3			○	○				○			
Instrument	Receive circuit breaker 2	$52R_2$	2/3			○	○				○			
Instrument	Receive circuit breaker 3	$52R_3$	2/3				○							
Instrument	Receive circuit breaker 4	$52R_4$	2/3				△							
Instrument	Receive disconnecting switch 1	$89R_1$	2/2		○				○					
Instrument	Receive disconnecting switch 2	$89R_2$	2/2		○				○					
Instrument	Receive disconnecting switch 1	$89R_1$	2/3									○		
Instrument	Receive disconnecting switch 2	$89R_2$	2/3									○		
Instrument	Main unit breaker 1	52-1	2/3	○	○	○		○	○		○		○	
Instrument	Main unit breaker 2	52-2	2/3	○	○	○		○	○		○			
Instrument	Main unit breaker 3	52-3	2/3	○	○	○		○	△					
Instrument	Main unit breaker 4	52-4	2/3					△						
Instrument	Main unit disconnecting switch 1	89-1	2/3									○		
Instrument	Main unit disconnecting switch 2	89-2	2/3									○		
Instrument	Bus tie disconnecting switch 1	$89B_1$	2/2				○							
Instrument	Bus tie disconnecting switch 2	$89B_2$	2/2				○							
Instrument	Main transformer primary breaker 1	$52TP_1$	2/2				○							
Instrument	Main transformer primary breaker 2	$52TP_2$	2/2				○							
Instrument	Main transformer secondary breaker 1	$52TS_1$	2/2				○							
Instrument	Main transformer secondary breaker 2	$52TS_2$	2/2				○							
Instrument	Transmit circuit breaker 1	$52R_{21}$	2/3				○							
Instrument	Transmit circuit breaker 2	$52R_{22}$	2/3				○							
Instrument	Main transformer (No. 1-parallel-No. 2) switching	43LR	3/3				○							
Instrument	High speed breaker 1	$54F_1$	2/3	○	○	○		○	○	○	○	○	○	○
Instrument	High speed breaker 2	$54F_2$	2/3	○	○	○		○	○	○	○	○	○	
Instrument	High speed breaker 3	$54F_3$	2/3	○	○	○		○	○	○			○	
Instrument	High speed breaker 4	$54F_4$	2/3	○	○	○		○	○	○			○	
Instrument	High speed breaker 5	$54F_5$	2/3	○	○									
Instrument	High speed breaker 6	$54F_6$	2/3		○									
Instrument	High speed breaker 7	$54F_7$	2/3											
Instrument	High speed breaker 8	$54F_8$	2/3											
Instrument	Distribution line (HT) breaker	52D	2/2			○		○						
Instrument	Distribution line (HT) descon. sw.	89D	2/2								○	○		
Instrument	High signal voltage breaker 1	$52S_1$	3/3			○		○			○	○		
Instrument	High signal voltage breaker 2	$52S_2$	3/3			○		○			○	○		
Instrument	High signal voltage breaker 3	$52S_3$	3/3											
Instrument	Light power breaker 1	$52D_1$	3/3			○		○						
Instrument	Light power breaker 2	$52D_2$	3/3			○		○						
Instrument	Light power breaker 3	$52D_3$	2/2			○								
Instrument	Sectional oil switch 1	OS_1	2/2											○
Instrument	Sectional oil switch 2	OS_2	2/2											○
Instrument	Disconnecting switch protection lock 1	LK_1	2/2	○	○	○	○	○	○	○	○	○	○	○
Instrument	Disconnecting switch protection lock 2	LK_2	2/2				○							

Note: ○ mark indicates the actual position
△ mark indicates the positions to be added in the future (Blank openings are provided on the control panel)

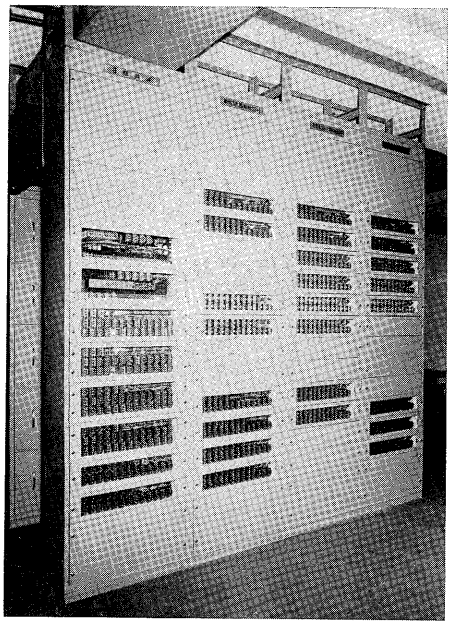


(a) Desk-type control panel

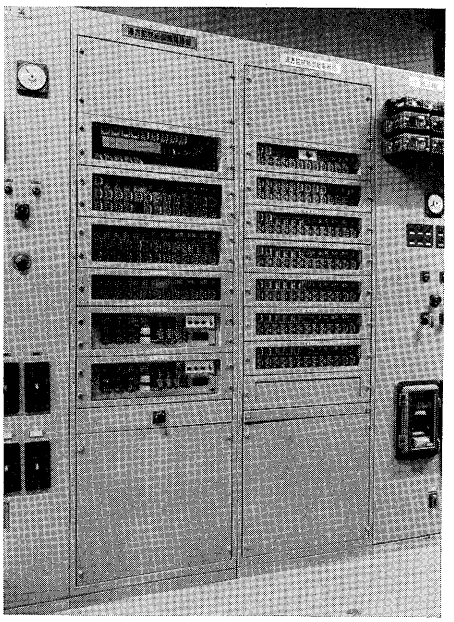


(b) Detail of control panel

Fig. 8 Control panel

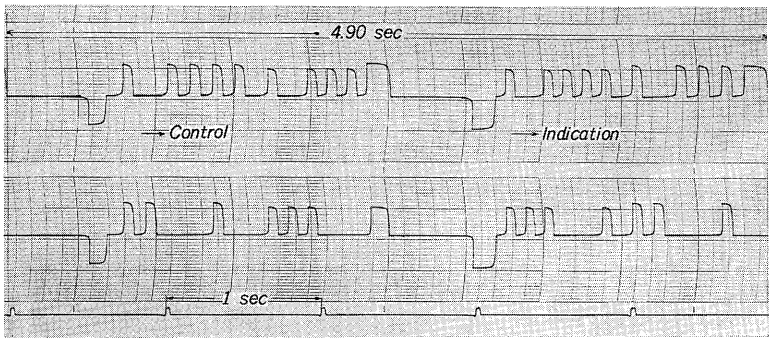


(a) Control area



(b) Controlled area

Fig. 9 Relay panel



Time required by signal
C.C. .....108 v } Ratings
Tsudanuma S.S. .....108 v }
Chart speed ..... 50 mm/sec

Fig. 10 Operation oscillogram

2) Relay panel

Relay panel construction is as follows:

Control area:	Common panels	3
	Individual panels	7
	Automatic recording equipment relay panels	2
Controlled area:	Relay panels for 10 areas	15

Connections between panels are all made with cables with 52 conductor round connectors attached. An example of the relay panel is shown in *Fig. 9*.

3) Capacity

Fig. 10 shows an oscillogram made during an actual test. The required signal time is about 2.5 seconds which satisfies all anticipations.

V. CONCLUSION

This concludes the introduction of an actual installation and outline of the wire spring relay type control equipment. This and similar equipment is now being manufactured for delivery to various customers.