Dear Client,

Thank you for purchasing our HT-TC Cable Fault Locator. Please read the manual in detail prior to first use, which will help you use the equipment skillfully.

Our aim is to improve and perfect the company's products continually, so there may be slight differences between your purchase equipment and its instruction manual. You can find the changes in the appendix. Sorry for the inconvenience. If you have further questions, welcome to contact with our service department.

The input/output terminals and the test column may bring voltage, when you plug/draw the test wire or power outlet, they will cause electric spark. PLEASE CAUTION RISK OF ELECTRICAL SHOCK!

Company Address:

- **T4， No. 1, High-tech 2 Road，East Lake High-tech Development Zone， Wuhan**
- Sales Hotline: 86-27- 87492243
- After Service Hotline: 86-27- 87459656
- Fax: 86-27- 87803129
- E-mail: whhuatian@163.com
- Website: www.whhuatian.com

◆ SERIOUS COMMITMENT

All products of our company carry one year limited warranty from the date of shipment. If any such product proves defective during this warranty period we will maintain it for free. Meanwhile we implement lifetime service. Except otherwise agreed by contract.

◆ SAFETY REQUIREMENTS

Please read the following safety precautions carefully to avoid body injury and prevent the product or other relevant subassembly to damage. In order to avoid possible danger, this product can only be used within the prescribed scope.

Only qualified technician can carry out maintenance or repair work.

--To avoid fire and personal injury:

Use Proper Power Cord

Only use the power wire supplied by the product or meet the specification of this produce.

Connect and Disconnect Correctly

When the test wire is connected to the live terminal, please do not connect or disconnect the test wire.

Grounding

The product is grounded through the power wire; besides, the

ground pole of the shell must be grounded. To prevent electric shock, the grounding conductor must be connected to the ground.

Make sure the product has been grounded correctly before connecting with the input/output port.

Pay Attention to the Ratings of All Terminals

To prevent the fire hazard or electric shock, please be care of all ratings and labels/marks of this product. Before connecting, please read the instruction manual to acquire information about the ratings.

Do Not Operate without Covers

Do not operate this product when covers or panels removed.

Use Proper Fuse

Only use the fuse with type and rating specified for the product.

Avoid Touching Bare Circuit and Charged Metal

Do not touch the bare connection points and parts of energized equipment.

Do Not Operate with Suspicious Failures

If you encounter operating failure, do not continue. Please contact with our maintenance staff.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in Explosive Atmospheres.

Ensure Product Surfaces Clean and Dry.

—Security Terms

Warning: indicates that death or severe personal injury may result if proper precautions are not taken

Caution: indicates that property damage may result if proper precautions are not taken.

Contents

I. Product introduction

The normal operation of cable-communication and electric transport completely rely on the good condition of the cable-circuit. Once the circuit breaks down and without punctually examination and repairing, it will no doubt trigger the mass economic loss and bad social influence. So the electric fault measuring testing instrument is a very important tool. The intellectual testing instrument uses multiple testing methods and adopts the most advanced electronic devices and with computer and special electronic technology, combining our company's successful experience of long-time exploitation on cable-fault measuring testing instruments, and it is absolutely of high tech, intelligence and abundant functions.

Our cable-fault detector is a testing device of good integrity. It can test on the High Resistance Flashover Fault, Grounding High and Low Resistance Fault, Short & Off Circuit on the Cable Fault and Poor contact and etc. If being equipped with sounding method and locating instrument, it can exactly detect the fault point. Furthermore, it especially applies to test for various power cable and communication cable.

II. Product features

1. Complete function

Safe, quick and accurate to test. The instrument applies the methods of Low Voltage Pulse and High Resistance Flashover. It can test all kinds of faults, especially on the Flashover and High Resistance fault testing and without burning through. If it is equipped with sounding method and locating instrument, it can exactly point out the location of the fault.

2. High Precision

Our instrument uses the tech of high speed data sampling, the speed of A/D is 100MHz, and makes resolution ratio of 1m and testing dead zone of 1m.

3. High intelligent

The testing results automatically show by wave form and data on the large LED. It is easy for viewing. It does not need especial training for operators.

4. Function of Wave Form and Parameter Saving & Reading

It uses non-volatile devices and after turning off, it still saves the wave form and data.

5. Function of Double-trace Showing

It can compare the wave forms of fault-manner cables and those of the regular ones. It is benefit for the further testing of the

fault.

6. Function of Magnifying on the Scale of Wave Form

Through magnifying the scale of the wave form, it can make further exact testing.

7. It can wantonly change the position of the cursor, showing the direct or indirect distance of fault point and testing point.

8. It has the function of changing the speed of communication depending on the tested cable.

9. The instrument is portable and with a chargeable battery to provide power. It is convenient to take and use.

III. Technique parameters

1. Scope of application and using purpose

The instrument can test all kinds of electric cable(voltage of 1KV-35KV) and the Short Circuit, Grounding, Leakage of High Resistance. High Resistance Flashover, Out Line and Bad Contact fault on the local cables, frequency modulation communication cables, coaxial cable and metal aerial cables. It also can test the length of cable and the spread velocity on the cable.

2. longest testing distance：32KM (100KM for the open-wire line)

3. Testing .dead zone：1M.

4. Resolution of reading：1M.

5. Power dissipation：5VA.

6. Service condition :

environment temperature：0℃～＋40℃

terminal temperature：－10℃～＋50℃

relative humility：40℃(20～90)%RH

Atmospheric pressure：(86～106)Kpa

7. Dimension：225×165×125mm^3

8. Weigh：2kg

IV. Principle of Testing

The principle of cable fault testing is based on the asymmetrical resistance's reverse on the communication of the electric wave in the cable.

Based on the theory of Transportation Line, every line has a unique resistance $Z_{c,}$ which is depending on the structure of the circuit but not the length of the line. In the symmetrical transportation line, the resistance input equals the unique resistance at any point. If the load of terminal equals the unique resistance, the current wave and voltage wave on the transportation reverse none but absorbed totally by the terminal. When the resistance at any point is unequal to $Z_{c,}$ the electric wave reverse all or partly. The scale of reverse polarity can be expressed

by parameter P, the relation is on the below:

$$P=\frac{U_r\text{（reflection wave）}}{U_i\text{（incident wave）}}=\frac{Z_o-Z_c}{Z_o+Z_c} \qquad (1)$$

Z_c is the resistance of the transportation line

Z_o is the resistance of the reverse transportation line

(1) When it works without fault, $Z_o=Z_c$, $P=0$, no reverse.

(2) when the circuit is off line, $Z_o=\infty$, $P=1$, it reverse totally and the polarity of the incoming wave and its reflex are the same.

(3) when the circuit is short circuit, $Zo=1$, $P=-1$, it minus totally reverse and the polarity of the incoming wave and its reflex are the opposite .

1. Low voltage impulse method (pulse method)

When there is an impulse electric wave, the impulse conveys on the line by the speed of V, and reflex to the input terminal when the row distance L_x meets the fault point. The time of the reverse is T, so the relation is on the below:

$$2L_x=VT$$

$$\therefore\ L_x=\frac{1}{2}VT \qquad (2)$$

V is the speed of the electric wave of the line, and is related to the linear circuit parameter and constant to an case which can be detected by the instrument and calculated by computer. When the displayer show the the impulse and the reverse wave from the fault point in real time, we can get the time T by providing the

instrument's time signal. So we can get the location of the fault point from (2). Different kinds of faults has wave charts as below:

Method of impulse can easily detect the fault in the off line, short circuit and cable's low voltage grounding. In the situation of high resistance fault, for it still shows high resistance in the condition of low voltage impulse and makes no or few reverse wave. In this situation, we need add amount of current or high voltage impulse to discharge it and get the reverse wave by the short circuit in a wink by flashover electric arch.

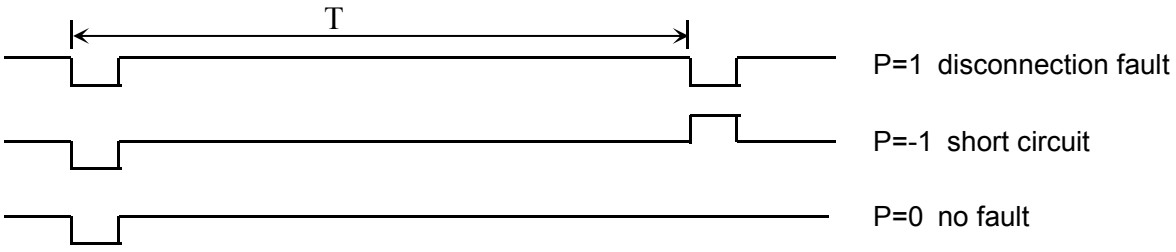

Figure 1 reflection wave of different fault

2. DC high voltage flashover method (direct flash method)

When the fault resistance is extremely high, it can be used to measure the cable to be measured before the stable resistance channel has not been formed. To a certain voltage value after the fault point is the first choice to be breakdown, the formation of flashover, the arc of the added voltage to form a short circuit reflection, reflection echo in the input side is high resistance source to form an open circuit reflection. The voltage between the input and the fault point will be reflected many times until the energy is exhausted. Test principle circuit diagram shown in Figure 2, the line

of the reflected waveform as shown in figure 3.

Fault distance: $L_x = \frac{1}{2} V \cdot T$

Among: $T = t_2 - t_1 = t_2 - t_1 = t_2 - t_1 = \cdots\cdots$

Theoritically the wave form should be steep square wave, but refer to the incomplete reverse and circuit comsuption the real wave becomes smaller and smoother.

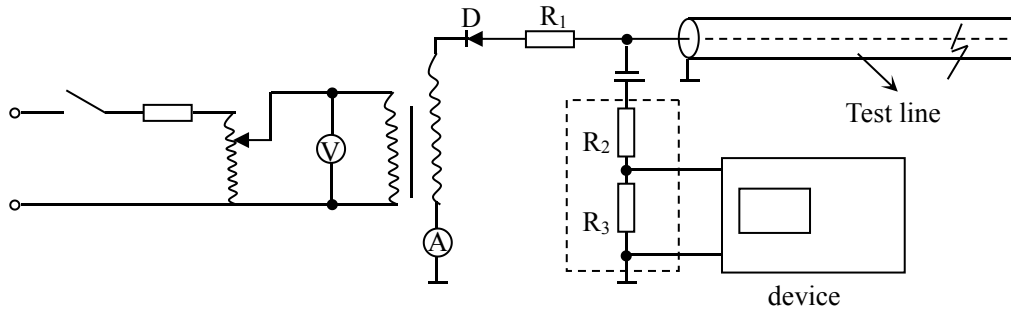

Figure 2

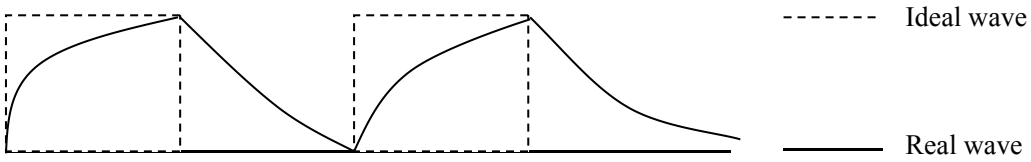

Figure 3

3. Impact high voltage flashover method (referred to as the flash method)

When fault point reduces the resistance and forms constant resistance tunnal, we have to choose the voltage impulse method for we can not add more high voltage current by the limit of instrument capacity. High voltage current through sphere gap can charge the cable until spark-over, and we still use the reverse wave

produced by the flashover electirc arch. At the input terminal of cable we detect the inductance L to read the reverse wave. The circuit principle graph is as below. Electric wave reverse at the fault point and reverse by L at the input terminal, so it forms multiple reverse. Because of the self-inductance phenomenon, it shows as open reverse at frist for the resistant effort of L, and shows as short circuit reverse by the acumulation of current. And the whole circuit is made of process of discharge by electric capacity C and inductance L. So at the output terminal the curve shows as a reducing cosine wave added by several quick impulse reverse waves. As the graph below. We can get distance of fault from the internal of reverse wave.

Fault distance: $L_x = \frac{1}{2} V \cdot T$

$T+\Delta T \geq T$, ΔT is time of discharge decay.

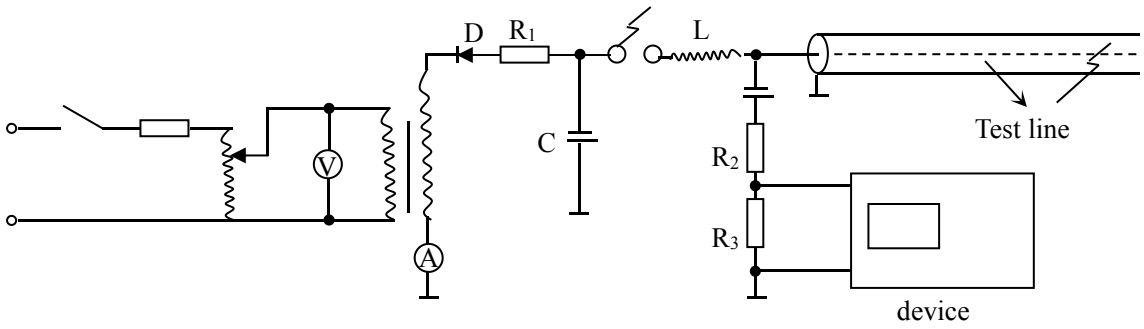

Figure 4

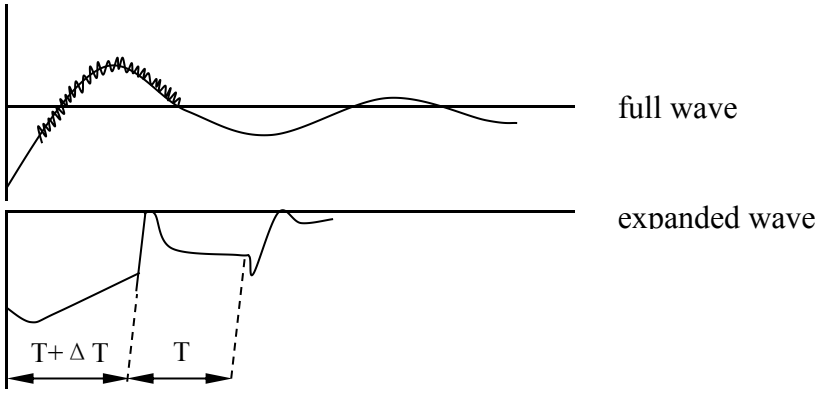

Figure 5

V. Fundamantal Principle and Composition

1. Fundamantal Principle of Instrument

Based on the fault testing principle, when the device is in the trig mode of flashover, the flashover wave formed by electric arch on the fault point is random einmal transient wave, so the instrument should have the function of saving, capture and displaying the einmal transient wave. The instrument applies the technology of digital storing using the high speed A/D converter to get sample, and converts the transient analog signal to digital signal in real time and saves it in the cache. Then sent the signal to LCD displayer control circuit after processing in the CPU as time series dot matrix signal and then shows the sampling parameter on the LED displayer.

When the instrument in the mode of impulse trigging, it sent detective impulse to the tested cable and input circuit in certain

cycle. At the same time the A/D works and has the same process of sampling, storing, processing and displaying as stated before. LED displayer should have reverse wave form.

2. Composition of the Instrument

Instrument is designed as the core of micro processor and controlling the signal's sending, receving and digitalizing processing. The principle of the operation is as below:

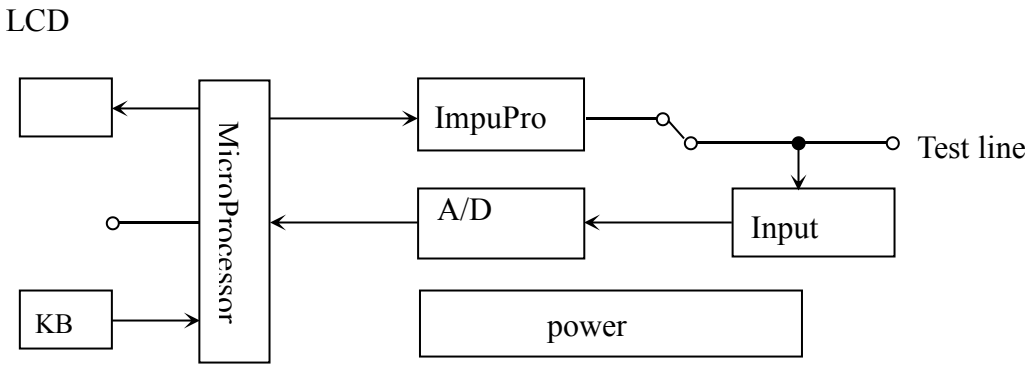

Figure 6

The word done by microprocessor concludes: data sampling, data storing, data filtration, cursor moving, distance computing, graph comparing, graph size changing and displaying on the LED. And it also can depend on need to communicate by the tranportion port and PC.

Impulse producer forms the a logic impulse of a certain width by the coding signal from the micro processor. The impulse will be converted by transmitting circuit to high range and eventually to the tested cable.

High speed A/D producer is to convert reverse signal on the tested cable through input circuit sending A/D sampling and finally sent ot the micro processor.

Keyboard it the window for communication between human and computer. Opertators can type the command by keyboard to computer by the testing and then the computer controller complete some kind of testing.

VI. Panel control mechanism and the role of the button menu a) Controlling Mechanism

1. Control mechanism

(1) Triggering: uesed by triggering operation mode. Press the button to choose the flashover method. Under the method of impulse testing, switch the button.

(2) Output: the output line of device connected to the tested terminal of cable.

(3) Charge: The instrument use current chargeable battery team, if it is in the low power, plug into adapter and the power indicating light will light.

2. Illustration of the Keys

(1) “on” and “off” button: control the power of the device on or off. Press the button, the device has the power and displayer will

show the window of operations.

(2) “sample” button: press the button and send the impulse to the tested cable, every time press it sends an impulse and does the sampling. If pressing the button for 3 seconds, the device will send signals continually untill any button is pressed.

(3) “◄►” Has two kinds of functions:

when it refers to the testing function, they can move the cursor. When it refers to the manual function, they can move the manual choice on right or left.

(4) “+○—” button: adjust LCD displayer contrast ratio.

3. The Perpose and Operation of the Function Manual

(1) scope: using for fault detecting. Because when it is testing, it usually tests from the near to the far.

Turning on the machine, the testing range is 198m, it means the range of fault is between 0-198m. If there is no fault wave, you must change the range of testing from 198m and add to twice every time until the maxim of 12720m. For variaty length of cable, when it changes the range, the width of the impulse varies to larger and wider.

Operations as below:

Press the measurement range key, every time, range doubled.

(2) starting: using for the high speed cursor’s starting

position.When you turn on the machine, there are two cursors and one is on the most right place and other is on the middle. If you want to change the place of cursor, you can use “◄►” button to adjust it, and then press the “zero point” choice to accept it. So the starting cursor coresponse the motive cursor, and the data shows as 0m. Operations are as below:

Press the “scale” button, when there is a “zero point” choice in the manual, the “◄►” button will light. Then press the “scale” button.

(3) Scale: using for expanding the wave to get exact location of fault point. Operations are as below:

Press “scale” button, when there is a scale manual on the buttom of the screen, you can adjust “◄►” to make it lighter, and then press the “scale” button.

(4) Wave Velocity: Since the speed of electric wave are different on the different structural cables, when testing different kinds of cables, the machine must adapt to the wave velocity of the cable quickly. When you turn on the machine, the default velocity is 200m/ns. In the testing, it should be varied depending on the cable. Operations are as below:

Press the “velocity” button, the value turns light. Then press “◄►” button to adjust the wave velocity. Arriving at the expected

velocity, press the “velocity” button to turn off the light.

(5) Storing: the machine has the ability to store the wave form and data. This function make provide the storing of the wave form and data in the nonvolatile store. Operations are as below:

Press “◄►” button to light it, then press the “scale” button.

(6) Reading: Since the machine applies the nonvolatile store, the data stored will not lose when power off, and you can read the data stored at any time to analysis, and even can compare it to the recent wave form and make the more exact position of the fault point. Operations are as below:

Press “scale” button, when there is a manual choice on the bottom of the screen, then adjust “◄►” button to light it, then press the “scale” button.

(7) Date: press the “date” button, adjust “◄►” button to change the value, then press “date” button to complete the operation.

(8) Print: press the “press” button and the operation will complete itself.

After the operations before, on the bottom of screen, there is a operation window.

VII. Preparing Work before Testing

1. Review the condition of the machine

Before using the machine, you can follow the operations as below to review which the machine works well.

(1) Under the condition of impulse triggering mode, press the “power” button, the LED displayer will show the main window, the distance of the tested staff, wave velocity, scope of testing. Scale and so on.

(2) Press the “◄ or ►” button, the middle cursor will move, at the same time, the data of fault will vary.

(3) Adjust the multiple electric potential, on the screen the wave range will rise or reduce.

Follow the operations of the manual, testing scope varies and the width of the emission impulse will also vary. To now, it shows the machine works well.

2. First judgment to variant faults

Analysis before the testing is very necessary. You can use general devices like Ohmmeter or Ohm KM and combining the real conditions to get first judgment of the fault.

3. Choose the mode of triggering

If it is out line, bad contact, low resistance grounding or short circuit, it should apply the impulse method. If it is the high

resistance flashover fault, it should apply the flashover method. And choose the mode to triggering mode.

VIII. Using of Machine and Testing Method

1. Low voltage impulse method

The low voltage impulse method applies the scope of communication and cable line out of line, bad contact, low resistance grounding and short circuit and measuring of the length of line and velocity of wave.

Operations are as below:

A. Position the panel on the "pulse" (▙) position.

B. Plug the testing line to input port on the panel, and connect the testing line to tested line. If it is grounding fault, it should connect the black keep to tested cable.

C. Break the tested line to income equipment

D. Search the fault reverse wave and judge the properties of fault.

Turn the “multiple” to maximum, see whether there is reverse impulse wave on the screen. If there is none, please refer to the method 6.3.1 to change the scope of testing. Every time changing the scope and see whether there is a reverse wave until the reverse wave exists. The properties of fault can be judged by the

polarity of reverse wave. If it is a positive impulse, the fault is open out line. If it is a negative impulse, the fault is grounding or short circuit.

E. Testing distance, press the “▲or▼” button to make the impulse steepest. Then move the cursor to adjust “◄or►” for 3 seconds. The cursor will automatically move to the turning of the fault reverse wave, at the time the screen shows the distance of the fault point. The make more exactly, please refer to 6.3.4 method to change the scale of the wave and after expanding the wave, you can get the exact location.

2. High Voltage Current Flashover Method

(1) First check the triggering working mode switch in the position of flashover and the velocity of transport should equal the velocity of wave.

(2) Scope: the resistance of the fault point is very high and not forming a fixed tunnel, under a certain voltage it can create a flashover discharging fault of the electric cable. Preventative spark-over testing usually applies this method.

(3) The time of the high voltage current flashover method varies, and the short one can exist for some times. The wave form is simple, can be easily recognized and with a high accuracy and value it.

(4) The principle graph of the current flashover method is as below. In the real testing, apply the high voltage equipment and our high voltage testing production. The connecting graph is as below too.

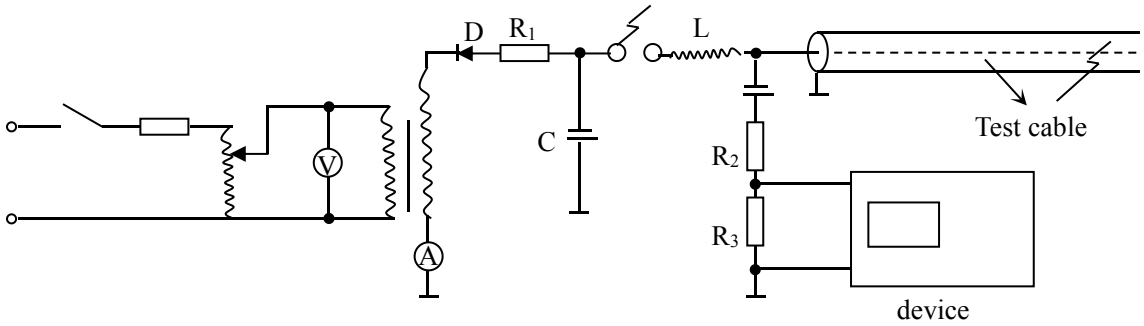

Figure 8

T1 voltage adaptor……2KVA

T2 high voltage transformer……0～50KV，2KVA

D high voltage silicon stack……ReV: 100KV，FoV: 100mA

C High voltage capacitor……0.1μF＞10KV

The AC/DC meter: 0-300V; The current meter: 100mA;

In the high pressed testing equipment,

Resistance：30±20/5kΩ;

Output resistance：500Ω±10%.

(5) Turning on the machine, the screen lights with a window. Then rise the voltage gradually by adaptor, and when the fault point has the phenomenon of flashover, the current in the microamp meter rises heavily and the indicator in voltage meter also alters heavily. The wave form as below should be on the screen. From the

graph, the interval of $t_1$and t_2 should be the distance of the fault points.

(6) The voltage of high voltage flashover testing method could be as high as thousand or ten thousand voltage and operators should obey the operation rules like connecting the equipment to the ground and high voltage equipment's base line and grounding line of the equipment should connect to the cable in lead which is connected to the ground. Connect the lines as 9.3 and check the water resistance and voltage divider resistance in the high voltage testing.

3. Impulse High Voltage Flashover Method

(1) Scope: the fault point with a high resistance but already forms a fixed a tunnel in cable. The high voltage equipment's capacity is in limit, if the current can not reach the certain level, it should apply flashover method. The fault which can not be tested out by current flashover and impulse method, the method applies it in theory.

(2) As the same, it shuold check the switch whether on the position of flashover and the high voltage testing equipment whether has a good water resistance and voltage divider.

(3) Connect the devices as below. The ground line works as 8.2.6 and 9.3. The capacity in it is demanded higher than 1μF, the

withstand voltage should be in demand. The other demands are as the same of the flashover method. The inductance usually uses as in the device 2 or device 3. The adjust the wave form according to the length of the tested cable.

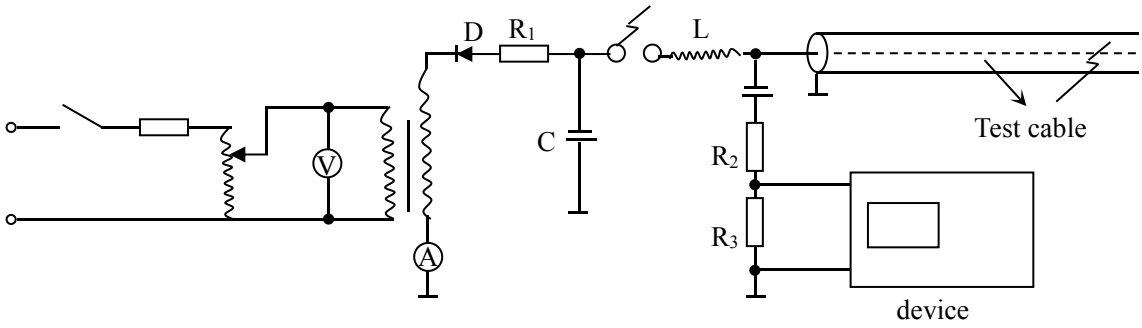

Figure 9

(4) Testing method: adjust the adaptor to rise the voltage to the spark-over of the tested staff. The gap of the spheres should account to the resistance and whether the tested voltaeg could discharege normally. The impulse flashover fault point whether discharge normally can be detected by the whole wave form.

(5) It can detect whether there is a fault of spark-over flashover phenomenon by the sound of the gap sphere dischargin and indicator of the electric meter. If the discharging phenomenon does not clear, it can add the voltage, sphere gap, or the capacity of storage capacitor.

(6) The testing of the fault distance is as the same as before.

IX. Announcement

1. In the method of impulse testing, it shuold drop off any inside devices and do the testing on the outmost line.

2. In the method of flashover testing, it must turn the triggering switch to the position of flashover.

3. In the method of current flashover or impulse, operators should pay great attention on the safety. Arrange the lines as ordered.

4. After the flashover testing, it should cut off the power, remove the connecting line between the device and high voltage testing equipment. Then discharge the high voltage capacitor and the electric charge stored on the cabel. In discharging, it should first add the current limit resistance R to limit the discharging current and assuage the process of discharging. After the voltage of capacitor is low, it can discharge directly to the ground until the voltage is zero. If discharging in seconds, the instant current can reach hundred amps and it can demage the device or operators.

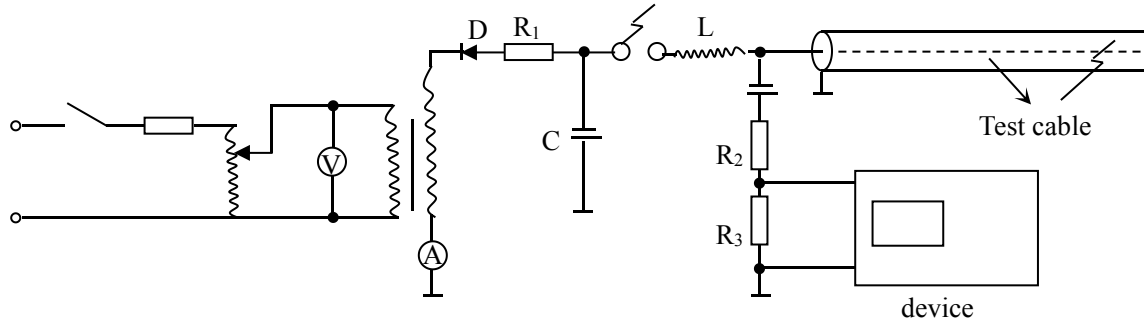

Figure 10

5. In the testing of current flashover, the whole process must be under carefully monitoring to avoid the sudden rising in current. If the flashover phenomenon does appear, it should reduce the voltage at once and change to the impulse method.

X. Some Technical Problems in the Testing

1. procedure of the measuring of velocity of wave

(1) Connect the tested cable of a certain length (assuming as 500m) to the output port of device which should be on the position of mode of triggering. Change the testing scope to 636m, at the time there should be a backward wave impulse on the screen.

(2) Press the "►" button to move the cursor the starting of the backward wave.

(3) Alter the wave velocity as 6.3.5 to make the fault distance of 500m. At the time, the velocity showed is the wave velocity on the tested cable. And it can presume the velocity of wave in the testing.

2. Comparison between wave forms

The way of comparing between wave forms is unique way of testing. The operation procedure is to find a good pair of lines in the fault cables and first tests the wave form in impulse method and store the wave form as said before. Then connect the fault lines to

the testing ports of the devices to get the wave form as the procedure before to get the good pair of lines. The screen will show the fault wave form and wave form of good pair of lines and then compare the difference of them to detect the fault. The graph is as below:

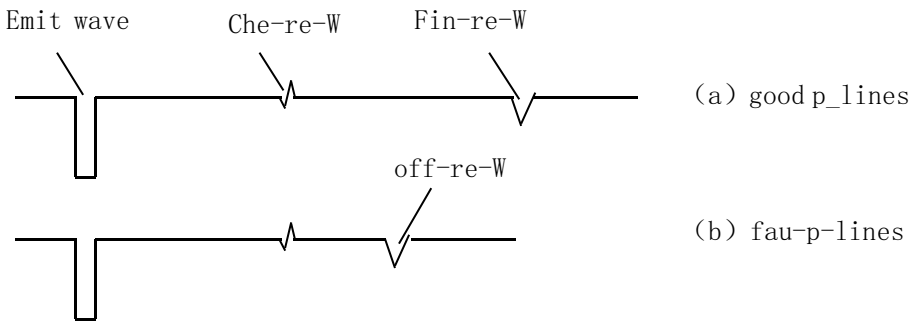

Figure 11

3. Charging

(1) In order to keep the instrument battery can maintain the working time, easy to carry out, the instrument above the screen there is the battery power, has been unable to maintain the normal operation of the instrument, the screen will appear tips are discharge, please wait....." After the discharge work is completed, the automatic protection shutdown is performed to prevent the battery from being damaged.

Appendix

Chart of common velocity on the cable(Ref)

unit：m/μs

name	model	Test cable	velocity
Hi-Fre cable	HEQ－2527×4×1.2＋6×0.9	Gap of cables	232m/μs
		other	240～244m/μs
	HEQ－2521×4×1.2	Gap of cables	248/μs
	HDYFLE22－156	Gap of cables	224m/μs
		other	230m/μs
Lo-Fre cable	HEQ212×4×12	Gap of cables	240m/μs
		other	248m/μs
Oil immersed communicating insulating cable in lead	ZUQ 6KV3×703×150	Core-core	160m/μs
PVC insulating cable	VLZ 3×120＋1×35 1KV3×50＋1×16	Core-core	178m/μs
PVC insulating cable	VKV20 1KV3×50	Core-core	172m/μs
Mi-coaxial cable	4×2.6/9.4	Core-screen	283m/μs
Sm-coaxial cable	4×1.2/4.4	Core-screen	274m/μs
Local cable	0.5×50	Core-core	196m/μs
	0.4	Core-core	190m/μs
	0.32	Core-core	182m/μs
Opening cable		Core-core	288m/μs