

# FUJI LEAK NOISE CORRELATOR

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## LC-2500

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### INSTRUCTION MANUAL



Instruments for the location of underground utilities and water leaks.

**FUJI TECOM INC.**

## **Preface**

This manual describes the Fuji leak noise correlator Model: LC-2500.

Before using your equipment, be sure to read this manual to comprehend proper operating and handling procedures.

## **Applicability**

Pick-ups are mounted to the fittings such as fire hydrant, valve, or meter on the underground piping to capture the leak noise and identify the leak position.

## Precautions

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Before using this correlator, completely read and comprehend the safety notes listed below.

- Follow the instructions and procedures described in this manual to operate this instrument.
- Always observe the precautions indicated on this instrument and manual.

### <Symbols>

The following symbols are used in this manual for the purpose of warning so that you can avoid property and personal damages.

 <b>WARNING</b>	This symbol indicates the existence of a potential danger that may cause death or serious injury.
 <b>CAUTION</b>	This symbol indicates the existence of a potential danger that may cause slight or moderate injury.
<b>CAUTION</b>	This symbol indicates the existence of a potential danger that may cause serious damage of LC-2500 or surrounding properties.

 <b>WARNING</b>
<ul style="list-style-type: none"><li>● While listening the leak noise with a headphone set during the operation of this unit, be completely careful since it will be difficult to hear the background sounds.</li><li>● Do not replace the batteries and/or operate this unit with wet hands.</li><li>● When the batteries have been mounted to the battery box, handle this unit with great care. If the terminals are short-circuited, heat generation, bursting, fire, and/or injury will occur.</li><li>● When inserting the batteries into the battery case, pay attention to the polarity. Incorrect polarity will result in leakage, heat generation, damage, and other troubles.</li><li>● Do not put the batteries into the fire. Otherwise, you will suffer from bursting, fire, and/or injury.</li><li>● Do not disassemble the batteries. Otherwise, you will suffer from bursting, fire, and/or injury.</li></ul>



## CAUTION

- Do not hold the handle to swing the detector.
- Mount the battery cover certainly. Otherwise, the battery box may come off.
- Do not swing the pick-up.

## CAUTION

- Do not leave or install this unit in a hot place. Otherwise, the detector may fail.
- Use this unit only for the leak noise detection.
- This detector is not a complete waterproof model.
- Avoid immersion into water or operation in the rain.
- Do not drop the detector nor apply strong impact to it.
- Do not disassemble the detector.
- Do not touch the panel display strongly. Otherwise, the detector may fail.
- When the detector will not be used for a long period, remove the batteries.
- Do not bend the antenna by applying unreasonable force.
- Do not pull the pick-up cable unreasonably. Otherwise, the cable may be broken to dysfunction the pick-up.
- Always be aware of the ambient conditions.
- When disposing this detector, follow your local rules and regulations.

## Warranty Period

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FUJI TECOM warrants this correlator LC-2500 to be free from defects in material and/or workmanship for one (1) year from the purchase.

The written warranty is an effective tool with which FUJI TECOM can provide utmost service operations to the customer.

If this correlator fails within the warranty period, FUJI TECOM will repair it free of charge.

The repair within the warranty period needs showing the written warranty with the serial numbers of this instrument. So the customer should keep it carefully.

If the customer does not or fails to notify its serial numbers, FUJI TECOM will claim repair fees.

If this correlator fails after the expiration of the warranty period or the failure is attributable to customer's abuse, misuse, modification, and any other unauthorized actions, the repair will be non-gratuitous. Please consult FUJI TECOM for details.

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## 1-1 Component List

This leak noise correlator LC-2500 consists of the following components. After you purchased the detector, check the components for completeness. FUJI TECOM performs a complete inspection before shipment. However, if you find missing component (s), immediately inform us of the fact.

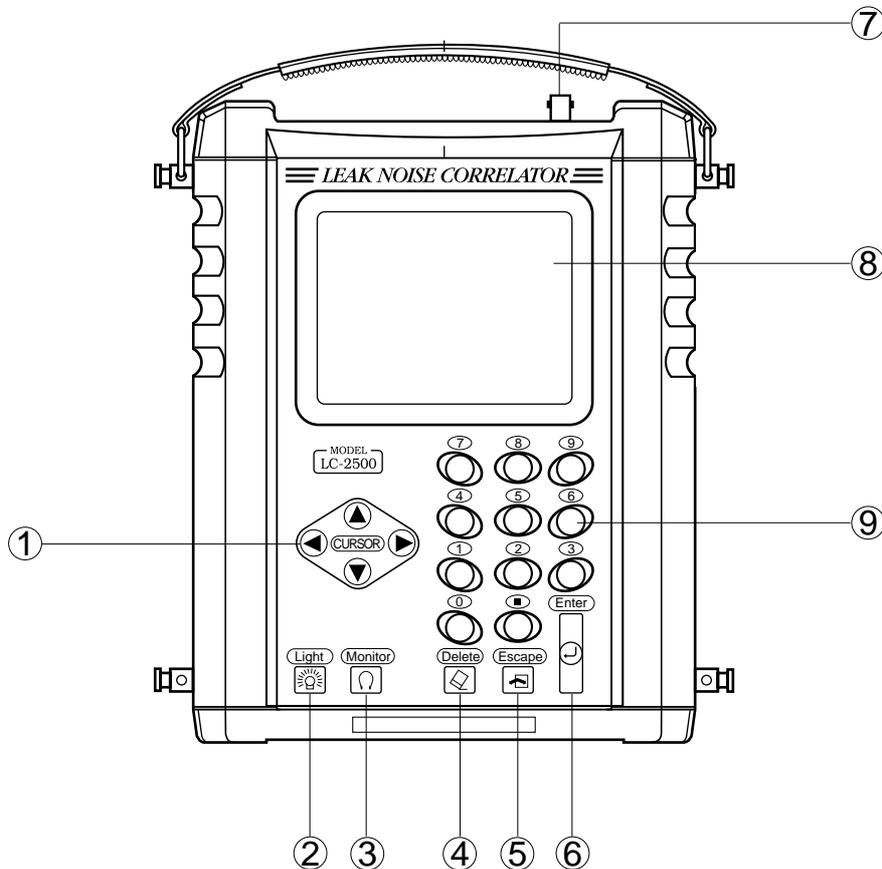
Designation	Quantity
● Main Unit .....	1 (with battery case)
● Pre-amplifier (blue and red) .....	2 (with battery case)
● Pick-up Sensor .....	2
● Stereo Headphones .....	1
● Receiving antenna (Main Unit) .....	1
● PC soft with connecting cable .....	1
● LC-2100's sensor connecting cable .....	2
● Alkali battery .....	16
● Shoulder strap .....	1
● Spare fuse (2A, slow blow type) .....	1
● Waist strap .....	1
● Aluminum carrying case .....	1
● Instruction manual .....	1

For the correlator operated outside Japan, the following components are available as the optional items if circumstances require.

- Battery charger: 1
- Battery : Battery pack for main unit (composed of four size D Ni-Cad batteries) 1 ea.  
                   Battery pack for pre-amplifiers (composed of six size D Ni-Cad batteries) 2 ea.

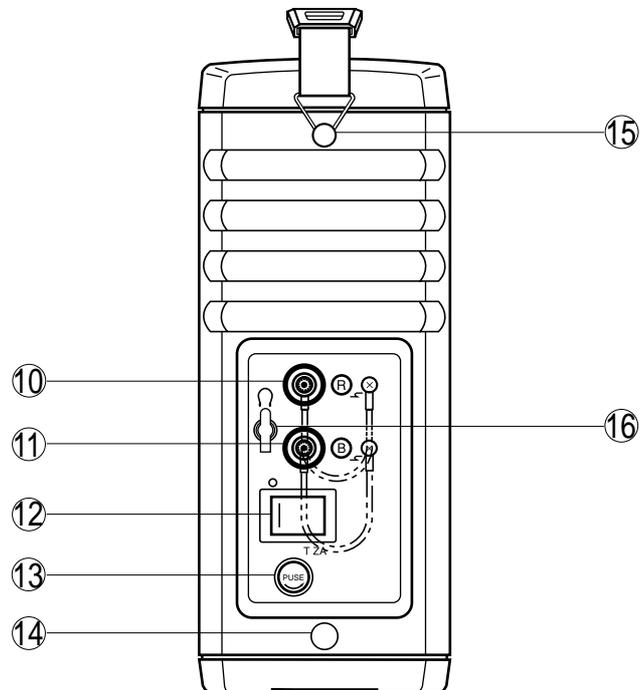
#### 2-1 Panel and Switches (Main Unit)

##### (1) Front panel



- ① CURSOR key : Moves the cursor up, down, right, or left.
- ② Light key : Turns on/off the backlight for membrane switches and LCD.
- ③ Monitor key : Changes the output style to the headphone set. (Blue, Red, or Stereo can be set.)
- ④ Delete key : Deletes the data input.
- ⑤ Escape key : Returns to the previous screen.
- ⑥ Enter key : Confirms the menu and setting.
- ⑦ Antenna connector : A receiving antenna is mounted here.
- ⑧ LCD : You should make an operation through this screen.
- ⑨ Numeric key : Enters numerical data and selects items.

**(2) Right panel**

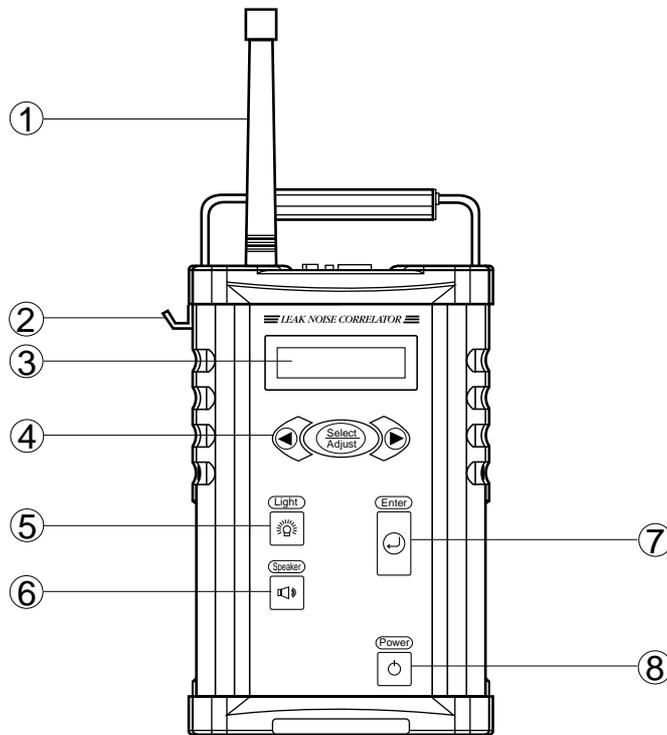


- ⑩ Cable connector (red) : To use the unit in the cable mode, plug in the red pre-amplifier here.
- ⑪ Cable connector (blue) : To use the unit in the cable mode, plug in the blue pre-amplifier here.
- ⑫ Power switch : Turns on the unit.
- ⑬ Fuse : Protects the unit from over current. In case of blowout, replace it with new one.
- ⑭ Waist strap hook : You should hook both ends of the waist strap here.
- ⑮ Shoulder strap hook : You should hook both ends of the shoulder strap here.
- ⑯ Headphone jack : To listen the leak noise with a headphone set, plug in it here.

Items ⑭ and ⑮ are located on the left panel as well.

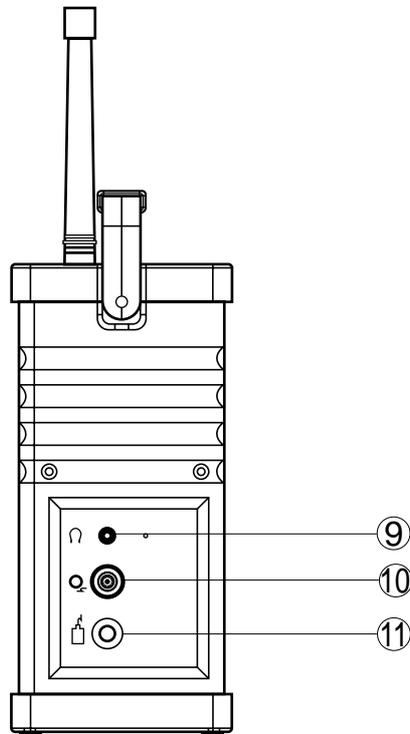
## 2-2 Panel and Switches (Pre-amplifier)

### (1) Front panel



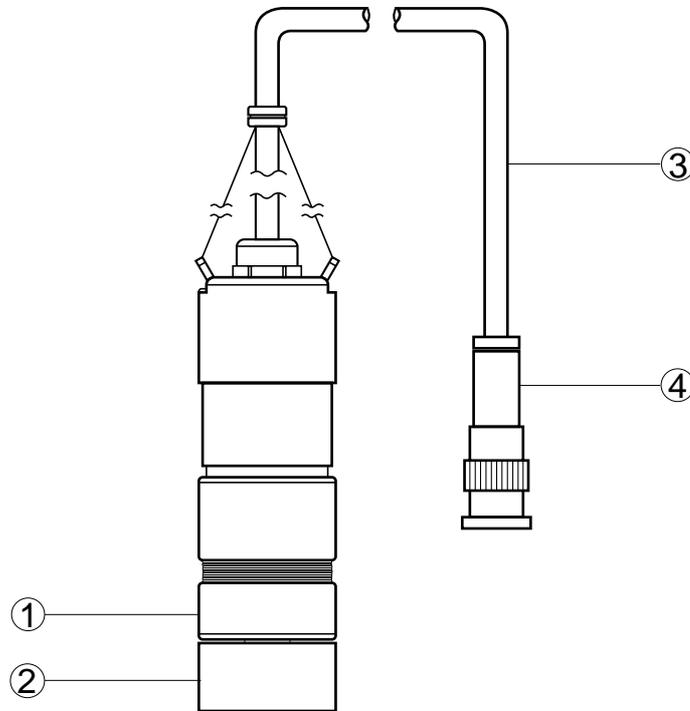
- ① Antenna : Transmits radio waves.
- ② Hook : Hooks the pick-up sensor
- ③ LCD : You should control the pre-amplifier through this screen.
- ④ Select/Adjust key : Selects the setting and adjusts the sensitivity.
- ⑤ Light key : Turns on/off the backlight for membrane switches and LCD. While this Light key is active, a light symbol is observed on the upper right corner of the LCD.
- ⑥ Speaker key : Turns on/off the speaker.
- ⑦ Enter key : Changes the menu and confirms the setting.
- ⑧ Power key : Turns on/off the pre-amplifier.

(2) Right panel



- ⑨ Headphone jack : To listen the leak noise with a headphone set, plug in it here.
- ⑩ Cable connector : To use the pre-amplifier in the cable mode, plug in the cable here.
- ⑪ Pick-up input connector : The pick-up is connected here.

## 2-3 Pick-up Sensor



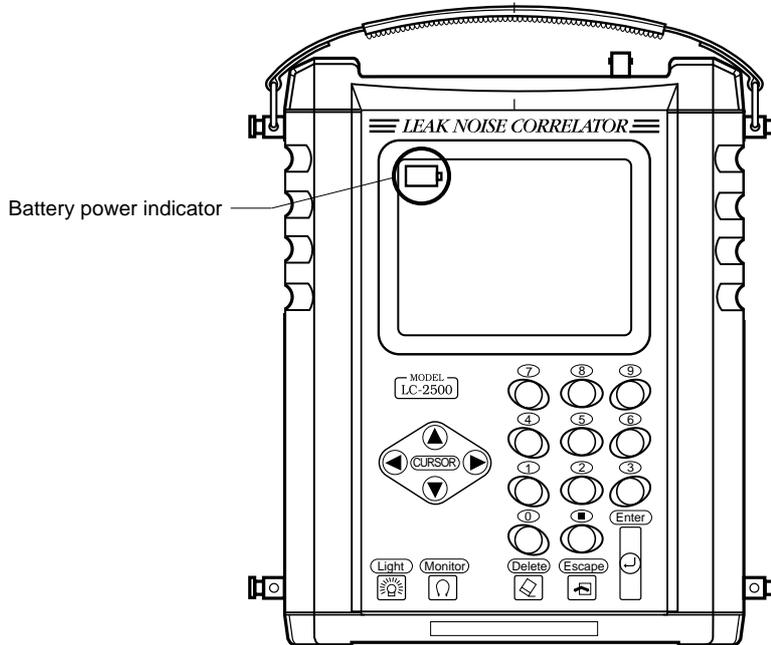
- ① Pick-up sensor : Detects the leak noise at the measurement point.
- ② Magnet : Allows the pick-up to attract a pipe or other target.
- ③ Pick-up cord : Sends the signals acquired with the pick-up to the pre-amplifier.
- ④ Pick-up connector : Connects the pick-up and pre-amplifier.

### 3. Pre-operation Check

#### 3-1 Checking and/or Replacing the Batteries (Main Unit)

#### 3-1 Checking and/or Replacing the Batteries (Main Unit)

##### (1) Checking the battery power



- Before using the correlator, be sure to check the batteries have enough capacity. To this end, turn on the main unit.
- When it is not fully charged, the open space is observed in the battery power indicator as shown in the figure above. This open space is enlarged as the main unit consumes the battery power. If the battery power indicator is flashing, replace the batteries immediately.
- Before the replacement, be sure to turn off the main unit.
- Fuji Tecom recommends that you should prepare spare batteries to cope with the runout of battery power during the operation.

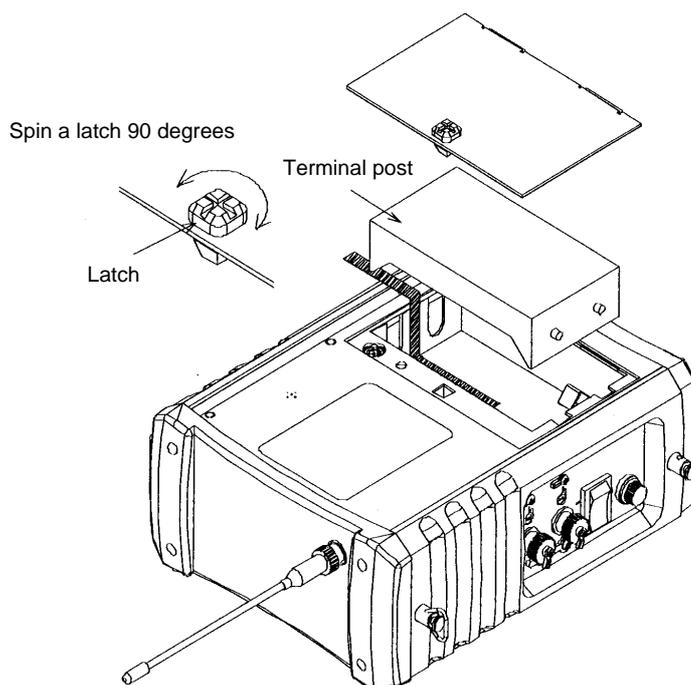
## (2) Removing and attaching the battery cover and replacing the batteries

The main unit needs four (4) commercially available size D alkali dry batteries (LR20)

- When other batteries are used, the continuous operating time of the detector will differ from the specification described herein due to difference in battery capacity.

Remove the battery cover, take out the battery box, and replace the old batteries with new ones.

After reinsertion of battery box, be sure to remount the battery cover.



### WARNING

- If those batteries that are not specified by FUJI TECOM are used and resultantly the detector fails, the warranty statement will be invalid.
- When replacing batteries, be careful of their orientations. Incorrect orientation will cause bursting, fire, and/or injury.
- Do not mount different types of batteries mixing in the battery box. Otherwise, bursting or leakage will occur.
- Dispose of the replaced batteries according to your local rules and regulations.
- Pay attention not to dispose of the battery box together with the batteries.

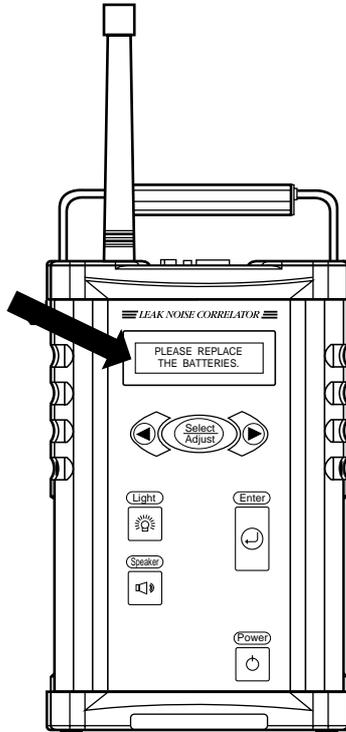
### 3-2 Backup Battery

A data backup battery is built in the main unit. This battery is used to count dates and times and store the recorded leak noise data. This secondary vanadium coin battery is rechargeable. After the main unit is turned on, the secondary battery is automatically charged with the main batteries. Therefore, when the main unit stands for longer period, the secondary battery is self-discharged to decrease the power level. If the backup battery is completely discharged, the date, time, and recorded leak noise data are lost. After the main unit has been turned off for a long period, check the date and time for correctness after power-on. If they differ from the current ones, provide resetting by referencing Section 3-6 “Setup of Date and Time”.

- For the reference purpose only, about one-hour charging can retain the data for about one to two weeks.
- Other data will not be erased.
- The backup battery is not fully charged before the shipment. Fuji Tecom recommends you to turn on the main unit to charge this backup battery after the equipment is delivered to you.

### 3-3 Checking and/or Replacing the Batteries (Pre-amplifier)

#### (1) Checking the battery power



- There are blue and red pre-amplifiers. Check both units, respectively.
- Before using the pre-amplifiers, be sure to check the batteries have enough capacity. To this end, press the Power switch on each pre-amplifier. Each unit is equipped with the self-check function that always monitors the battery voltage. After the pre-amplifier is turned on, it checks the battery voltage first of all and, if the voltage is below the specified level, the message “Change batteries” appears on the LCD. When this is your case, replace the batteries with new ones. If the LCD is turned off during the self-check, replace the batteries as well.
- Fuji Tecom recommends that you should prepare spare batteries to cope with the runout of battery power during the operation.

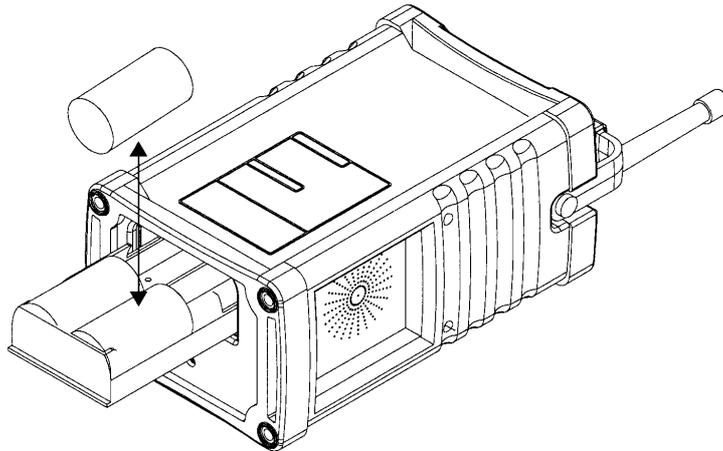
## (2) Replacing the batteries

Each pre-amplifier needs six (6) commercially available size D alkali dry batteries (LR20)

- When other batteries are used, the continuous operating time of the detector will differ from the specification described herein due to difference in battery capacity.

Remove the battery cover, take out the battery box, and replace the old batteries with new ones.

After reinsertion of battery box, be sure to remount the battery cover.



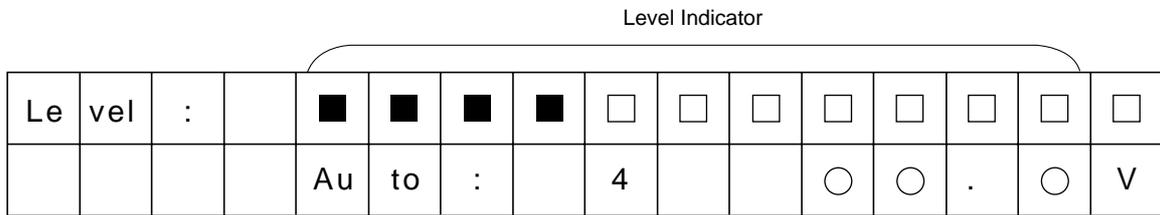
### **WARNING**

- If those batteries that are not specified by FUJI TECOM are used and resultantly the detector fails, the warranty statement will be invalid.
- When replacing batteries, be careful of their orientations. Incorrect orientation will cause bursting, fire, and/or injury.
- Do not mount different types of batteries mixing in the battery box. Otherwise, bursting or leakage will occur.
- Dispose of the replaced batteries according to your local rules and regulations.
- Pay attention not to dispose of the battery box together with the batteries.

### 3-4 Inspection of Pre-amplifiers

There are blue and red pre-amplifiers. Check both units respectively using the same procedures.

- (1) Plug the pick-up in the pre-amplifier.
- (2) Press the Power switch.
- (3) Press the Enter key and tap lightly on the pick-up magnet. This time, check the level indicator oscillates. If the indicator is standstill or moves slowly, the pick-up may be faulty. Plug in another pick-up and repeat checking. Otherwise, change the pre-amplifier and conduct the same checking. If the level indicator normally oscillates on another pre-amplifier, the former unit may be faulty.



LCD Screen on Pre-amplifier

## 3-5 Comprehensive Inspection

### (1) Main unit and pre-amplifiers

- Checking the signal transmission and receive performance in radio communications



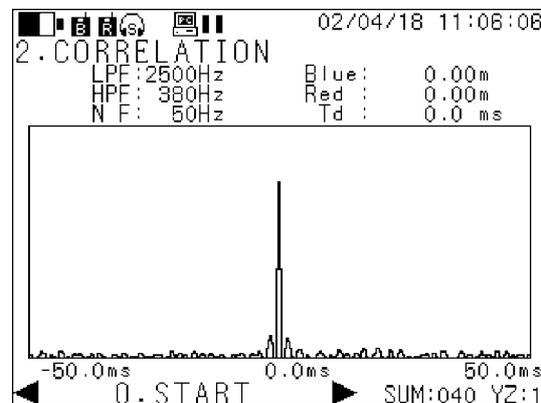
- ① Turn on both the main unit and blue pre-amplifier.
- ② The symbol shown left appears on the upper section of the main unit LCD. No indication shows the signals from the pre-amplifier do not reach the main unit. If this is your case, the main unit cannot receive the signals due to environmental conditions or the pre-amplifier's transmission system or the main unit's receiving system may be faulty. Conduct the same checking for the red pre-amplifier (R is observed instead of B).

### (2) Main unit and pick-up sensors

- Checking the correlation

- ① Plug the pick-ups in both the blue and red pre-amplifiers respectively and turn on the units.
- ② Turn on the main unit.
- ③ Access the main menu of the main unit and select "2. CORRELATION".
- ④ Rub the pick-up magnets (bottom surfaces) each other.
- ⑤ Check the following operation result and correlation waveform appears on the correlation screen.

The delay time is  $T_d=0.0$  ms. The peak correlation waveform is displayed at the position where this delay time is 0.0 ms.

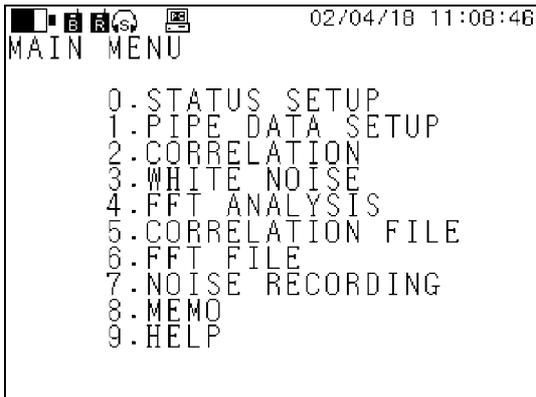


**Note 1 :** Do not rub the pick-ups strongly. Otherwise,  $T_d$  might not be 0.0 ms.

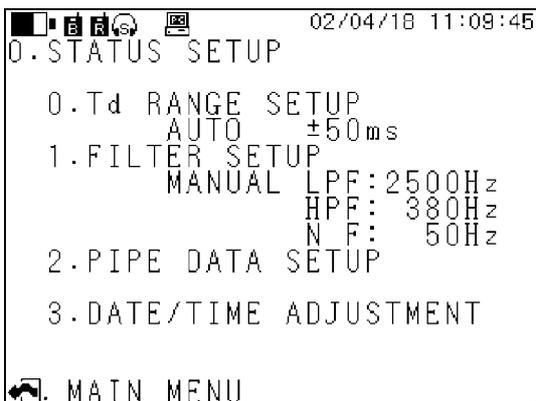
**Note 2 :** When contaminants such as mud are adhered to the magnet,  $T_d$  might not be 0.0 ms. Before checking, remove these contaminants.

### 3-6 Setup of Date and Time

The current time (last two digits of Christian Era, month, day, hour, minute, and second) is displayed on the upper right corner of the LCD. Check the date and time. If they differ from the current ones, conduct resetting according to the following procedure. The date and time determined will be saved together with the measured data and, therefore, you should provide correct setting.



Select “ 0. STATUS SETUP ” from the main menu.



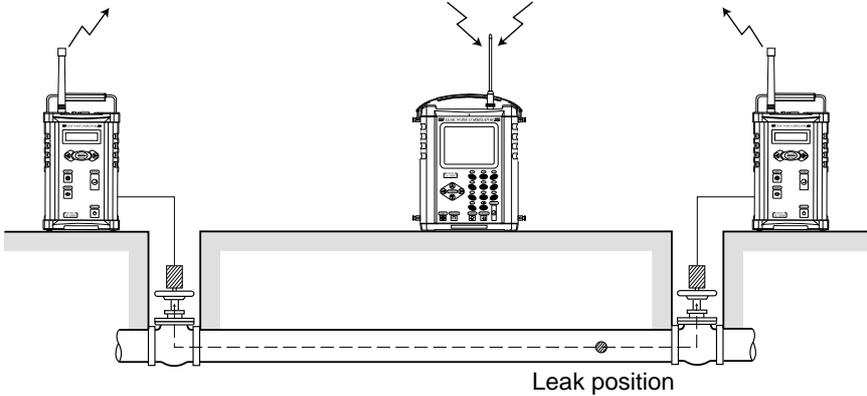
Select “ 3. DATE/TIME ADJUSTMENT ” from the main menu.



The cursor appears. Move the cursor to the parameter you want to change and enter the value. Then, press the Escape key. The previous screen reappears. This sets the new date and time.

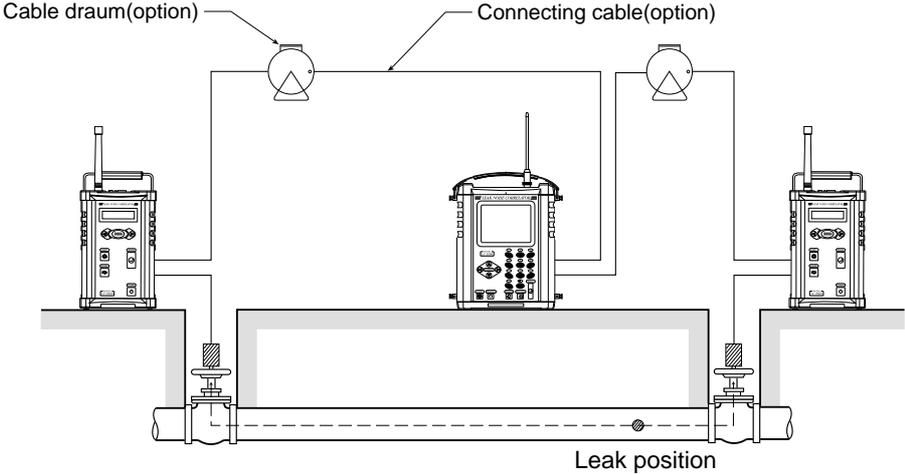
4-1 Radio and Cable Modes

(1) Radio mode



(2) Cable mode

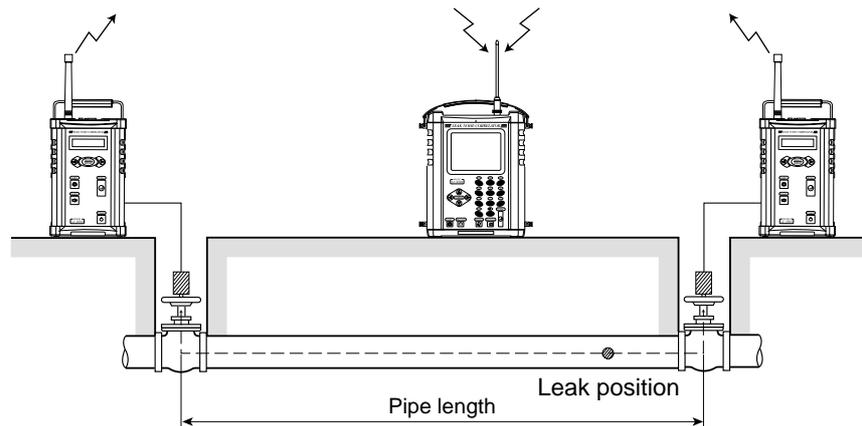
This mode is used when the radio communications cannot be established between leak detector and pre-amplifiers due to interference with buildings and the like or the radio waves interfere with those emitted from any radio stations. Usually, the leak detection is implemented under the radio mode shown in (1) above.



## 4-2 Example of Operation

This section describes how to operate the leak detection for the pipe shown below.

In this example, it is assumed that the water leaks from a certain position of the pipe. The pre-amplifiers detect the leak noise and send the signals to the main unit.



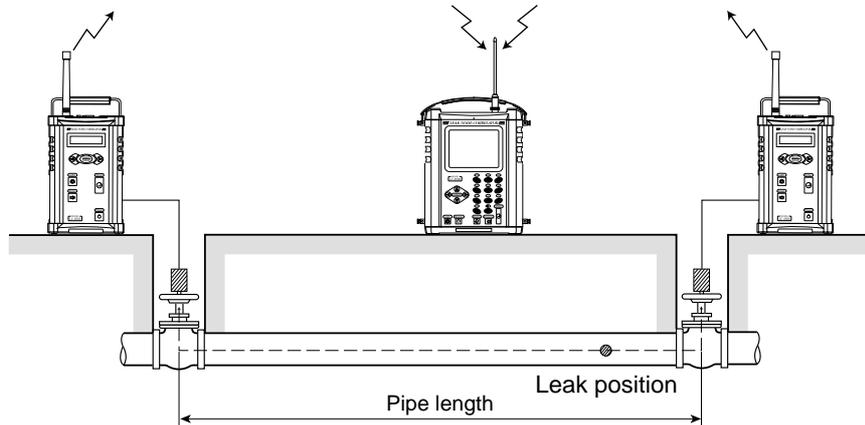
## 4-3 False Leak Noise

When the blue and red pick-ups detect other noise than leak noise, the correlator will identify the noise source as leak position and display the data on the LCD. When the correlator reports the leakage, you should check whether the pipe is actually embedded and has leakage by means of another water leak detection device, bowling, and investigation.

- **False leak noises include the following items.**
  - (1) Friction noise between flowing water and pipe
  - (2) Noise generated from sewage
  - (3) Noise generated from flowing water
  - (4) Mechanical noise

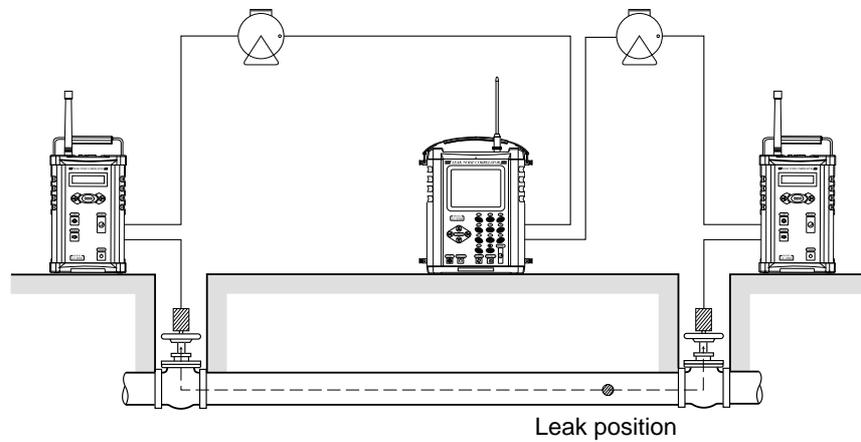
## 4-4 Preparations

### (1) Radio mode



- Insert battery boxes into the main unit and pre-amplifiers.
- Mount the receiving antenna to main unit.
- Plug pick-ups in the pre-amplifiers, respectively.
  - \* If you do not connect the pick-up sensor, an error message “No sensor connection” appears when the pre-amplifier is turned on.
- Turn on the main unit and pre-amplifiers.

**Note :** The two pick-ups must have the same specifications. The standard pick-up cannot be used together with the pick-up for VP pipe (option).

**(2) Cable mode (the cable drum and connecting cable are optional)**

- Insert battery boxes into the main unit and pre-amplifiers.
- Arrange cables from cable drums to pre-amplifiers.
- Plug the cable in each pre-amplifier.
- Plug in the main unit by use of the connecting cable from each cable drum.
  - \* Identify the blue and red pre-amplifiers to avoid illegal cable connection.
- Plug pick-ups in the appropriate pre-amplifiers.
  - \* If you fail to connect the pick-up, an error message “No sensor connection” appears when the pre-amplifier is turned on.
- Turn on the main unit and pre-amplifiers.

**Note :** After turning on main unit, check the following symbol appears on the LCD.



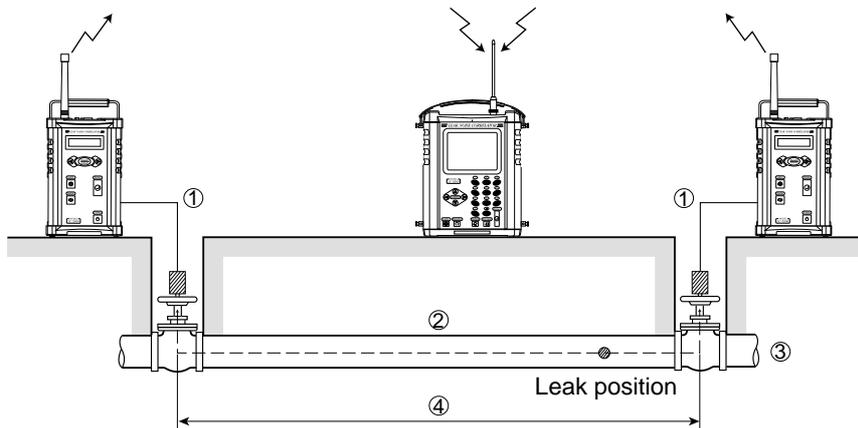
: Cable mode indication symbol

- After pulling out the cable from the cable drum, plug it in the main unit. If the connecting cable has been connected to the main unit in advance, the cable will be twisted and damaged by means of rotating cable drum.

## 4-5 Preparation at Site

### (1) Preparation of necessary conditions and data

To find the leak position with the correlator as shown below, the following four conditions as well as data must be needed.



- ① The noise generated from the leak position is transmitted to both the pick-ups.
  - \* If the noise is transmitted to only one pick-up, the leak position cannot be identified. In such the case, try to reduce the distance between pick-ups.
  - \* The existence of leak noise must have been identified based on the pre-investigation.
- ② The material of the target pipe is identified.
  - \* The reason is that the sound velocity (propagation speed of the leak noise) depends on the pipe material.
- ③ The bore of the target pipe is identified.
  - \* The reason is that the sound velocity (propagation speed of the leak noise) depends on the bore.
- ④ The pipe length between pick-ups is identified.

## **(2) Installation of pick-ups**

- ① The candidate pick-up mount positions include fire hydrant, gate valve, and meter. Determine the mount positions and install the pick-ups.
  - \* Since the pick-up is completely waterproof, it can be immersed into the water.
  - \* According to Section 3-4 “ Inspection of Pre-amplifiers ”, check the signals from each pick-up reach the appropriate pre-amplifier.
  - \* Check the mount positions and pick-up magnets are free from contaminants such as mud. The contaminants may prevent correct leak detection.
- ② When several leak positions exist on the same pipe (including branch pipe), determine the pick-up mount positions so that the position that is generating the largest leak noise is located between these positions.

## **(3) Operation of pre-amplifiers**

- ① Plug the pick-up in each pre-amplifier.
  - \* When the pre-amplifier is turned on without connection of pick-up, an error message “ No sensor connection ” appears.
- ② Tap lightly on each pick-up magnet to check signals are certainly reaching the pre-amplifier.
- ③ To set the sensitivity of the pre-amplifier manually, adjust it so that the normal signal level will be 5 or 6.

## 4-6 Menus on Main Unit

### (1) Operation on main unit

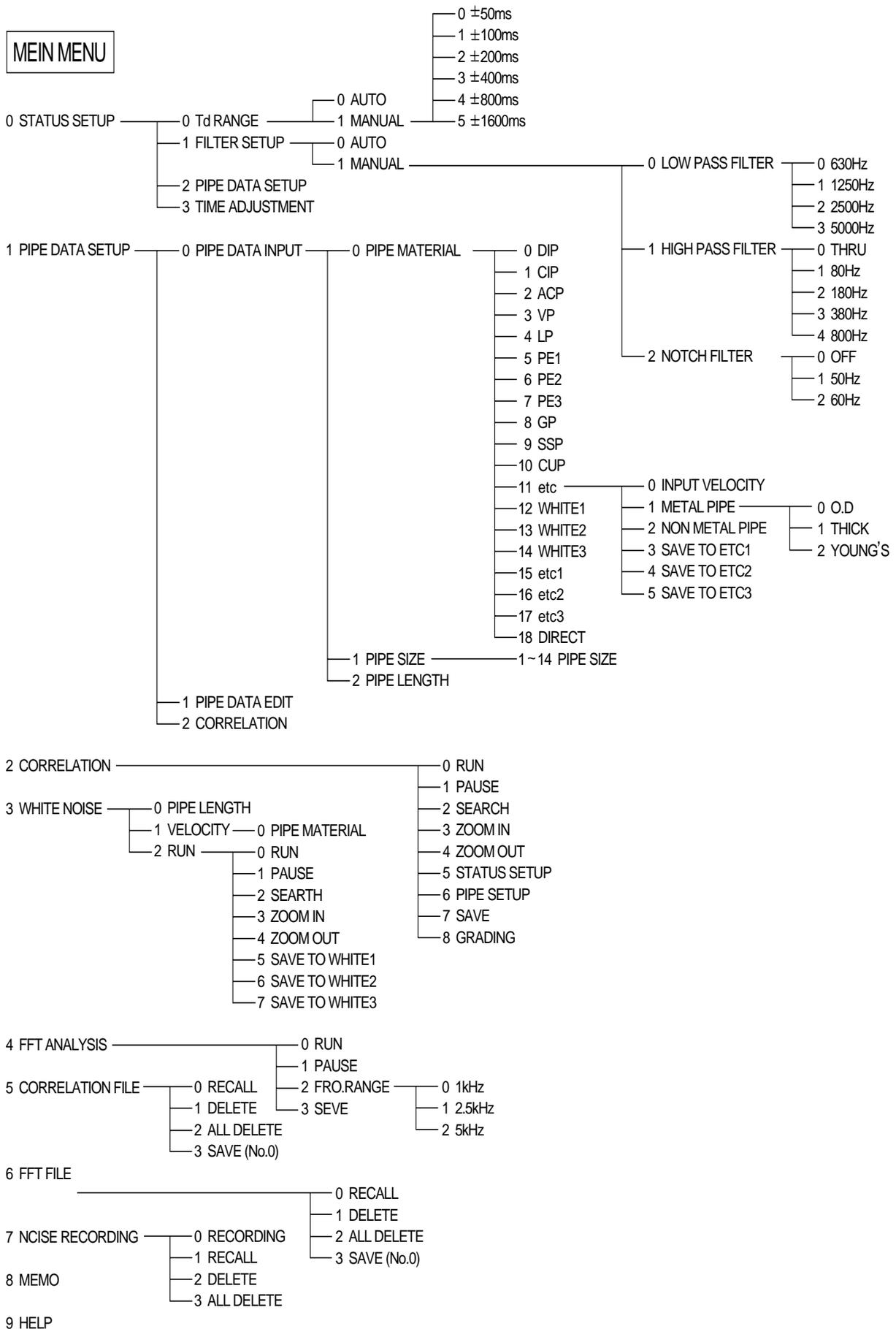
An interactive system is employed for operations on the main unit. Operate the equipment by following the messages displayed on the screen.

- Start the operation from the main menu.
- Select the desired menu with the numeric key and confirm the selection with the Enter key. (This procedure may be omitted depending on the situation.)
- The following indication, if observed at the bottom of the screen, shows that pressing the Escape key returns you to the previous screen.

#### MAIN MENU

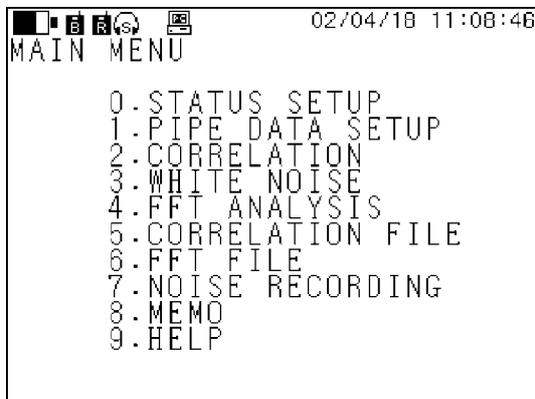
- After the numerical parameters such as pipe length are input, pressing the Enter key confirms those parameters.
- The following indication, if observed on any of screens, including leak position detect screen, selecting “ 0 ” starts detection of leakage. Pressing up, down, right or left button of the CURSOR key changes the menu items among “ 1. Pause ” through “ 8. Evaluation ” so that you can select the desired menu item.

◀ 0. START ▶



## 4-7 Menu on Main Unit

### <MAIN MENU>



After the main unit is turned on, “FUJI TECOM” appears in the center of the screen and changes to the main menu shown left several seconds later. This section describes this main menu. The current date and time appear on the upper right corner of the screen. When the date and time are not correct, provide resetting by referencing Section 3-6 “Setup of Date and Time”.

#### 0. STATUS SETUP

You can specify the Td range, filters, and date and time. In addition, you can access “ 1. Set Pipe Conditions ” from this menu.

#### 1. PIPE CONDITION SETUP

You can enter or change the pipe data (material, bore, and length). After the data input, you can directly access “ 2. Leak Position Detect ” from this menu.

#### 2. CORRELATION

You can start the detection after the necessary conditions are defined. The leak position and correlation waveform, which were processed based on the data obtained from the measurement, are displayed. The result of operation can be saved to the internal memory.

- \* The result is saved to the internal memory by selecting “ 2. Correlation ” - “ 7. Save ”.
- \* The number of data savings is 100.

#### 3. WHITE NOISE (Pipe Length / Sound Velocity Measurement)

When the pipe data is incomplete, you can measure the pick-up-to-pick-up distance and the sound velocity of the leak noise through this menu to complement the data. The calculated sound velocity can be saved to the internal memory.

The calculated sound velocity is saved to the internal memory by selecting “ 3. White Noise ” - “ 2. Measurement ” - “ 5. WHITE1 ”/“ 6. WHITE2 ”/“ 7. WHITE3 ”.

#### 4. FFT ANALYSIS

The leak noise data collected with the pick-ups is subject to frequency analysis and the result is plotted as a graph. The result can be saved to the internal memory.

- \* The result is saved to the internal memory by selecting “ 4. Waveform Monitor ” - “ 3. Save ”.
- \* The number of data savings is 50 for blue and red pick-ups respectively (i.e., 100 in total).

**5. CORRELATION FILE**

The data processed with the menu “ 2. CORRELATION ” can be saved to the internal memory. This data processing menu displays, deletes, or all-deletes the data saved.

**6. FFT FILE**

The data processed with the menu “ 4. FFT ANALYSIS ” can be saved to the internal memory. This data processing menu displays, deletes, or all-deletes the data saved.

**7. NOISE RECORDING**

The leak noise measured with the pick-ups is recorded to the internal memory. This data processing menu records, replays, deletes, or all-deletes the data.

\* The recording time is about 16 seconds for one data set.

\* Up to four data sets can be recorded.

**8. MEMO**

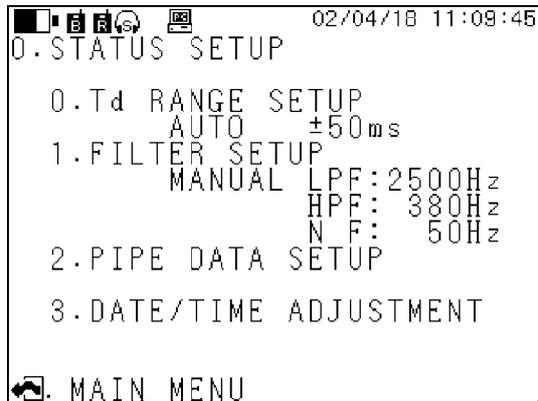
You can enter up to 227 characters showing necessary information, for example, site situation.

\* Only alphanumeric and basic symbols can be used.

**9. HELP**

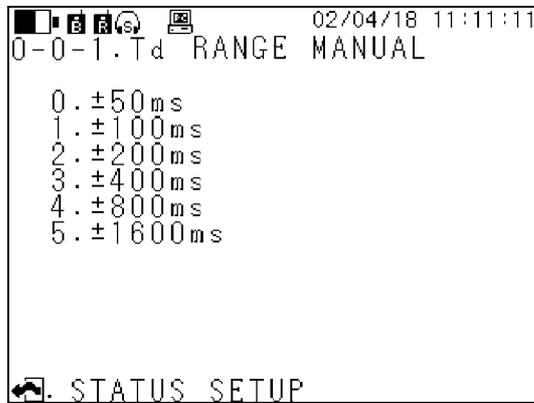
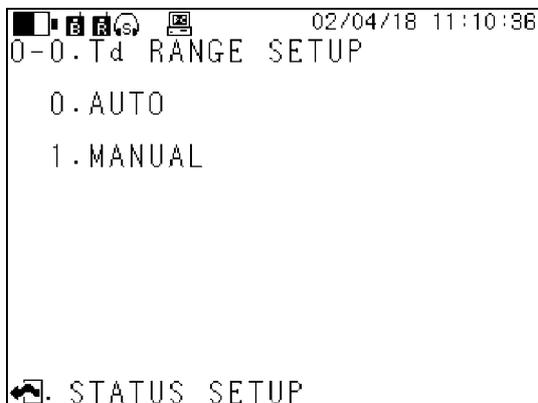
When this menu is selected, descriptions about keys and menus appear on the screen.

\* The data save function will be discussed in Chapter 5 “Practice” in detail.

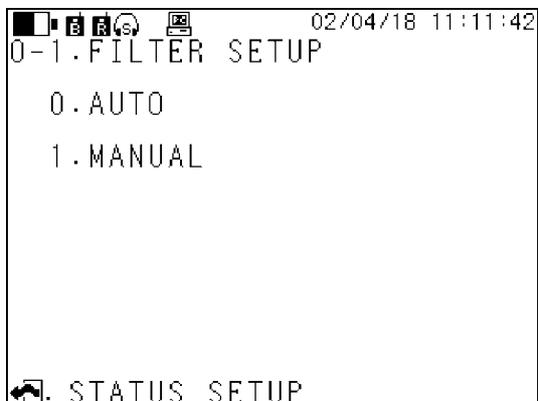
**< 0 : STATUS SETUP >**

When “0. STATUS SETUP” is selected from the main menu, the screen shown left appears.

This screen contains the previously set values.

**0. Td RANGE SETUP**

You can specify the Td range (delay time). Two modes, automatic and manual, are available and the automatic mode has already been selected as shipping default. Normally, you should use the automatic mode. When the manual mode is selected, TdMax is displayed in the pipe condition setup menu and, therefore, you should specify Td so that it will not exceed the maximum value.

**1. FILTER SETUP**

You can specify high-pass, low-pass, and notch filters. Two modes, automatic and manual, are available and the automatic mode has already been selected as shipping default. Normally, you should use the automatic mode.



When the manual mode is selected, generally set the filters by referencing the following examples.

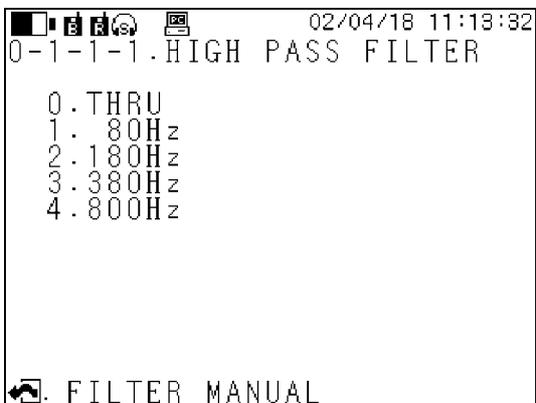
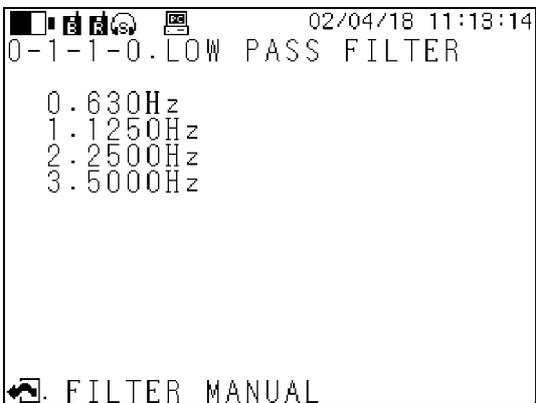
High-pass filter: 380 Hz

Low-pass filter: 2500 Hz

For resin pipes, the leak noise contains lots of low-frequency components and, therefore, the following settings may improve the filter performance.

High-pass filter: 80 Hz

Low-pass filter: 630 Hz



The notch filter will be discussed in Chapter 5 “Practice” in detail. Generally, turn on this filter.

- When the automatic mode has been selected, the notch filter is turned off.

## 2. PIPE DATA SETUP

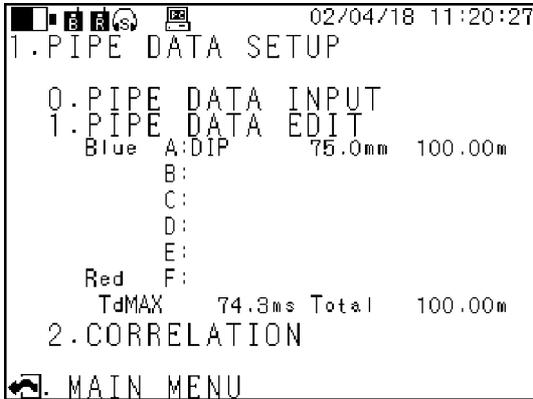
This menu will be discussed in the next paragraph.

## 3. CALENDAR AND TIME SETUP

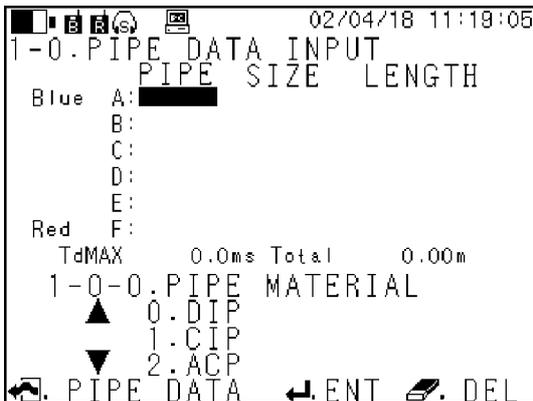
You should use this menu when it is necessary to set or change the date and time. For the procedure, see Section 3-6 “Setup of Date and Time”.

< 1 : PIPE DATA SETUP >

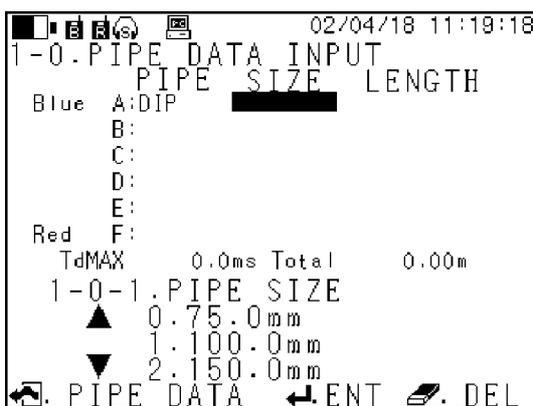
0. PIPE DATA INPUT



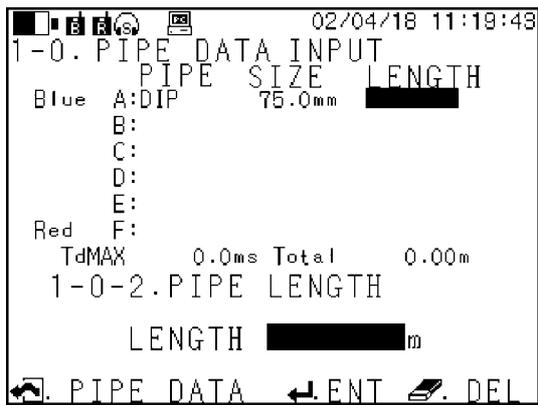
After “ 1. PIPE DATA SETUP ” is selected from the main menu, the screen shown left appears. This screen contains the previously set values. You can enter the material, bore, and length of the pipe.



Select “ 0. PIPE DATA INPUT ”. A part of the pipe material list appears at the bottom of the screen as shown left. Move up or down the cursor with the up or down button of the CURSOR key to find and select the material number corresponding to the embedded pipe.



After the material is confirmed, the cursor appears on the bore. A part of the bore list appears at the bottom of the screen, as seen in the material. Move up or down the cursor with the up or down button of the CURSOR key to find and select the bore number.



After the confirmation, the cursor appears on the length. Enter the pipe length with the numeric keys.

When you intend to measure multiple pipes, enter the parameters to “B” and following fields one after another.

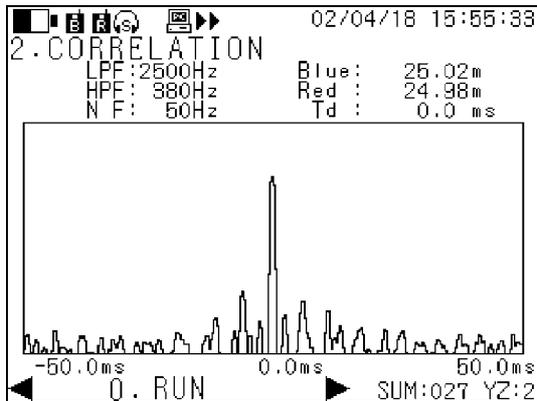
### 1. PIPE DATA EDIT

You can change or add the pipe data. For the data input, see the previous paragraph.

### 2. LEAK POSITION DETECT

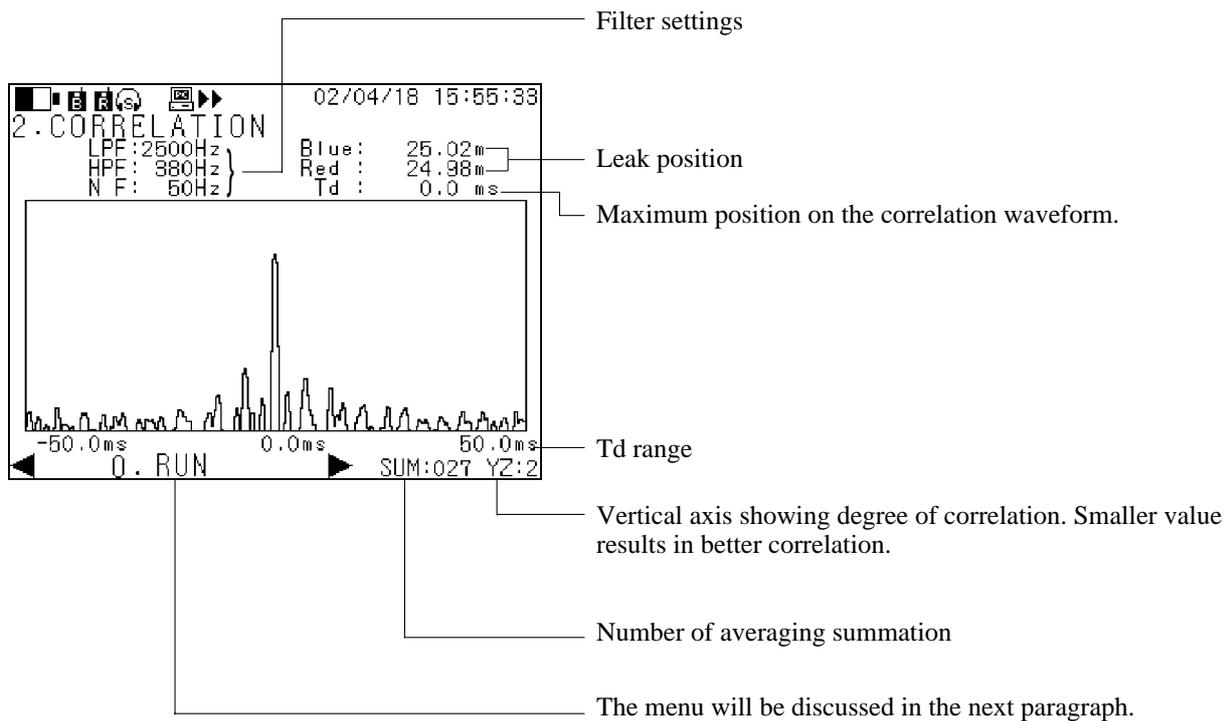
This function will be discussed in the next paragraph “2 : CORRELATION”.

< 2 : CORRELATION >



After the parameter setup is complete in “ 0 : STATUS SETUP ” and “ 1 : PIPE DATA SETUP ”, selecting “ 2. CORRELATION ” from the main menu displays the screen shown left. The leak position is calculated based on the set parameters. After the calculation is completed, the distances to the leak position from blue and red pre-amplifiers are displayed.

- This screen shows the distances from blue and red pickups are both 0 m. The symbol shows ►► that the leak position is under calculation. During the calculation, the value in SUM at the bottom is increased one after another. This value shows how many times the calculation is iterated (the maximum is 999). Larger SUM value provides higher reliability of the calculation result.



## About menu

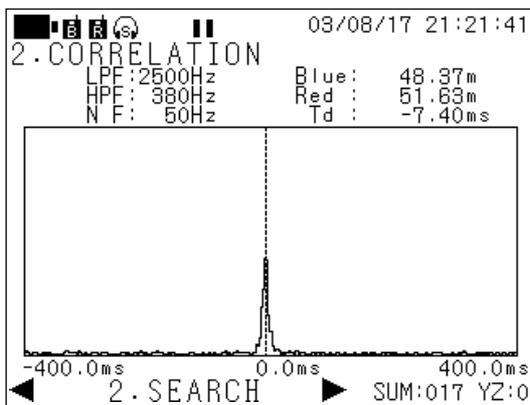
### 0. RUN

You should select this menu to start the calculation. To recollect the data, select “1. PAUSE ” once and start the calculation.

### 1. PAUSE

This menu suspends the calculation. To resume the calculation, select this “ 1. PAUSE ” again. When you press “ 0. START ” mistakenly, the current calculation result is cleared and the calculation is initiated from the beginning (i.e., SUM is reset to 0). Basically, when you want to go to the next sequence (such as save) from the calculation process, be sure to activate this pause function.

### 2. SEARCH



When this menu is selected, the cursor appears on the correlation waveform. As a default, the cursor is automatically located at the position with the highest degree of correlation. You can move the cursor horizontally with left and right buttons of the CURSOR key. Move the cursor when several correlation peaks are observed. When the cursor is moved, Td, Blue, and Red values are changed accordingly.

When “ 2. SEARCH ” is selected again, the cursor disappears.

### 3. ZOOM-UP

This menu magnifies the horizontal axis of the correlation waveform.

### 4. ZOOM-DOWN

This menu reduces the horizontal axis of the correlation waveform.

### 5. 0 : STATUS SETUP

This menu allows you to enter into the condition setup screen.

### 6. 1 : PIPE DATA SETUP

This menu allows you to enter into the pipe condition setup screen.

### 7. SAVE

This menu saves the measured leak position data to the internal memory.

### 8. EVALUATION

This menu will be discussed in Chapter 5 “ Practice ”.

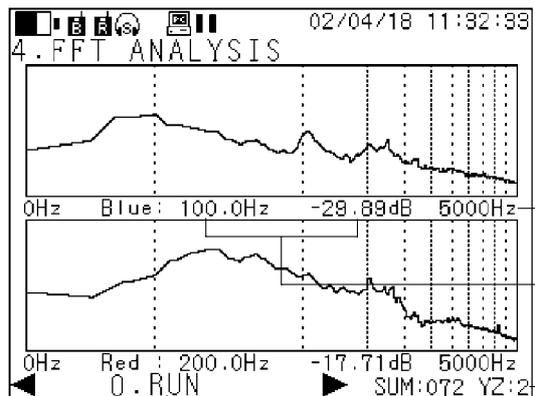
**< 3. WHITE NOISE >**

When the pipe data is incomplete, you can measure the pick-up-to-pick-up distance and the sound velocity of the leak noise through this menu to complement the data.

This menu will be discussed in Chapter 5 “Practice” in detail.

**< 4. FFT ANALYSIS >**

When “4. FFT ANALYSIS” is selected from the main menu, the screen shown below appears. The upper waveform shows the result of the frequency analysis for the data collected with the blue pick-up while the lower waveform shows the result of the frequency analysis for the data collected with the red pick-up. The vertical and horizontal axes show signal level and frequency, respectively. The frequency (horizontal axis) can be changed with the menu “2. FREQUENCY RANGE”.



Frequency range

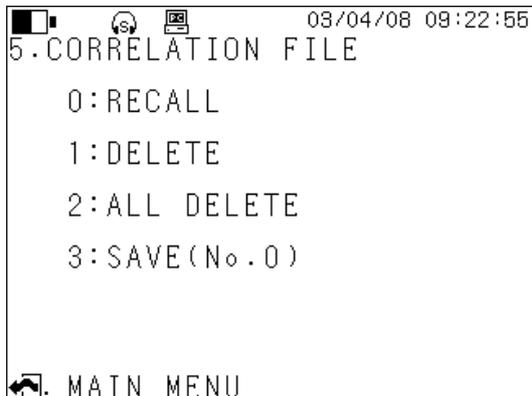
Frequency and maximum signal level

Magnification factor of vertical axis. Smaller value shows larger leak noise.

Number of averaging cycles

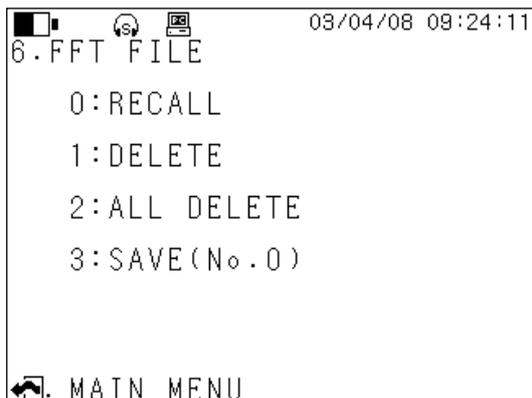
Menu. It has the following contents.

- 0. RUN : Starts the calculation.
- 1. PAUSE : Suspends the calculation. To resume the calculation, reselect this menu.
- 2. FREQUENCY RANGE : Changes the display range of the horizontal axis (1, 2.5, and 5 kHz ranges are available).
- 3. SAVE : Saves the measured waveform monitor data to the internal memory.

**< 5. CORRELATION FILE >**

When “ 5. CORRELATION FILE ” is selected from the main menu, the screen shown left appears. You can display, delete, or all-delete the leak position data saved. Selecting the desired item displays the list that contains data file numbers as well as corresponding measurement dates and times. Select the file number to be displayed or deleted with the numeric key, and confirm it. When “ 2. All DELETE ” is selected, a confirmation message pops up. When you really want to delete all the data, acknowledge the deletion.

- The deleted data cannot be recovered.

**< 6. FFT FILE >**

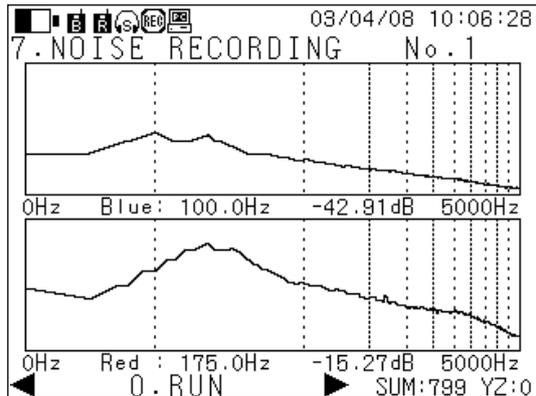
When “ 6. FFT FILE ” is selected from the main menu, the screen shown left appears. You can display, delete, or all-delete the waveform monitor data saved. Selecting the desired item displays the list that contains data file numbers as well as corresponding measurement dates and times. Select the file number to be displayed or deleted with the numeric key, and confirm it. When “ 2. All DELETE ” is selected, a confirmation message pops up. When you really want to delete all the data, acknowledge the deletion.

- The deleted data cannot be recovered.

**< 7. NOISE RECORDING >**

When “ 7. NOISE RECORDING ” is selected from the main menu, the screen shown left appears. You can record, replay, delete, or all-delete the leak noise data collected with the pick-ups. When “ 0. RECORDING ” is selected, the main unit prompts the file number to which the recorded noise data will be saved. After you select the file number, the main unit furthermore prompts you to determine whether the recorded noise data is saved or not. If the current file number is OK, press the Enter key.

- If the data has already been saved to the selected file number, pressing the Enter key will erase the existing data.



During the recording, the same screen as the waveform monitor is displayed as shown left. While the leak noise is being recorded, the following menus are active.

0. RUN

1. PAUSE (also used for reexecution)

After the leak noise is recorded for sixteen seconds, the screen stops movement. When “0. RUN” is selected during the recording or standstill mode, or after the elapse of sixteen-second recording time, recording is restarted and the existing data is lost.

To save the data, press the Escape key to return to the previous screen. Even if the recording time is less than 16 seconds, the data already recorded will be saved.

  : During the replay, the symbol shown left is observed in the center of the screen.

  : During the recording, the symbol shown left is observed in the center of the screen.

Selecting any of menus 1 through 3 displays the list that contains data file numbers as well as corresponding measurement dates and times. Select the file number to be displayed or deleted with the numeric key, and confirm it. When “2. ALL DELETE” is selected, a confirmation message pops up. When you really want to delete all the data, acknowledge the deletion.

- The deleted data cannot be recovered.

**< 8. MEMORANDUM >**

When “8. MEMO” is selected from the main menu, the screen shown left appears. You can enter up to 227 characters showing necessary information, for example, site situation. First, the cursor appears on the alphanumeric table at the bottom.

Enter the note in alphanumeric and press the Enter key to confirm it. Now, the note appears from the upper left corner in the frame. To edit the note, move the cursor to EDIT on the bottom corner and select it. The cursor appears in the frame. Move the cursor to the desired position and press the Enter key. This allows you to enter characters.

After you complete entering the note and return to the main menu with the Escape key, the note will automatically be stored.

When the main unit is turned off on this memo screen, the memo will be erased. When the Delete key is pressed on this memo screen, all the data being displayed on the screen will be deleted.

**< 9. HELP >**

When “9. HELP” is selected from the main menu, the screen shown left appears. This screen contains descriptions about keys and menus. You should use this menu when you are not confident on how to operate the equipment on site. The next paragraph describes the contents.

**Help menu list****● KEY FUNCTION**

- 0-9 : Enters numerical values or selects a menu.  
 . : Enters a decimal point.  
 Enter : Confirms the input.  
 Escape : Returns to the previous screen.  
 Delete : Erases the numerical values input.  
 CURSOR : Moves the cursor or selects the item.  
 Monitor : Changes the headphone output.  
 Light : Turns on/off the backlight.

**● MAIN MENU****0 : STATUS SETUP**

Specifies the Td range, filters, and calendar and time.

**0-0 : Td Range Setup**

Selects automatic or manual setup. When the automatic mode is selected, the Td range is automatically set based on the pipe conditions. When the manual mode is selected, you should select the Td range from the table.

**0-1 : Filter Setup**

Selects automatic or manual setup. When the automatic mode is selected, the main unit internally processes the signals sent from the pick-ups and select suitable low-pass and high-pass filters, and/or notch filter.

When the manual mode is selected, you should select suitable low-pass and high-pass filters, and/or notch filter from the table.

**0-1-2 : Notch Filter**

Cuts the commercial frequencies and their harmonics.

**0-2 : Calendar and Time Setup**

Specifies the calendar (year, month, and day) and time.

**1 : PIPE DATA SETUP**

You can enter or change the pipe data, and execute leak detection.

**1-0 : Pipe Data Input**

Specifies the material, bore, and length of the pipe.

**1-0-0 : Pipe Material**

You should select the appropriate pipe material from the table.

**1-0-0-11 : etc**

When the pipe material is unknown, you can directly enter the sound velocity or calculate the sound velocity from the external bore, wall thickness, and Young's modulus of the pipe.

**1-0-0-11-1, 2 : Metal Pipe or Resin Pipe**

You should select metal or resin pipe to calculate the sound velocity.

**1-0-0-11-3, 4, 5 : Save to etc1/2/3**

You can save the calculated sound velocity to etc1, 2, or 3.

**1-0-0-12, 13, 14 : WHITE1/2/3**

Sound velocity calculated by the white noise method.

**1-0-0-15, 16, 17 : etc1/2/3**

Calculated sound velocity for metal or resin pipe.

**1-0-1 : Pipe bore**

You should select the appropriate pipe bore from the table.

**1-0-1-20 : Sound Velocity Input**

You can directly enter the sound velocity.

**1-0-2 : Pipe Length**

You should enter the pipe length.

**1-1 : Pipe Data Change**

You can change the pipe data input.

**2 : CORRELATION**

You can detect the leak position.

**2-0 : Run**

Starts the leak detection.

**2-1 : Pause**

Suspends the leak detection.

**2-2 : Search**

Turns on/off the search function.

**2-3 : Zoom-up**

Magnifies the screen.

**2-4 : Zoom-down**

Reduces the screen.

**2-7 : Save**

Saves the measurement result.

**2-8 : Evaluation**

Evaluates the degree of abnormal noise detection based on the correlation waveform.

**3 : WHITE NOISE**

You can calculate the pick-up-to-pick-up distance or sound velocity.

**3-0 : Pipe Length**

You should use this menu when the length is known but the material and bore (sound velocity) are unknown.

**3-1 : Sound Velocity**

You should use this menu when only the material and/or bore (sound velocity) is known but the length is unknown.

**3-2 : Measurement**

You can measure the pipe length or sound velocity.

**3-2-5 : Save to WHITE1/2/3**

You can save the measurement result.

**4 : FFT ANALYSIS**

You can execute the frequency analysis for the data collected with the pick-ups.

**4-0 : Start**

Starts the frequency analysis.

**4-1 : Pause**

Suspends the frequency analysis.

**4-2 : Frequency Range**

Sets the frequency range (horizontal axis).

**4-3 : Save**

Saves the result of frequency analysis.

**5: CORRELATION FILE**

You can display, delete, or all-delete the leak position data saved.

**5-0 : Display**

Displays the specified leak position data.

5-1 : Delete

Deletes the specified leak position data.

5-2 : All Delete

Deletes all the leak position data saved.

**6 : FFT FILE**

You can display, delete, or all-delete the waveform monitor data saved.

6-0 : Display

Displays the specified waveform monitor data.

6-1 : Delete

Deletes the specified waveform monitor data.

6-2 : All Delete

Deletes all the waveform monitor data saved.

**7 : NOISE RECORDING**

You can record, replay, delete, or all-delete the leak noise.

7-0 : Record

Records the leak noise.

7-1 : Replay

Replays the specified leak noise data.

7-2 : Delete

Deletes the specified leak noise data.

7-3 : All Delete

Deletes all the leak noise data saved.

**8 : MEMO**

You can record the necessary information, for example, site situation.

## 4-8 Basic Data Input Operation on Main Unit

This section describes the basic flow for the detection of leak position.

- The following flow shows the operation in wireless communication mode.

- (1) Turn on the main unit, and check the battery power is enough and the equipment receives signals from each pre-amplifier.
- (2) Select “ 0 : Status Setup ” - “0. Td Range Setup ”- “ 0. Automatic Setup ”.
- (3) Select “ 0 : Status Setup ” -“ 0. Filter Setup ” -“ 0. Automatic Setup ” to set the filters.
- (4) Access “ 1 : Pipe Data Setup ” and enter the material, bore, and length of the target pipe.  
This completes the setting necessary to detect the leak position.
- (5) Select “ 2 : Correlation ”. The measurement is executed and the result appears on the screen.

To ensure the correctness of the result, manually set the Td range and filters, re-execute the measurement, and check the change from the previous data.

- Smaller Td range increases the resolution of data collection. Fuji Tecom recommends you to use small Td range as far as possible when the distance between pick-ups is short.



## 4-10 Pre-amplifier Menu

### < Sensitivity Adjustment >

You can select automatic or manual adjustment. Although the automatic adjustment will be discussed in Chapter 5 “Practice” in detail, selecting this mode processes the signals input from the pick-up and controls the pre-amplifier to a certain sensitivity level. In the manual adjustment, you should control the sensitivity by yourself. This time, set the sensitivity being careful that the level indicator will not exceeds the specified range. Fuji Tecom recommends that you should adjust the sensitivity while listening the noise from the speaker or headphone. Listening the noise helps you judge whether the sensitivity adjustment is appropriate or not.

- The screen where the signal level is displayed indicates the automatic or manual adjustment mode, whichever effective.
- After plugging in the headphone jack, press the Speaker key.



### CAUTION

- When listening the noise with the headphone, use complete care so that you will not hurt your ears.

### < Filter >

You can select the option whether the low-band noise is filtered or not. Usually, select STD. When the waveform monitored on the main unit contains many frequency components of less than 100 Hz, attempt the THRU setting. The correlation may be improved.

- Generally, external noises contain many frequency components of less than 100 Hz. Therefore, if even these components are collected with the pre-amplifier, the measurement result may be incorrect due to influence of unwanted noises.

## 4-11 Self-Check Function of Pre-amplifier

The pre-amplifier contains the following self-check functions.

### (1) Battery voltage check (the error message blinks)

After the pre-amplifier is turned on, this function works first. If the battery voltage is below the specified level, an error message appears on the screen and all the keys, except for the Power key, are disabled. This function is always working and, when the battery voltage gets below the specified level during the measurement, the same action will be implemented.

### (2) Pick-up connection check (the error message is highlighted)

When the pick-up is still not plugged in the pre-amplifier after power-on, an error message appears and you cannot access any other screen until the pick-up is connected to the pre-amplifier. This function prevents faulty pick-up connection.

### (3) Cable connection check

When the cable is plugged in the cable operation mode connector, the pre-amplifier automatically recognizes the cable and cuts the power to the radio transmitter.

## 4-12 Forced Turn-off Function

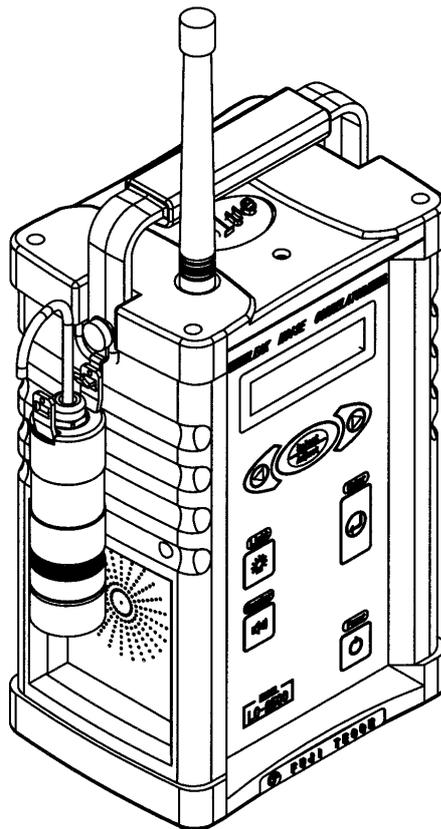
The power supply voltage is always monitored on the main unit and pre-amplifiers. When the battery voltage gets below the specified level, the operation of the equipment becomes unstable and resultantly the accurate measurement might not be continued. If the battery voltage gets below the certain reference level, the equipment is forcibly shut down. When this shutdown occurs, the LCD is turned off. Replace the batteries with new ones.

Forced turn-off threshold (main unit) : Less than 4.0 V

Forced turn-off threshold (pre-amplifier) : Less than 6.0 V

## 4-13 Pick-up Sensor Mount Hook

When you move on the site, the pick-up can be engaged to the pick-up mount hook as shown below.



## 4-14 Listening with Headphone

After the headphone is connected to this main unit and pre-amplifiers, you can listen the noise captured by the pick-ups. After plugging in the headphone jack, press the Speaker key.



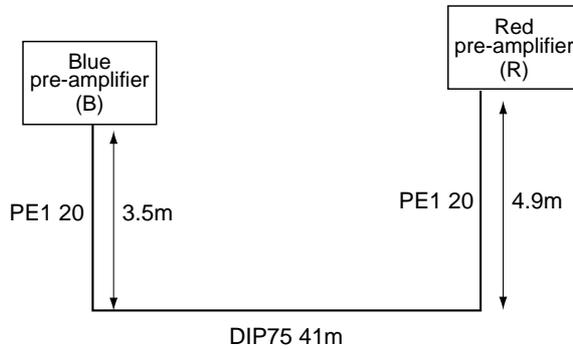
### CAUTION

- When listening the noise with the headphone, use complete care so that you will not hurt your ears.

# 5. Practice

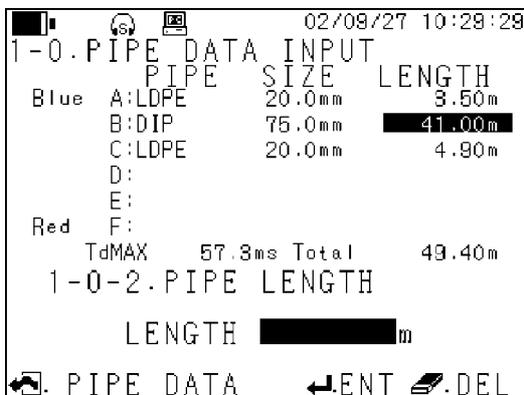
< Main Unit >

## 5-1 Pipe Data Handling



This section describes the data handling based on the example where three different types of pipes exist as shown above.

- To detect the leak position based on the multiple pipe data sets as shown in this example, be sure to enter the data starting from the blue pre-amplifier.



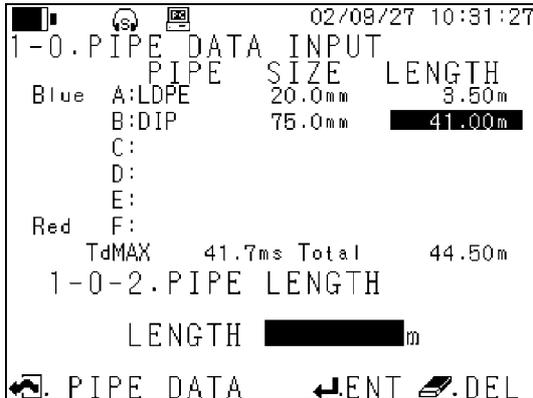
- Up to six pipe data sets, A to F, can be input.

For the data input procedure, see the relevant section in this manual.

The table below lists pipe materials and bores.

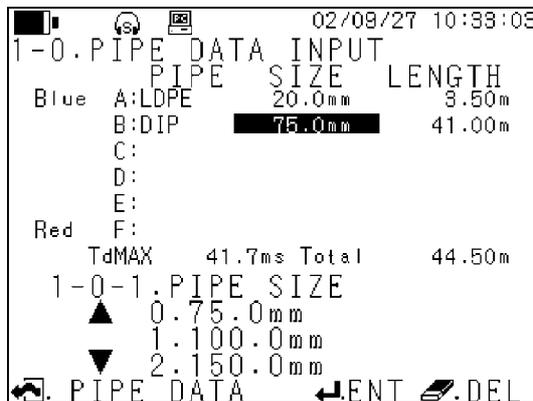
Material	Young's modulus, Mpa	Material	Young's modulus, Mpa
DIP	157000	HDPE	823
CIP	117500	PE MAINS	784
ACP	23500	SP	191000
PVC	3000	COP	124500
LEAD	15200	GALV (GP)	210000
LDPE	215		

**- Adding the pipe data -**



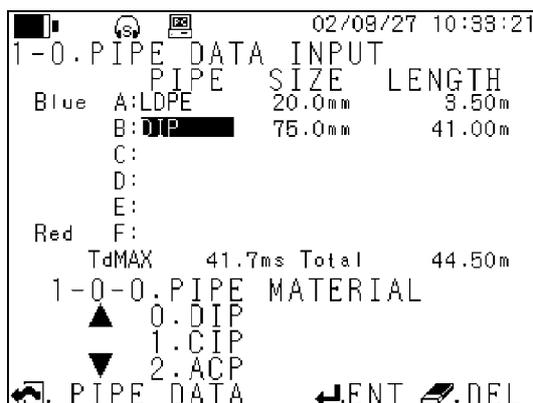
To add the pipe data, be sure to select “ PIPE DATA EDIT ”. When “ PIPE DATA INPUT ” is selected, new data input mode becomes active and resultantly the data already input is deleted. To add another pipe to “ C : ” in the condition shown left, press the Enter or CURSOR key. The cursor moves to the Material field of “ C : ”

**- Changing the pipe data -**



To change the pipe data, be sure to select “ PIPE DATA EDIT ”. When “ PIPE DATA INPUT ” is selected, new data input mode becomes active and resultantly the data already input is deleted. As shown left, move the cursor to the item you want to change, and change the data with numeric keys.

**- Deleting the pipe data -**



To delete the pipe data, be sure to select “ PIPE DATA EDIT ”. When “ PIPE DATA INPUT ” is selected, new data input mode becomes active and resultantly the data already input is deleted. As shown left, move the cursor to the Material field of the item you want to delete, and delete the data with the Delete key.

- This function deletes the data in the Material, Bore, and Length fields of the target item.

## 5-2 Waveform Monitor Function

This function uses DSP (Digital Signal Processor) built in the main unit and executes the FFT (Fast Fourier Transform) operation for the leak noise data collected with pick-ups to analyze the leak noise frequencies. The waveform monitor function can analyze the frequency components of the leak noise collected with pick-ups and help the filter setup (manual setup).

## 5-3 White Noise Method

To detect the leak position with this correlator, it is necessary that the material and bore (sound velocity) of the pipe, and the distance between pick-ups have been identified. If any of these parameters is unknown, the leak position cannot be measured. However, a part of the pipe data may be unknown depending on the site condition. The white noise method will be an effective solution. The white noise method can handle the following three cases.

Case	Material	Bore	Items to be obtained	
			Sound velocity	Distance
①	?	?	?	○
②	○	○	○	?
③	○	?	(Estimated value)	?

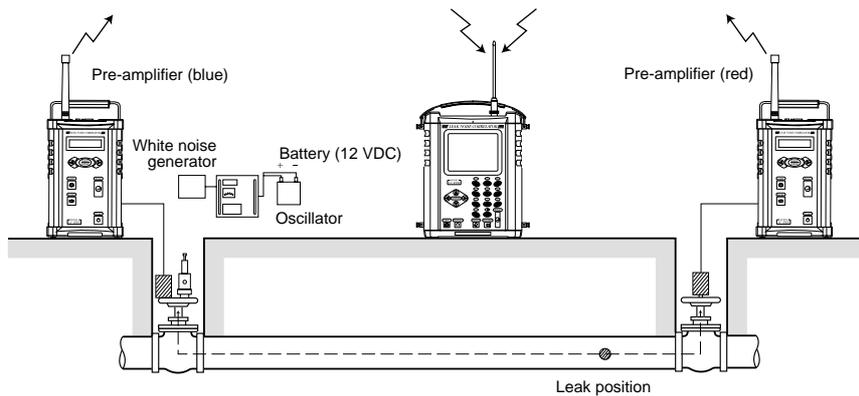
Using the white noise method, calculate the value identified with [?].

Upon completion of data calculation, enter the pipe data.

### - Principle of white noise method -

An white noise method is mounted to the same position as the blue pick-up, and the sound velocity and pick-up-to-pick-up distance are calculated from the time difference generated on the vibration sounds propagating to the red pick-up from the blue pick-up.

The following figure shows the system configuration for the white noise method. The white noise oscillator system (composed of oscillator and vibrator) is mounted to the same position as the blue pick-up.



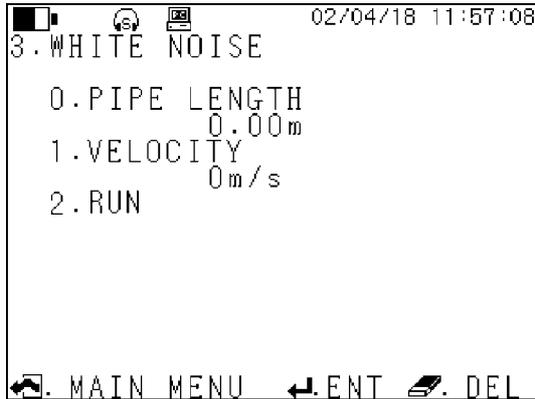
#### Caution

The white noise method can be used as long as the section between the pick-ups consists of only one pipe. When multiples pipes exist between the pick-ups, this method is invalid.

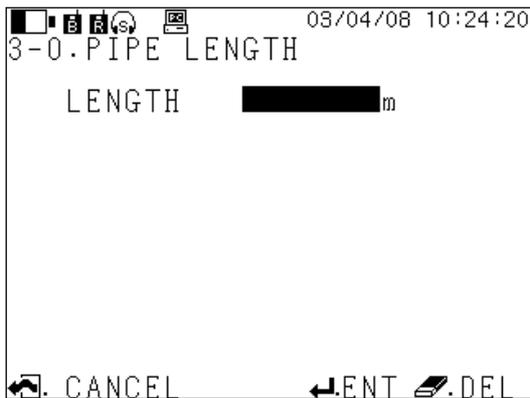
- The white noise oscillator system is optional unit.  
Please contact Fuji Tecom Inc. about its details.

The following paragraphs describe concrete operating procedures.

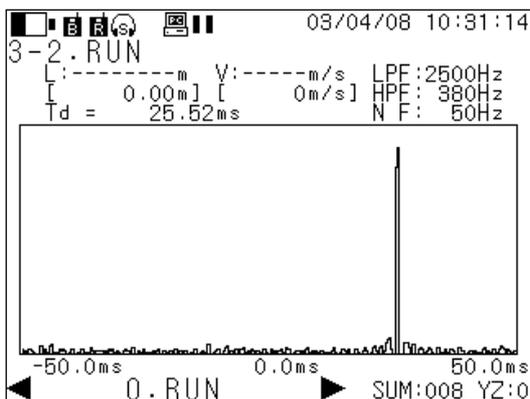
**Case (1) :**



Select “ 3. WHITE NOISE ” from the main menu. The screen shown left appears. Since the pipe length is known but the sound velocity is unknown in this case, select “ 0. PIPE LENGTH ”.



The screen shown left appears. Enter the pipe length.

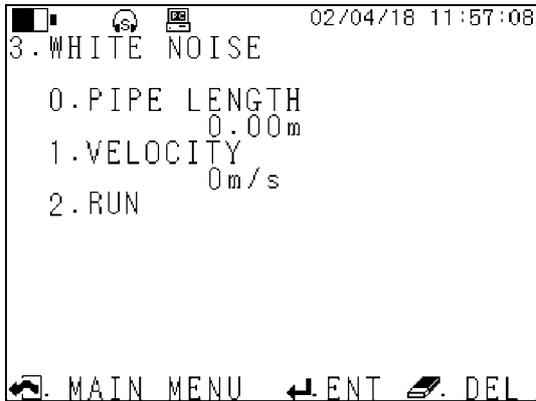


Return to the white noise screen with the Escape key and select “ 2. RUN ”. Although the values and calculation result are not shown in this screen, the calculated sound velocity is actually displayed in the field of “ V ”. Also, the input values are displayed in the parentheses. You can save the calculated value to the internal memory. To this end, use the menu “ 3 - 2 : RUN ” - “ 5. WHITE1 ” “ 6. WHITE2 ” “ 7. WHITE3 ”.

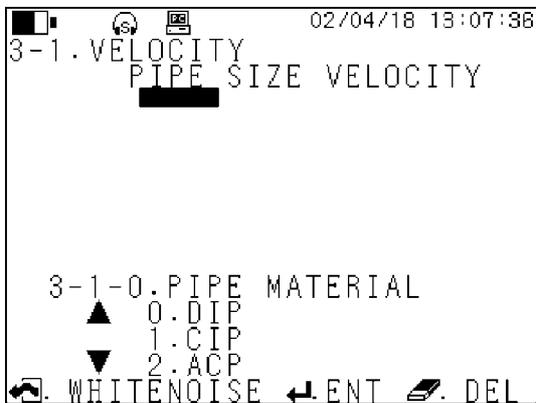
**<Saving the data>**

Basically, use the same operation as the leak position data. Select “ 3-2 : RUN ” - “ 1. PAUSE ” during the measurement. Change the menu and select “ 3-2-5 : Save to WHITE1 ”. The data will be saved to 1-0-0-12, 1-0-0-13, or 1-0-0-14 (WHITE1, 2, or 3 for pipe material).

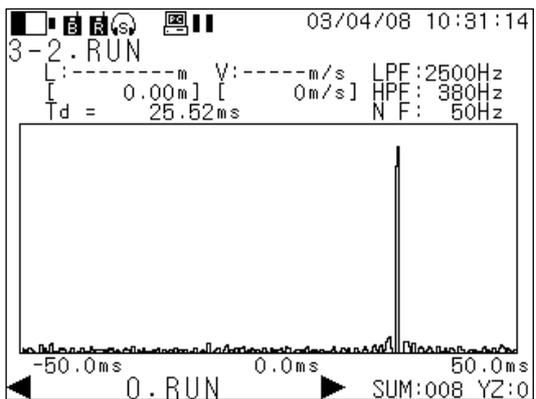
**Case (2) :**



Select “ 3. WHITE NOISE ” from the main menu. The screen shown left appears. Since the material and bore are known but the length is unknown in this case, select “ 1. VELOCITY ”



The screen shown left appears. Enter the sound velocity.



The calculated length is displayed in the field of “ L ”. Access the pipe data input screen and enter the value as pipe length.

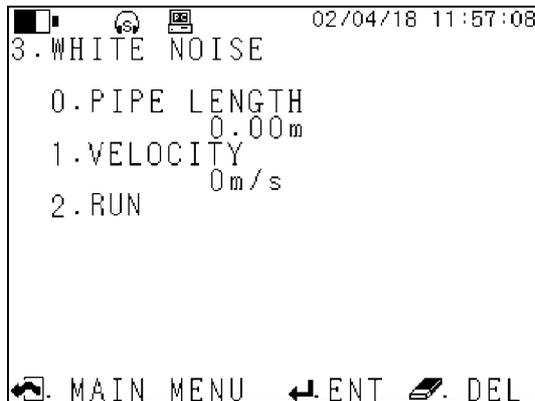
**Case (3) :**

In this case, both the bore (sound velocity) and length of the pipe are unknown and, therefore, the sound velocity data obtained from the pipe material type is input as an estimated value to temporarily detect the leak position.

For the sound velocities, see the table below.

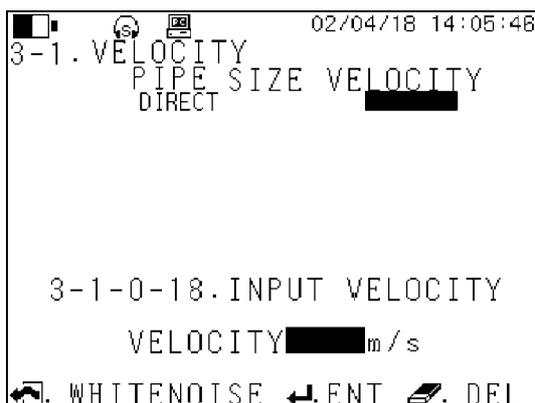
- The speed of the leak noise propagating inside the pipe generally depends on the material and bore. Metal pipes provide higher sound velocity than resin pipes while larger bore decreases the velocity for the same pipe material.

Material	Bore, mm	Sound velocity, m/s
Ductile iron pipe (DIP)	75 ~ 1500	1341 ~ 1039
Vinyl chloride pipe (PVC)	13 ~ 600	622 ~ 344
Polyethylene pipe (LDPE)	10 ~ 50	314
Polyethylene pipe (HDPE)	10 ~ 50	314 ~ 311

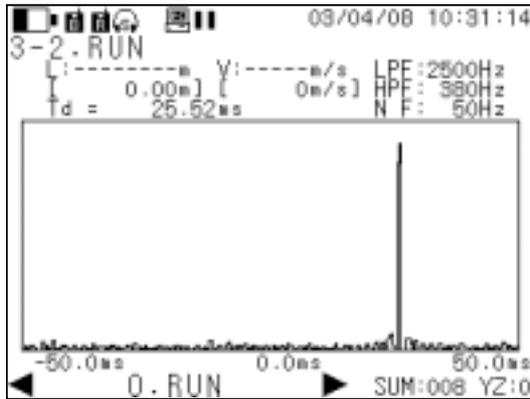


Select “ 3. WHITE NOISE ” from the main menu. The screen shown left appears. Both bore and length are unknown in this case. Therefore, estimate the sound velocity from the material and enter the estimated value.

Select “ 1. VELOCITY ”.



The screen shown left appears. Enter the estimated sound velocity. Select “ 18. DIRECT ” from “ 3-1-0. Pipe Material ”.



The calculated length is displayed in the field of “L”. Access the pipe data input screen and enter the value as pipe length.

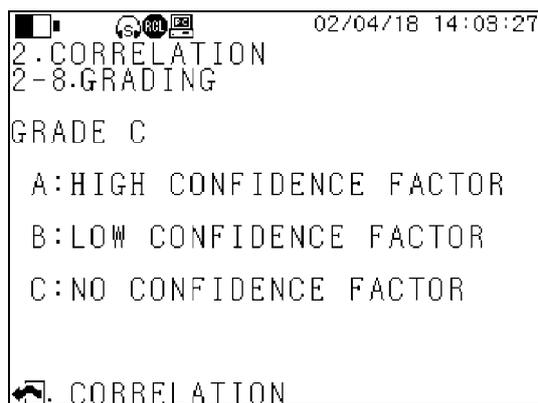
**Caution**

The distance, L, is calculated from the estimated sound velocity and, therefore, L is an approximate value.

### 5-4 Leak Noise Record Function

You can record and replay the leak noise data collected with pick-ups. In addition, the frequency analysis can be executed using the waveform monitor function. This means that during the record or replay process you can access the result of frequency analysis on the waveform monitor screen while listening the leak noise.

### 5-5 Evaluation of Detected Position



When “1. PAUSE” - “8. GRADE” is selected on the Correlation screen, the screen shown left appears. This screen shows the degree of correlation evaluated based on the leak position measurement. The evaluation is classified into three ranks,

- A, B, and C.
- { A : HIGH CONFIDENCE FACTOR.
- { B : LOW CONFIDENCE FACTOR.
- { C : NO CONFIDENCE FACTOR.

This evaluation is based on the correlation waveform and, therefore, you should use it as a guideline. Even when the evaluation result “A” is reported, there is necessarily no leakage.

## 5-6 Auto Filter

When you select “0. STATUS SETUP” - “1. FILTER SETUP” - “0. AUTOMATIC SETUP”, the leak detector automatically sets the filters. This function executes the FFT operation for the leak noise signals sent from the blue and red amplifiers, processes the frequency components under certain conditions, and determines appropriate filter setting. Basically, the filter setting is determined so that the major frequency components of the leak noise data will be included.

Upon completion of FFT operation, select “5. FILTER SETUP” from the menu. Now, the filters are set and the condition setup screen reappears.

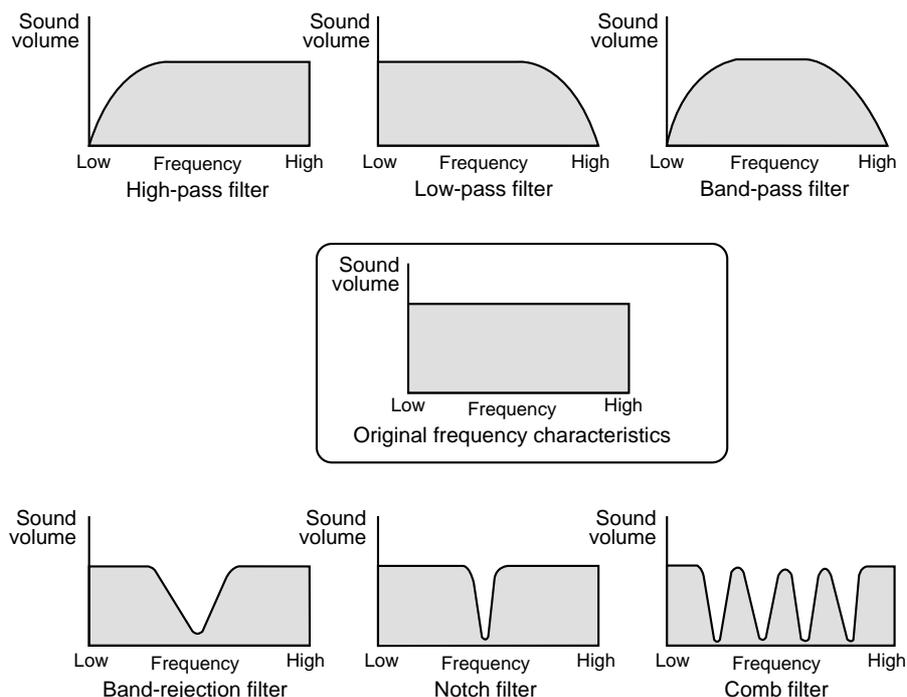
## 5-7 Notch Filter

After selecting “0. STATUS SETUP” - “1. FILTER SETUP” - “1. MANUAL SETUP” - “2. NOTCH FILTER”, you can select the notch filter setting from OFF, 50 Hz, and 60 Hz. OFF is the normal setting.

- The notch filter setting can be selected only in the manual mode.

The following paragraph describes filter types.

In addition to high-pass or low-pass filter, which cuts the frequency components above or below the certain level, there are various filters such as band-pass filter (BPF) that passes a certain frequency band, band-rejection filter (BRF) that does not pass a certain frequency band to some extent (this filter does not remove the relevant frequency band completely and, therefore, it is not called “band-cut filter”), notch filter (NF) that is one type of the band-rejection filter and handles the narrower band, and comb filter that is an aggregation of multiple notch filters.



As shown above, the notch filter cuts the components in a certain frequency band. Although multiple notch filters are combined in this leak detector and thus it may be appropriate to essentially call comb filter, the word “ notch filter ” is used for the sake of convenience. Five notch filters are used to process the 50 Hz and 60 Hz frequency bands, respectively. For 50-Hz band mode, the filters cut the harmonics in 50, 100, 150, 200, and 250 Hz bands. For 60-Hz band mode, the filters cut the harmonics in 60, 120, 180, 240, and 300 Hz bands. When it is likely that pick-ups acquire the harmonics in 50 and 60 Hz commercial bands, Fuji Tecom recommends you to use the notch filters in the detection of leak position.

### 5-8 Manual Calculation of Sound Velocity

This main unit stores sound velocities of various pipes in its internal memory. Basically available pipe materials and bores are stored to the memory, but they might not cover all the applications encountered. When parameters of the pipe (material and bore) are known but the data is not defined in the internal memory, you can calculate the sound velocity of the pipe from the outside diameter, wall thickness, and Young’s modulus (modulus of longitudinal elasticity).

When selecting “ 1. PIPE DATA SETUP ” - “ 0. PIPE DATA INPUT ” - “ 0. PIPE MATERIAL ” - “ 11. ETC ”, you can access the following options.

- 0. SOUND VELOCITY INPUT
  - 1. METAL PIPE
  - 2. RESIN PIPE
  - 3/4/5. SAVE TO ETC 1/2/3

The reason why metal and resin pipes are separately used is that the different equations are needed although they use the same data (outside diameter, wall thickness, and Young’s modulus) in calculation. For outside diameter, wall thickness, and Young’s modulus, refer to the relevant standard.

- The pipe manufacturers have the data. Since diameters and wall thickness are stipulated in the JIS standard, you should also refer to it.

List of Young's Modulus

Material	Young's modulus, Mpa	Material	Young's modulus, Mpa
DIP	157000	HDPE	823
CIP	117500	PE MAINS	784
ACP	23500	SP	191000
PVC	3000	COP	124500
LEAD	15200	GALV (GP)	210000
LDPE	215		

- Above figures are our survey data and for reference purpose only.  
After you select metal or resin pipe and enter the outside diameter, wall thickness, and Young’s modulus, the calculation is automatically executed. Upon completion of calculation, be sure to save the result to etc1, etc2, or etc3.

- Note that the result will not automatically be saved.

**Operation flow:**

Selection of “ 1. METAL PIPE ”    selection of “ 0. OUTSIDE DIAMETER ”    input of outside diameter  
selection of wall thickness    input of wall thickness    selection of Young’s modulus    calculation    selection of “ 3. SAVE TO ETC 1 ”.

After the above sequence is completed, the data will be saved to the internal memory of the leak detector.

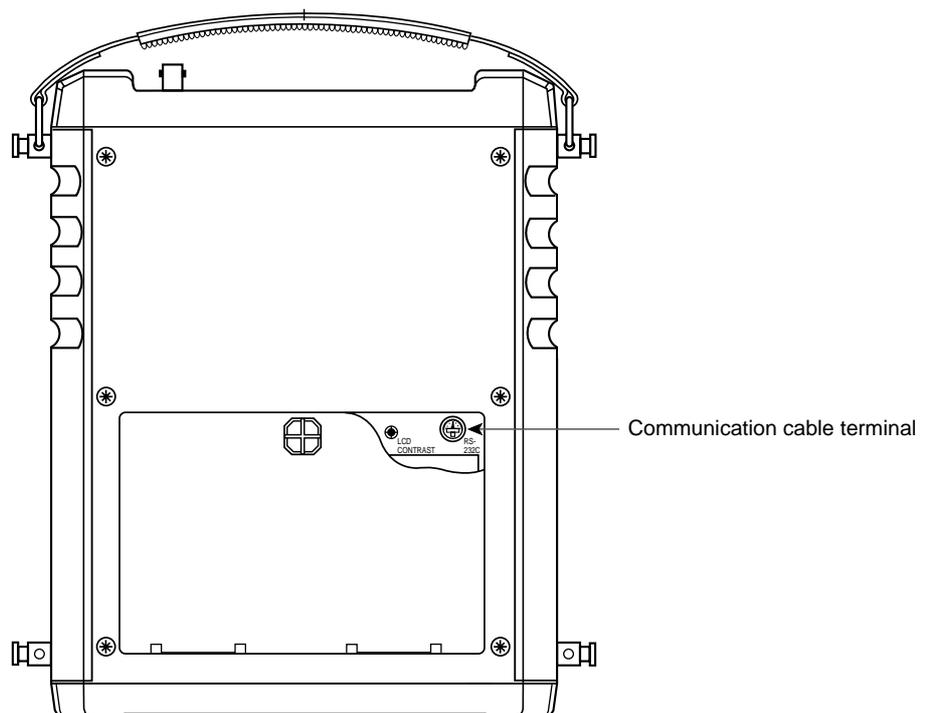
- The saved data can be called when you enter the pipe data.

### 5-9 LCD Contrast

The contrast of the LCD is adjusted in the factory before shipment. Do not adjust the contrast.

### 5-10 Data Transfer to PC

The data saved in the internal memory (detected leak position data, waveform monitor data, and leak noise data) can be transferred to a personal computer (“ PC ”). The paragraph below describes the procedure.



**< Operating procedure >**

(1) Remove the battery cover from the main unit. Place this unit with the back facing upward.

- Do not remove the battery box from the unit.

Turn on the main unit. Note that the data cannot be transferred to the PC with the detector turned off.

(2) Prepare the communication cable specified by Fuji Tecom. Plug the communication cable in the communication cable terminal on the leak detector and the COM port on the PC.

Proceed the operation according to “ LC-2500 for Windows : User’s Manual ”.

**<Pre-amplifier>**

**5-11 Automatic Sensitivity Adjustment**

Each preamplifier is capable of automatically adjusting the sensitivity of the signals input from the pick-up. When the input signals are weak, the sensitivity can be increased to enhance the reliability. If the sensitivity is excessively increased, the input signals are distorted to fail accurate measurement.

- Always check the sensitivity using the level indicator. If the indicator exceeds the specified range, the data acquisition may be illegal.

This automatic sensitivity adjustment automatically sets the signal level input from the pick-up to a certain value. The level indicator of the pre-amplifier has ten adjustment steps, and this function, when works, adjusts the sensitivity so that the indicator points level 5 or 6.

However, if the input signal level is extremely strong or weak, the indicator might not point 5 or 6 due to internal processing.

### 6-1 Storage Method

When this correlator will not be used for a long period, store it according to the following procedures.

- (1) Check any of the system components, including instruction manual, is not missing.
- (2) Remove the batteries. If the batteries are mounted in the unit for a long period, leakage may occur to damage the equipment.
  - Before storing the batteries, cover and insulate each of them with vinyl tapes to prevent short-circuit.
- (3) Do not store the batteries in a wet place.

#### < After Operation >

When storing the detector after operation, observe the following precautions.

- (1) Clean each pick-up to remove the mud and dirt completely and place it in the storage case.  
The contaminated pick-up may stain the main unit and pre-amplifiers to cause malfunctions.
- (2) If the detector is wet by rain, wipe it to remove raindrops completely and place it in the storage case.
- (3) Place only the detector in the storage case. Otherwise, it may be damaged or faulty.

### 7-1 Definitions

This section describes the terms used in this manual.

- **Correlator**

This equipment calculates the correlation coefficient of the signals acquired with pick-ups. The pre-amplifiers send the signals, which have been acquired with the pick-ups mounted in two places, to the leak detector, and the leak detector calculates the correlation coefficient of these signals, calculates the time difference between the two signal inputs, and obtains the leak position.

- **Sound velocity**

The leak detector displays the velocity of the sound propagating in the water filled in the pipe. Metal pipes provide higher sound velocity than resin pipes while larger bore decreases the velocity for the same pipe material.

- **Filter**

As already explained in Section 5-7 “ Notch Filter ”, using filters can extract only the frequency components necessary for the measurement.

- **Td range**

Td range means a delay time. The delay time refers to the time difference between the time when one pick-up acquires a signal and the time when another pick-up acquires a signal. When a signal source exists in the center of the span between pick-ups, the signal propagation times are identical and the time difference (Td) equals to 0. When the signal source is close to the reference pick-up, Td will be positive value. When the signal source is far from the reference pick-up, Td will be negative value.

- **DSP (Digital Signal Processor)**

This microprocessor can process the digital signals such as audio, image, and animation signals in real time at high speeds.

- **FFT (Fast Fourier Transform)**

Concretely speaking, the FFT operation calculates the Fourier coefficients of the Fourier series. This leak detector digitally samples the input signal waveforms, stores the sampled waveforms, executes the FFT operation for them, and displays the result. Pick-ups acquire the time-dependent data and it is difficult to execute the frequency analysis for the raw data. After the data is processed by the FFT operation, the frequency analysis can be executed for those signals that alter as the time changes.

\* Even when the noise acquired with the pick-ups are listened, you cannot identify the major frequency components. (You can identify the time-dependent signal change.) After the FFT operation, the frequency analysis can be used and, therefore, you can identify the major frequency components of the signal.

- **White noise**

This noise uniformly contains all the frequency components that exist in a certain frequency band.

- **Young's modulus (modulus of longitudinal elasticity)**

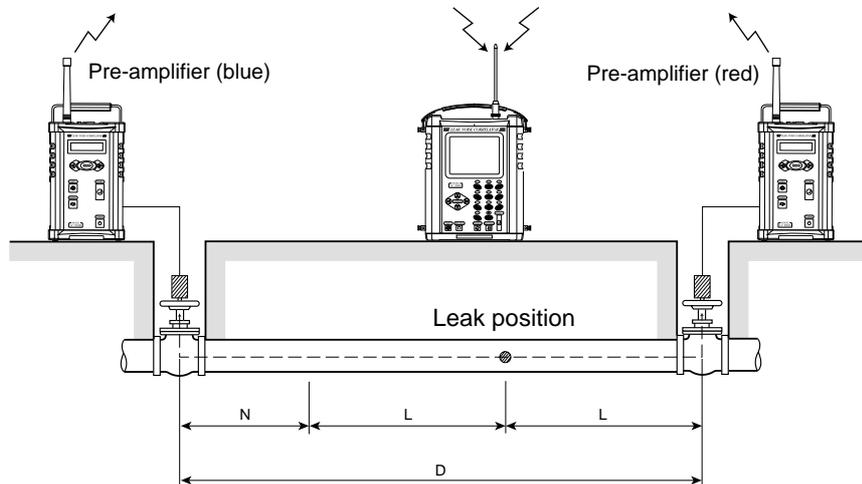
When a load is applied to an object within a certain range and removed, the object completely recovers to the original state. This property is called “ elasticity ”. The displacement is proportional to the load within the elastic region. The relationship is expressed as follows.

$$\sigma = E \cdot \epsilon \quad \text{Where, } \sigma : \text{Stress}$$
$$E : \text{Young's modulus}$$
$$\epsilon : \text{Strain}$$

The proportional constant E is called “ Young's modulus ”.

## 7-2 Principle of Leak Noise Correlator

This section describes the principle of the leak noise correlator.



Before commencing the leak detection process, the following four conditions are required.

- (1) The leak noise is reaching the two measurement points.
- (2) The material of the target pipe is identified.
- (3) The bore of the target pipe is identified.
- (4) The distance between the two pick-ups is identified.

If any of these conditions is not met, the leak position cannot be detected.

### Calculation of leak position

The leak position is close to the red pre-amplifier. The leak noise generated from the leak position is detected with the pick-up of the red pre-amplifier first. The leak noise is propagating to both the blue and red pick-ups. The propagation speeds are identical. When the leak noise is generated at a given timing and reaches the red pick-up, it has also traveled toward the blue pick-up by distance,  $L$ , which is equal to the distance from leak position to red pick-up. The leak noise furthermore travels by remaining distance,  $N$ , and reaches the blue pick-up. Therefore, an additional time equal to  $N$  divided by sound velocity is needed for the leak noise to reach the blue pick-up (this additional time is called “time difference”). Since the time difference is determined by calculating the correlation coefficient,  $N$  is a product of time difference and sound velocity. When  $N$  is known, the distance from the leak position to the red pick-up is calculated from  $(D - N) / 2$  since  $D$  is given as one of preconditions.

The equation is expressed as follows.

$$L = \frac{D-N}{2} = \frac{D - (V \times T_d)}{2} \quad \text{Where, } T_d: \text{Delay time (time difference)}$$

### 7-3 Specifications of Main Unit

- Applicable standard : IP52
- Storage temperature range : -20 to 60°C
- Storage humidity range : 10 to 90 % RH (No condensation permitted)
- Service temperature range : -20 to 50°C
- Service humidity range : 30 to 90 % RH (No condensation permitted)
- External dimensions : 197mm (W) × 100mm (D) × 250mm (H)  
\* Projections are not included in these figures.
- Weight : Approx. 3.1 kg (including batteries)
- Battery : LR20 × 4 (6V DC), Ni-Cad pack (size D battery × 4, 4.8 VDC)
- Consumption ampere : Under 550mA at 6V (Backlight is turned on)
- Continuous operating time : 8 h, min. (at 20°C) \* Backlight is turned on and the signals are being received.
- Minimum operating voltage : 4.2 V
- Impact resistance (applicable standard) : JIS C0041 (1999)
- Vibration resistance (applicable standard) : JIS C0040 (1999)
- Display : Dot matrix LCD
- Operating key : Membrane switch (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, ., ↑, ↓, →, ←, Enter, Escape, Delete, Light, Monitor)  
\* Some pictorial symbols are used.
- Interface and terminal : Receiving antenna (waterproof)  
Wired control input (with waterproof cap)  
Headphone output (with drip-proof cap)  
RS-232C  
Fuse holder  
Power switch (with drip-proof cap)  
LCD contrast
- Input : Radio or Cable
- Function:
  - Correlation operation
    - Operation : Polarity correlation
    - Delay time range : ±50 ms, ±100 ms, ±200 ms, ±400 ms, ±800 ms, ±1600 ms
    - Time resolution : 25 μs (in ±50 ms range)  
50 μs (in ±100 ms range)  
100 μs (in ±200 ms range)  
200 μs (in ±400 ms range)  
400 μs (in ±800 ms range)  
800 μs (in ±1600 ms range)
    - High-pass filter : 80 Hz, 180 Hz, 380 Hz, 800 Hz, THRU
    - Low-pass filter : 630 Hz, 1250 Hz, 2500 Hz, 5000 Hz
    - Notch filter : OFF, 50 Hz, 60 Hz
    - Auto filter : Filters are automatically selected according to the result of FFT operation.
    - Correlative operation data memory : Measurement conditions, calendar and time, and operation result can be saved by 100 data sets.

Pipe conditions	: Pipe material (11 types), bore (XXXX mm), sound velocity (XXXX m/s), pipe length (XXXX.XX m)
• Manual sound velocity calculation function	
Input	: Outside diameter (XXXX.X mm), wall thickness (XX.X mm), Young's modulus (XXXXXXX MPa)
• Automatic delay time range setup function	
Conditions	: The delay time is automatically set according to Td max displayed on the pipe condition input screen.
• Correlation evaluation function	
Rank	: A, B, and C
• Waveform monitor function	
Display channel	: 2
Frequency range	: 1 kHz, 2.5 kHz, 5 kHz (common to both channels)
Monitor screen data memory	: Measurement conditions, calendar and time, and operation result can be saved by 50 data sets for blue and red pre-amplifiers respectively (i.e., 100 data sets in total).
• Record and replay function:	
Record channel	: 2
Replay channel	: 2
Recorded data memory	: Measurement conditions, calendar and time, and recorded 16-second noise can be saved by 4 data sets.
Replay	: The recorded noise can be listened with headphone set or displayed on the waveform monitor.
• Note function:	
Input character	: ASCII codes
• Time count function:	
Contents	: Year, month, day, hour, minute, and second (24-hour mode)
Accuracy (monthly error)	: ±1 min (at 25°C)
• Memory backup function:	
Backed up device	: SRAM memory and real-time clock
Retention time	: Approx. 2.5 months (at 25°C)
Backup battery	: Secondary vanadium-lithium coin battery
• Key operation confirmation function	: A confirmation sound is generated from the buzzer (built in the equipment) and headphone.
• Backlight function:	
Backlit device	: LCD and operation keys
• Monitor function:	
Headphone output	: Selectable from Blue, Red, and Stereo * The current output mode is displayed on the screen.
• Continuous monitor function	
Item	: Battery voltage. (When the battery voltage gets below the specified level, the warning symbol flashes at an interval of 1 s.) Wired operation mode is detected. Radio operation mode is detected. * The unique symbol is displayed on the screen.

- PC data transfer function:
  - Transferable data : Correlated data, waveform monitor data, and recorded noise data.
- Low-battery shutdown function:
  - Voltage : 3.9 V
- External interface : RS-232C

## 7-4 Specifications of Pre-amplifier

- Applicable standard : IP52
- Service temperature range : -20 to 50°C
- External dimensions : 150mm (W) × 110mm (D) × 240mm (H)
  - \* Antenna and Grip are not included in these figures.
- Weight : Approx. 2.85 kg (including batteries)
- Battery : LR20 × 6 (9 VDC)
- Consumption ampere : Under 550mA at 9 V (Backlight is turned on)
- Continuous operating time : 8 h, min. (at 20°C)
  - \* Backlight is turned off and the signals are being received.
- Minimum operating voltage : 6.0 V
- Display : Character LCD
- Operating key : Membrane switch
  - (Power, Enter, Select/Adjust, Light, Speaker)
  - \* Some pictorial symbols are used.
- Terminals : Pick-up input (waterproof)  
Wired control input (with waterproof cap)  
Headphone output (with drip-proof cap)
- Function
  - Correlation mode
  - Amplifier gain setup mode : Automatic or manual mode is selected.
  - Filter setup mode : Standard (STD) or though (THRU) mode is selected.
  - Monitor function : The speaker and headphone outputs (stereo) are monitored.
  - Power save function : Only the backlight is supported. (When there is no key input for 3 min, this function works.)
  - Key operation confirmation function : A confirmation sound is generated from the speaker and headphone.
  - Backlight function : LCD and operation keys are backlit.
  - Self-check and continuous monitor function
    - : Battery voltage. (When the battery voltage gets below the specified level, a warning message is issued and then the equipment is turned off.)
    - Pick-up connection is detected.
    - Wired operation mode is detected.

- Input
  - Input frequency range : 0.1 Hz to 5 kHz (at THRU filter setting)  
100 Hz to 5 kHz (at STD filter setting)
  - Input sensitivity : 50 $\mu$ V, max.
  - Signal to noise ratio : 35 dB, min.
- Radio communication system
  - Transmission frequency : 400 MHz band
  - Modulation : Direct frequency modulation
  - Transmitting power : 0.5 W (500 mW)
  - Output impedance : 50  $\Omega$
- Compatible sensor : Amplifier built-in type acceleration pick-up,  
LC-2100 standard pick-up, VP pick-up and Hydrophone sensor.

## 7-5 Specifications of Pick-up

- Type : Piezoelectric pick-up
- Voltage sensitivity : 2.5 V/g (peak)
- Applicable standard : IP68. (The pick-up must meet the standard after it is submerged in the water at the depth of 2 m for 5 days.)
- Drop resistance : 1 m (asphalt)
- External dimensions :  $\phi$  30 mm x 130 mm (H)
- Weight : 0.42 kg
- Power supply voltage : 5 V
- Power supply system : 3-wire
- Output impedance : 100  $\Omega$ , max.

## 8. Troubleshooting

The procedures described herein should be used when your leak detection system is faulty. If the appropriate troubleshooting does not restore the equipment or the troubles are not defined in this chapter, please contact Fuji distributor or Fuji Tecom.

<p>(1) The main unit and/or pre-amplifier are not turned on :</p>	<ul style="list-style-type: none"> <li>• Check whether batteries are mounted.</li> <li>• Take out the battery box and replace the batteries with new ones.</li> <li>• Check whether the polarity of the batteries is correct.</li> <li>• Check whether the fuse is blown out. If it is broken, replace it with new one. (Fuse : 2A, slow blow type)</li> </ul>
<p>(2) Keys on the mainunit and/or pre-amplifier are not operable :</p>	<ul style="list-style-type: none"> <li>• Press each key certainly. The key, when pressed, generates a confirmation sound.</li> </ul>
<p>(3) The main unit does not receive the radio signals or the receiving performance is poor :</p>	<ul style="list-style-type: none"> <li>• Check whether the pre-amplifiers are turned on.</li> <li>• Check whether a receive antenna is certainly connected to the main unit.</li> <li>• Check whether buildings exist between main unit and pre-amplifiers. If these structures exist, the radio waves might not reach the main unit. Hold the pre-amplifiers and try to approach the main unit.</li> <li>• The coverage of the radio communication (distance between the main unit and each pre-amplifier) is about 750 m in the open space.</li> <li>• Try to install the pre-amplifiers at higher position.</li> </ul>
<p>(4) The material, bore, and length of the pipe are not known :</p>	<ul style="list-style-type: none"> <li>• Use the white noise method to calculate the unknown parameters.</li> <li>* See Section 5-3 “ White Noise Method ” for details.</li> </ul>
<p>(5) The error message does not disappear from the pre-amplifier :</p>	<ul style="list-style-type: none"> <li>• Try to replace the batteries with new ones.</li> <li>• Plug in the pick-up connector firmly.</li> </ul>

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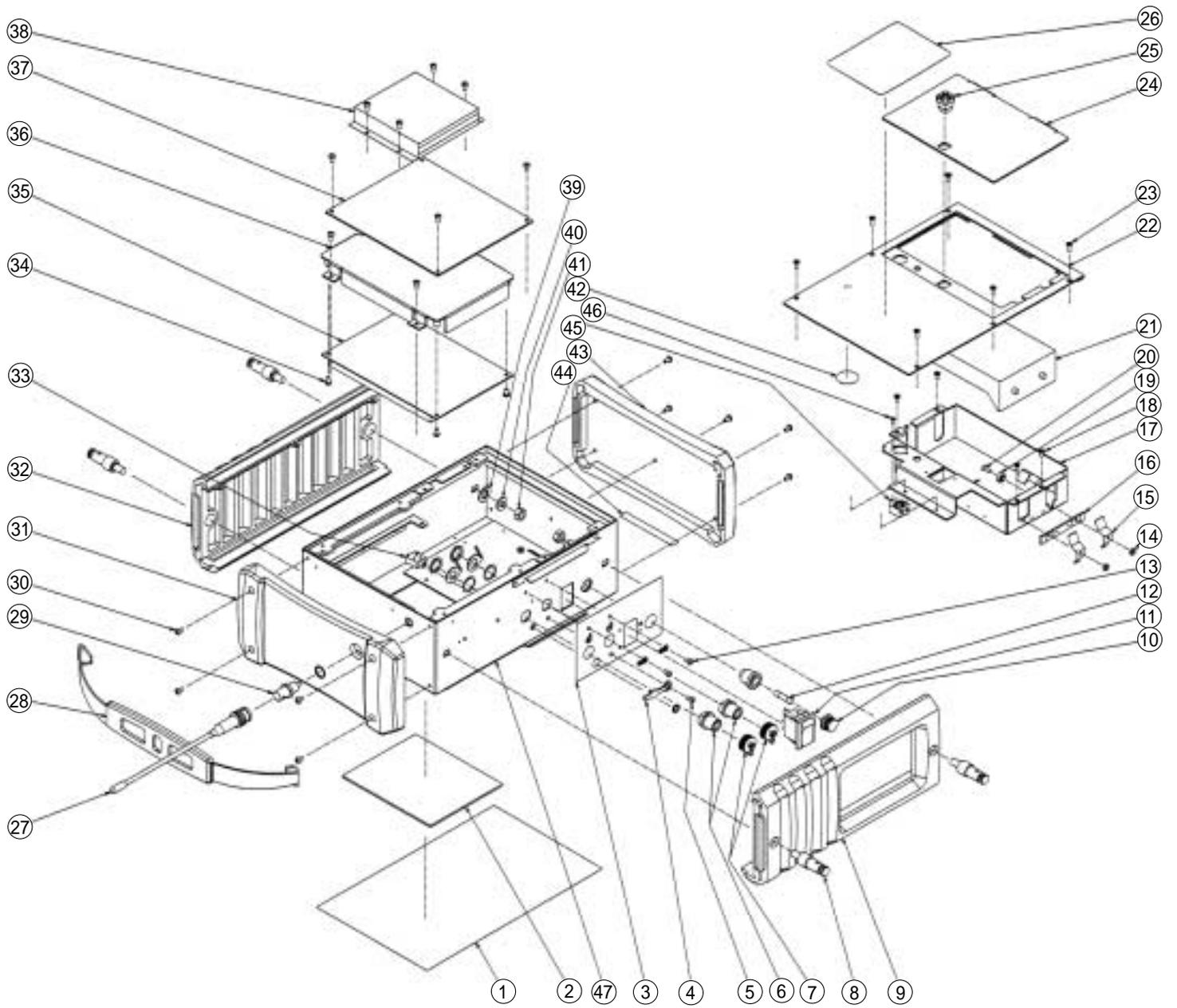
8-6-16 Nobidome Niiza-city, Saitama 352-0011 Japan

Tel +81-48-479-0582

## ● Parts list of Main Unit

- ① Switch membrane (LC250A14A)
- ② Acrylic resin plate (LC250A16A)
- ③ CONT-Seat (LC250A12A)
- ④ Waterproof cap for headphone jack (4-M942027)
- ⑤ M3x8 Screw
- ⑥ Cable connector (R01-02R9-6F)
- ⑦ Cable connector cap (R04-CR6)
- ⑧ Shaft-A (LC250A30A)
- ⑨ Side cover - right (LC250A17A)
- ⑩ Fuse holder (F-7155)
- ⑪ Rocker switch (JW-MW-11RK)
- ⑫ Fuse
- ⑬ M3x8 Screw
- ⑭ M3 Hexagon Nut
- ⑮ Battery terminal (LC250A26A)
- ⑯ Battery terminal plate (LC250A28A)
- ⑰ Box assembly (LC250A22A)
- ⑱ M3x6 Screw
- ⑲ Battery terminal spacer (LC250A27A)
- ⑳ M3x10 Screw
- ㉑ Battery box (TYPE C103)
- ㉒ Right-cover assembly (LC250A36A)
- ㉓ M3x8 Screw
- ㉔ Battery cover (LC250A33A)
- ㉕ Latch
- ㉖ Serial number seal for main unit (4-MP142035)
- ㉗ Receiver antenna (G-02-004)
- ㉘ Belt assembly (LC250A32A)
- ㉙ BNC connector (BNC356-BJ)
- ㉚ M3x8 Screw
- ㉛ Top cover (LC250A19A)
- ㉜ Side cover - left (LC250A18A)
- ㉝ Headphone jack (01J0154)
- ㉞ M3x8 Screw
- ㉟ LCD
- ㊱ LCD fixing plate (LC250A21A)
- ㊲ Receiver unit (G-02-007)
- ㊳ M6 Spring washer
- ㊴ M6 Flat washer
- ㊵ M6 Hexagon nut
- ㊶ Waterproof ventilation filter
- ㊷ Bottom cover (LC250A20A)
- ㊸ Company seal
- ㊹ RS232C connector
- ㊺ M2x8 Screw
- ㊻ Frame assembly for main unit (LC250A02A)

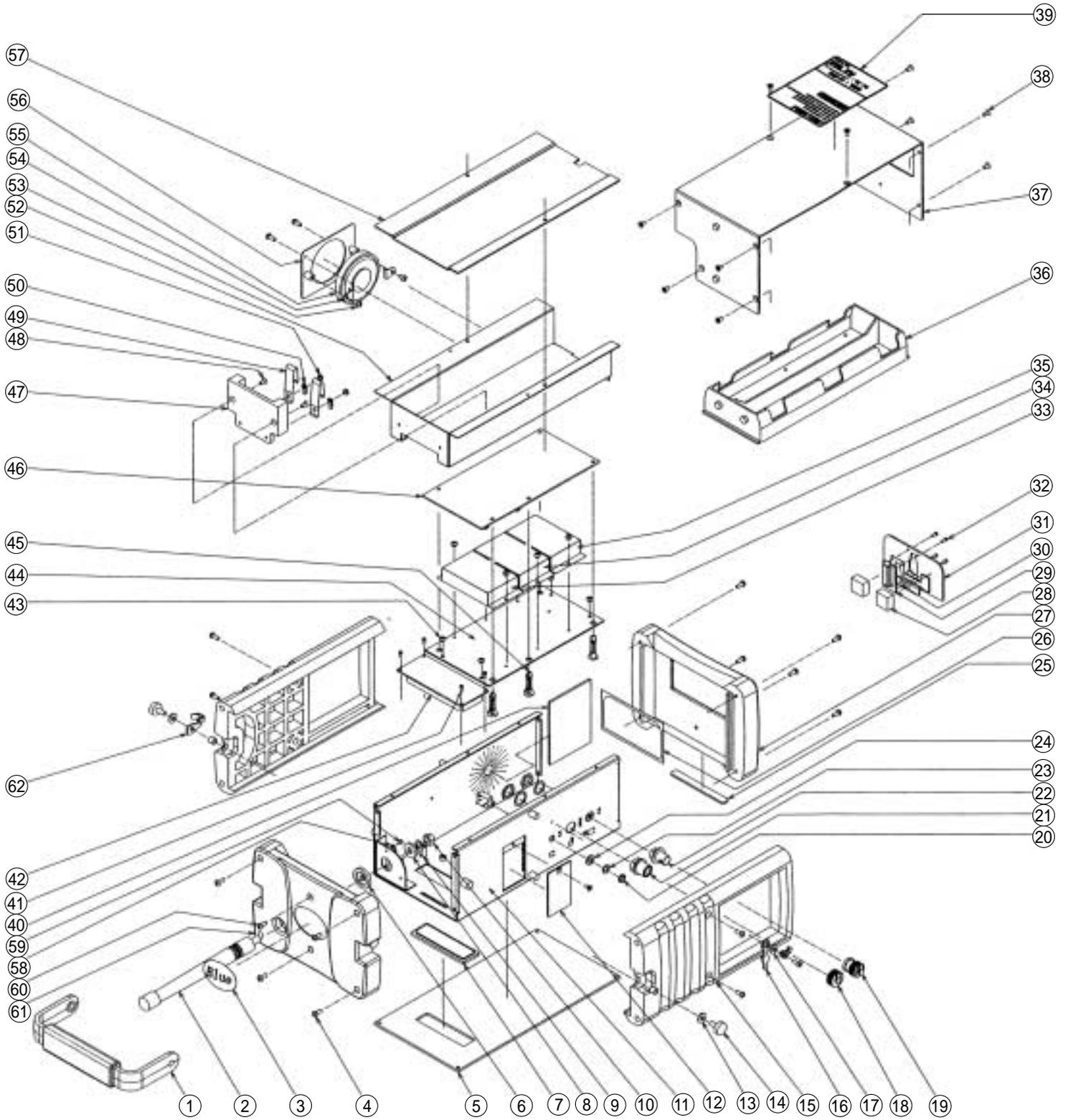
● Main unit



## ● Parts list of Pre-amplifier

- |  |  |
|--|--|
| ① Handgrip (3-MP142050)                          | ③② M2x5 Screw                                |
| ② Antenna (G-93-044)                             | ③③ Power unit (G-02-010)                     |
| ③ Blue/Red colour plate (4-MP142039/40)          | ③④ Transmitter unit (G-02-009)               |
| ④ M3x8 Screw                                     | ③⑤ P.U. unit (G-02-011)                      |
| ⑤ Switch membrane (4-MP142003)                   | ③⑥ Battery box                               |
| ⑥ Antenna isolation bushing (4-MP142022)         | ③⑦ Rear cover for pre-amplifier (1-MP142024) |
| ⑦ Acrylic resion plate (4-MP142042)              | ③⑧ M3x5 Screw                                |
| ⑧ Isolation washer for antenna (4-MP142021)      | ③⑨ Serial number seal for pre-amplifier      |
| ⑨ M6 lug terminal                                | ④⑩ Waterproof net for speaker (4-MP142043)   |
| ⑩ M6 Hexagon Nut                                 | ④⑪ M2x5 Screw                                |
| ⑪ Frame assembly for pre-amplifier(1-MP142023)   | ④⑫ LCD                                       |
| ⑫ Cover for test (only for demestic use)         | ④⑬ M3x3 Screw                                |
| ⑬ Grip packing (4-MP142052)                      | ④⑭ Module fixing plate (3-MP142027)          |
| ⑭ Round knob                                     | ④⑮ Rocking card spacer (KGLS-18RT)           |
| ⑮ Rubber cover (side) (2-MP142000)               | ④⑯ Control board                             |
| ⑯ Waterproof cap for headphones (4-MP942027)     | ④⑰ Terminal cover (4-MP142020)               |
| ⑰ M4 Flat metal washer                           | ④⑱ M3x10 Screw                               |
| ⑱ Cable connector cap (R04-CR6)                  | ④⑲ Battery terminal (4-MP142031)             |
| ⑲ P.U. connector cap (R20-CR)                    | ④⑳ Pressure terminal                         |
| ⑳ Headphone jack (01J0164)                       | ④㉑ M3x3 Screw                                |
| ㉑ Cable connector (R01-02R9-6F)                  | ④㉒ Battery box case (2-MP142025)             |
| ㉒ P.U. connector (R20-R8M)                       | ④㉓ M3x5 Screw                                |
| ㉓ Flat metal washer                              | ④㉔ Fastening lug for speaker (4-MP142028)    |
| ㉔ Waterproof packing for headphones (4-MP142033) | ④㉕ Speaker (with speaker cushion)            |
| ㉕ Fuji Tecom seal (4-MP142041)                   | ④㉖ Fastening plate for speaker (4-MP142030)  |
| ㉖ Battery cover packing (4-MP142051)             | ④㉗ Battery box case cover (3-MP142026)       |
| ㉗ Rubber cover - Bottom (4-MP142002)             | ④㉘ M3 Rug terminal                           |
| ㉘ Rubber cushion (4-MP142032)                    | ④㉙ M3x5 Screw                                |
| ㉙ Snap latch (C-10-5)                            | ④⑵① M3x3 Screw                               |
| ⑵① Packing for snap latch (4-MP142053)           | ④⑵② Rubber cover (Top) (2-MP142001)          |
| ⑵② Battery cover (4-MP142028)                    | ④⑵③ Hook for P.U. (4-MP142054)               |

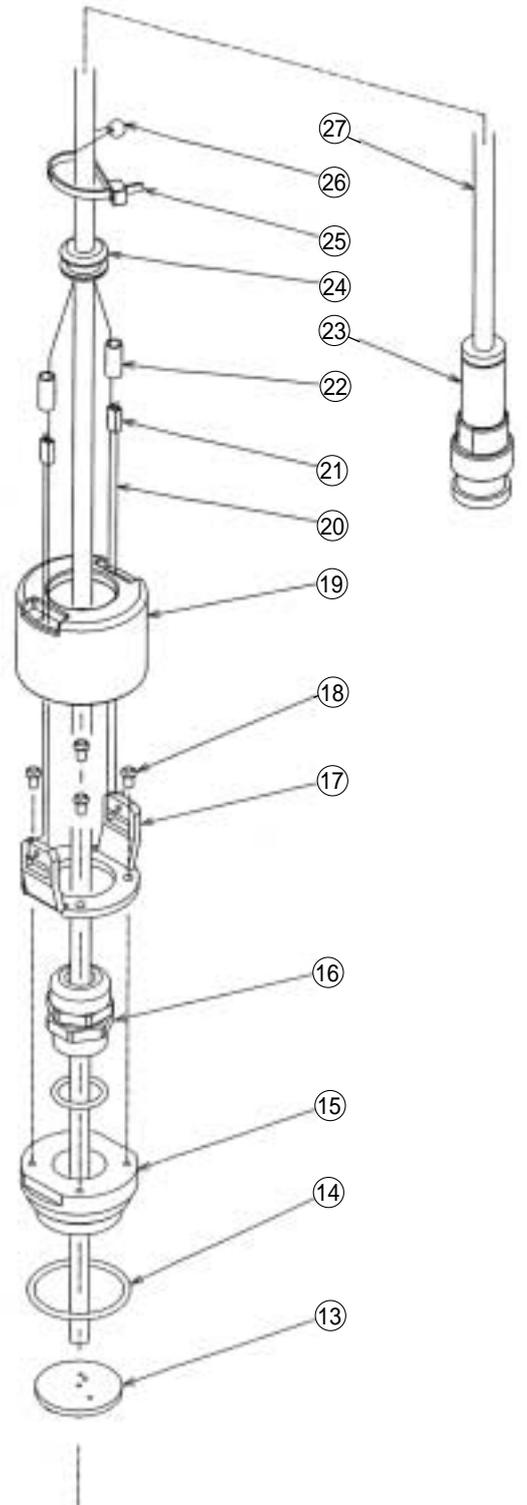
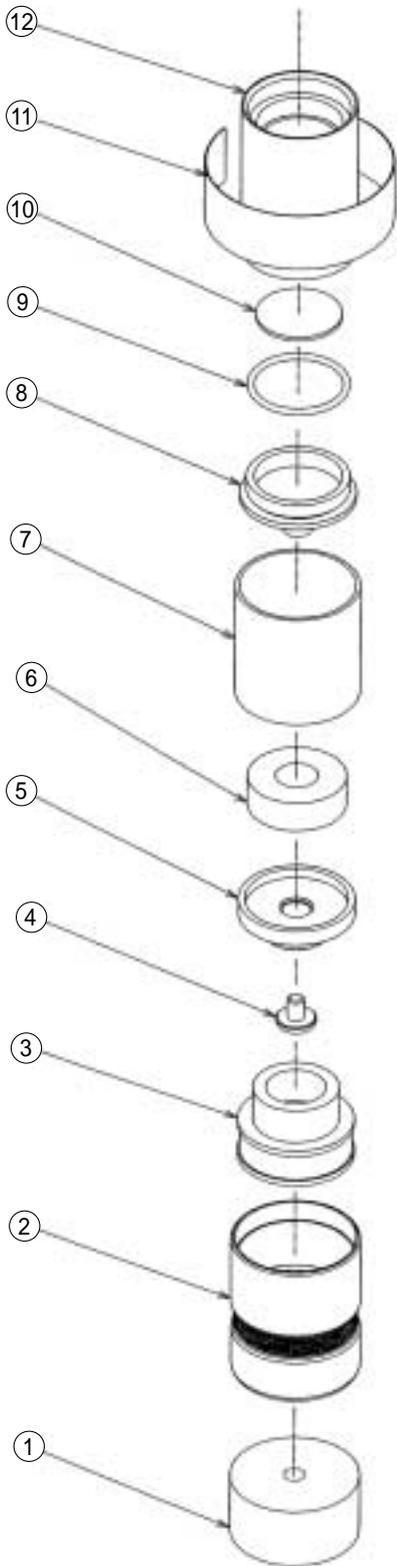
● Pre-amplifier



## ● Parts list of Pick-up sensor

- ① Magnet Base
- ② Under Rubber Cover
- ③ Filter
- ④ M4x8 Screw
- ⑤ Filter Holder
- ⑥ Cushion
- ⑦ Thermal Shrinkage Tube \_35
- ⑧ Element Plate
- ⑨ O Ring
- ⑩ Element
- ⑪ Care Label
- ⑫ Element Case
- ⑬ PCB
- ⑭ O Ring
- ⑮ Element Case Cover
- ⑯ Metal Cable Clump
- ⑰ Lifting Lug
- ⑱ M2x5 Screw
- ⑲ Upper Rubber Cover
- ⑳ Stainless Steel Wire
- ㉑ Wire Connection Lug
- ㉒ Thermal Shrinkage Tube \_5
- ㉓ Waterproof Connector
- ㉔ Rubber Bushing
- ㉕ Tying band (CV-70)
- ㉖  $\phi$  4 Bead
- ㉗ Noiseless Cable 3m

● Pick-up sensor



## List for Velocity of Each Pipe Diameter used by LC-2500

Kind of Pipe	Ductile Cast-Iron Pipe			Cast Iron Pipe			Asbestos Cement Pipe			Polyvinyl Chloride Pipe			Lead Pipe		
Mark	DIP			CIP			ACP			PVC			LEAD		
	Diameter	Velocity (ft/s)	Velocity (m/s)	Diameter	Velocity (ft/s)	Velocity (m/s)	Diameter	Velocity (ft/s)	Velocity (m/s)	Diameter	Velocity (ft/s)	Velocity (m/s)	Diameter	Velocity (ft/s)	Velocity (m/s)
	75 (3inch)	4400	1341	75 (3inch)	4300	1311	75 (3inch)	3640	1109	13 (1/2inch)	2040	622	10 (3/8inch)	3710	1131
	100 (4inch)	4300	1311	100 (4inch)	4200	1280	100 (4inch)	3540	1079	20 (3/4inch)	1870	570	13 (1/2inch)	3610	1100
	150 (6inch)	4170	1271	150 (6inch)	4070	1241	150 (6inch)	3480	1061	25 (1inch)	1810	552	20 (3/4inch)	3480	1061
	200 (8inch)	4070	1241	200 (8inch)	3940	1201	200 (8inch)	3440	1049	40 (1 1/2inch)	1590	485	25 (1inch)	3410	1039
	250 (10inch)	3900	1189	250 (10inch)	3870	1180	250 (10inch)	3440	1049	50 (2inch)	1470	448	30 (1 1/4inch)	3380	1030
	300 (12inch)	3770	1149	300 (12inch)	3770	1149	300 (12inch)	3410	1039	75 (3inch)	1440	439	40 (1 1/2inch)	3310	1009
	350 (14inch)	3710	1131	350 (14inch)	3740	1140	350 (14inch)	3410	1039	100 (4inch)	1370	418	50 (2inch)	3280	1000
	400 (16inch)	3710	1131	400 (16inch)	3670	1119	400 (16inch)	3410	1039	150 (6inch)	1370	418			
	450 (18inch)	3670	1119	450 (18inch)	3640	1109	450 (18inch)	3410	1039	200 (8inch)	1370	418			
	500 (20inch)	3640	1109	500 (20inch)	3610	1100	500 (20inch)	3380	1030	250 (10inch)	1370	418			
	600 (24inch)	3580	1091	600 (24inch)	3540	1079	800 (32inch)	3150	960	300 (12inch)	1370	418			
	900 (36inch)	3510	1070	750 (30inch)	3510	1070	1100 (44inch)	3230	985	400 (16inch)	1130	344			
	1200 (48inch)	3480	1061	900 (36inch)	3480	1061				450 (18inch)	1130	344			
	1500 (60inch)	3440	1049	1200 (48inch)	3440	1049				500 (20inch)	1130	344			
				1500 (60inch)	3410	1039				600 (24inch)	1130	344			

Kind of Pipe	Low Density Polyethylene Pipe			High Density Polyethylene Pipe			Polyethylene Main Pipe			Steel Pipe			Copper Pipe			Galvanized Steel Pipe		
Mark	LDPE			HDPE			PEMAINS			SP			COP			GALV (GP)		
	Diameter	Velocity (ft/s)	Velocity (m/s)	Diameter	Velocity (ft/s)	Velocity (m/s)	Diameter	Velocity (ft/s)	Velocity (m/s)	Diameter	Velocity (ft/s)	Velocity (m/s)	Diameter	Velocity (ft/s)	Velocity (m/s)	Diameter	Velocity (ft/s)	Velocity (m/s)
	20 (3/4inch)	1030	314	20 (3/4inch)	1020	311	75 (3inch)	899	274	13 (1/2inch)	4550	1387	10 (3/8inch)	4300	1311	10 (3/8inch)	4560	1390
	25 (1inch)	1030	314	25 (1inch)	1030	314	100 (4inch)	899	274	25 (1inch)	4510	1375	13 (1/2inch)	4200	1280	13 (1/2inch)	4560	1390
	30 (1 1/4inch)	1030	314	30 (1 1/4inch)	1030	314	150 (6inch)	899	274	50 (2inch)	4400	1341	20 (3/4inch)	4070	1241	20 (3/4inch)	4530	1381
	40 (1 1/2inch)	1030	314	40 (1 1/2inch)	1030	314	200 (8inch)	899	274	100 (4inch)	4290	1308	25 (1inch)	3900	1189	25 (1inch)	4490	1369
	50 (2inch)	1030	314	50 (2inch)	1030	314				150 (6inch)	4120	1256	30 (1 1/4inch)	3970	1210	30 (1 1/4inch)	4460	1359
										200 (8inch)	3960	1207	40 (1 1/2inch)	3940	1201	40 (1 1/2inch)	4430	1350
										300 (12inch)	3700	1128	50 (2inch)	3840	1170	50 (2inch)	4400	1341
										450 (18inch)	3390	1033				65 (2 1/2inch)	4360	1329
										600 (24inch)	3110	948				75 (3inch)	4300	1311
										900 (36inch)	3010	917				100 (4inch)	4230	1289
										1200 (48inch)	3110	948				125 (5inch)	4130	1259
										1500 (60inch)	2920	890				150 (6inch)	4100	1250
										1800 (72inch)	3010	917				200 (8inch)	4040	1231
										2100 (84inch)	3080	939				250 (10inch)	4000	1219
										2400 (96inch)	2960	902				300 (12inch)	3900	1189

## INSPECTION CERTIFICATE

MODEL: **LC-2500**    DATE: \_\_\_\_\_

SERIAL No: \_\_\_\_\_

We hereby certify that the undersigner checked the above instrument with careful attention under the Fuji interoffice inspection standard consisting of four main items as follows:-

(1) EXTERNAL APPEARANCE .....

(2) MECHANICAL WORK .....

\*Knob, lever & key   \*Connector   \*Joint

(3) ELECTRIC FUNCTION .....

\*Indicator & Display   \*Output   \*Sensitivity

\*Frequency                \*Input   \*Power

(4) OPERATION ON TEST SITE .....

\*Distance                \*Location                \*Level

\*Depth                    \*Flow

\*Direction                \*Pressure

Inspected by: \_\_\_\_\_



Instruments for the location of underground utilities and water leaks.

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Technical development & training center : Niiza