by Y. Ohki

Development of a Compact On-Site Power Source

It is of prime importance to conduct maintenance of electric power transmission lines such as underground cables and overhead lines regularly, in order to secure a stable and reliable supply of electric power. Various devices that require electric power are needed for maintenance work. However, it can be difficult to position an adequate power source within a power cable manhole, or in the vicinity of an overhead power line. In the latter case, a combination of solar and storage batteries is frequently used, especially in mountainous areas; large storage batteries are needed to cover continual rainy days or night operation. In the case of manholes, since solar batteries cannot be used, storage batteries need frequent re-charging, during which time the manhole covers must be kept open. If the entrance to the manhole is on a road, traffic is obstructed. Under these circumstances, development of a compact on-site electric power source, which does not need re-charging, is desirable.

Dyden Corporation, Kurume, Japan, recently announced that it had developed two types of portable power sources suitable for the maintenance work just described. The two devices are called "Leicoupler®," an abbreviation of "line electric induction coupler." The first type is for use in cable manholes, and the other for use with overhead transmission lines.

The Leicoupler for cable manholes utilizes electromagnetic induction. When a current transformer (CT), or coils with an iron core at their center, are positioned around a power cable in operation, an electromotive force will appear. Similar power sources using the same principle are already commercially available. However, the latter cannot release or dissipate adequately the excess power that they generate. If the excess power is to be dissipated as heat, a large heatsink or large cooling fins will be needed, inevitably increasing the size of the equipment.

A power source for use in manholes must be compact. It must also be water resistant, since manholes are often filled at least partially with water. With these considerations in mind, Dyden developed a new compact and water-resistant power source that releases excess power in a form other than heat. Details of this source cannot be disclosed for proprietary reasons.

Figure 1 shows the new compact power source device with its controller, and typical installation. CT IN represents a receptacle

Figure 1. Components of the developed compact power source for use with underground cables, and its installation. CT = current transformer; CT IN = a receptacle to connect the device to a current transformer.

Table 1. Specifications of the power source for underground cables	
Item	**Specifications**
Frequency	50 or 60 Hz
Supported power cable diameter	<176 mm
Supported power cable load current	<2,000 A_{rms}
Output voltage	12 V DC (2 channels)
Water resistance	1 hour at a depth of 10 meters in water
Operating ambient temperature range	−10 ~ +40°C
Size	CT: 335 × 300 × 110 mm Control box: 210 × 225 × 95 mm
Weight	CT: 7.5 kg Control box: 6 kg

to connect the device to a current transformer. The specifications of the device are listed in Table 1. One or two CTs may be used; the output power is 1 W when using one CT for a cable passing a current of 60 A. Although the maximum cable current that can be handled is 2,000 A, the maximum output power that can be supplied is 5 W, irrespective of the number of CTs. This device became commercially available in Japan in July 2017.

The second type of Leicoupler is for use with overhead transmission lines. According to the general theory of electrostatic induction, an electric potential will appear on an electrode placed close to a high voltage conductor such as a transmission line. The second type of Leicoupler uses this phenomenon. Suppose that an electrode of a power source is connected to ground through a resistive load. If the impedance of the resistive load is low compared to the impedance between the transmission line and the electrode, the resultant electrostatic potential appearing across the resistive load will be small. If the resistive load has a high impedance, the induced electrostatic potential will be larger, but the current flowing through the resistive load will be smaller. Consequently, the impedance of the resistive load should be chosen so that the power obtainable, namely the product of the electrostatic potential appearing across the resistive load and the current flowing through it, is a maximum.

With this in mind, Dyden developed a new electric circuit and increased the internal impedance of the device by utilizing L-C resonance and impedance matching, as shown in Figure 2. Here, a is the winding ratio of the equivalent ideal transformer and R is the resistance of the load. The load impedance seen from the primary side of the transformer is a^2R. Using L-C resonance, the effect of the electrostatic capacitance C_0 between the electrode

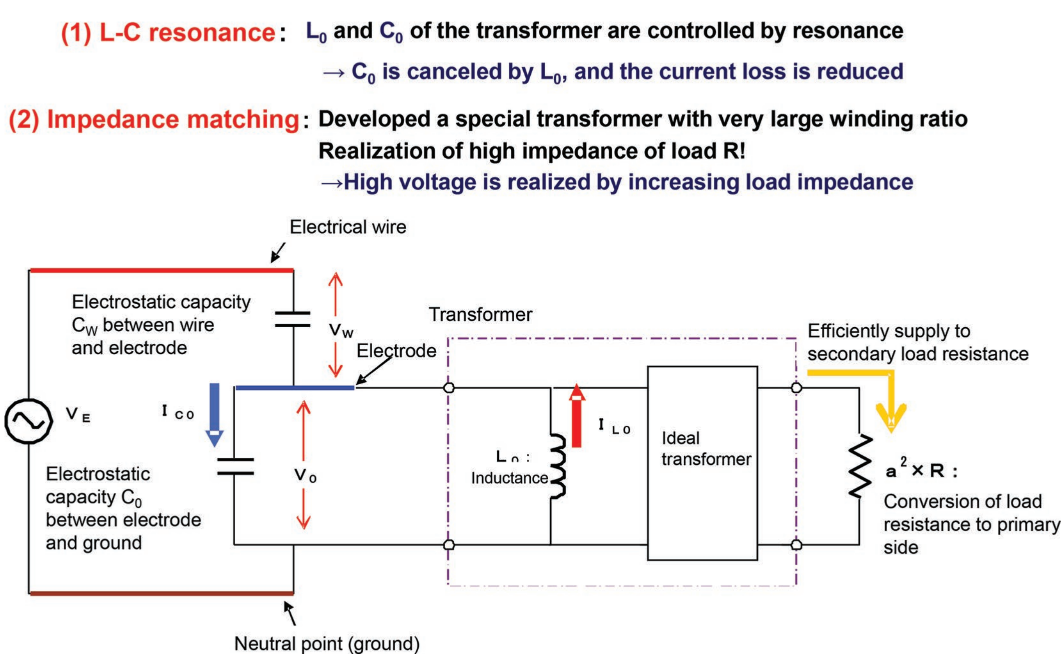

Figure 2. New technology in the compact power source for use with transmission lines.

Table 2. Power output of the power source versus transmission voltage						
	Transmission line voltage classification[1] (kV)					
	500 (6.5 m)	275 (4.5 m)	220 (3.5 m)	154 (2.7 m)	110 (2.0 m)	66 (1.3 m)
Power output[2] (W)	3.0	1.8	1.5	0.8	0.7	0.5

[1]Typical distance from the transmission line is given in parentheses.
[2]A single induction electrode at 60 Hz.

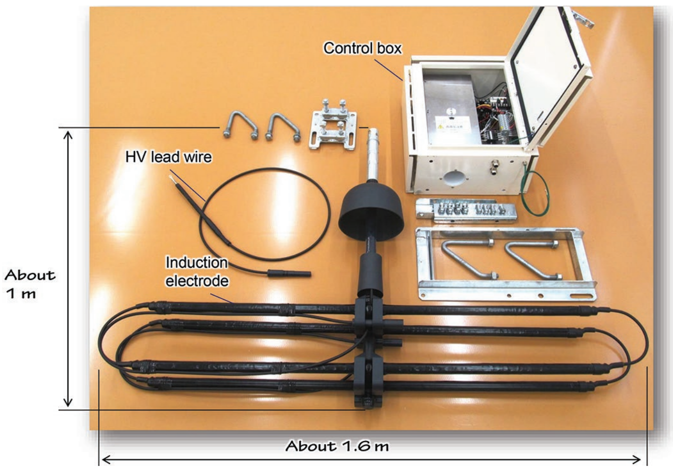

Figure 3. Components of the developed compact power source for use with transmission lines.

and the ground is canceled by L_0, which is the magnetizing susceptance of the transformer. The transformer has a very large winding ratio, i.e., the number of turns N1 on the primary side is much larger than the number of turns N2 on the secondary side. As mentioned above, the impedance of the load R becomes as high as a^2R, viewed from the primary side of the transformer. Consequently, a large power is available.

Figure 3 shows this type of power source, and Figure 4 is a schematic diagram of its installation. Table 2 lists the available power output as a function of the operating voltage of the transmission line. The distances (in parentheses) are typical recommended safety clearances from the wire, in front of which the device is positioned.

The company submitted a patent for this latter Leicoupler device for use with overhead transmission lines. This patent has already been registered in the USA, China, Korea, and Japan, and is being reviewed in Europe and India. The company plans to put this device on the market in July 2018.

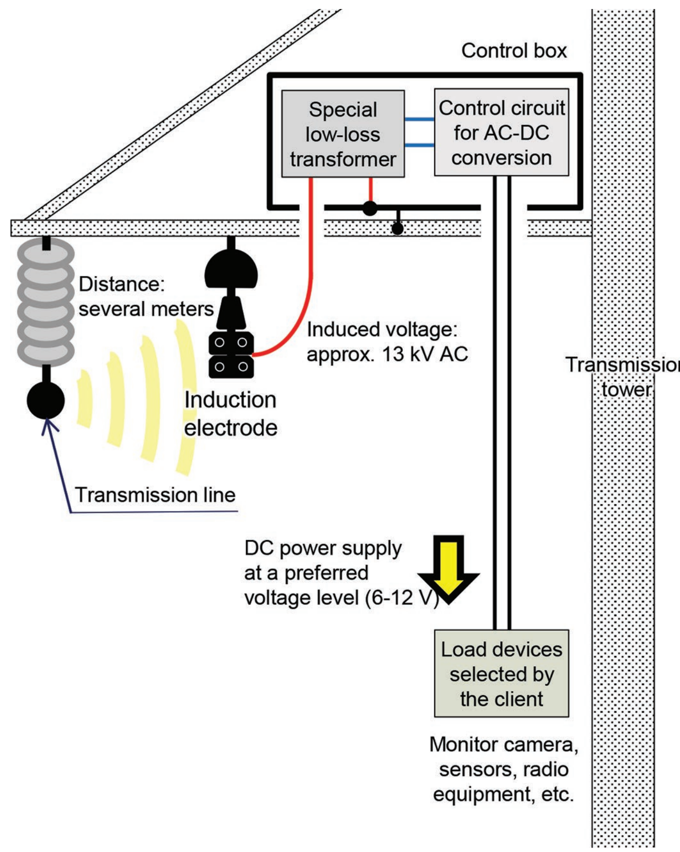

Figure 4. Schematic diagram showing the installation of the power source near a transmission line.

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