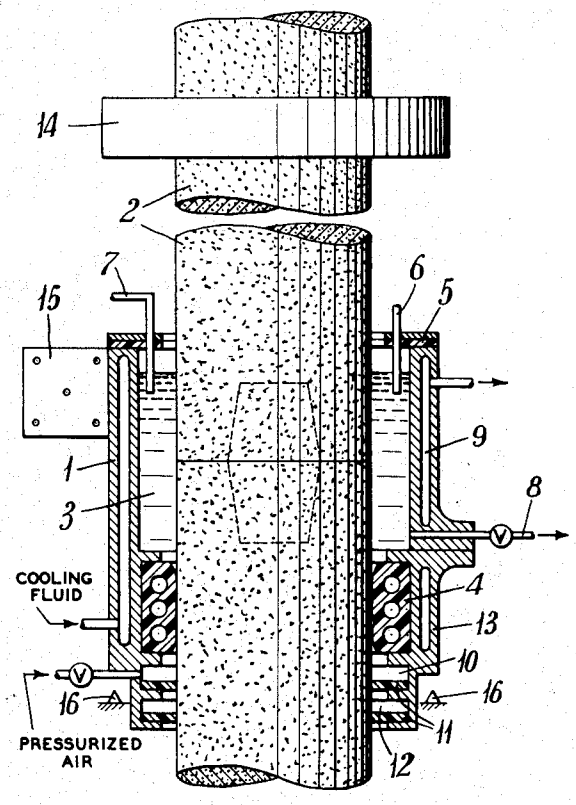
Feb. 13, 1962 V. J. JAMAL ETAL 3,021,377

ELECTRICAL CURRENT TRANSFER DEVICE

Filed March 22, 1960

Fig. 1.



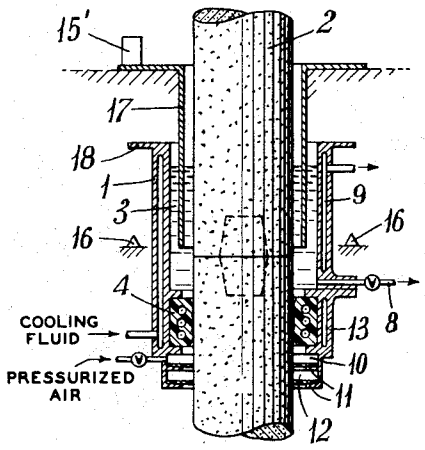


Fig. 2.

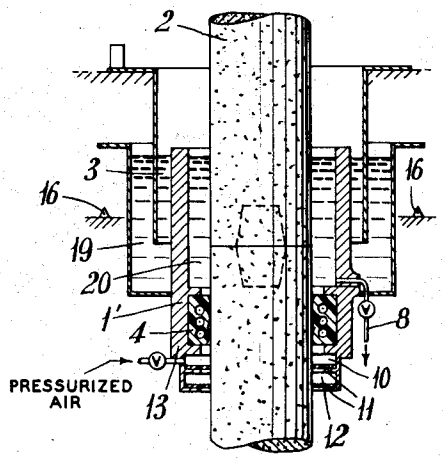


Fig. 3.

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ELECTRICAL CURRENT TRANSFER DEVICE

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This invention relates generally to electrical current transfer devices, and more particularly to electrical current transfer devices for electrodes.

Although this invention is described as being used in conjunction with metallurgical electrical furnaces, it is to be understood that it is applicable to the transfer of electrical current in other types of apparatus.

In order to explain this invention a brief discussion of the use of electrodes in the metallurgical art will be presented.

Metallurgical electrical furnaces are used for various arc-melting proceses and employ therein electrodes of various sizes to supply the heat energy required in the processes. Most often these electrodes are composed of several approximately cylindrical attachable sections having diameters of several feet. These sections when connected together form an assembled element which is positioned vertically in the arc-melting furnace, and an arc is struck between the electrode and the metal to be processed. Due to the large size of the electrodes and the requirements of arc-melting processes in general, high values of electrical current are required to energize the electrodes. The energizing electrical current is generally supplied to the electrode by connecting an electrical power source to a bus-bar and connecting the bus bar through flexible conductors to heavy metallic contact plates. These contact plates usually require cooling by water or air and are pressed against the side of the electrode. Clamping devices serve to press these plates against the electrode, and also to hold and position the electrode in the furnace.

During the melting operation several individual adjustments in the position of the electrode are necessary to provide proper furnace operation. These adjustments are usually accomplished by moving the electrode in a longitudinal direction.

One such adjustment is the substantially continuous raising and lowering of the electrode to obtain proper furnace regulation, that is, arc stabilization, by controlling the distance between the electrode and the melt.

A second adjustment is the lowering or slipping of the electrode into the furnace to replace that portion of the electrode which has been consumed in the melting process.

In the practice of arc melting, the prior art techniques and energizing circuitry for the transfer of energy from an electrical power source to an electrode, particularly the use of contact plates and flexible connectors, do not provide a satisfactory degree of efficiency. The contact that is established between contact plates and an irregularly surfaced electrode is poor and causes a substantial loss of electrical energy. In addition, the contact plates introduce an inductance into the energizing circuit which contributes toward low power factor operation.

A considerable length is required for the flexible connectors in order to accommodate the furnace regulation adjustment and consequently there is a considerable dissipation of electrical energy in these connectors. Moreover, the flexible connectors introduce additional inductance into the energizing circuit causing a further lowering of the power factor. Furthermore, whenever it is required to lower or slip the electrode to replace a portion consumed in the melting operation, it is necessary to completely de-energize the electrode and remove

the contact plates in order to re-position the electrode. This discontinuity of operation is highly undesirable for economic reasons and otherwise.

As mentioned and described hereinabove, one of the primary disadvantages associated with the prior art current transfer apparatus is low electrical efficiency, caused in great measure by the high electrical resistance between the contact plates and electrode, the energy loss in the flexible connectors and the relatively high inductance of the energizing circuit. Further disadvantages are the need for cooling the contact plates, discontinuity of operation, large capital investment and high operating costs.

Therefore it is an object of this invention to provide a novel and efficient means of current transfer between an electrical power source and a moving electrical conductor.

Another object is to provide a novel means of current transfer for the purpose of energizing electrodes.

Another object is to provide a simply fabricated and easily maintained current transfer device which may be used with electrical furnaces employed in the metallurgical art.

A further object is to provide a method of conducting electrical energy efficiently from an electrical power source for the purpose of energizing an irregularly surfaced electrical conductor.

These and other objects will be apparent from the following description, drawing and appended claims.

With reference to the drawing,

FIGURE 1 is a sectional view of the improved current transfer device as it is used in conjunction with an electric furnace.

FIGURE 2 is a sectional view of a preferred embodiment of the invention; and

FIGURE 3 is a sectional view of the preferred embodiment of the invention which incorporates additional modifications.

A preferred form of this invention may be stated in general terms as including a receptacle adapted to surround a longitudinal portion of an electrode and containing a metal in the liquid state. The receptacle is provided with an annular seal at its lower extremity which contacts the surface of the electrode. The metal receptacle travels with the electrode during longitudinal movement of the electrode in furnace regulation, but is held fixed and permits the electrode to slip through the seal when it is necessary to replenish a consumed portion of the electrode. The nature of the seal is such that the liquid metal is completely retained in the receptacle throughout all movements and adjustments of the electrode. Energy is supplied to the electrode from an electrically energized, fixedly positioned, metal casing which fits telescopically within the liquid metal receptacle so that its lower portion is immersed in the liquid metal. The liquid metal constitutes an efficient conducting means between the energized metal casing and the electrode regardless of any movement of the electrode or dimensional anomalies in its surface and a continuous and efficient arc-melting operation is thereby ensured.

Referring to the drawing forming part hereof, FIGURE 1 shows a basic form of the invention as it may be used in conjunction with an arc-melting furnace operation. The invention is shown as comprising a receptacle **1** surrounding a portion of an electrode **2** and containing a liquid metal **3** which contacts a portion of the surface of electrode **2**. Receptacle **1** may be externally insulated by any suitable means such as fire clay or asbestos and is shown to be sealed at each of its extremities. Bottom seal **4** is designed to withstand the relatively high operational temperatures and the frictional wear and tear due to the slipping adjustment of the electrode. Seal **4** is pressurized and flexible to ac-

commodate possible dimensional irregularities in electrode 2. Seal 4 presses against the surface of receptacle 1 and electrode 2 to prevent any leakage of liquid metal 3 and is held in place by means of split sealing ring 13.

Upper cover seal 5 is designed to protect the liquid metal 3 against contamination by foreign objects, and may be adapted to allow introduction into the liquid mass of indicating devices, for example, a thermocouple temperature detector 6, and a level detector 7, which may be of the pneumatic or electrical type. A standard conduit connection 8 is connected to the lower portion of receptacle 1 for draining the liquid metal.

Air or water-cooling may be provided for receptacle 1 by circulation of suitable cooling fluid through jacket 9.

A pressurized air chamber 10 is provided beneath and contacting lower seal 4 to provide protection against the electrode and furnace temperature and the possibility of metal leakage.

Supplementary sealing rings 11, held in place by split ring 13, complete the sealing of receptacle 1, and an air trap 12 is provided between them for additional protection.

Receptacle 1 may be supported by friction clamps (not shown) which may be either air-cooled or water-cooled to contribute to the cooling of the lower bottom seals of the receptacle. Electrode 2 may be supported by suitable suspension means such as collar 14.

Electrical energy is supplied to electrode 2 from a suitable source through rib connection 15.

Under operating conditions the embodiment of FIGURE 1 functions as follows.

Electrical current is transferred from a source of electrical energy through suitable connections to rib connection 15. The current passes through receptacle 1 to the liquid metal 3. The particular liquid metal is chosen so that it is maintained in the liquid state at the normal operating temperature of the process. The electrical current is transferred through the liquid metal 3 to electrode 2, thus providing a continuous and efficient electrical contact at the surface of the electrode regardless of irregulariies in the surface of the electrode.

When it is desired to slip the electrode further into the furnace, receptacle 1 is placed in contact with stops 16, which may be located on the body of the furnace, and the electrode is forced through the lower seals 12 and 11. These seals and the structural features of the invention prevent leakage of liquid metal from receptacle 1 and thus the electrical contact between the liquid metal and electrode is uninterrupted and there is no need to de-energize the electric circuit or interrupt the arc melting operation.

In the embodiment of FIGURE 2, electrically conductive stationary cylinder 17 is adapted to be directly connectable to a source of electrical energy through rib connector 15'. Stationary cylinder 17 is fixedly positioned with respect to the furnace and fits telescopically within receptacle 1 to make contact with liquid metal 3. Thus, as receptacle 1 moves with electrode 2 during furnace regulation adjustments, a continuous and efficient electrical connection is maintained between the electrode and stationary cylinder 17. When it is desired to slip the electrode, flange 18 of receptacle 1 is placed in contact with stops 16 and the electrode is forced through the lower seals in the same manner as described hereinabove in connection with the embodiment of FIGURE 1.

The embodiment of FIGURE 2 allows direct connections to be made from an electrical energy source to the current transfer device since there is no requirement for flexible connectors to accommodate the longitudinal movements of the electrode. As a result the efficiency of the energizing circuit is substantially improved. As with the embodiment of FIGURE 1, there is no need to de-energize the electrode when it is required to slip the electrode.

The embodiment of FIGURE 3 shows an alternative construction for a metal receptacle, wherein the receptacle 1' is shown divided into distinct and separate adjoining compartments 19 and 20. These compartments are electrically connected and prevent, in case of accident, the loss of large amounts of liquid metal. The respective capacities of the adjoining compartments are not critical.

In the practice of this invention the transducing metal is often placed in the metal receptacle in contact with the electrode while it is in its solid form, and then caused to melt by energizing the electrode.

A metal, to be suitable for such use must be of such a nature that it melts at a sufficiently low temperature to accommodate arc-melting processes, is a good electrical conductor, and is non-corrosive in the liquid state and non-toxic in its vapors. It has been found that alloys containing from about 20 to about 45 percent lead, up to about 16 percent tin, up to about 8 percent cadmium, up to about 20 percent indium with the balance being bismuth and incidental impurities, are suitable for use as transducing metals in the practice of this invention, particularly those alloys having melting points between about 100° F. and 270° F.

Specific alloys which have been found suitable are the following:

Composition:	Melting point, °F.
52% Bi—32% Pb—16% Sn	205
52% Bi—40% Pb—8% Cd	198
49.6% Bi—5% Cd—22.3% Pb—12.6% Sn—10.5% In	113
55.5% Bi—44.5% Pb	255

With regard to the lower sealing rings 4 and 11, many materials may be satisfactorily used, provided they are capable of withstanding the relatively high operational temperatures and considerable friction. Substances which have been found suitable for this purpose are polyhalocarbon polymeric materials, for example, polytetrafluoroethylene. Silicone type rubbers and synthetic hydrocarbon type polymers such as co-polymers of butadiene and acrylonitrile, and co-polymers of butadiene and styrene, are also suitable seal materials.

An advantage of the present invention is in the provision of a novel and efficient current transfer device which may be uesd compatibly with substantially all types of electrodes employed in metallurgical electrode arc-melting furnaces.

This novel current transfer device provides a continuous and efficient electrical contact at the surface of the electrode regardless of imperfections and irregularities in the electrode surface. Moreover, the present invention makes possible continuous arc-melting operation since there is no need to deenergize the electrode in order to adjust for furnace regulation or to slip the electrode. In addition, the low contact resistance at the electrode and the substantial reduction of inductance in the energizing circuitry ensure a high degree of efficiency in the arc-melting operation.

The novel combinations, constructions and arrangements of the present invention provide an efficient, simply constructed, economical and easily maintained current transfer device.

What is claimed is:

1. An improved current transfer device for transducing electrical current from an electrical power source to an electrode which comprises an electrically conductive receptacle connectable electrically to said power source, said receptacle normally movable longitudinally but adapted to be fixedly positioned with respect to said electrode and adapted to surround an intermediate longitudinal portion of said electrode, first annular sealing means fixedly positioned at the lower portion of said receptacle sealably contacting said receptacle and arranged to sealably contact a portion of the surface of

said electrode therethrough upon fixedly positioning said receptacle, said receptacle adapted to receive liquid metal to contact a portion of the surface of said receptable and a portion of the surface of said electrode, at least one supplemenatry annular sealing means fixedly positioned at the lower portion of said receptacle sealably contacting said receptacle and arranged to sealably contact a portion of the surface of said electrode and permitting longitudinal movement of said electrode therethrough upon fixedly positioning said receptacle, said supplementary sealing means positioned below said first annular sealing means and separated therefrom by a pressurized air chamber, said air chamber defined by a portion of the inner surface of said receptacle, the lower surface of said annular sealing means, the upper surface of said supplementary sealing means and a portion of the surface of said electrode.

2. An improved current transfer device for transducing electrical current from an electrical power source to an electrode which comprises an electrically conductive casing, connectable electrically to said power source and arranged to be fixedly positioned with respect to said electrode and adapted to surround an intermediate longitudinal portion of said electrode, a receptacle adapted to surround said casing and an intermediate longitudinal portion of said electrode, said receptacle normally movable longitudinally but adapted to be fixedly positioned with respect to said electrode, annular sealing means fixedly positioned at the lower portion of said receptacle sealably contacting said receptacle and adapted to sealably contact a portion of the surface of said electrode and flexible to permit longitudinal movement of the electrode therethrough upon fixedly positioning said receptacle, said receptacle adapted to receive liquid metal to contact a portion of said casing and a portion of the surface of said electrode, at least one supplementary annular sealing means fixedly positioned at the lower portion of said receptacle sealably contacting said receptacle and arranged to sealably contact a portion of the surface of said electrode and permitting longitudinal movement of said electrode therethrough upon fixedly positioning said receptacle, said supplementary sealing means positioned below said first annular sealing means and separated therefrom

by a pressurized air chamber, said air chamber defined by a portion of the inner surface of said receptacle, the lower surface of said first annular sealing means, the upper surface of said supplementary sealing means and a portion of the surface of said electrode.

3. An improved current transfer device for transducing electrical current from an electrical power source to an electrode, which comprises an electrically conductive first casing, said first casing connectable electrically to said power source and arranged to be fixedly positioned with respect to said electrode and adapted to surround an intermediate longitudinal portion of said electrode, a receptacle adapted to surround said first casing and an intermediate longitudinal portion of said electrode, said receptacle normally movable longitudinally but adapted to be fixedly positioned with respect to said electrode, annular sealing means fixedly positioned at the lower portion of said receptacle sealably contacting said receptacle and adapted to sealably contact a portion of the surface of said electrode and flexible to permit longitudinal movement of the electrode therethrough upon fixedly positioning said receptacle, an electrically conductive second casing disposed within said receptacle intermediate said first casing and said electrode, said second casing integrally connected at its lower extremity to the inner surface of said receptacle to provide two compartments therein, said receptacle adapted to receive liquid metal in both compartments thereof to contact a portion of said first casing and a portion of the surface of said electrode whereby electric power is transferred continuously from said power source to said electrode throughout longitudinal adjustments of said electrode.

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