

[54] **APPARATUS FOR INDICATING THE RISE OF LIQUID IN A MOLD**

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[22] Filed: **June 17, 1970**

[21] Appl. No.: **46,917**

[30] **Foreign Application Priority Data**

June 18, 1969 Austria A 5750/69

[52] U.S. Cl. 73/321, 33/126.6

[51] Int. Cl. G01f 23/10

[58] Field of Search 73/321; 33/126.6 R

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[57] **ABSTRACT**

A refractory float is adapted to float on liquid metal in a mold and is connected to a rotatably mounted winding drum by a flexible connecting element, which is adapted to be wound up on said drum and to be unwound therefrom by a rotation of said drum. Drum-driving means are operatively connected to said drum and arranged normally to exert on said drum a torque which is insufficient to raise said float when the same is supported only by said flexible connecting element and which is sufficient to maintain said flexible connecting element taut when said float is supported by means other than said flexible connecting element. A transducer is provided as well as means operatively connecting the transducer to the drum. The transducer is operable to produce an electric output signal in response to an angular movement of said drum. Signal-utilizing means are connected to said transducer and responsive to said output signal.

11 Claims, 2 Drawing Figures

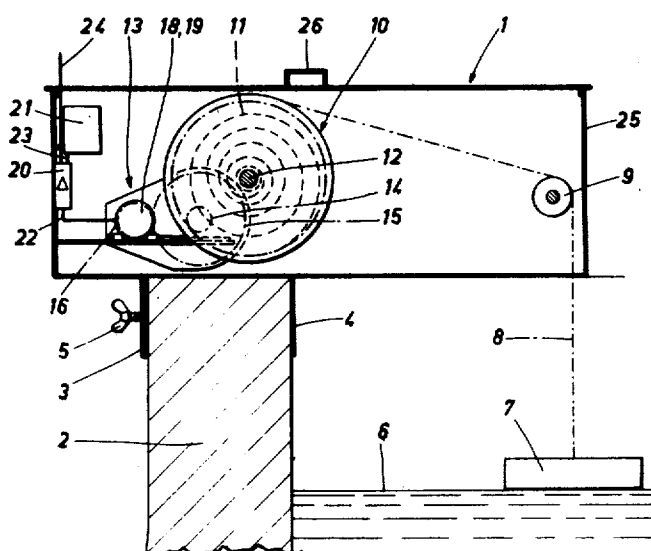


FIG.1

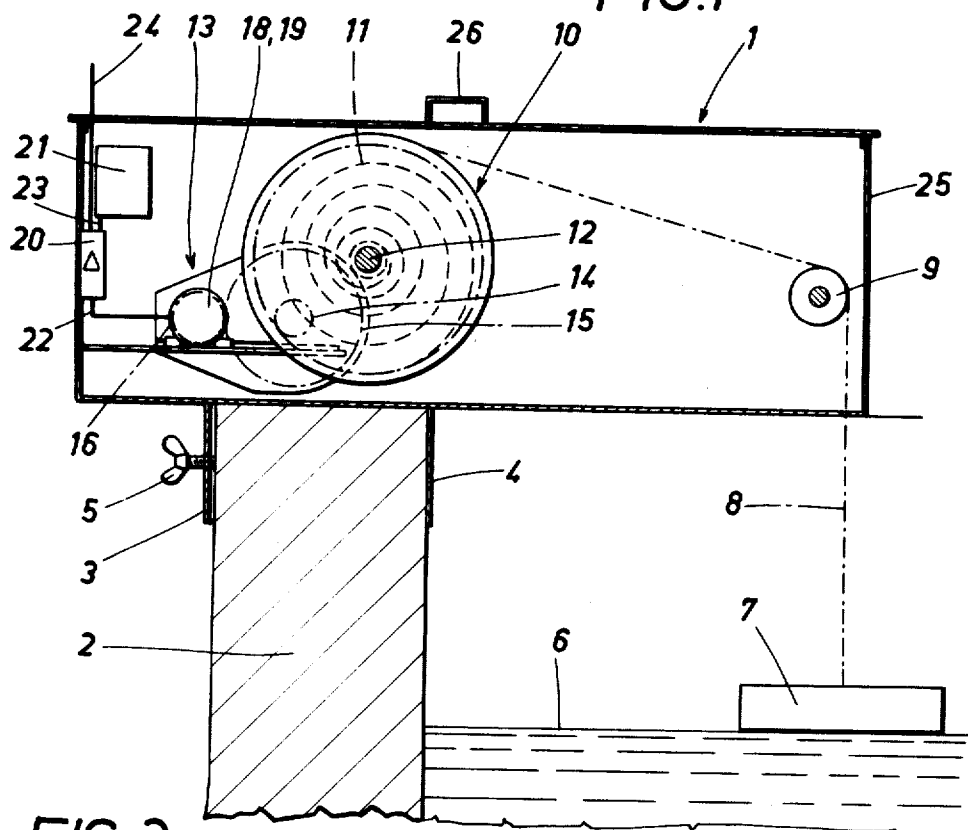
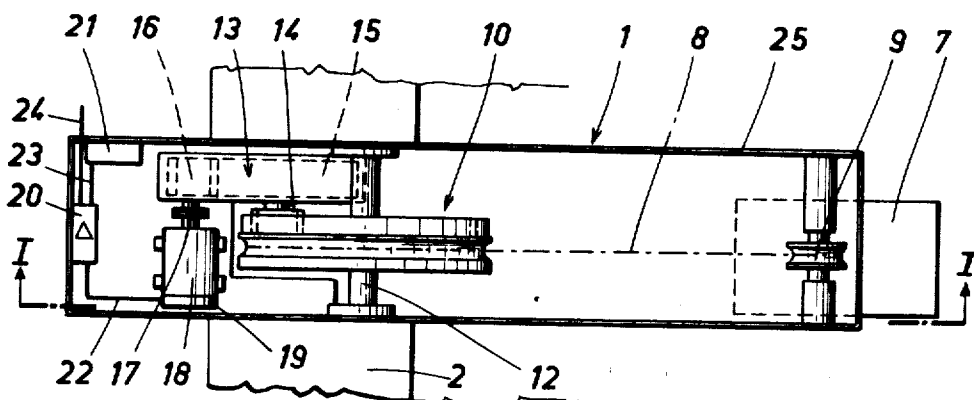


FIG. 2



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APPARATUS FOR INDICATING THE RISE OF LIQUID IN A MOLD

This invention relates to apparatus for measuring the rising speed of liquid metal in molds and the like, particularly in ingot molds, as the metal is poured into the mold.

When molten metal and particularly steel is poured into ingot molds or other molds, the rising speed of the metal in the mold depends on the pouring rate and exerts a strong influence on the solidification and surface finish of the cast product. For this reason it is desired in casting operations, particularly in the casting of steel, to control the pouring rate and rising speed at the values which are optimum in view of the kind of steel being cast, the temperature of the steel, and the cross-section of the ingot mold or other mold, and to maintain said pouring rate and rising speed constant at said values throughout the pouring or to vary them in an exactly controlled manner in accordance with certain rules, which may have been established as a result of experience. Particularly in bottom pouring operations, in which the molten metal enters the ingot mold or other mold at the bottom thereof, the rising speed should be exactly maintained at a predetermined or preselected value.

In the previous practice, the rising speed of the metals during the pouring operation is empirically set. It will be understood that this practice involves large deviations from the rising speed which would be optimum for the respective operation. An improvement has been provided in that weighing devices have been incorporated in the ladle crane so that the amount of metal poured in a predetermined time can be exactly checked. Because the size of the mold is approximately known, the rising speed can be controlled in view of the result of such check. It has been found, however, that crane balances will not operate satisfactorily unless they are incorporated in new cranes. The incorporation of crane balances into existing cranes involves structural difficulties, which continually result in disturbances of the balances so that this indirect measurement of the rising speed of liquid metals being poured cannot be adopted in old steelworks. Besides, the balances are highly expensive and liable to be damaged by the rough usage in a steel-making plant.

To control the capacity of the pump for discharging a crucible for melting metals so that the rate at which metal is discharged by the pump remains constant independently of the level of the bath, it is known to provide a refractory float, which operates a rod that extends out of the crucible and at its upper end carries a rack, which is operatively connected to a regulating valve included in a compressed-air conduit leading to a compressed-air motor which drives the discharge pump. This valve is thus controlled by the float, which must exert the forces required to operate the valve. The various forces applied to the float may cause the latter to rise irregularly or suddenly. This arrangement serves only for a coarse control of a motor whereas there is no measurement of the level of the bath or of the speed at which said level subsides. The arrangement cannot be used in conjunction with a plurality of molds or the like because it is stationary, also because inaccurate measurements would have to be expected and because the transmitting linkage is bulky.

It is an object of the invention to provide a simple apparatus for measuring the rising speed of liquid metals in molds or the like, particularly in ingot molds, which apparatus may also be used, if desired, for a direct or indirect control of the pouring operation and can easily be used in conjunction with a plurality of different ingot molds or other molds in succession.

The apparatus according to the invention is of the kind defined first hereinbefore and comprises a refractory float, which floats on the liquid metal and is operatively connected to a transducer, which is operated by the float and in which the level or the rising speed of the float is converted into a signal which can be sensed electrically or electronically. The invention resides in that the float is connected by a flexible connecting element, such as a cable or wire, to a winding drum, which is adapted to be driven by a spring or by a motor operatively connected to the drum by torque-limiting means, and the drum is operatively connected by a transmission to the transducer, which consists of a generator or potentiometer, the torque which is exerted on the drum by the spring or the torque-limiting means is smaller than the torque required to freely raise the float, so that the transducer is adapted to be controlled by the drum in dependence on the level of the float and can be driven only during a movement of the float in response to a change of the level of the liquid metal supporting the float, whereas the flexible connecting element secured to the float is held taut.

In the apparatus according to the invention, a major portion of the forces required to move the float and drive the transducer are produced by the additional drive means so that very small control forces exerted by the float will be sufficient to produce the desired control or indication. This fact enables an exact indication of the level and rising speed of the float exactly in dependence on the level of the metal. Due to the use of the flexible connecting element, the apparatus is handy and can easily be moved from one mold to another when the connecting element is wound up.

The transducer may consist of an alternating-current generator, which is adapted to be driven by a speed-increasing transmission and the output of which is connected by a rectifier and, if desired, by a voltage amplifier, to an indicating or recording apparatus. Alternatively, the transducer may consist of a potentiometer, which is connected to a source of constant voltage and which is adjustable in response to a movement of the float and connected to an operational amplifier, integrator and analog-digital converter or to a moving-coil recorder having a driven chart so that the vertical deflection performed by the stylus in response to the potentiometer and the feeding speed of the chart result in a recording of the rising speed of the metal in the mold.

A converter may be provided which delivers pulses at a rate which is proportional to the rising speed. A simple converter for this purpose may consist of an interrupter, which is arranged to be driven by the spring-loaded drum. This interrupter may consist of a mechanical interrupter having an interrupter contact which is operated by a gear, or of an optical interrupter consisting, e.g., of a hole disc for interrupting a light beam of a photo-electric device. Alternatively, the interrupter may consist of a piezoelectric transducer.

In a preferred embodiment, the transducer and the drive means or the like are accommodated in a closed refractory housing, which can be secured to a wall of the ingot mold and from which the wire or the like extends which holds the float. In this case, the apparatus can easily be moved from one ingot mold or other mold to the next.

The invention is shown by way of example on the accompanying drawing, in which

FIG. 1 is a sectional view taken on line I—I of FIG. 2 and showing an apparatus according to the invention, and

FIG. 2 is a top plan view showing the apparatus with the housing in an open condition.

The entire measuring apparatus 1 is supported by the wall 2 of an ingot mold and is detachably secured by means of holders 3, 4 and a fixing device 5 consisting of a set screw. The apparatus comprises a refractory float 7, which floats on the surface of liquid metal which has been poured into the mold 2 so that the float rises during the pouring operation at the same speed as the metal in the mold. A cable or wire 8 is secured to the float by means which are not shown and is trained around a deflecting roller 9 and connected to a spring-loaded drum 10.

One end of a spiral spring 11 is secured to the spring-loaded drum 10, on which the wire 8 can be wound. The other end of the spring 11 is rigidly connected to an axle 12, on which the drum 10 is rotatably mounted, so that the spring 11 is stressed as the wire 8 is unwound. The wire 8 is unwound when the float 7 is lowered to the bottom of the ingot mold or other mold before a measuring operation. The spring force is selected so that it can constantly maintain the wire 8 in a taut condition and can drive a transducer which in the embodiment shown by way of example consists of an a.c. generator connected to the drum by a transmission 13, whereas the spring cannot raise the float 7 as long as it is freely suspended from the wire.

The transmission 13 is a speed-increasing transmission and consists of a pinion or friction wheel 14, which is adapted to be driven by the spring drum 10, a gear 15 and another pinion 16. The pinion 16 is operatively connected by a clutch 17 to the alternating-current generator 18.

The alternating current generated by the alternating-current generator 18 is rectified by a rectifier 19 and fed to an indicating device 21 which utilizes the rectified signal to indicate the rise of the liquid metal in the mold. An optional voltage amplifier 20 is connected by an input lead 22 to the rectifier 19 and by an output lead 23 to the indicating device 21. Another lead 24 may be provided to apply the output voltage of the generator to a recorder or to a control device for controlling the pouring operation, the recorder utilizing the rectified signal to record the rise of the liquid metal in the mold and the control device utilizing the signal to control the pouring operation. The output voltage of the generator may be suitably transformed for this purpose. The control device for controlling the pouring operation may be arranged to maintain the rising speed at a desired value in response to the signal transmitted in lead 24. The indicating device and the recorder are preferably calibrated to indicate the pouring rate or the rising speed of the metal in the ingot mold or other mold.

The entire apparatus is accommodated in a housing 25, which is provided with a carrying handle 26 so that it can be transported to any ingot mold or other mold where it is required.

An embodiment has been described hereinbefore by way of example with reference to the drawing and may be modified as has been outlined hereinbefore.

What is claimed is:

1. Apparatus for indicating the rise of liquid metal in a mold, which apparatus comprises
 - a refractory float adapted to float on liquid metal in a mold,
 - a rotatably mounted winding drum,
 - a flexible connecting element which is connected to said float and to said drum and adapted to be wound up on and unwound therefrom by a rotation of said drum,
 - drum-driving means operatively connected to said drum and selected normally to exert on said drum a torque which is insufficient to raise said float when the same is supported only by said flexible connecting element and which is sufficient to maintain said flexible connecting element taut when said float is supported by the liquid metal in the mold,
 - a transducer comprising an alternating-current generator operable to produce an a.c. output signal in response to an angular movement of said drum,
 - a speed-increasing transmission mechanically connecting said generator to said drum whereby the output signal is representative of the speed of said drum,
 - a signal-utilizing means comprising indicating means connected to said generator and responsive to said output signal, and
 - a rectifier arranged between the generator and the signal-utilizing means to convert said a.c. signal into a d.c. signal.
2. Apparatus as set forth in claim 1, in which said flexible connecting element consists of wire.
3. Apparatus as set forth in claim 1, in which said flexible connecting element consists of a cable.
4. Apparatus as set forth in claim 1, in which said drum-driving means comprise a torsion spring connected to said drum and arranged to be torsionally stressed as said flexible connecting element is unwound from said drum and to exert on said drum a torque which is insufficient to raise said float when said flexible connecting element has been entirely unwound from said drum and said float is supported only by said flexible connecting element.
5. Apparatus as set forth in claim 1, in which said signal-utilizing means comprise a voltage amplifier operable to amplify said d.c. signal.
6. Apparatus as set forth in claim 1, in which said signal-utilizing means comprise an indicating device operable to indicate said d.c. signal.
7. Apparatus as set forth in claim 1, in which said signal-utilizing means comprise a recorder operable to record said d.c. signal.
8. Apparatus as set forth in claim 1, in which said transducer comprises
 - a constant-voltage source and
 - a potentiometer connected to said constant-voltage source and mechanically connected to said drum

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and arranged to convert an angular movement of said drum into a change of voltage representing said output signal.

9. Apparatus as set forth in claim 8, in which said signal-utilizing means comprise:

an operational amplifier connected to said potentiometer and responsive to said change of voltage to produce an amplified signal,

an integrator connected to said amplifier and operable to integrate said amplified signal to produce an integrated analog signal,

an analog-digital converter connected to said integrator and operable to convert said integrated analog signal into a digital signal, and

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means adapted to utilize said digital signal.

10. Apparatus as set forth in claim 8, in which said signal-utilizing means comprise a moving-coil recorder connected to said potentiometer and responsive to said change of voltage.

11. Apparatus as set forth in claim 1, in which said transducer, said drum, and said means operatively connecting said transducer to said drum are contained in a closed housing,

means are provided for fixing said housing to a wall, and

said flexible connecting element extends out of said housing to said float.

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