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METHOD AND APPARATUS FOR PROCESSING MATERIALS INTO FOIL AND STRIP FORM

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ABSTRACT OF THE DISCLOSURE

A method and apparatus for forming sheet or strip material by flowing liquid through an elongated channel and on to a surface which is wet by the liquid, and causing the liquid to form a bridge between that surface and a moving surface adjacent to that surface to coat the moving surface with a film of liquid which is solidified and stripped from the moving surface as a continuous sheet.

This invention relates generally to the manufacture of foil and strip and particularly to the manufacture of continuous lengths of metal foil and strip. More particularly the invention relates to the manufacture of continuous lengths of metal foil and strip from molten metal.

Broadly the invention comprises means for continuously coating liquid material on to a moving surface so as to allow subsequent solidification and removal of the coated material continuously from the moving surface as a continuous length of foil and strip.

In the present context "foil" means sheetlike material having a thickness between a fraction of a thousandth and a few thousandths of an inch and "strip" means sheetlike material having a thickness between a few thousandths and a few tens of thousandths of an inch. A "continuous length" of foil or strip means an arbitrary length of foil or strip limited as a matter of convenience and not by limitation of the manufacturing process.

Numerous processes for manufacturing foil and strip of both metals and non-metals are of course well known and some are well established commercially. Confining attention to metal strip and foil which are the especial concern of the present invention, the most widely used foil manufacturing process is that of "rolling." In the rolling process a metal slab is successively reduced in thickness and increased in area by successive passages between rollers. This rolling process is entirely satisfactory for producing thick strip but somewhat less than satisfactory for producing thin strip and foil. The main difficulty with the rolling process for manufacturing foil is that to maintain uniformity of foil thickness as thickness decreases generally requires proportionate reduction in foil width which is to say the thinnest foil can be satisfactorily rolled only in very narrow width. The reason for this width difficulty with the rolling process is that the problems of maintaining small clearance accurately between two rollers increase exponentially with roller width. Hence, for example, whereas to produce copper foil one thousandth of an inch thick and a few inches wide by rolling process is relatively easy, to produce copper foil of the same thickness but several feet wide by rolling process is relatively difficult. Consequently, because a considerable demand for wide foils, particularly copper foil, has developed in recent years, alternatives to the rolling process for manufacturing foil have received widespread attention. In the case of copper foil, for example, by far the most successful of these alternative foil manufacturing processes to date has been that of electrolytically depositing a copper coating onto a moving surface so as then to remove the coating as foil. This electrolytic-coating foil-process produces copper foil of thickness down to a fraction of a thousandth of an inch in widths up to several feet. The quality of copper foil produced by the electrolytic-coating foil-process of course ultimately depends upon the quality of of the anode copper and of the electrolytic tank chemicals used. Even using the best available grades of anode copper and tank chemicals, the quality of the electrolytically produced copper foil is still somewhat below the highest grade of foil that can be produced by rolling out the highest grade of copper slab. That is to say, in the case of copper for example, the electrolytic-coating foil-process while overcoming the width difficulty of the rolling process does not usually produce as high a quality of foil. In fact, for a number of the applications of wide copper foil, notably those requiring very high electrical conductivity and substantially complete freedom from mechanical imperfections such as pin holes, the quality of foil produced by the electrolytic-coating foil-process is less than adequate. Accordingly, widespread attention has been lately directed toward further alternative processes for manufacturing foil, particularly copper foil, with a view to overcoming both the width limitation of the rolling process and the quality deficiency of the electrolytic process. The principle of coating a surface so as subsequently to remove the coating from the surface as foil, as has been commercially established in the electrolytic-coating foil-process outlined above, can obviously be applied to convert almost any coating process into a foil manufacturing process. A number of other foil-manufacturing-processes which share with the electrolytic foil-process the principle of coating material onto a moving surface so as then to be stripped as foil are hence based on well known coating-processes. These other foil processes which may be regarded as obvious adaptions of well known coating processes in view of the electrolytic coating foil-process include the pyrolytic-coating foil-process, the powder-coating foil-process, the vapor-coating foil-process and the liquid-coating foil-process. Most closely akin to the electrolytic coating foil-process is the pyrolytic-coating foil-process in which a chemical vapour containing the foil material as a constituent is decomposed by heat at the moving surface so as to coat foil material on the surface. This pyrolytic foil process, when used for copper foil, has much the same advantages and disadvantages as the electrolytic process which is to say there is no width limitation but there is a quality potential somewhat less than the rolling process. Widely different from either the electrolytic-coating foil-process or the pyrolytic-coating process, in that foil material is coated directly without chemical action, are the three "direct-coating" foil-processes of powder-coating, vapor-coating and liquid-coating. In the powder-coating process a moving surface is coated with powdered material which is then melted together and removed as foil. In the vapor-coating foil-process vaporised material is condensed on a moving surface to form a coating which is then removed as foil. In the liquid-coating foil-process a moving surface is coated with liquid material which is then solidified and removed as foil.

The above mentioned three direct-coating foil-processes all have intrinsic potential of producing the highest quality of foil without limitation as to width from a variety of materials. However, so far as is known, none of the three direct-coating foil-processes has yet been commercially used for the manufacture of wide metal foils for the reason that the considerable difficulties which are encountered in implementing these three direct-coating foil-processes have not yet been overcome on a commercial scale. As will be explained later, if satisfactory means for applying the coatings are available for each of the three direct-coating foil-processes, the liquid-coating foil-proc-