A vacuum coating system having at least two separate induction heated crucibles, the crucibles being sufficiently closely spaced so that there is appreciable coupling between the two separate induction coils surrounding the crucibles. Means are provided for inducing in the tank circuit feeding each induction coil a voltage equal to and opposite to that induced in the coil by the adjacent induction coil.

3 Claims, 1 Drawing Figure
The present invention relates to the vacuum coating art wherein a material such as aluminum is heated to vaporizing temperature in a vacuum chamber and the vapors are then condensed on a substrate which is moved past the source of vapors. In present commercial vacuum coating apparatus for aluminumizing (for example) large areas of flexible substrate such as Mylar, it is common practice to provide a number of crucibles containing a sufficient charge of aluminum so as to permit the coating of thousands of linear feet of the substrate in a single coating run. In such apparatus, it is often extremely important that the coating be very uniform and not have appreciable variation across the width of the substrate. In order to achieve such uniformity, it is necessary that the aluminum charge in each crucible be essentially at the same temperature. It is also important that the crucibles be positioned rather close together so that the vapor patterns from the crucibles overlap to give essentially uniform concentration of vapors impinging on the substrate at any point across the substrate width.

In the past, one satisfactory method of providing this uniformity has been that disclosed in the Baer et al. U.S. Pat. No. 2,935,589, wherein a single turn coil surrounds a plurality of crucibles rather closely spaced. The disadvantage of this arrangement, however, is that it does not permit the adjustment of the amount of power fed to each crucible to compensate for problems of crucible mounting, differences in crucible materials, differences in degree of insulation and other factors which can affect the coupling of the coil and the individual crucible. Accordingly, if one of the crucibles is operating at a slightly different temperature than the others because of a difference in heat balance or coupling, there is nothing basically that can be done during the course of the operation to change the power input to the malfunctioning crucible. While attempts have been made to have separate induction coils surrounding each crucible, these have not, in the past, achieved any commercial success due to the difficulty of preventing substantial interaction between the individual coils.

Accordingly, it is a principal object of the present invention to provide an induction heated vacuum coating system which provides the flexibility of operation obtainable with an individually powered induction coil for each crucible while permitting stable operation of the total system by providing a simple method of eliminating the effect of coupling between adjacent separate induction coils.

In considering the present invention, it is simpler to discuss a coating system containing only two separate induction coils, while obviously the principles of the present invention are equally applicable to systems having three or more separate induction heated sources. In the present invention, each coil has its own source of power and its own tuned tank circuit which is tuned to the frequency of the alternating power supply to provide high amperage, low voltage, current in each induction coil. Typically, the currents will run on the order of 800 amperes through a three-turn coil. The first coil during operation will induce a strong voltage in the second coil. In the present invention, the current flowing in the first tank circuit also flows through a coupling means which is arranged to induce in the second tank circuit a voltage equal to and opposite to that induced in the second coil by the current flowing through the first coil. Thus, as the power is raised or lowered in the first tank circuit to adjust the temperature in the first crucible, for example, the current flowing in the first tank circuit changes. This changes the amount of voltage induced in the second coil and also changes the amount of the balancing voltage induced in the second tank circuit by the coupling means, thus providing neutralization of the coil-to-coil coupling despite individual adjustment of the power level in each coil.

Referring to the FIGURE for a more detailed description of the invention, there is illustrated in a very schematic, diagrammatic fashion one preferred embodiment of the invention as applied to two separately heated crucibles. In this FIGURE and the dotted line 8 represents a vacuum coating chamber, for example of the type shown in U.S. Pat. No. to Eng., 2,996,037, which patent shows three separate inductively heated crucibles.

In the figure, the first crucible 10 is shown in dotted lines as being surrounded by induction coil 12 which is energized from a variable power supply 14 connected to a source of high frequency (e.g., 10,000 Herz) alternating power 16. In series with induction coil 12 is a condenser 16, this condenser being schematically indicated as a single condenser, but obviously it may be a plurality of condensers and may be adjustable for fine tuning of the tank circuit comprising the coil 12 and the condenser 16. Also in series with the tank circuit is a second coil 18 positioned outside of the vacuum chamber 10. The second crucible 16a is surrounded by a second coil 12a having its own variable power supply 14a, power source 16a, condenser 16a and external coupling coil 18a.

In constructing the system briefly outlined above, the coupling coils 18 and 18a are designed so that each induces into the other tank circuit a voltage equal to and opposed to the voltage induced in the other tank circuit by its own series related induction heating coil. Thus, the external coil 18 induces into the coil 18a a voltage equal to and opposed to the voltage induced in induction heating coil 12a by induction coil 12. The relationships between these coils can be roughly calculated by using generally accepted design criteria. The actual coupling can be adjusted by the spacing between the coils 18 and 18a, or by other techniques well known to those skilled in the art.

With the above described system, the power fed to each individual crucible can be rather widely varied without adversely affecting the power level of the adjacent crucible, thus permitting careful control of the coating process.

While only two crucibles have been illustrated, three or more may be equally used, in which case the various coupling means 18 and 18a etc., are arranged to provide for the generation of counterbalancing voltages in the adjacent tank circuits. As a practical matter, the adjustment is only necessary for the immediately adjacent tank circuits, since more distant tank circuits are only insignificantly affected by the remote induction coils surrounding the remote crucibles. Similarly, while separate sources of power have been illustrated at 14 and 14a, these can be taken from the same alternating power source, such as a motor generator set.

Since certain changes can be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a vacuum coating system wherein two individual crucibles are heated by two separate induction coils to heat the contents of the crucibles to vaporization temperature and to provide coating of a substrate passing over the crucibles, wherein the two crucibles are positioned sufficiently close to each other that appreciable coupling occurs between the two coils and wherein each coil has its own tuned tank circuit, the improvement which comprises coupling means in the first tank circuit separate from the first coil and in series with the first coil and arranged to induce in the tank circuit of the second coil a voltage equal to and opposite to that induced in the second coil by the first coil.

2. The system of claim 1 wherein the second tank circuit includes a similar coupling means for inducing into the first tank circuit a voltage equal and opposite to the voltage induced in the first coil by the second coil.

3. The system of claim 1 wherein the two tank circuits are connected to separate power supplies.