The present invention is related to a method for the manufacture of projection screens, particularly of screens with embossed surfaces.

Projection screens have become known which show a directed diffusion, i.e. the light reflected by the screen is directed preferentially to that part of the space occupied by the spectators. Screens with a reflecting surface composed of a multitude of small—e.g. convex—specular elements have proved particularly efficient. By a suitable choice of the form and curvature of the individual elements any desired characteristic of diffusion may be obtained. Generally such screens are manufactured by pressing between rolls, the surface of which shows the negative relief of the desired embossing.

The precision of the diffusion characteristic obtainable by such a process of rolling is, however, unsatisfactory for screens with high gain. With such screens the angles of diffusion of all elements on the screen surface must be within very narrow limits and must be oriented with a corresponding precision, so that the light reflected by each element is directed to exactly the same part—and only this part—of the space. With the normal methods of processing the surface of the rolls certain errors of the form of the elements may not be avoided. These errors appear on the screen and cause strip-shaped irregularities of the screen brightness along the screen.

The present invention has the object to remedy these disadvantages and is related to a method for the manufacture of the strips composing the surface of an embossed screen. According to the invention the method is characterized by the feature that the individual strips are produced from metal foil with highly reflectant surface by stamping, the embossing being stamped across the entire breadth of the strip with each stroke of the tool, and the advance of the foil between two strokes being of the same order of size as the division of the embossing in this direction.

The present invention will be explained in the following with the aid of embodiments shown by the attached drawings, where

Fig. 1 shows a strip composing such an embossed screen,

Fig. 1A shows a single element of this embossing and Figs. 2 and 2A show the stamping tool employed for manufacture.

Figs. 3 and 4 schematically show the relative position of stamping die and metal foil for the production of screens with varying angles of deflection and

Figs. 3A and 4A the metal foil strip produced by this process.

Fig. 1 schematically shows a foil produced by the method of manufacture according to the invention. The individual diffusion elements 1 may be seen on the parts already stamped.

Fig. 1A shows a single element which according to the representation is of toroido-concave shape, i.e. the surface is curved inwards and the radii of curvature are of different size in sections 2 and 3. Elements of embossing of this kind are known and do not form the subject of the present invention.

When judging the relation of the breadth of the strip to the size of the elements it must be kept in mind that the centre part of the strip is shown cut away in the drawing. The size of the elements must be such that they do not appear as separate elements to the spectator. They thus must be so small that the eye is not capable to resolve them. The breadth of the strip, however, is chosen as large as possible with respect to the conditions of manufacture.

According to the invention the embossing of the strip is obtained by stamping, the embossing being stamped across the entire breadth of the strip by each stroke and the advance of the foil from stroke to stroke being approximately of the same order as the division of the screen in direction of the advance. The foil shown by Fig. 1 is not yet finished so that the unstamped portion of foil 4 is seen at the upper part. By the last stroke, by way of example, two rows (divisions) 5 were stamped and, by the preceding stroke, the two preceding rows (divisions) were stamped. The advance of the foil from stroke to stroke is thus equal to two divisions, i.e. it is of the order of size of a division of the embossing as compared with the breadth of the strip.

The advantages of this method of manufacture according to the invention are easily understood. By every stroke only one or only a few divisions are stamped the size of which, as mentioned above, is lower than the resolving power of the eye of the spectator. Small irregularities occurring within the embossing stamped by the same stroke which may not be avoided with regard to the accuracy of manufacture of the tool will therefore not cause disturbing irregularities of the screen brightness.

An identical form of the elements adjoining at right angles to the direction of the strip may be obtained without excessive cost by careful processing of the tool as the tool only has one or a few rows of elements and its breadth is of the order of size of the steps of division of the embossing. With regard to the reduced thickness of the tool, i.e. the low number of elements, the individual elements of the tool may be obtained with the necessary precision and identical shape without great difficulty.

Figs. 2 and 2A schematically show a tool 10 which may be inserted in any of the well-known stamping presses shows on its working face 11 an embossing 12, which is the negative relief of the embossing to be produced. The breadth 13 of the tool corresponds to the breadth of the strip to be embossed. The thickness 14 of the tool is of the same order of size as the division of the screen, i.e. the working surface in direction of the thickness 14 shows only one or a few elements of the embossing.

For producing screens with extreme accuracy a stamping die is employed which reaches across the entire breadth of the strip and the thickness of which at right angles to the strip is equal to one division of the embossing. With such a tool only one single division of the embossing is stamped by each stroke, which directly adjoins to the embossing stamped by the preceding stroke. In this case the individual elements adjoining in direction of the strip are practically identical as they have been stamped by the same portion of the tool.

If in place of such a tool a roll would be employed the elements adjoining in direction of the strip would have been produced by different parts of the roll surface. The identity of individual elements at different points of the roll is thus limited as the accuracy of such rolls is also limited. Particularly differ-
ence of the elements will show in direction of the axis of the roll which will cause strip-shaped irregularities of the embossing. As furthermore the circumference of the roll is smaller than the entire length of the strip appearing on the screen, these irregularities along the strips will produce periodically distributed disturbances on the finished screen.

If, however, a great number of divisions of the embossing was produced by each stroke of the stamping die the advance step being consequently considerably larger than the division of the embossing in this direction, irregularities may be caused by the limited accuracy of the advance mechanism. First the distance between two elements, i.e. the division at the parting line between two stamping strokes is not equal to the division of the elements stamped by the same stroke. Furthermore the accuracy of stamping is always reduced along the edge of the tool, so that these elements will show a slightly deviating characteristic of diffusion. This will cause irregularities of the screen brightness at the adjoining points between the embossing stamped by succeeding strokes.

The accuracy required for the angle of diffusion and the orientation of the individual elements of a screen with high gain—and only such screens are of importance for practical application—may be obtained only by a process of manufacture which with each stroke stamps the embossing across the entire breadth of the strip and where the advance of the foil from stroke to stroke is of the order of size of the dimension of the division of the embossing in this direction.

In most cases the maximum gain of screen brightness may be obtained if the angle of deflection of the embossing is varied in at least one direction. Embossed screens of this kind are well known. Such an embossing the division is substantially different in both directions and the angle of deflection varies at least in direction of the larger division.

An embossing with varying angle of deflection may very easily be obtained with the process according to the present invention by employing a stamping die, the thickness of which is equal to the division of the embossing at right angles to the strip and where the height of the holding-down devices located in front of and at the rear of the stamping die is changed according to the desired angle of the deflection. This is schematically shown in Figs. 3 and 4.

Fig. 3 schematically shows the manufacture of an embossing where the elements and thus the diffusion characteristic are oriented perpendicularly to the plane of the foil. Foil 20 is passed from left to right under stamping die 21, which executes its strokes in the direction of arrow 22. Underneath the stamping die is a counter die 23. After stamping, the foil shows the desired embossed form 24. In order to avoid warping of the foil during stamping, holding-down devices 25 and 26 are disposed in front and at the rear of stamping die 21. These move in the same manner as the stamping die, but do not touch the counter devices 27 and 28 in their lower dead point.

Fig. 3A shows that with the stamping produced in this manner the perpendicular 32 to the plane 31 of the foil coincides with the axis 30 of the element. If the angle of deflection shall be varied, the holding-down devices 25 and 26 and the counter devices 27 and 28 are shifted relative to the stamping die 21, as schematically shown by Fig. 4. Thus by way of example, holding-down device 26 and counter device 28 are shifted upwards, holding-down device 25 and counter device 27 are shifted downwards. The embossing hereby obtained is schematically shown by Fig. 4A. The axes 30 of the elements are no longer at right angles to the plane 31 of the foil, but are inclined by an angle 33 to the perpendicular 32 on plane 31. The inclination of the plane of the foil with respect to the direction of the stroke of the die necessary for varying the angle of deflection may thus be obtained by a corresponding variation of the height of the holding-down devices disposed in front of and at the rear of the stamping die.

The variation of the angle of deflection along the strip as discussed in the preceding paragraph must be effected continuously in order to obtain a high light efficiency of the screen. This is possible with the arrangements shown by Figs. 3 and 4 if the relative variation of the height of the holding-down devices is effected in dependence upon the advance of the foil. The advance of the foil is effected step by step and it is made easily possible by use of a suitable gear or spindle to vary the height of the holding-down devices for each stroke of the stamping die by an amount which corresponds to the desired variation of the deflection angle along the strip.

I claim:

1. The method of manufacturing embossed strips of metal foil of the type forming a projection screen where in placed in side-by-side relationship, said foil having a high reflective surface embossed throughout by specular elements having a size which is less than the resolving power of the eye of the spectator and which are arranged in side-by-side relation, said method comprising the steps of forming, by means of sequential stamping operations of the same stamping die, not more than a few rows of said specular elements extending across the entire width of said metal foil strip at each stamping operation, and advancing said metal strip relative to said stamping die between successive stamping operations of said die such that a row of said specular elements formed by one stamping operation lies immediately adjacent a row formed by the preceding stamping operation, the distance between successive strokes of said stamping die as measured in a lengthwise direction of said strip being less than the resolving power of the eye of the spectator whereby minor irregularities which may occur within the embossing attributable to inherent complementary irregularities in the die create no apparent irregularities in brightness of the projection screen.

2. The method of manufacturing embossed metal strips for projection screens as defined in claim 1 wherein only one row of said specular elements is formed at each stamping operation of said die.

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