Nov. 14, 1939. W. H. FINKELDEY 2,180,293

ZINC ENGRAVING PLATE

Filed July 26, 1938

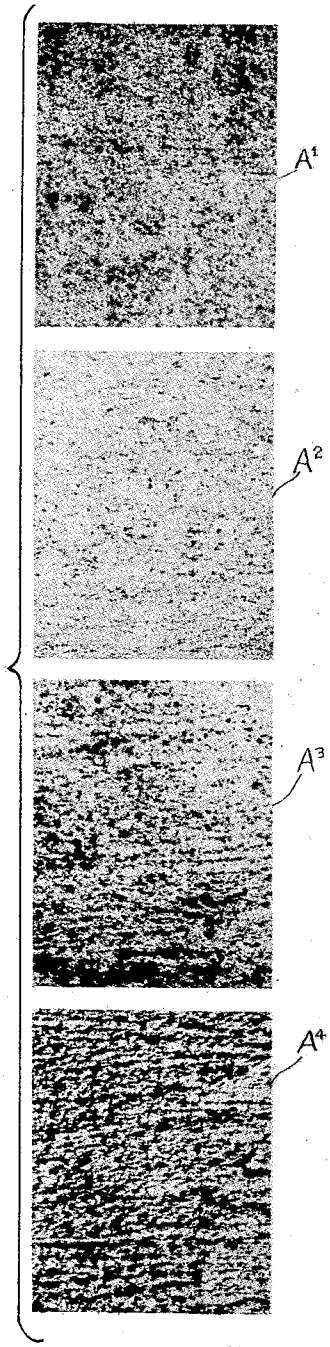


Fig. 1.

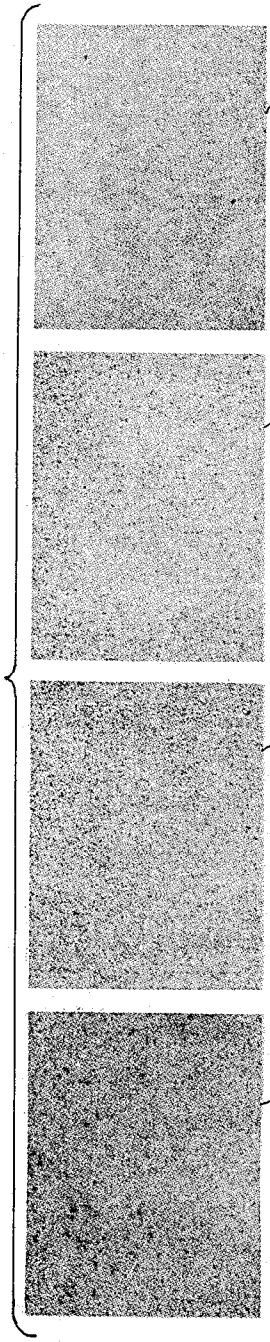


Fig. 2.

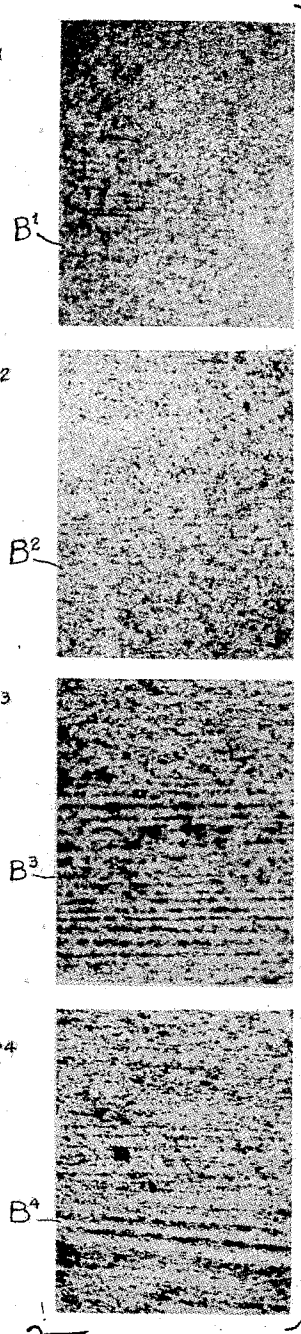


Fig. 3.

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Patented Nov. 14, 1939

2,180,293

UNITED STATES PATENT OFFICE

2,180,293

ZINC ENGRAVING PLATE

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Application July 26, 1938, Serial No. 221,347

12 Claims. (Cl. 101—401.1)

This invention relates to new and improved zinc engraving plates, particularly of the type used for photo-engraving work in the graphic arts industry.

The photo-engraving process involves the treatment of ground and highly polished rolled metal plates by photography and etching to produce images in relief on etched plates which are used in transmitting the images to printed matter. In some types of work the printing is done directly from the etched plates. In newspaper and similar types of work the etched plates are used as molds in forming stereotype mats, and the latter then serve as molds on which to cast molten stereotype metal to produce stereotype plates for the printing presses.

In a typical photo-engraving process, a polished zinc engraving plate is first coated with a special "hot top" enamel and then heated to a temperature of about 600° F. to burn in the enamel and develop a light-sensitive, acid-resistant coating on the plate. The desired image is then transferred to the enamel coating by exposing the coating to a strong light passing through a photographic negative bearing the image to be reproduced, whereupon the portions of the coating affected by the light are rendered water insoluble. The portions unaffected by light are washed off with water, and the plate is then ready for the etching operations which develop the image on the plate in relief and prepare the plate for use in printing or in mat molding operations.

In preparing half-tone cuts, the etching is usually carried out so that the image projects above the etched surface of the plate from three to seven thousandths of an inch, while in the case of line cuts the image may project upwardly from thirty to forty thousandths of an inch, or even more for certain special purposes. The small pin-point dots in the "highlights" of a half-tone etching and the fine lines in a line cut may be only a few thousandths of an inch in width. If the etching were carried out to the depths mentioned in a single operation, the unetched portions of the plate would be undercut by the etching acid in a manner destroying their support and making it impossible properly to carry out the stereotype mat molding operation, in which paper board is pressed into the finished etching and thereafter removed from the etching with the image molded in the mat. Consequently, the sensitized and washed plate is subjected to a series of etchings. A first bite of the etching acid is made, and after etching has proceeded to a small depth the plate is rinsed, dried and then brushed carefully in four different brushing stages with an acid-resistant powdered resin known as "dragon's blood powder", to bank the powder against the edges of the unetched parts, or "tops", and protect them from attack from acid when etching is resumed. The plate is heated to a temperature of approximately 300° F. after each of these brushing stages to set or burn in the dragon's blood powder, and another bite of the etching acid is then made. From two to five bites of the etching acid are taken in practice, so that the heating operations are repeated from eight to sixteen times in the preparation of line cuts for newspaper and similar work, until finally the image projects the required distance from the etched surface of the plate. Thereafter, in the case of line cuts, the plate is carefully gone over with a "routing machine" to cut away objectionable irregularities projecting from the etched surface, and it is then ready for use in the stereotype mat molding operations.

It should be apparent from the foregoing that the facility with which the photo-engraver is able to carry out his work and the service and quality of printing obtainable by the use of etched engraving plates are limited by the characteristics of the plates used in the photo-engraving process. The most common types of plates are rolled zinc plates, of various thicknesses and suitably ground and polished, made of commercial zinc metal of which a composition containing about .18 cadmium, .015 iron, .30 lead and the remainder zinc is typical. These plates are prepared by casting molten zinc into metal molds, rolling the castings into sheets of suitable thickness, and grinding and polishing the smoother side of each sheet (corresponding to the side of the casting that contacted the bottom of the mold) to finish it for the photo-engraving process. For reasons which will be explained below, the usual zinc engraving plates are subject to serious objections in many types of work, and it is often necessary to use much more expensive rolled engraving plates, made of metal such as copper or brass, in order to secure satisfactory service and

printing results. For example, the usual zinc engraving plates are seldom used for direct printing work or for work in which accurate reproduction of detail is essential. Moreover, in the many uses for which they apear to be satisfactory, sacrifices of printing quality and engraving difficulties are tolerated for lack of other plates that will give better results without involving a substantial increase in printing costs.

The first influence which a satisfactory engraving plate must withstand, when using a "hot top" type of photo-sensitive enamel, is the heating of the plate to a temperature of approximately 600° F. in order to develop the acid-resistant photo-sensitive coating. Next, regardless of the particular type of photo-sensitive coating, the plate must withstand anywhere from eight to sixteen heatings to a temperature of about 300° F. in order to set or burn in the dragon's blood powder in the course of the etching process.

These various heating operations have a pronounced effect upon the hardness of ordinary zinc engraving plates. They reduce the plates from an original Rockwell hardness of about 75 to a hardness of about 45 to 55, the loss of hardness in any particular case varying with the temperature and number of times of heating.

In newspaper work and similar types of printing, the etched plates are subject to great pressure in the stereotype mat molding operations. Where the "dry mat" molding process is used, pressures as high as four thousand pounds per square inch are often reached. Further, since several mats are commonly required from each etching, this molding pressure is often applied to the etching a number of times, and in the case of etchings for syndicated printed matter the number of mats required and the number of times the pressure is applied may run as high as two or three hundred.

The ordinary grade of zinc engraving plate, having a Rockwell hardness of as much as 55 after the etching process, is satisfactory in respect of hardness and resistance to deformation for many less-exacting types of printing work. When these plates are subjected to the high pressures used in the so called "dry mat" molding process, however, photo-engravers have found it difficult, if not impossible, to maintain fine lines or fine dots in the zinc etching. This is particularly true where a large number of mats must be made from a given etching, as in the case of syndicated printed matter. When poor quality of printing is not likely to be criticized, the ordinary zinc engraving plates are commonly used notwithstanding the results. Where the difficulty must be obviated, the engravers must either make a number of zinc etchings of a given image, so that new etchings can be substituted for used ones as they are deformed and broken down in the mat molding operation, or else they must resort to the use of much more expensive plates made of copper, brass or other alloys which possess greater hardness and resistance to deformation. To withstand repeatedly the high pressures of the "dry mat" molding process an etched engraving plate should have a Rockwell hardness of at least 65 to 67. This is not attainable with ordinary zinc engraving plates. While a special hard grade of zinc engraving plate is known which will retain a Rockwell hardness of about 70 to 73 after the coating and etching process, this and the ordinary type of zinc engraving plates are both subject to further objections in other important respects.

In addition to possessing satisfactory hardness and toughness for the service in view, it is of basic importance that an engraving plate possess good etching qualities. The etched surface of the metal should be free at all times from objectionable "grain", streaks or other roughness, since uneven surfaces between the dots of a half-tone or the lines of a line cut, due to any cause whatsoever, will generally catch and hold the dragon's blood powder which is brushed over the plate between stages of the etching process. Where the dragon's blood powder is caught by such a roughened surface and not removed by the brushing operation, the resin is fixed to the plate when it is next heated to set the powder, and an acid resistant area is produced. The metal is then protected at such areas against further attack by the acid etching solution, with the result that the original surface roughness or unevenness is accentuated by the next etching step. This roughness or unevenness is further aggravated during succeeding powdering operations until, in some cases, it becomes so pronounced that the plate must be discarded. Even where the plate is not discarded considerable extra time is spent in machining the roughened areas and raised portions of the etched surface from the image proper, by use of the "routing machine", in order to avoid trouble in the mat molding operation or in the use of the plate for direct printing work.

All of the zinc engraving plates heretofore known in the art cause difficulty due to roughness or unevenness to an objectionable extent, where the etching is carried out to an appreciable depth, and these difficulties have been avoided only by the use of copper or brass engraving plates.

In printing work of high quality, and where printing is done directly from half-tone engravings, line cuts or etching, it is the usual practice in this country to use engraving plates made of copper or brass because of the poor etching properties of the known zinc engraving plates and because they do not possess sufficient hardness and resistance to wear to permit the printing of very many impressions before loss of detail in the etched image occurs. Furthermore, in preparing the engravings in work of high quality it is frequently necessary to re-etch by hand certain areas of the half-tone, such as in the high-lights, or to re-etch by hand the fine lines in the line cut, in order to reduce the size of the dots or lines. Such re-etching cannot be carried out satisfactorily with known zinc engraving plates because of their non-uniform etching properties and their lack of smoothness in the etched surface. For example, if an attempt is made to reduce the size of the pin-point dots in the high-lights of an ordinary zinc half-tone engraving, it will be found that the edges of the dots will etch irregularly and crumble off in the re-etching process instead of being reduced smoothly and uniformly as in the case of brass or copper. This is an especially important consideration where half-tone engravings are made with the finer screens, i. e., 120 lines or finer.

Copper and brass engraving plates are preferred over zinc plates for the more critical types of printing, especially three- and four-color work, for the further reason that present day commercial zinc engraving plates undergo

objectionable dimensional changes upon repeated heating. These dimensional changes are not the ordinary increases or decreases in dimensions which many metals exhibit due to temperature changes, but are permanent increases and decreases in dimensions which, though small in amount, are readily measurable in a zinc plate at room temperature providing it has previously been heated a number of times. All photo-engraving plates are necessarily heated and cooled a number of times in the course of developing the image on the plate, and with ordinary zinc plates it is not uncommon for dimensional changes to take place which are of sufficient magnitude to cause serious difficulty in securing "register" of the printed image where two or more zinc plates are used, as in multicolor printing work. This property of known zinc engraving plates is familiar to photo engravers and has limited their use in multicolor printing to the less critical type of printed matter, such as Sunday newspaper comic strips. Even in this field, "register" trouble is often experienced.

An object of my invention is to provide new and improved zinc engraving plates having suitable qualities of hardness and resistance to deformation and wear combined with superior etching properties as compared with the zinc engraving plates heretofore known for photo-engraving work.

Another object of the invention is to provide zinc engraving plates having desirable hardness qualities together with improved etching properties such that etched surfaces of the plates, even when deeply etched, remain comparatively free of objectional "grain", streaks or other roughness and avoid difficulties which have heretofore been encountered due to the lodging of dragon's blood powder on surface irregularities.

Another object is to provide zinc engraving plates which are attacked uniformly by etching acid and may be readily re-etched by hand in photo-engraving work of high quality.

Another object is to provide zinc engraving plates which are fully resistant against deformation and wear under high pressures encountered in the "dry mat" molding process, so that mats having accurate impressions may be obtained, and so that a large number of mats may be molded from a single etched plate while retaining accuracy and clarity of detail in each of the many impressions.

Another object is to provide zinc engraving plates which has a satisfactory initial hardness and resistance to deformation, and which retain these qualities to a much greater extent than known zinc engraving plates after repeated heating or annealing operations such as encountered in the photo-engraving process.

Another object is to provide zinc engraving plates which are less subject to dimensional changes when heated than known zinc engraving plates, and thus to avoid difficulties which have heretofore been encountered in obtaining registration of different parts of a printed image in multicolor work.

Another important object of the invention is to provide zinc engraving plates which may be used in various types of printing work with results comparable to those obtainable by the use of copper or brass engraving plates, but at much less expense.

A further object of the invention is to provide zinc engraving plates which effect important savings of time and cost in photo-engraving operations by reducing difficulties in etching, reducing the amount of finishing work with the "routing machine", eliminating the necessity of discarding etched plates because of pronounced roughness, and making it unnecessary to etch a plurality of plates with a given image when molding a large number of stereotype mats, as in the case of syndicated printed matter, all of which elements of time and cost have attended the use of zinc engraving plates prior to the present invention.

I have found that one of the principal causes of etching difficulties in the use of known zinc engraving plates is the presence in the zinc plates of certain impurities, principally lead and, to a less extent, iron, both of which are present in the zinc photo-engraving plates now on the market. I have found that the presence of these impurities is responsible for certain roughness of the etched surfaces and causes etching troubles which are particularly objectionable when the plates are deeply etched, as in the preparation of line cut engravings. While these metallic impurities are soluble in zinc to a limited extent when in a molten state, they separate out as the zinc solidifies, after being cast in molds, in the form of globules or droplets, in the case of lead, which tend to be entrapped in the cast metal somewhat above the bottom surface of the casting, and in the form of fine crystalline particles of iron-zinc compound in the case of iron. When cast zinc metal containing these impurities is subsequently rolled into plates the impurities are scattered through the mass of the rolled metal as streaks of lead-rich material or broken up crystallites of iron-zinc alloy, and it is lack of homogeneity in the rolled plates, caused by these impurities, which I have found to be largely responsible for etching difficulties that have attended the use of zinc engraving plates prior to my invention.

When a rolled zinc plate containing these impurities is placed in the nitric acid etching solution commonly used in the photo-engraving process, the elongated lead-rich droplets and the particles of iron-zinc compound do not dissolve at the same rate as the surrounding zinc metal in which they are dispersed. As a result, these particles of impurities tend to stand out in relief and cause a roughening of the etched surfaces, leading to difficulties described in the foregoing paragraphs.

I have found that rough surfaces leading to etching difficulties are also caused by the large grain structure of the metal in ordinary zinc engraving plates, and by the effects on grain structure of the several heating or annealing operations which occur during the photo-engraving process. As heretofore explained, this annealing is unavoidable, since it will occur either when the plate is heated up to burn in the "hot top" enamel, when such enamel is used, or when the plate receives repeated heatings at temperatures of about 300 to 350° F. to set the dragon's blood powder. Ordinary zinc metal and zinc alloys in the so-called "cold worked" or "strain hardened" condition undergo structural changes when heated to a sufficiently high temperature, through the growth of new grains or crystals of the metal or alloy in the mass of wrought material. Zinc engraving plates are "strain hardened" to a certain extent in the rolling operation, and if heated high enough annealing or recrystallization takes place. In addition, selective grain growth frequently oc-

curs in the heating of known zinc engraving plates, that is, some grains will grow to a much larger size than their neighbors. Some of these grains may be so large that they may be seen clearly with the naked eye, while others can be seen only with the aid of a microscope. When such a recrystallized zinc is subjected to attack by the nitric acid etching solution, the grains dissolve at different rates, depending upon their respective orientation. Thus grains having an orientation most favorable to resist the attack of the acid dissolve more slowly. Less favorably oriented grains dissolve at greater speed. If the etching is continued long enough the etched surface will finally consist of a "mosaic" of grains, the surfaces of which are at different heights. Such an etched surface causes difficulty in the powdering operation by reason of the fact that dragon's blood powder lodges at the edges of those grains which project above their neighbors and thus, by building up an acid-resistant area, causes even greater unevenness on further etching.

This roughening of the surface of the zinc plate due to the selective solution of the grains of metal by acid has been found to be one of the most serious handicaps to securing a smoothly etched zinc plate for photo-engraving purposes. Although the grains may be too small to be readily visible to the naked eye, they still can be or become coarse enough to cause an objectionable roughening of the surface through the selective action of the etching acid.

I have discovered that the harmful effects of lead and iron inclusions on the etching properties of zinc engraving plate may be avoided by using plates made of zinc-base compositions containing less than .01% of heavy metal ingredients such as lead and iron. Rolled engraving plates made of very high purity zinc alone, however—such as known material containing at least 99.99% zinc—are characterized by very large grain size which causes difficulty in etching, and they are so soft that they have no utility for photo-engraving purposes because they break down under pressures encountered in mat holding or direct printing operations. I have further discovered, however, that zinc engraving plates having suitable qualities of hardness and resistance to deformation and wear for various conditions of service in photo-engraving work, together with superior etching properties, may be obtained by making the plates of zinc-base compositions containing very high purity zinc, less than .01% of lead and iron, and less than 2%, preferably less than 1%, of aluminum and alloying ingredients from the group consisting of magnisum, manganese and copper, which lend hardness to the wrought plates while improving their etching properties. In general, the zinc engraving plates produced according to my invention are much easier to etch properly, are susceptible to re-etching by hand and are much less subject to objectional dimensional changes on heating as compared with the zinc engraving plates known to the art prior to my invention, while at the same time they possess hardness and wearing qualities after heating or annealing which at least equal, and in preferred embodiments greatly surpass, those of the ordinary zinc engraving plates. Their hardness after heating generally exceeds 60 on the Rockwell "B" scale, and in many preferred embodiments is considerably more than 10 points higher than the hardest zinc engraving plates heretofore known, approaching the hardness of copper plates.

In making my improved plates it is important that the metal used as the base material be of exceptionally high purity, preferably containing at least 99.99% of zinc and considerably less than .01% of iron and lead. A suitable zinc material is the "Bunker Hill" brand of electrolytic zinc, of which the following is a typical analysis:

	Per cent
Cadmium	.0002
Iron	.0003
Lead	.0008
Copper	.0009
Magnesium	.0015
Zinc	Remainder

The harmful impurities, lead and iron, in zinc metal of this sort are so low that they have no deleterious effect on the etching properties of the wrought plates. Using this material as a base, and thereby excluding objectionable quantities of lead and iron from the final product to permit a homogeneous product free of lead-rich and iron-rich segregations to be obtained, I add beneficial alloying ingredients, totalling less than 2%, and preferably less than 1%, of the final metal composition, to obtain compositions consisting essentially of zinc and aluminum, combined with which at least one additional hardening or grain-controlling metal from the group consisting of magnesium, manganese and copper, and with at least two of such metals in preferred embodiments of the invention. After the desired metal compositions have been compounded, the improved engraving plates are made therefrom by casting the molten metal into metal molds, rolling the cast slabs into sheets or plates of the desired thickness and grinding and polishing the plates to prepare them for use by photo-engravers, all according to known practice.

In making my improved plates, however, benefits are obtained in the treatment of the metal which have important effects on qualities of the product. The molten metal compositions are unusually free of oxide and dross which, if carried into casting and rolled plates, would cause trouble in polishing and etching. The metal flows freely into molds when cast and forms cast slabs characterized by extraordinarily small and uniform grain structure and freedom from shrinkage cavities. The slabs may be readily rolled or worked into plates, and the wrought plates have a homogeneous structure, good grinding and polishing properties and unusually good etching properties.

Furthermore, the extremely low cadmium and lead content of the zinc base metal which I use is an important factor in insuring the stability of the plates. It is well known in the die-casting industry that inter-crystalline oxidation and undesirable structural changes occur in ordinary zinc-aluminum alloys and that such changes are accelerated by the presence of lead, cadmium, tin and antimony. These meals are either absent from my engraving plates or are present in such small amounts that their effect is negligible within the life-time of the ordinary zinc photo-engraving plate.

In some embodiments of my invention, wrought engraving plates may be made of zinc-base compositions consisting essentially of high purity zinc, considerably less than .01% of lead and iron impurities, and from about .10 to 1.75% of aluminum. These compositions will ordinarily contain a small amount of magnesium, detectable

by spectrographic analysis, which is inherent in the zinc. The aluminum content is kept above .25% to obtain the desired hardness before, and especially after, heating the plates. The preferred content of aluminum, for best results, lies between .35 and .75%. In addition, at least one other added metal from the group consisting of magnesium, manganese and copper is included in the composition to obtain the desired improvements in the qualities of the plates, as disclosed hereinafter, and in the best embodiments at least two of these metals are added to the plate composition.

In certain embodiments of the invention, the engraving plates are made of compositions such as mentioned above including from about .001 to about .035%, preferably from .003 to .02%, of magnesium. I have found that the inclusion of aluminum and very small proportions of added magnesium in plates having a base of high purity zinc, with less than .01% of lead and iron impurities, causes pronounced improvements in their hardness and that aluminum and magnesium are also effective in improving the etching properties of the annealed plates by preventing, to some extent, coarse grain growth. Thus zinc engraving plates are obtained which are free of the harmful effects on etching of lead and iron segregations, are subject to objectionable coarse grain structure to a less extent than known zinc plates, and have a hardness superior to known zinc plates of the hardest grade. For example, a rolled plate made of a composition consisting of "Bunker Hill" zinc, .50% of aluminum and .01% of added magnesium has a Rockwell hardness of 89 before annealing and a hardness of 75 to 77 after annealing at 600° F. Its resistance to deformation and wear is fully sufficient to withstand multiple mat molding operations, using the "dry mat" process, as well as the strains imposed by use in direct printing.

Advantages of my invention may also be obtained when the plates are made of compositions consisting of high purity zinc, .10 to 1.75% aluminum and .002 to .25% manganese, with less than .01% of lead and iron. An aluminum content between .35 and .75% and a manganese content between .005 and .15% are preferred for best results. For example, a rolled plate composed of zinc of at least 99.99% purity, .50% aluminum, and .10% manganese has a Rockwell hardness of 60 before heating and a hardness of 62 to 63 after heating to 600° F. Instead of suffering a loss of hardness upon heating, the hardness of the plate is actually increased. While its hardness after heating is considerably lower than in the case of zinc-aluminum-magnesium compositions, it is still much harder than ordinary zinc engraving plates, and its etching properties are not only superior to the known plates but are somewhat better than in the cases of zinc-aluminum and zinc-aluminum-magnesium compositions, due to a more pronounced effect of manganese in preventing grain growth upon heating.

I have further discovered that the desirable qualities of engraving plates made of high purity zinc and aluminum, or of high purity zinc, aluminum and magnesium or manganese, with considerably less than .01% of lead and iron, may be surpassed and that plates of extremely fine etching properties combined with very high hardness and resistance to dimensional changes and softening upon heating, may be produced by the inclusion of high purity zinc, aluminum and small percentages of both magnesium and manganese in the plate compositions. As disclosed above, it is essential in obtaining very smooth etched surfaces that the grain size of the annealed plates be so fine that any differences in level of the grain surfaces, due to selective solution of the grains in the etching acid, be too small to catch and hold the dragon's blood powder. I have found that manganese in certain percentages is a most effective element in restricting the growth of grains in plates of my preferred composition, when the rolled zinc plates are annealed. It is particularly effective in preventing selective grain growth, that is, the growth of a few grains to a very large size in comparison with others. Additions of as low as .002% of manganese to the molten compositions have a marked effect in preventing the growth of large grains on annealing, although at least .005% manganese should be included in the compositions to obtain the best types of etching plates.

Thus particularly valuable zinc engraving plates are made according to my invention from zinc base compositions consisting essentially of high purity zinc, aluminum, magnesium and manganese, with considerably less than .01% of lead and iron impurities, within the following ranges of proportions: .10 to 1.75% aluminum, .001 to .035% magnesium, .002 to .250% manganese, the remainder substantially all high purity zinc.

Illustrative examples of rolled engraving plates composed of such compositions are as follows:

	Base metal	Composition			Rockwell hardness—	
		Al	Mg	Mn	Before heating	After heating at 600° F.
1	High purity zinc "Bunker Hill"					
2	do	.25	.010	.05	86–87	76–77
3	do	.45	.015	.002	89–92	74–77
4	do	.45	.015	.003	88–90	80–81
5	do	.45	.015	.005	89	84–85
6	do	.45	.015	.010	89–90	85
7	do	.45	.015	.020	89–91	82–83
8	do	.50	.003	.10	88–89	74–76
9	do	.50	.010	.10	90–91	80–81
10	do	.50	.020	.10	89–90	83–84
11	do	.55	.010	.05	88–89	82–84
12	do	.55	.010	.10	88–89	81–84
13	do	.75	.010	.05	88–89	83–85
		1.50	.010	.10	88–89	86–87

These plates are free of objectionable lead-rich and iron-rich segregations, have a very fine and uniform grain structure, and exhibit no objectionable coarse grain growth or dimensional changes on heating. While some of them, near the limits of the ranges of ingredients, show some fine grain growth on heating and roughness on etching, their deep-etching and re-etching properties, and also their hardness after heating, are superior to any zinc plates used prior to my invention.

The optimum plates for hardness, toughness, good grinding and polishing qualities and smooth etching are secured substantially within the following ranges of ingredients; .35 to .75% aluminum, .003 to .02% magnesium, .005 to .15% manganese, the remainder substantially all extra high purity zinc containing at least 99.99% zinc. Examples 4, 5, 6, 8, 9, 10 and 11 typify these optimum products.

For comparison of compositions and hardness qualities, the following data are presented with respect to (I) an ordinary zinc photo-engraving plate and (II) a special hard grade of photo-engraving plate, both representative of the best plates of their types used prior to my invention, and (III) a plate made of high purity zinc alone:

		Composition					Balance	Rockwell hardness	
		Cd	Fe	Pb	Cu	Mg		Before heating	After heating at 600° F.
I	Ordinary commercial engraving plate	.18	.015	.30	-------	.0015	Zinc	74–75	55–56
II	Hard grade zinc engraving plate	.26	.015	.31	-------	.009	do	83	73
III	High purity zinc plate "Bunker Hill"	.0002	.0008	.0008	.0009	.0015	do	17–22	9–19

The accompanying drawing presents photo-macrographs (x15) showing etched surfaces of engraving plates such as used prior to my invention and of an engraving plate made according to the optimum embodiments of my invention. The photo-macrographs of the A and B series, as seen in Figures 1 and 3, respectively, show etched surfaces, at different depths of etching, of two plates made of compositions such as indicated in Examples I and II above, respectively. The photomacrographs of the C series, as seen in Figure 2 show etched surfaces of a plate such as specified in Example 6 hereinabove. The etching solutions and etching procedures were the same in all cases.

The depths of etching for the several photo-macrographs are as follows:

A^1 .007"	C^1 .007"	B^1 .006"
A^2 .015"	C^2 .014"	B^2 .014"
A^3 .026"	C^3 .025"	B^3 .025"
A^4 .039"	C^4 .041"	B^4 .040"

These photo-macrographs vividly illustrate the homogeneity and smoothness of the etched surfaces of my improved plates, at various depths of etch. On the other hand, both the ordinary plate and the special hard grade of plate exhibit numerous surface irregularities in the form of streaks and projections at all depths of etching, and these are greatly multiplied as the etching cuts deeper into the plate. The dark areas in the pictures of the A and B series are caused by lead-rich segregations at the surfaces of the plates.

It should be observed that the surface characteristics shown by the photo-macrographs have resulted from straight etching, without intermediate brushing of the etched surfaces at different stages of etching with dragon's blood powder and subsequent heating to set the powder. When using the ordinary plates for photo-engraving, their roughness on etching is further accentuated by the lodging of powder against surface irregularities and the ensuing protection of local areas against attack by the etching solution, and also by grain growth resulting from repeated heating operations. These difficulties are substantially eliminated by using the plates of my invention.

In still further embodiments of my invention, the described compositions may contain small percentages of copper. The inclusion of copper in zinc engraving plates in substantial proportions above about .20% is not desirable because of a tendency for the copper to form a troublesome adherent scum during nitric acid etching operations. I have found, however, that amounts of copper below .20% do not create this trouble to an objectionable extent, and that they impart desirable hardness and etching qualities to many of the compositions made of high purity zinc and hardening ingredients. Copper may be included in proportions from .01 to .20% of the plate compositions; the best results are obtained in the range from .05 to .15%, while keeping the proportions of aluminum, or aluminum and magnesium and/or manganese, within the preferred ranges set forth hereinabove. For example, a rolled plate made of a composition consisting of high purity zinc, .50 aluminum and .15 copper has very good polishing and etching properties and a Rockwell hardness of 62–63 after heating at 600° F. Another example is a plate composed of high purity zinc, .40% aluminum, .05% manganese, and .10 copper, which has very good polishing and etching properties and a Rockwell hardness of 63–64 after heating at 600° F. Further examples are (a) high purity zinc, .50 aluminum, .003 magnesium and .05 copper—hardness 72–73 after heating; (b) high purity zinc, .25% aluminum, .003% magnesium, .10 manganese, and .10 copper—hardness 72 after heating.

Maintaining the aluminum content of my plates in excess of .25% results in an increase of hardness before, and especially after, heating the plates. Similarly, raising the magnesium content above .003 increases the hardness and resistance to deformation and wear. The manganese content, in addition to its beneficial effect on etching properties, also improves the hardness of the plates after heating, its hardening effect apparently reaching a maximum at about .05%. In all cases the amount of hardening ingredients is kept below 2% and preferably below 1%, and the amount of lead and iron impurities is kept below .01%.

Useful engraving plates can be made from compositions consisting of high purity zinc and less than 2% but more than 1% of beneficial hardening ingredients; the cast metal of such compositions can be rolled satisfactorily, and the rolled plates have a hardness considerably greater than known zinc engraving plates and, in some cases, suitable etching properties. I have found, however, a greater tendency to encounter difficulties in the grinding and polishing of those plates containing the higher amounts of the alloying ingredients, apparently due to metallic inclusions in the rolled metal which may be compounds of zinc and manganese or zinc and magnesium or zinc and aluminum.

Any of the usual methods of alloying may be used in preparing the zinc-base compositions used according to my invention, i. e., any suitable apparatus or procedure may be used as long as the metal produced possesses the chemical composition and physical characteristics set

forth. In my preferred procedure, high purity zinc slab metal is first melted in a crucible or other suitable apparatus and the molten metal raised to a temperature sufficiently above its melting point (800–900° F.) to permit easy incorporation of the alloying ingredients, which may be in the form of "master" alloys of predetermined composition. Aluminum may also be added as pure aluminum sheet clippings, which dissolve in the molten zinc reasonably fast. Since aluminum, manganese, and magnesium have de-oxidizing properties, and since the amounts of manganese and magnesium added are small, I prefer to alloy the zinc first with aluminum to take off any de-oxidation of the zinc bath which may be necessary, and thus avoid any loss of alloying effect of the elements manganese or magnesium through their acting as de-oxidizers. The small amount of aluminum consumed in the de-oxidation reaction is not important in view of the relatively large amount of aluminum added.

The percentages of alloying elements are so low in the case of manganese, magnesium and copper, that in many cases they would probably be reported as "traces" in analyses made by ordinary wet analytical chemical methods. It is, therefore, desirable to carry out such determinations spectrographically, or by other special methods capable of determining such small amounts.

The following example is illustrative of a preferred procedure for making an engraving plate having the approximate composition of: aluminum 0.45%, manganese 0.05%, magnesium 0.010%, balance high-purity zinc containing not more than 0.01% of lead plus iron plus cadmium as impurities:

One thousand pounds of high-purity zinc is first melted in a crucible, the metal raised to a temperature between 840 and 880° F., and the bath skimmed free of dross and oxides accumulated during the melting operation. While holding the metal within the foregoing temperature range, four pounds, eight ounces of pure metallic aluminum in the form of rolled sheet clippings is added to the molten zinc bath and dissolved in the same, solution being aided by stirring. After the aluminum is thoroughly dissolved and stirred into the zinc, ten pounds, fourteen ounces of a zinc-manganese master alloy containing 4.63% manganese is next dissolved and stirred into the bath. When this operation is complete, one pound, twelve and a half ounces of a zinc-magnesium master alloy containing 5.6% magnesium is then added to the melt. After this has been thoroughly incorporated into the melt, the metal is skimmed and cast into suitably-shaped slabs. The cast slabs are rolled into sheets or plates, and their bottom surfaces are ground and polished to provide very smooth surfaces for the photo-engraving process. Smaller plates cut from these sheets or plates are then used by photoengravers.

Zinc engraving plates of my preferred compositions can be used in place of copper for fine screen half-tone engravings, and because of their superior etching properties can be re-etched the same as copper or brass plates. Their high hardness and toughness permits printing direct from the plates, in many thousands of printing operations, without undue wear, and their freedom from dimensional changes, i. e. permanent shrinkage or expansion after heating, permits their use in making engravings for four-color engravings, for the higher quality printed matter. These plates can also be used in place of copper for line etchings and hand-cut engravings.

The Rockwell hardness figures which I have used are obtained on plates of .065" thickness using a Rockwell hardness testing machine, reading the "B" scale on the dial, using a 100 kg. load, a ⅛" diameter ball, and maintaining the load for 10 seconds time.

In referring to compositions consisting essentially of certain ingredients, I contemplate that minor amounts of other ingredients may be present where they do not destroy the effects produced by the specified ingredients.

I claim:

1. An engraving plate consisting essentially of high purity zinc containing at least 99.99% zinc, from .25 to 1.75% aluminum, and at least one metal from the group consisting of magnesium, manganese and copper within the following ranges of proportions: magnesium, .003 to .035%; manganese, .002 to .250%; copper, .01 to .20%.

2. An engraving plate consisting essentially of high purity zinc containing at least 99.99% zinc, from .35 to 75% aluminum, and at least one metal from the group consisting of magnesium, manganese and copper within the following ranges of proportions: magnesium, .003 to .02%; manganese, .005 to .15%; copper, .05 to .15%.

3. An engraving plate consisting essentially of high purity zinc containing at least 99.99% zinc, from .25 to 1.75% aluminum, and from .003 to .035% magnesium.

4. An engraving plate consisting essentially of high purity zinc containing at least 99.99% zinc, from .35 to .75% aluminum, and from .003 to .02% magnesium.

5. An engraving plate composed of a zinc-base composition comprising from .10 to 1.75% aluminum, from .001 to .035% magnesium, and from .002 to .25% manganese, the remainder being substantially all zinc.

6. An engraving plate composed of a zinc-base composition comprising from .10 to 1.75% aluminum, from .001 to .035% magnesium, from .002 to .25% manganese, less than .01% of lead, iron and cadmium, and the remainder zinc.

7. An engraving plate composed of a zinc-base composition comprising from .35 to .75% aluminum, from .003 to .02% magnesium and from .005 to .15% manganese, the remainder being substantially all zinc.

8. An engraving plate consisting of zinc, from .35 to .75% aluminum, from .003 to .02% magnesium, from .005 to .15% manganese, and less than .01% lead, iron and cadmium, said plate having a uniform and fine grain structure and a Rockwell hardness of at least 75 after heating at 600° F. and being free of objectionable grain growth or dimensional changes on repeated heating.

9. An engraving plate consisting essentially of high purity zinc containing at least 99.99% zinc, from .35 to .75% aluminum, and from .005 to .15% manganese.

10. A zinc engraving plate composed of high purity zinc and less than 2% of modifying elements consisting of aluminum and metal from the group consisting of magnesium, manganese and copper, said plate being free of lead-rich and iron-rich segregations and having a Rockwell hardness on the "B" scale in excess of 60 after heating at 600° F.

11. A rolled zinc engraving plate composed of

high purity zinc and less than 1% of modifying elements consisting of aluminum and metal from the group consisting of magnesium, manganese and copper, said plate having a uniform grain structure free of lead-rich and iron-rich segregations and having a Rockwell hardness on the "B" scale in excess of 60 after heating at 600° F.

12. A rolled zinc engraving plate composed of high purity zinc, from .10 to 1.75% of aluminum and at least two metals from the group consisting of magnesium, manganese and copper within the following ranges of proportions: magnesium, .001 to .035%; manganese, .002 to .250%; copper, .01 to .20%.

WILLIAM H. FINKELDEY.

CERTIFICATE OF CORRECTION.

Patent No. 2,180,293. November 14, 1939.

WILLIAM H. FINKELDEY.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 64, for the word "meals" read metals; page 7, second column, line 26, claim 2, for "75%" read .75%; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of December, A. D. 1939.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)