Make Your Own Meter Scales

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Simple instructions on how to make scales for shop-constructed equipment to give a professional appearance with a minimum of cost and time.

METER SCALES on special instruments, in all too many instances, are poorly drawn and hard to read. With a few notable exceptions, scales on special meters are not as well drawn as the dials on bargain alarm clocks; and some of them appear to have been drawn on used blotting paper with a dime-store ball point pen. This prevalent unsatisfactory condition not only reflects unfavorably on the makers of the instrument, but also impairs the accuracy of all readings made from the instruments. Most people will read a workmanlike instrument scale with considerable care, but will give only a cursory glance to a sloppy dial.

By use of a number of improved and simplified drafting techniques—originally developed for newspaper work where speed of production is essential, and more recently applied to technical drafting[1,2,3]—workmanlike scales for special instruments can be constructed at relatively low cost in both hours and dollars.

Direct Drafting Procedures

Special instrument scales can be drawn directly on the scale card by an ordinarily skilled draftsman, using black India ink throughout, and applying the lettering with the aid of a Leroy or other lettering guide. This procedure is quite satisfactory for large scales, when only one of a kind is needed; but becomes quite difficult as the size of the scale decreases. Direct drafting is not satisfactory when a number of identical scales is needed, and the procedure is not suitable when the scale card has a special surface not suited for ink work.

Highly skilled draftsmen can draw complicated instrument scales not much larger than a postage stamp, and do "perfect" freehand lettering upon them. Draftsmen having these capabilities are few in number, and most of them are already employed full-time by instrument and watch manufacturers.

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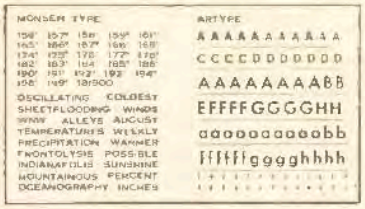

Fig. 1. Samples of trans-adhesive lettering. At left is Monsen type; at right is Artype. Note guide lines furnished with the latter.

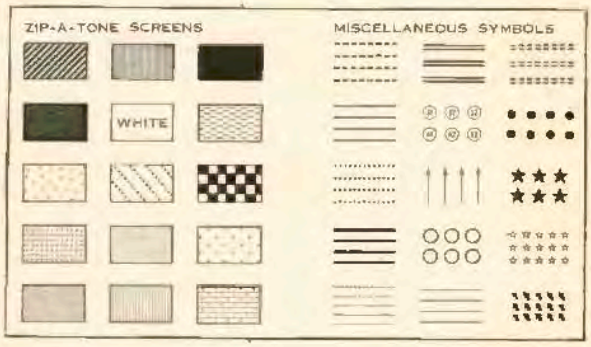

Fig. 3. Zip-A-Tone screens (left) and Artype special symbols (right).

Large Scale Drafting

Most of the difficulties inherent in the fine line work and small lettering required on most meter scales can be eliminated by drawing the scale several times as large as the desired finished dimensions, and reducing it photographically. This same procedure makes possible the production of any reasonable number of scales all alike. Both Leroy and Copperplate lettering will stand great reduction without loss of legibility; and many minor and unavoidable defects inherent in hand drafting will "drop out" in the reduction process.

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Fig. 2. Map label printed on trans-adhesive material. This is handled as a single unit, and can be applied in about 20 seconds.

Optimum results are obtainable with this method when the drawn scale is about three times as large as the finished dimensions; and when line weights and type faces are chosen so that no line is narrower than about .01 in. in the reduced scale and no letter or symbol is smaller than about 1/16-in. high. Although thinner lines and smaller letters can be produced by this method, they become difficult to read, even when perfectly executed and skillfully copied, so that the smaller sizes should be avoided. An instrument scale, no matter how accurate it may be, isn't much use if you can't read it!

Pre-Printed Letters and Symbols

Use of printed symbols, letters, and words in illustrative material has been common in the graphic arts industries for more than half a century. During the last two decades, a number of manufacturers of graphic arts supplies have produced and marketed a wide variety of pre-printed patterns, symbols, and letters. One of the pioneers in this field was the Craftint Co.,[4] who produce a variety of patterns printed on transparent acetate sheeting. The base (sheeting) is cemented to the drawing over the area to be patterned, and surplus pattern is rubbed off the upper surface. A convenient method of assembling textual material has been developed by Fototype.[5] Their product consists of individual letters, printed on cards. These are assembled upside down in a composing stick (supplied by them). The assemblage is made permanent by applying cellophane tape over it. The completed text, removed from the composing stick, is mounted, as a unit, wherever desired. More than 300 sizes and styles of type are provided by this manufacturer.

Best suited for most meter scale work is trans-adhesive type, which consists of type symbols printed on the under side of thin transparent acetate sheeting. This is then coated with a white waxy adhesive, also on the under side. Trans-adhesive type is cut from the sheet, placed in the desired position, and then burnished into place.

Several kinds of trans-adhesive material are available. Words and special symbols, to order, in almost any type face extant, are produced by Monsen.[6] Samples of Monsen copperplate are shown in *Fig.* 1, left. This material is manufactured for a setting charge plus a charge for each impression, so that

the cost per sheet depends upon the number of impressions ordered at one time. Monsen will also print to customer's specifications, on trans-adhesive sheets, almost any trade mark, label, title-box or caption desired, as in *Fig.* 2. Use of Monsen trans-adhesive material is economically advantageous when the same words or symbols, in the same type face, are used quite frequently.

Some reduction in the amount of printing needed can be brought about by careful choice of words, as the setting charge is usually on a per word basis. Combinations of substantial parts of words can also be made quickly and neatly. For example, if the word *milliamperes* is ordered, it is not necessary to order *amperes* also; and the *micro* from *microfarads* can be combined easily with the *amperes* from *milliamperes* to produce *microamperes*. Some draftsmen, particularly those who speak more than one language, become highly skilled in finding and using desired letter groups. Although the setting charge for a "two dollar word" is usually the same as that for a "ten cent word," copy containing jawbreakers such as *polydipseudaukis-trodcsmus pietenpolensis* (the name of a diatom) is likely to carry an additional charge for "difficult copy."

Trans-adhesive alphabets and a wide variety of symbols are produced by Artype.[7] This material consists of individual letters, with attached guide lines (*Fig.* 1, right). The text is assembled in the desired location on the drawing, aligned by use of the guide lines, and burnished in place. The guide lines are then removed and discarded. With a little ingenuity, symbols not contained in English type fonts can be produced with Artype,[8] and only an expert printer can tell, from the appearance of the finished work, that these symbols were not printed directly from a special type font.

A few of the many special symbols made by Artype are shown in *Fig.* 3 (right). Repeated symbols, patterns, shades, and screens printed on a trans-adhesive base, are manufactured by the Para-Tone Co.,[9] and marketed under the name Zip-A-Tone. These, a few of which are shown in *Fig.* 3 (left), are useful for zoning meter scales. Solid white Zip-A-Tone is useful for blocking out parts of a drawing; and solid red Zip-A-Tone, which photographs black with most engravers' films, is ideal for filling large black areas uniformly, and without cockling the paper, as commonly takes place when a large area is inked in solid.

Scale Construction Procedure

Procedure for making a special meter scale, using these art aids, is relatively simple and straightforward. First step is to calibrate the meter in terms of any scale which you choose to put on it. Usually the scale supplied with the meter will be entirely satisfactory.

Remove the scale from the meter, put it on a piece of black paper, and make a photostatic copy of it. This, for convenience should be a positive photostat, and should be enlarged by a convenient factor, such as 2, 3, or 5, to simplify drafting procedure. Such a copy is shown at A in *Fig.* 4. The black paper backing outlines the scale, and shows the mounting holes plainly.

Mount the photostat on the drawing board using drafting tape in any alignment convenient to the draftsman. Cover it with tracing linen or matte acetate, and ink in all lines desired on the new scale. Be sure to locate the scale outline and mounting holes accurately. Tracing with completed line work will appear as at B in *Fig.* 4.

Apply the desired lettering and symbols to the scale by the standard method for the art aid employed. Trim away all guide lines and other extraneous material, and the scale is ready for photographing. Finished scale appears as at C in *Fig.* 4. Other samples of scales made by these methods appear in *Fig.* 5.

To insure that the finished scale has the proper dimensions, mark the finished dimension on some part of the scale very plainly for the photographer. A convenient method of doing this is to draw a line equal to the exact dimension between the mounting holes on the scale to be photographed, and label it "Reduce so that this line is exactly 2 inches long," the dimension here given being correct for a Triplett Mod. 327-T scale.

Copying

Reduced copies of original drawn scales are normally made by a photographer, using standard copying equipment and films. Use of a process lens is desirable, to obtain maximum resolution in the copy negative; and lithographer's films, such as *Reprolith, Kodalith,* and *Lithaloid,* exposed and developed according to manufacturer's instructions, give adequate contrast.

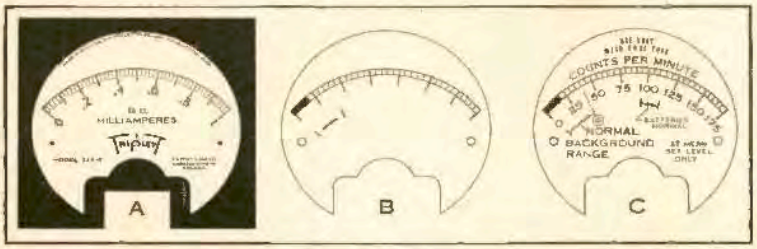

Fig. 4. Steps in making a special meter scale. (A), photostat of the scale, taken against a black background. (B), tracing of (A) on which the new scale has been drawn. (C), the same tracing, with lettering applied.

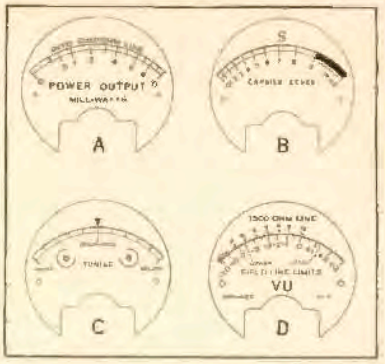

Fig. 5. Special meter scales made by use of standard drafting for the line work and trans-adhesive lettering for the text and symbols.

A wide variety of printing papers is available, and most glossy and semi-matte papers make suitable scale prints. Some care is needed in printing from scale copy negatives. Contact between negative and paper must be intimate, or lines will be widened and blurred. Over-printing must be avoided, or parts of the image will "bleed" into surrounding areas ("all the *o*'s fill in"). Development, fixing, and washing, in accord with good standard practice, will give entirely satisfactory prints. Life of a photographically produced meter scale is somewhat more than fifteen years, most of those made by the writer prior to 1940 still being in service (1954).

Prints may be mounted on the meter scale plate by use of high-grade library paste, purified rubber cement (the stationer's variety, not from the garage), or dry mounting tissue. Most of the library pastes are short-lived in this service, the paper coming unmounted from scale plate after three or four years. The better grades of rubber cement are apparently immortal if correctly used. Best procedure seems to be to coat the scale plate lightly with cement, then coat the back of the print with a medium thickness of cement, then let both dry for a couple of minutes. When the cement is tacky, align the holes in the scale print with the holes in the scale plate, and press the print firmly onto the plate. Keep the assembly under heavy pressure for a reasonable time, such as 30 minutes, then trim the edges and install.

Dry mounting tissue, which is a thin sheet of paper impregnated with wax, can also be used, and gives very good results in skilled hands. The tissue is tacked onto the scale plate with a small tacking iron, then the scale is placed over the plate in proper register, and the whole heated under pressure. After cooling, the edges are trimmed, and the scale installed in the meter.

Special Features

By combining the best features of standard drafting and trans-adhesive letters and symbols, a wide variety of special meter and instrument scales can

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METER SCALES

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be produced rather rapidly, and at a relatively low cost. Samples of special scales other than those for use in conventional panel meters comprise *Fig.* 6. At right is a GMT dial, for use in a 24-hour "time of day" panel clock. At left is the dial for a self-computing anemometer timer. Outer scale is calibrated in seconds. Next inward scale is calibrated in miles per hour of wind, for use with a 1/6-mile contacting anemometer. Innermost scale indicates numerical significance of intermediate markings on the wind-speed scale, and was designed to reduce interpolation blunders.

Several very complicated multicolored scales have been made by an extension of this general technique, color printing being done by use of *wash off relief* film. Use of a second calibration in red is quite satisfactory, but additional calibrations in other colors are difficult to read unless overall illumination is quite rigidly controlled. Yellows become unreadable under ordinary incandescent lighting, and most blues "drop out" under fluorescent lights.

A special meter scale, made by any ordinary method, is likely to cost at least as much as the meter in which it is installed. Relatively simple scales, such as those shown in *Fig.* 5, require from one to two hours of drafting time if made as single jobs. Ten or twelve scales of about the same dimensions and complexity, can be drawn up in a single working day if the entire group is assigned at one time as a single job; and provided the instructions are both adequate and simple.

Copying of scales entails only a few minutes of actual work, but also requires a considerable time for developing, fixing, washing and drying. Most commercial photographers can produce copies in 24 hours as "straight run" work; and in three hours, at a higher price, as "rush" work. Copy negatives cost from one to five dollars each, with three dollars for an 8×10 negative being fairly standard. Five 3-in. diameter meter scales, all to the same reduction, can be copied on a single 8×10 negative.

Contact prints cost from ten cents to two dollars, with one dollar for an 8×10 print being a common charge. Usually, if a number of prints from the same negative are ordered at the same time, the cost of additional prints is considerably less than that of the first.

When more than about 25 copies of a scale are wanted, multilith reproduction may be economical; and when much more than 200 prints are needed within a year, printing from a line engraving should be considered.

Mounting of the scale on the scale plate, and installation in the instrument, takes from 10 to 45 minutes, depending upon the mounting method used. Mounting of a dozen scales, however, all done at the same time, requires only slightly more than two hours.

Emergency Expedients

Although makers of trans-adhesive art aids have regular outlets in most large and medium-sized cities, there will be times when a single symbol, or group of them, cannot be obtained. When this occurs, or when material cost is more important than labor cost, symbols cut from printed texts can be cemented onto a scale, in suitable alignment, with gratifyingly satisfactory results. In one "war emergency" situation, a complicated meteorological computing scale was completely numbered and lettered with type cut from pages of the *Saturday Evening Post*.

Coloring Scales

When scales in several colors are desired, construction may become somewhat involved and difficult. The most common need, the red line accompanying instructions "Set to red line," is also the most easily applied. Clean the surface of the print with carbon tetrachloride or clean (not motor) ether, and draw in the desired line with red drafting ink using a clean ruling pen.

If the need is for a scale with black lines and letters on a colored field, a standard black and white print can be made, and the field (the white portions) dyed any desired color by use of photographic dyes (available at most photographic supply houses) or high-grade colored drawing inks (K and E or Craftint) applied by immersing the entire scale, or painted on with a clean brush or cotton swab. Use of cheap "easter egg" dyes leads to fading and ultimately blotchy appearance of the scale. Application with a pen usually plucks the paper surface, producing nonuniform coloring.

Colored zones on a meter scale, like those commonly used in tube checkers, can be produced by outlining the areas to be colored with a thin black line in the original print, and then filling in the outlines with the desired color, using dye or ink applied with a brush or swab, not with a pen. Large areas can also be colored by application of solid color Zip-A-Tone.

When multicolored scales are needed in moderate numbers, such as 25 or more at one time, excellent results can be obtained by two-color multilith. For this, the lithographer requires one original for each color used, and register marks, so that the various prints will superimpose properly in the finished scale. This process is usually too costly for only one or two scales, as almost the entire cost is the making of the separation plates and setting them up for multilithing. Cost of a single scale

Fig. 6. Special timer scales made by combining standard drafting and trans-adhesive lettering.