coincides with the circle of radius r. The area of a spherical cap with polar angle θ on a sphere of unit radius is given by the equation

$$\iint \sin\theta \, d\theta \, d\phi = 2\pi(1 - \cos\theta) \tag{16}$$

The equation for the streamline therefore is

$$\text{flux} = 2\pi q \left(1 - \frac{z}{\sqrt{r^2 + z^2}}\right) - \pi r^2 W = 0 \tag{17}$$

upstream of the source, and is

$$\text{flux} = -\,2\pi q \left(1 - \frac{|z|}{\sqrt{r^2 + z^2}}\right) - \pi r^2 W = -\,4\pi q \tag{18}$$

downstream of the source. The two equations are equivalent. Solution for z leads to the equation

$$\left(\frac{W}{q}\right)^{\frac{1}{2}} z = \frac{1 - \dfrac{W}{2q} r^2}{\sqrt{1 - \dfrac{W}{4q} r^2}} \tag{19}$$

along the streamline. The velocity of flow from the source is given by the equation

$$\frac{q}{r^2 + z^2} = W\left(1 - \frac{W}{4q} r^2\right) \tag{20}$$

along the streamline. The square of the local velocity is given by the equation

$$\mathrm{v}^2 = W^2 - \frac{2qWz}{(r^2 + z^2)^{\frac{3}{2}}} + \frac{q^2}{(r^2 + z^2)^2} = W^2\left(\frac{W}{q} r^2 - \frac{\frac{3}{16} W^2}{q^2} r^4\right) \tag{21}$$

When the square of the velocity is integrated over the surface of the boundary, the only surviving component of ds is $2\pi\, r\, dr$ in the z-direction by symmetry. Thus the force $\mathbf{f}$ on the boundary is given by the equation

$$\mathbf{f} = \pi\rho W^2 \mathbf{k} \int \left(1 - \frac{W}{q} r^2 + \frac{\frac{3}{16} W^2}{q^2} r^4\right) r \, dr \tag{22}$$

Integration with respect to r in the range

$$0 \leq r^2 \leq \frac{4q}{W} \tag{23}$$

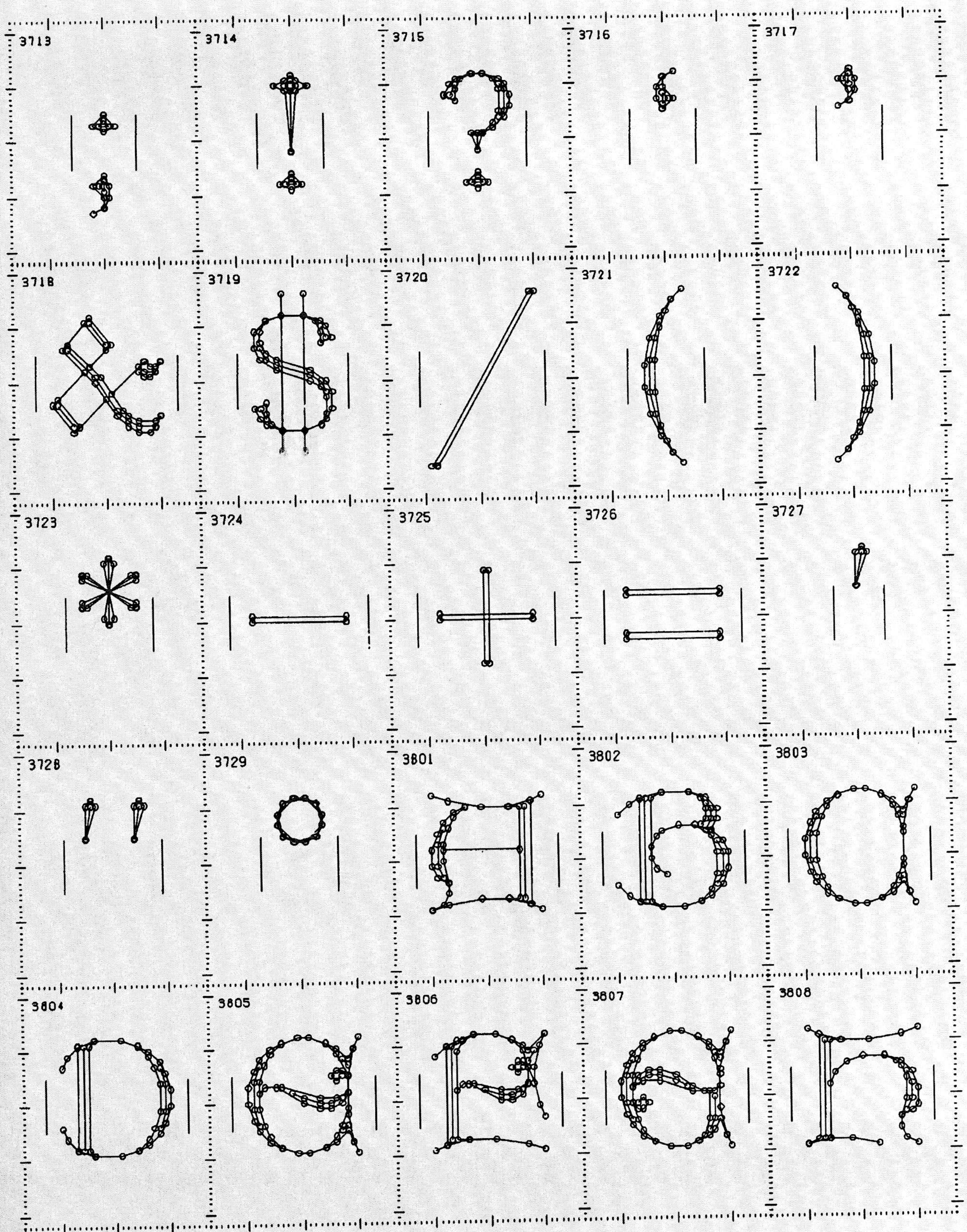
leads to the equation

$$\mathbf{f} = 0 \tag{24}$$

Thus the force on the boundary is not equal to the force on the source.

That the force on the boundary can be zero may be seen by a consideration of the variation of v^2 along the boundary. At the vertex of the boundary there is a stagnation point and the Bernoulli pressure is positive. At a point opposite to the source the square of the velocity is the sum of the squares of the free-stream velocity and the radial velocity from the source. The Bernoulli pressure is negative and is applied over

Figure 4. This page taken from reference 7 shows the typographic quality of this application of the Hershey character set. The art for this page was produced by a 60% reduction from an original drawn on a flat-bed plotter.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SR SIMPLEX ROMAN

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0 , . ( ) – + * / = $ &

DR DUPLEX ROMAN

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0 , . ( ) – + * / = $ &

CR COMPLEX ROMAN

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0 , . ( ) – + * / = $ @

TR TRIPLEX ROMAN

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0 , . ( ) – + * / = $ &

CI COMPLEX ITALIC

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0 , . ( ) – + * / = $ @

TI TRIPLEX ITALIC

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0 , . ( ) – + * / = $ &

SS SIMPLEX SCRIPT

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0 , . ( ) – + * / = $ &

Figure 6. Here we see the appearance of various alphabets when drawn via the Hershey system at normal typographic scale (21 raster units). The same set can also be produced in indexical size (13 raster units). Capitals can also be produced in cartographic size (9 raster units).