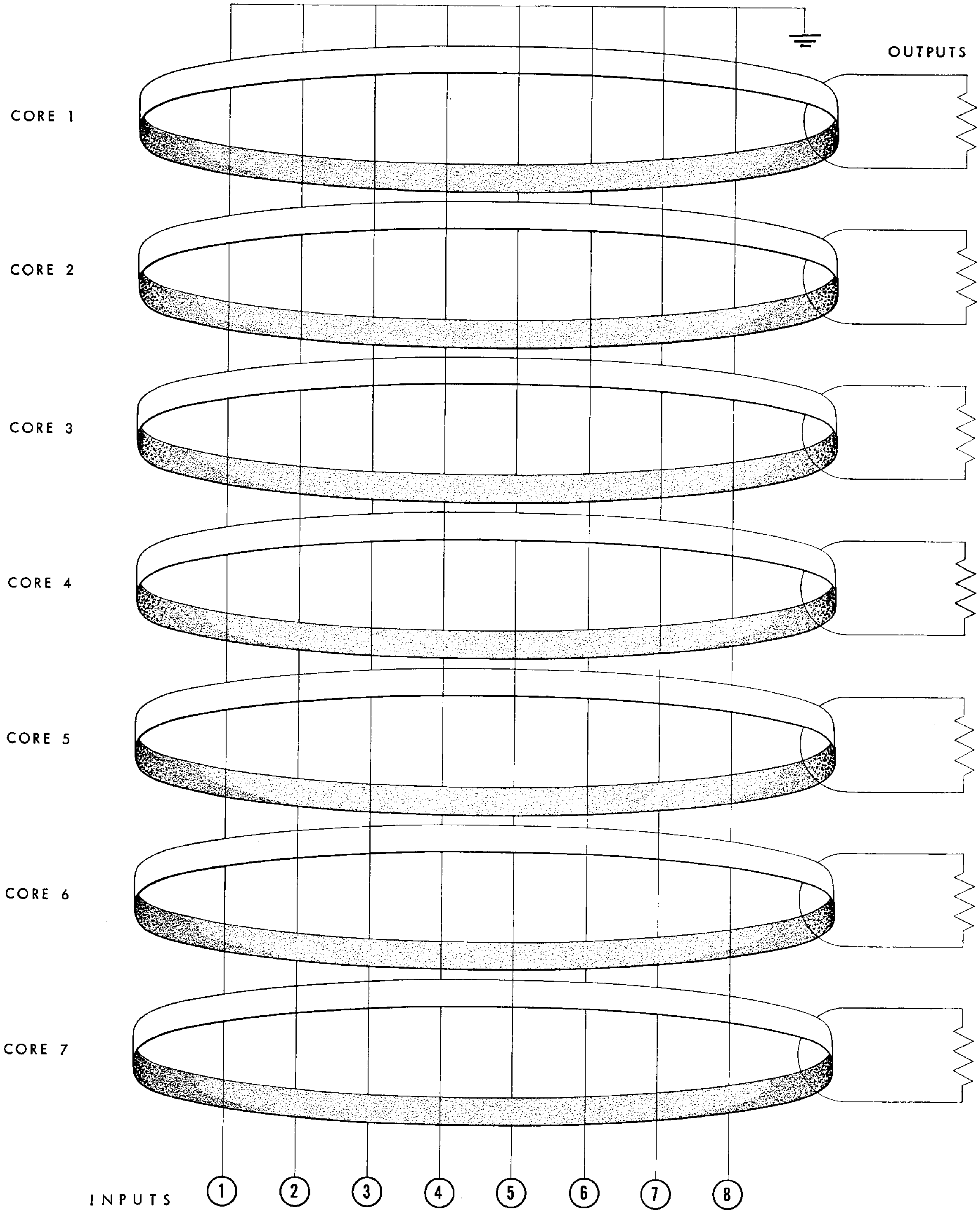

Figure 1 **Winding diagram for 8-input, 7-output matrix switch.**

M. P. Marcus

Doubling the Efficiency of the Load-Sharing Matrix Switch

Constantine* describes a novel load-sharing matrix switch in which the input winding pattern allows the selection of a single core, while ideally all other cores have zero net excitation. These patterns realize 2^{n-1} outputs with 2^n inputs, the inputs being grouped in 2^{n-1} complementary pairs.

By treating the inputs independently, rather than in pairs, we can double the efficiency of these matrices (except in one special case, which is noted at the end of this article), halving the required number of drivers and associated equipment. With 2^n inputs, 2^{n-1} outputs can be realized.

A few matrices are tabulated below for illustration. Each input is a single winding. (The lines dividing up the matrices have been added only for the purpose of clarity, making the general pattern more obvious.) In these matrices, the last 2^{n-1} outputs relate to those which Constantine obtains with complementary pairs of inputs; the first $(2^{n-1}-1)$ outputs are the additional ones that can be obtained if the inputs are not restricted to complementary pairs.

The winding diagram for an eight-input, seven-output matrix switch, featuring load-sharing, is shown in Fig. 1. It can be noted that the winding of Cores 4, 5, 6 and 7 corresponds to the winding of Cores 1, 3, 2 and 4, respectively, in Fig. 1 of Constantine's paper.

The load-sharing matrix may be expanded, 2^n inputs yielding 2^n-1 outputs. Accordingly, a 16-input, 15-output matrix is shown in Table 3.

Given a present complete matrix, in order to obtain the next larger complete matrix:

1. Double the number of 1's and 0's of the first row of the present complete matrix.
2. Form two rows from each present row, as follows:

Present row	Present row
Present row	Complement of present row

The next larger complete matrix will have one more than twice the number of rows as the present matrix.

*G. Constantine, Jr., "A Load-Sharing Matrix Switch," *IBM Journal of Research and Development*, **2**, No. 3, 204-211 (July, 1958).

Table 1 **Excitation pattern for 4-input, 3-output matrix switch.**
(1's and 0's are used in the excitation patterns in place of the + and − signs used in Constantine's paper.)

	Inputs 1	2	3	4	Outputs
$2^{n-1}-1$ *additional*	1	1	0	0	1
	1	0	1	0	2
	1	0	0	1	3

Table 2 **Excitation pattern for 8-input, 7-output matrix switch.**

	Inputs 1	2	3	4	5	6	7	8	Outputs
$2^{n-1}-1$ *additional*	1	1	1	1	0	0	0	0	1
	1	1	0	0	1	1	0	0	2
	1	1	0	0	0	0	1	1	3
	1	0	1	0	1	0	1	0	4
	1	0	1	0	0	1	0	1	5
	1	0	0	1	1	0	0	1	6
	1	0	0	1	0	1	1	0	7

Variations of the matrix may be obtained by interchanging any rows or any columns, or by interchanging all 1's and 0's or by a combination of the two.

Incomplete matrices can, of course, be obtained by selecting any rows of the complete matrix.

For any number of desired outputs other than a power of two, half as many inputs are required with these matrices as with Constantine's. Only in the special case

Table 3 **Excitation pattern for 16-input, 15-output matrix switch.**

	Inputs 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	*Outputs*
	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1
$2^{n-1}-1$ *additional*	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	2
	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	3
	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	4
	1	1	0	0	1	1	0	0	0	0	1	1	0	0	1	1	5
	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	6
	1	1	0	0	0	0	1	1	0	0	1	1	1	1	0	0	7
	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	8
	1	0	1	0	1	0	1	0	0	1	0	1	0	1	0	1	9
	1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1	10
	1	0	1	0	0	1	0	1	0	1	0	1	1	0	1	0	11
	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	12
	1	0	0	1	1	0	0	1	0	1	1	0	0	1	1	0	13
	1	0	0	1	0	1	1	0	1	0	0	1	0	1	1	0	14
	1	0	0	1	0	1	1	0	0	1	1	0	1	0	0	1	15

where the number of desired outputs is exactly a power of 2, are the requirements the same.

The foregoing can be expressed as follows:

x = number of outputs required.

With Constantine's matrices, the number of inputs required $= 2[2^n_{\min} \geqslant x]$.

With these matrices, the number of inputs required

$= 2^n_{\min} > x$.

Some values are shown in the table at the right.

Some thought should be given, therefore, to the possible modification of a system requiring exactly 2^n outputs; such a requirement would most likely occur only in a straight binary system. One possible system modification might perhaps be the representation of the "zero" by the absence of all outputs. In any event, it is desirable to avoid a matrix with exactly 2^n outputs, otherwise twice the amount of input equipment is required.

Number of Outputs Required	*Number of Inputs Required* Constantine's Matrix	New Matrix
3	8	4
4	8	8
5	16	8
6	16	8
7	16	8
8	16	16
9	32	16
10	32	16
11	32	16
12	32	16
13	32	16
14	32	16
15	32	16
16	32	32
17	64	32
⋮	⋮	⋮
31	64	32
32	64	64
33	128	64
⋮	⋮	⋮
63	128	64

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