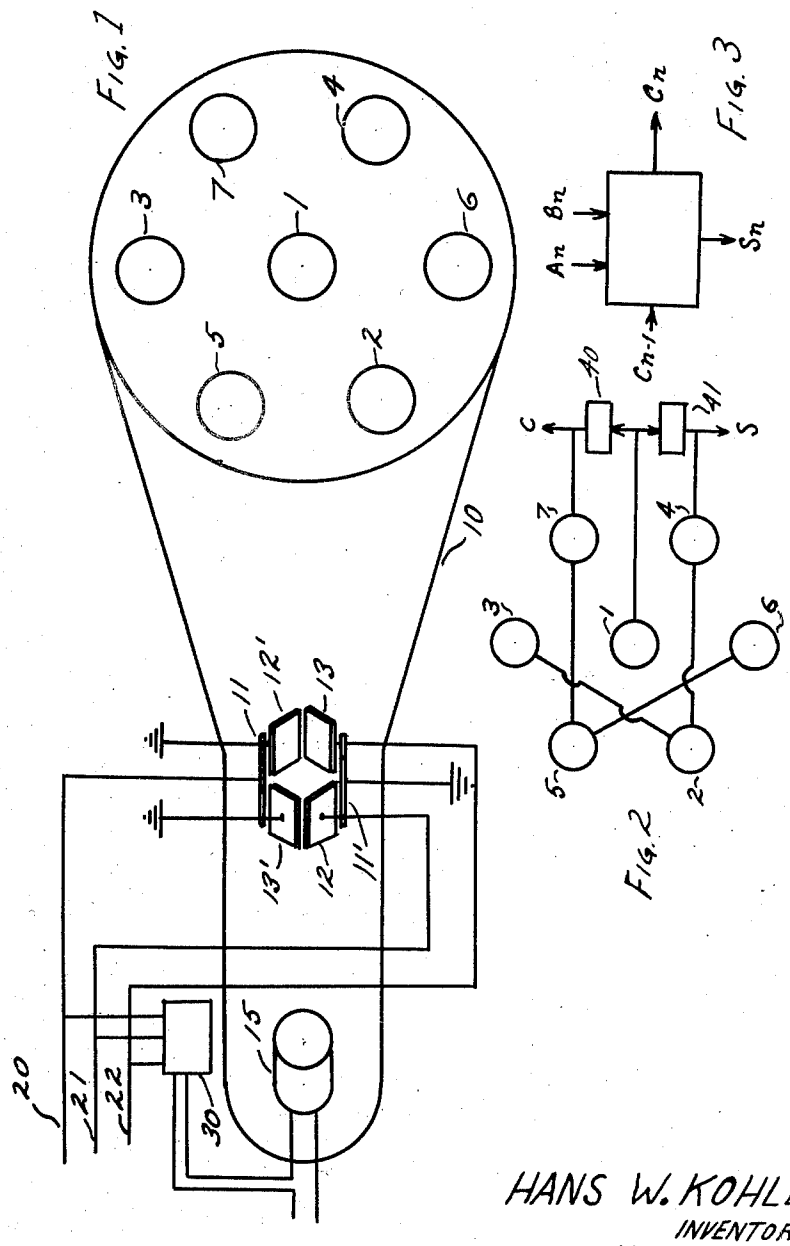
Aug. 19, 1958 H. W. KOHLER 2,848,162

CATHODE RAY TUBE BINARY ADDER

Original Filed March 7, 1950 2 Sheets-Sheet 1



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CATHODE RAY TUBE BINARY ADDER

Original Filed March 7, 1950 2 Sheets-Sheet 2

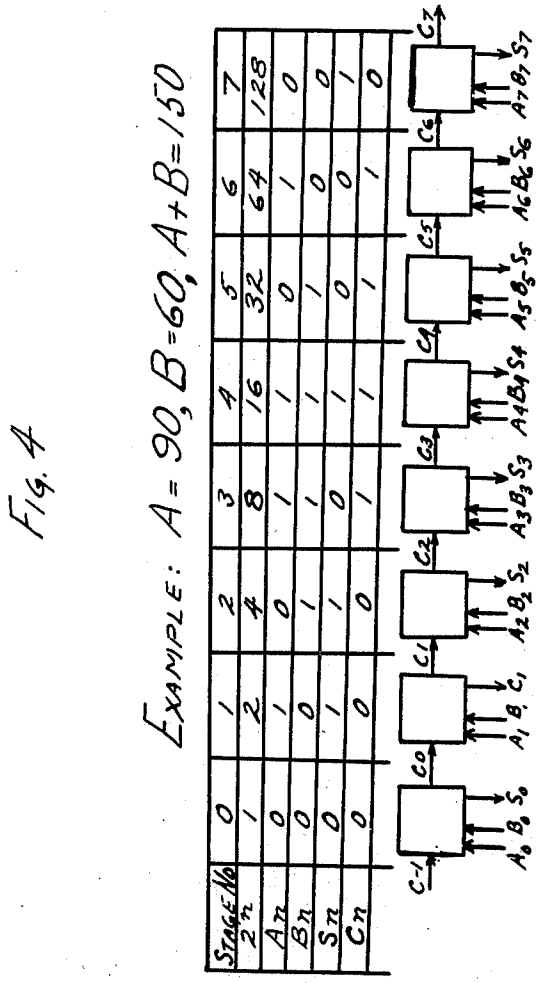

FIG. 4

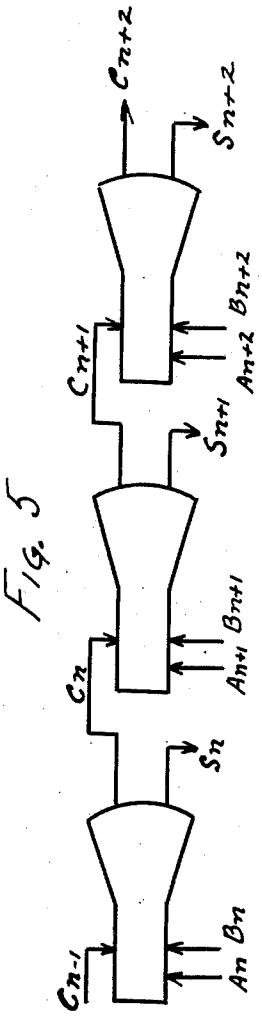

FIG. 5

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United States Patent Office 2,848,162 Patented Aug. 19, 1958

2,848,162

CATHODE RAY TUBE BINARY ADDER

Hans W. Kohler, Washington, D. C.

Original application March 7, 1950, Serial No. 148,251, now Patent No. 2,627,587, dated February 3, 1953. Divided and this application January 19, 1953, Serial No. 333,853

2 Claims. (Cl. 235—61)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This application is a division of application for patent Serial Number 148,251, of Hans W. Kohler, filed March 7, 1950, now Patent No. 2,627,587, for Cathode Ray Tubes.

This invention is in cathode ray tubes and particularly provides means for rapidly combining certain electrical conditions representing numerical values and indicating a mathematical sum therefor.

Otherwise considered, the apparatus indicates the condition of each of three electrical leads (whether "on" or "off") in all of a series of predetermined intervals in time.

The principal object of the invention is, therefore, to provide a cathode ray tube device for substantially instantaneously totaling certain kinds of values.

Another object of the invention is to provide in a cathode ray tube means for rapidly and accurately indicating the occurrence of one of a number of possible events.

More specifically, objects of the invention are to provide simple electronic means for performing standard and binary-scale mathematical problems.

Other objects will be apparent from a reading of the following specification and claims.

In the drawings:

Figure 1 is a digrammatic illustration of the cathode ray tube of my invention;

Figure 2 illustrates the manner in which it is possible to connect the plates of the cathode ray tube of my invention for certain purposes;

Figure 3 is a diagrammatic showing of the function of one stage of an adding circuit utilizing the cathode ray tube of my invention;

Figure 4 is a diagram of the manner in which several stages of my apparatus may be connected to perform binary-scale addition; and

Figure 5 shows schematically the input-output relations of a series of cathode ray tube adding units according to invention, the amplifiers and coupling networks being omitted.

Referring to the drawings, it will be seen that the cathade ray tube **10** of my invention is in general conventional in form, but that in place of the normal two pairs of deflecting plates it contains three sets **11—11′**, **12—12′**, and **13—13′** arranged to provide radial deflection of a cathode ray beam in planes 120° apart.

The cathode ray beam generator indicated at **15** is not of itself novel and will not be described herein. Standard focusing means for the beam are employed.

It will be seen that the target electrodes of which there are seven (**1–7**) are arranged so that six of the plates, **2–7**, are located at the corners of a regular hexagon, with plate **1** at the exact center thereof. Diametrically opposed target electrodes are lined up with corresponding pairs of deflection plates.

The system is so adjusted that, if, for example, a positive potential E is applied to deflecting plate **11** (all other plates being at ground potential), the electron pencil will be directed to target three. If, at a subsequent time, the same potential is applied to deflecting plates **12** and **13**, and removed from plate **11**, the beam will impinge upon target **6**, etc.

Table I indicates deflection plate potentials and the target electrodes corresponding to each combination thereof, when 1 indicates a marking or voltage impulse and 0 represents a spacing or no-voltage impulse.

Table I

Deflection Plates			Target Number in Figure 1
11	12	13	
1	0	0	3
0	1	0	2
0	0	1	4
1	1	0	5
1	0	1	7
0	1	1	6
1	1	1	1
0	0	0	Beam Out

The tube can be used for the addition of three binary-base signals, it being possible to represent numerically seven different conditions or sums. Conversely, these sums indicate the conditions of the wires carrying the on-off signals.

The three signals to be added are brought in on separate lines **20, 21,** and **22,** which control respectively the reflection of the pairs of plates **11—11′, 12—12′,** and **13—13′.**

The operation of the tube is as follows: with all of the three sets of deflecting plates active, i. e., all of them carrying marking or voltage impulses, the cathode ray beam is centered on target **1.** The beam would act in exactly the same fashion if all three leads were carrying spacing or no-voltage impulses, but differentiation between these two conditions is obtained by a coupling **30** which causes the beam to be extinguished except when at least one set of deflecting plates is energized.

As above indicated, the beam is caused to impinge upon targets **5, 6,** and **7** by coaction of two sets of deflecting plates. If, for example, lines **20** and **21** are both active, the beam will be driven to target **5.** Each of the other possible combinations of active and inactive plates determines a target for the cathode ray beam.

The manner in which the output of the tube is utilized forms no part of the present invention. Indicators or other terminal equipment of any convenient type may be employed. The targets may, for example, be coated and thus caused to fluoresce under the influence of the cathode ray beam.

Addition of binary-base numbers in different fashion is illustrated in Figures 2–5; here, operations with larger numbers are contemplated. Consider two binary numbers A and B which have digits A_0, A_1 . . . A_n and B_0, B_1 . . . B_n, respectively, where each "digit" represents a different fixed quantity (conveniently, different powers of 2), and the presence or absence of the quantity in the number is indicated by a voltage impulse or a no-voltage impulse.

A_n, B_n, and the "carry-over" from the next lower stage, C_{n-1}, compose the input data for the adder. S_n and C_n are the output data of the adder. S_n, the "sum" is the part of the output not transferred to the next higher stage of the adder, whereas C_n is the "carry." As noted, each of the quantities A_n, B_n, C_{n-1}, S_n, C_n is two-valued, either on or off, + or —, 1 or 0. Again, using the last notation, Table I may be transcribed as Table II for purposes of illustrating the operation of the apparatus of Figures 2–5.

Table II

Input			Target Hit	$A_n+B_n+C_{n-1}$	Output	
A_n	B_n	C_{n-1}			S_n	C_n
1	0	0	3	1	1	0
0	1	0	2	1	1	0
0	0	1	4	1	1	0
1	1	0	5	2	0	1
1	0	1	7	2	0	1
0	1	1	6	2	0	1
1	1	1	1	3	1	1
0	0	0	Beam Out	0	0	0

Consideration of Table II shows that targets **2**, **3**, **4**, and **5**, **6**, **7**, respectively, may appropriately be connected together since each target of the first group represents a sum of 1, and each target of the second group, a sum of 2. The center target **1**, which always represents a "sum" and a "carry" (in this case, **3**), is connected over two unilateral coupling devices **40** and **41** to the carry and sum terminals. It will be understood that in the second stage of the adder each input and the "sum" output represents a value of 2, and the "carry," a value of 4, while in the third stage the respective values are 4 and 8, etc.

Addition of two binary numbers by a chain of adders is illustrated in an example in Figure 4.

Figure 5 shows schematically the input-output relations of a chain of adders consisting of a series of cathode ray tubes according to my invention. All amplifiers and coupling networks are omitted since no claims are made for these circuits. The showing is similar to that of Figure 4 and merely makes it somewhat more clear that the input to an adding stage consists of a value for A, a value for B, and the carry over from the preceding stage, and that these three values are applied to the deflecting plates of a tube while the outputs of the tube (the sum and carry) are taken from the target electrodes.

The foregoing description is in specific terms, and many modifications will suggest themselves so that for the true scope of the invention reference should be had to the appended claims.

I claim:

1. An apparatus for performing binary-scale addition comprising a series of cathode ray tubes each of said tubes having three deflecting means for an electron beam therein each beam being normally substantially centered in its tube said deflecting means being effective when separately energized to deflect the same in three planes 120° apart, three inputs for each tube each connected to one of said deflecting means and each to a separate source of signals representing the presence or absence of binary scale digits said means being energized only by signals representing the presence of such digits and two outputs each said tube one of said outputs serving to provide a

binary-scale sum of the input signals of its tube and the other of said outputs serving to denote a quantity to be carried for further addition the last-mentioned output being connected to one of the inputs of another cathode ray tube of said series.

2. In an apparatus for performing binary-scale computation, a cathode ray tube having a beam-generating means the beam generated thereby being normally substantially centered in said tube and three deflecting means therefor said means being effective when separately energized to deflect said beam from said centered position in three planes 120° apart, an input connection to each of said deflecting means, and means for synchronously supplying signals thereto each representing the presence or absence of binary-scale digits, those representing the presence thereof to energize the associated deflecting means, a group of target electrodes located in said tube for contact by said beam whenever one of said inputs is energized said group including an electrode in each of said planes, another group of target electrodes located for contact by said beam whenever two of said inputs are energized said other group including further electrodes located in planes 120° apart relative to said centered position of said beam said last mentioned planes being symmetrically spaced between said first mentioned planes, a further target electrode contacted in similar fashion whenever three of said inputs are energized, an output connected to said first group of target electrodes, another output connected to said second group of target electrodes, and a further output connected to said further target electrode and to said first two-mentioned outputs, another substantially-like cathode ray tube, means connecting the output for the said second group of target electrodes to an input of said other cathode ray tube, and means for supplying other electrical signals to the other inputs of said other tube each such signal representing the presence or absence of a binary scale digit, said other signals being synchronous with said first mentioned signals.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,848,162 August 19, 1958

Hans W. Kohler

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 53, after "outputs" insert -- for --.

Signed and sealed this 27th day of January 1959.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

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