

Error-Detecting and Correcting System (Patent)

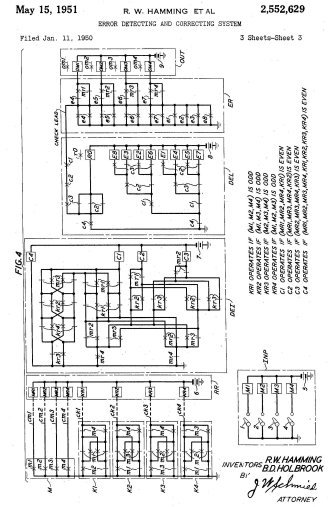
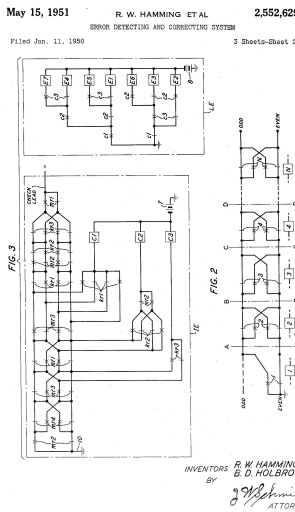
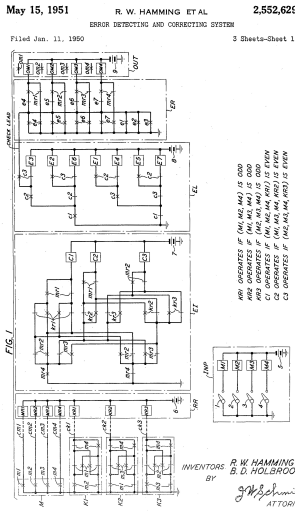
Richard W. Hamming, Morristown, and Bernard D. Holbrook, Madison, N.J., assignors to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York
 Application January 11, 1950, Serial No. 138,016
 20 Claims. (Cl. 177-353)

Information Theory Unit

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 ERROR-DETECTING AND CORRECTING SYSTEM

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This invention relates to permutation code systems and in particular to apparatus for and a method of detecting and correcting errors which impair the accuracy of the output information of such systems.

The invention may be exemplified in its practical application chiefly in systems employing binary permutation codes. That is, systems in which a code group consists of a numerical sequence of any number of 0's or 1's in any permutation arrangement. Any individual element of such a code, therefore, consists of a 0 or 1. In the telegraphic art such code permutation groups are referred to as consisting of marking and spacing elements. These marking and spacing elements may be differentiated from each other in practical arrangements by conditions of current and no current, positive current and negative current, or by any other suitable selected pairs of conditions. It is more or less customary for workers in the telegraphic and related arts to use the expression "code combination" rather than the expression "code permutation" in reference to a code group. It should, therefore, be understood that the word "permutation" is used herein in no being more accurate but should not be taken to distinguish from the terminology of code combination as used by telegraphers and others when applicable.

The prior art offers systems and methods of checking the accuracy of received or recorded permutation codes. In one known type of system there are added to the standard five-unit permutation code groups two additional elements for the purpose of checking accuracy. In such systems the permutations usable for information may consist of those having, for example, exactly four marking elements per code group of seven elements transmitted; and in such arrangements the receipt of a permutation or code group having less or more than four marking elements indicates some kind of error. Moreover, the principle involved in thus checking the accuracy of encoded received information may be extended to codes consisting of a greater number of elements. There are in the art systems employing so-called two-out-of-five codes. Upon analysis, there are found to be five-element binary permutation code systems in which but ten of the possible permutations are used, these being ten in

which there are exactly two marking (or spacing) elements. Arrangements have been devised whereby a single error in the receipt or recoding of a code group of such a system is detected in that such an error results in more or less than two marking or spacing conditions as the case may be. The principles of this type of checking and error indication may be extended to codes of greater than five units. Indeed, it may be shown upon analysis that error checking in the two-out-of-five systems and error checking in the four-out-of-seven systems involve similar principles.

Furthermore, in certain types of arrangements there have been used so-called binary systems wherein analogous methods have been employed whereby recording or reception in such a system may be accomplished with the indication of a single error.

All of these arrangements involve the limiting feature that an error upon being introduced, although detected, is not automatically corrected. The maximum result which the method or apparatus can achieve is indication of the presence of the error. This indication is accomplished in various ways, for example, by printing in the case of printing telegraphy, an auditory alarm signal indicating that an error has occurred by stopping the reception and sending back to the transmitting end of the system a signal indicating the necessity of retransmitting some portion of the information over again or, in the case of certain types of systems, causing the operation to cease until the erroneous condition is detected and corrected by human intervention.

In accordance with the present invention, the art may be advanced to a point where an actual error or errors of transmission or recording may be corrected automatically. Furthermore, in addition to correcting one or more such errors, code systems constructed in accordance with the principles of the invention may simultaneously incorporate error correction. If a first number of errors occurs and error detection if a second number of errors occurs. In its simplest aspect, the invention may consist of means for correcting a single error; in a further advanced aspect it may provide means for correcting one error or detecting two errors; in a more advanced aspect, it can provide means for correcting two errors,