On-line Visual Correction & Make-up Systems—I: Hardware

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Although cathode ray tube displays have been operated on-line to digital computers for some years now, it is only recently that a serious effort has been made in the United Kingdom to develop text editing display systems which will not only prove useful as production, rather than experimental, devices but also prove to be an economically worthwhile proposition. Naturally their use as program editing devices has been considered and several reports of such systems have appeared. This limited application has a definite role to play in the evolution of a full text editing and make-up facility, but the designer must go far beyond this in ergonomic details, and hardware and software features. What may be adequate for an enthusiastic experimenter is not necessarily suitable for an operator who has to satisfy production schedules using the equipment over a long period.

An advanced man-machine link of the type envisaged here cannot be designed in a "one step" manner. The requirements of the operator have to be evaluated by field trial and realistic testing, and the system has to evolve to reach a point where a meaningful and desirable specification results. It is important to realize that this point has not yet been reached. Suitable hardware is not readily available and the requirements of suitable systems are not precisely known.

This last point requires co-operation from the user—the printer—who will, perhaps for the first time, have to investigate his existing processes from the keyboard to the final corrected proof stage in sufficient detail to allow an accurate work study and costing to be carried out so that a precise specification for a production display system can begin to be drawn up, and its cost effectiveness estimated. The point here is not simply how to produce a text editing and display system using CRT techniques—we already know quite a lot about this—but how to arrive at a sound functional specification and an accurate assessment of performance.

The overriding consideration of costs makes design of an optimum system difficult because we are rather constrained in our choice of hardware components. We cannot necessarily use the most sophisticated or advanced techniques if these are expensive; on the other hand we must not restrict performance because of this to the point where it suffers significantly. Of course, this is the design problem that commercially always exists, but perhaps in exaggerated form in the case of computer typesetting where the consumer is so cost-conscious and where more or less adequate equipment and methods already exist.

Why CRT Editing and Make-up?

It is important to keep clearly in mind why such an exotic system for correction and make-up should be considered when alternative and less costly methods are available. If we lose sight of this we may get to the position where, as with some systems of straight computer typesetting, the intellectual incentive to develop the most sophisticated configuration leads the designer to recommend a quite unrealistic installation in terms of economic viability.

The problem of correction and make-up is dealt with fairly satisfactorily with hot-metal where a correction character or line, for example, can easily be inserted into a galley. With filmset matter, however, the problem of introducing corrections is more difficult, involving as it does the need to handle rather small sections of paper or film. In general this is more time consuming than carrying out hot-metal corrections and has proved to be a stumbling block to a wider use of filmsetting methods through the industry.

One way of using a computer to assist us is to adopt a punched tape system; to correct the original after proofreading by merging it with a correction tape so that a perfect tape, and film, is finally produced. This merging process can be carried out in conventional off-line fashion using a computer with one or two tape readers at its input.

The first difficulty with this method is in preparing the correction tape, which must specify with precision where each alteration has to go in the main text. This tape must be accurate and unambiguous but must be relatively easy to produce—objectives difficult in practice to reconcile. In addition, experience has shown that merging presents its own difficulties, mainly because corrections or make-up requirements often alter the copy to such an extent that further errors are introduced which have to be rectified in turn. This then involves a further correction tape and processing pass and so on, resulting, perhaps, in three or more iterations before an acceptable result is finally produced. The need for several passes and proofing stages can easily make the whole process quite unattractive, even using a small computer installation.

Apart from this, requirements for page make-up—for example, dividing up into pages, inserting headings, page numbers, blocks and so on—involve considerable handling of film or, indeed, metal. Tape merging techniques can, of course, also be used in this case, but the basic difficulties persist. The advantages of correcting directly with hot-metal are that position is easy to specify and that the corrections can be checked after insertion and any consequences noted and put right. It would be highly desirable to evolve an equipment for correction and make-up which possessed these features and made the whole process easier for film.

A system suitable for bookwork, which meets these requirements in some measure, is being closely studied by the Computer Typesetting Department of Elliott-Automation Computers Ltd. This makes use of a small, general purpose computer particularly well suited to typesetting applications—the 903—with 8,192 words of 18-bit main store. This machine is coupled on-line to a CRT display, positioning device, and operator's keyboard. The display will show to the operator a page of text read in from punched tape at the input to the computer. Using his positioning device, the operator will be able to indicate by means of a moveable marker or cursor any character or position in the text and by further keying operations to introduce corrections and then to observe the consequences of these corrections.

The system outline is shown in Figure 1, which represents the block schematic of an on-line display with buffer store. This buffer consists of a 4,096, 6-bit word core store and drives the display in a cyclic manner. The computer can gain immedate access to the store if it is required to alter any section, after a correction, for example. The character generator provides both upper and lower case characters and a range of special

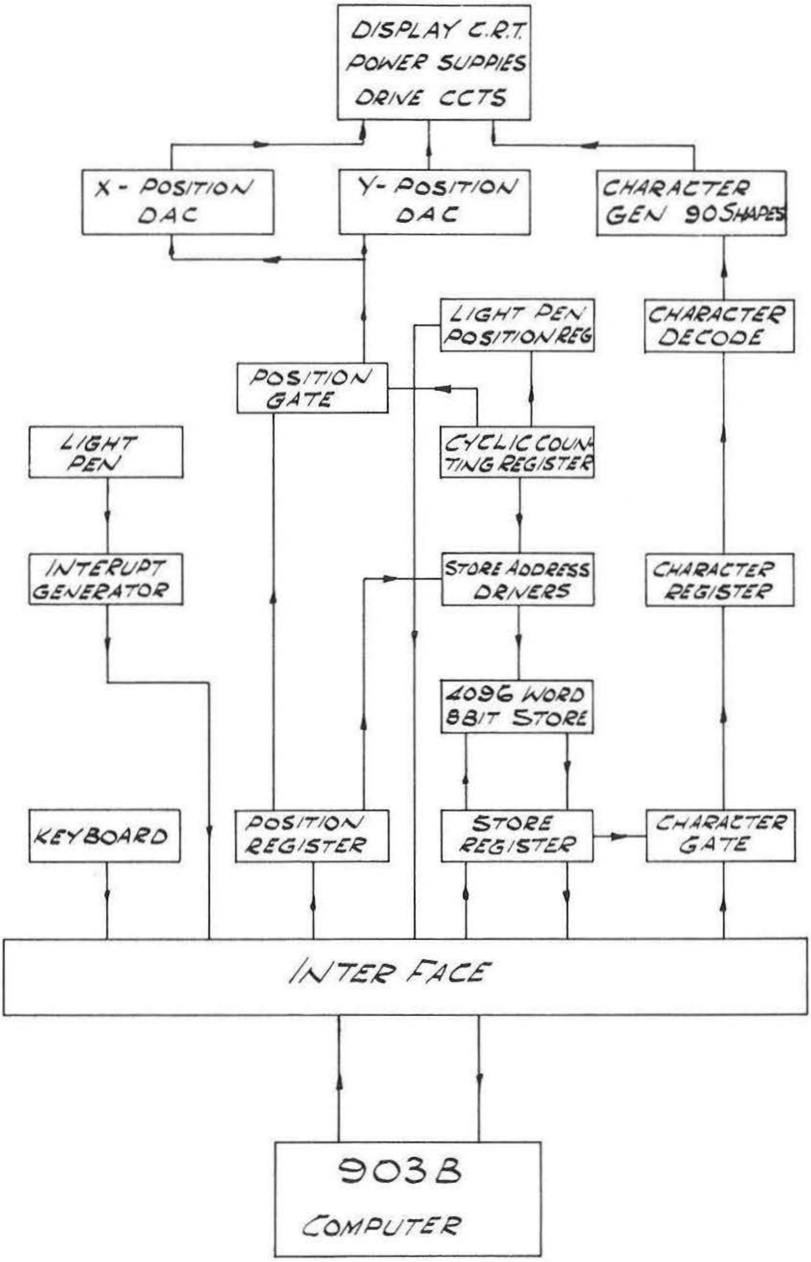

Figure 1. Block diagram of the display system.

symbols, and it can be driven either from the buffer store or direct from the computer. In this way a display can be sustained on the screen without direct intervention of the computer, or the computer can supplement the display with additional characters or symbols, if necessary.

Some Features of a System

A number of topics, by no means comprehensive, of importance in text editing display systems are dealt with here. Limitation of space and time restrict the treatment and coverage, but the intention is to indicate how the requirements anticipated in the last section influence the choice of hardware system components.

A. *Tube.* The two characteristics of the CRT which are of importance are phosphor performance and size of face—the latter will be considered within the context of screen format. The prime requirement for the phosphor is that under no circumstances must the display flicker; otherwise the operator will be distracted and will suffer strain if he uses the display for an extended period. In order to avoid any likelihood of flicker, the paint rate should exceed about 30 per second, although this figure can probably be reduced if the ambient lighting conditions are adjusted.

If, however, the amount of data presented on the screen and the character generation speed are such that the paint rate must be less than this flicker limit, it is necessary to use a long persistence phosphor. In this way paint rates of less than 10 per second can be readily accommodated without flicker, provided that the phosphor has a fairly level intensity of visible illumination during persistence. When phosphors are mixed so as to produce a short brilliance flash after regeneration to operate a light pen, for example, appreciable flicker may be observed even with long persistence types. The effect of the flash can be nullified by interposing a suitable filter, usually yellow, between the operator and the screen, but this makes the use of the light pen unmanageable.

If it is necessary to use a light pen in such a system, a flash which exists only in the ultra-violet or infra-red region of the spectrum has to be used. Suitable phosphors with these characteristics are now becoming available so that the need to use a light pen will not impose restrictions on paint rate.

When the phosphor light output is allowed to decay it is important that this happens with a relatively short time constant, so that if the screen conents are changed then the new data is easily discernible after only a brief delay. Probably a decay time of about one second or less is quite acceptable here; if it is longer, then the blurring effect after a change of screen contents becomes significant in assessing the speed with which the operator can use the system.

B. *Screen Size and Format*. It is probably true to say that, within limits, the larger the tube used the more generally useful will be the display. However, the cost aspect must be kept in mind since suitable large tubes can present special problems regarding shape, mounting, safety, etc., so that some intermediate size might prove to be the optimum. If it is assumed that at least an average book page should be completely accommodated on the screen, then a format of about 60 lines with up to 100 characters in a line is indicated. The average character content of a page may be about 3,000 to 4,000 so that a buffer capacity of 4,096 would be appropriate. If the content exceeds this figure it is possible to supplement the buffer by direct output from computer, but this facility is probably limited to 100 or 200 characters determined by the time available within the central processor. Although it would be desirable to accept even larger pages for complete display, it is likely that 80 to 90 per cent of the work can be dealt with adequately with a capacity of up to 4,300 characters. For larger page sizes a technique for handling partial pages would require development, but this will have greater implications for make-up than correction.

Evidence available relating to character size indicates that 10 per inch is acceptable, provided that the shape is well-formed. This corresponds to line printer and typewriter output density, which is satisfactory when read from the distance considered normal when reading or typing. For a format of 60 lines each of up to 100 characters at 10 per inch, a tube of 17″ diagonal is indicated. By using the tube turned 90° from its normal direction (i.e., so that the horizontal usable length is 10 inches and the vertical length 13 inches) it is possible to accommodate the 60 lines with sufficient leading to keep them clearly separated and to allow a marker to be moved between them.

The use of a tube larger than 17-inch diagonal does not necessarily lead to a larger capacity since legibility of characters of a given size is adversely affected by beam spot size and this tends to increase with size of screen. Another factor to be borne in mind is non-linear distortion effects which, among other things, will tend to defocus the spot towards the periphery of the tube face. These effects can be overcome by coil design or by avoiding the use of wide-angle tubes of the television type so that by adopting a CRT with maximum angle of 55° to 70° the useful face area will extend to the periphery with relatively little degradation. This type of tube, however, tends to be very bulky, difficult to mount and handle, and is inevitably expensive both in initial cost and for replacement.

C. *Character Generation.* Various methods have been developed for the high speed generation of character shapes on the face of the CRT. Apart from tracing by rasters, dots, or vectors, special tubes of the Monoscope type have been used. Although all these methods can yield characters which are quite legible, it seems unlikely that anything really approaching graphic arts quality will be possible at the present stage, since the necessary rate demands character generators with a capability of at least 50,000 per second to allow a book page to be repainted every 80 to 100 msecs. when a long persistence phosphor is used. Of course, if suitable phosphors with persistence times of the order of one second are developed with an adequate decay characteristic, it might be possible to reduce the general rate to the point where video techniques now being considered for high speed photo-typesetters will become relevant.

We are limited therefore to considering rather basic characters in one font only in upper and lower case, with a number of additional symbols making a total of 90 to 100 shapes. There is ample subjective evidence to indicate that such characters are in fact quite legible even if they are not aesthetically pleasing. An important feature of editing and make-up display systems has to be appreciated here in that the operator can tolerate a relatively low level of character representation if he is not called upon to read and comprehend the text rather than perform what is, in effect, a clerical function. This is the case if the displayed text is accompanied by an identical printed text previously edited and bearing correction instructions. For this reason there would be no serious intention of expecting an operator to carry out the function of proof reading and correction at the display. These two processes would be treated quite separately as at present.

As far as generation speed is concerned, two factors to be considered are the cost of the generator and the effect that the speed will have on the drive and deflection circuitry at the tube. Very high rates will require high power drivers and may also involve some extra complexity in coil design, so that for economical reasons a minimum speed generator system should be considered.

D. *Position Indicator*. Four possible methods of allowing the operator to indicate textual position on the screen are available. These comprise: light pen, rolling ball, joystick, and keyboard. The light pen appears superficially advantageous since it approximates most closely the method we use to mark text under normal circumstances. It also allows us to move across the text in a very direct manner, virtually unimpeded. It must be remembered, however, that the operator can only input corrections by keyboard and not by light pen (except in a very limited way) and the need for him to alternate between the use of the light pen and the keyboard makes this an inconvenient method of indicating position. Additional disadvantages are that the light pen tends to be a rather imprecise pointer and its use necessitates a phosphor with a short persistence flash which, as described earlier, can cause flicker trouble.

The tracker ball and joystick methods of indication are really quite comparable in performance and implementation. Without adequate subjective experience it is rather unsafe to be dogmatic about their relative merits. Both are relatively inexpensive compared with the light pen and allow a fairly rapid movement of the marker. Since they can be placed close to the keyboard, they allow the operator to move his hand from one to the other with relatively little wasted effort.

The most direct method of controlling marker position is to make use of specially assigned keys on the keyboard. Four keys would be reserved to allow movement up and down on a single- and repetitive-step basis. Although this method is the most economical to implement, it has proven to be rather restrictive and time consuming in that it may take up to 10 seconds to move from one extreme position in the display to another. With the other methods it seems less difficult for the eye to follow the marker movement so that the time is shortened to a reasonable level.

E. *Keyboard*. The type of keyboard which would prove useful in a display system is probably subject to as much controversy as the type of keyboard suitable for normal typographic work, and there is no intention to enter into such arguments here. The point that is worth considering is the kind of special facilities which the keyboard can present to the operator to allow him to instruct the central processor about his intentions.

The most direct approach would be to provide a set of separate keys, each of which would instruct the machine regarding a particular correction or make-up function. Such functions might include: i) delete, ii) substitute, iii) transpose, iv) store and delete, v) insert, vi) line release, vii) insert folio number, and so on.

An alternative approach allowing an unmodified keyboard to be used would make use of the normal keys preceded by an "instruct" key to indicate special functions. Because of the number of such functions and the frequency with which they would have to be used, it is likely that this approach could lead to operator confusion with a consequent overall reduction in productivity.

System Capability

A correction and make-up display system incorporating the various features outlined in the previous section will prove a powerful tool in the hands of a trained operator for practically all functions at present carried out by hand on metal, film, or paper. It will be possible to indicate any position or section of text and make insertions, deletions, or transpositions. If any changes lead to an alteration in the justifying situation it will be possible for the operator to monitor the re-justification condition, to check any new hyphenations, and generally to manipulate the text in a relatively unrestricted manner. The most important feature of the system will be, of course, the ability to check that alterations have been correctly introduced and to rectify any possible ill-effects.

Most forms of make-up will be carried out using the display system, in some cases, more or less automatically, where the operator will act purely as a monitor. For instance, correct insertion of page or folio numbers, pagination, insertion of headings will easily be possible. Insertion of extra leading sometimes required for page make-up can also be carried out, with or perhaps without operator assistance.

The whole area of merging or inserting new matter into text—whether it be adding footnotes, inserting blocks, or updating an index or catalogue by small massive addition—should be amenable to this display technique.

The effective cost of carrying out corrections and make-up with such a display system depends to what extent full use of the central processor can be made. Since the operator's reaction time really determines the necessary overall speed of the system, it is likely that the processor will not be heavily loaded by a single display. In order to reduce operating costs, an attempt should be made to operate the system on a multi-program, multi-access basis. Using a 903 in this way it is possible to operate one or two displays as well as an off-line justifying and hyphenating channel. The latter would be used for the initial run to produce a justified tape for driving the typesetter and would proceed at the same time as the display channels.

The most important point, of course, is not whether such a system can be developed in hardware and software terms—of this there is little doubt now—but whether it can be shown by an accurate cost evaluation that it is worthwhile to do so. In other words, it is important to try to show at an early stage that cost per correction using the display approach compares favourably with cost per correction using the conventional approach. In practice the situation is very unlikely to be as clear-cut as this; there will be problems in assessing long term operator productivity using such a novel system, and there will be many fringe benefits associated with a system of this flexibility that will have to be taken into account.

Although the system described here is oriented to book production, it is inevitable that its use will be extended, in time, to the newspaper field. The problems in this case are different in degree rather than principle, although the requirement for full page make-up involves an even more complex system where shapes could be manipulated and moved around the screen.

With newspaper production, time is an all-important factor. In a relatively short period a large quantity of material has to be read and corrected, which means that the computer system will require a peak capacity much greater than the average throughput. The implication is that a parallel correction facility would have to be available consisting of many inexpensive but capable displays, and that high-speed photo-typesetting would be used so that the need to set all matter twice would not prejudice the timing of the whole operation.