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RM-5218-PR
FEBRUARY 1967

JOSS: CONSOLE DESIGN

C. L. Baker

PREPARED FOR:
UNITED STATES AIR FORCE PROJECT RAND

The RAND Corporation
SANTA MONICA • CALIFORNIA

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PREFACE

The on-line typewriter console described in this memorandum is a direct outgrowth of the prototype typewriter stations designed and built at RAND in 1961 for JOSS,[†] RAND's personal on-line computing service. The experimental JOSS system was designed by J. C. Shaw(1) and implemented on RAND's JOHNNIAC computer;[‡] eight of these prototype stations saw service with JOHNNIAC JOSS through 1965.

In 1964 a decision was made to implement JOSS on a high-speed, modern computer, the Digital Equipment Corporation's PDP-6. The contract to procure this equipment called for DEC to build and deliver to RAND 30 JOSS consoles as a part of the complete system. These consoles were to be designed and built to RAND's specifications; it is with these specifications that the present memorandum deals in detail.

Our experience with the prototype typewriter stations provided the background to develop the specifications for the JOSS console.(2) We knew roughly which features had to be retained at all costs; which features, though desirable, were not essential and could be eliminated if required; what deficiencies were to be overcome; and which new features we wished to incorporate. The design of the present JOSS console, therefore, owes a great debt to its predecessor. Because an

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[†]JOSS is the trademark and service mark of The RAND Corporation for its computer program and services using that program.

[‡]The JOHNNIAC computer, designed in 1950-1951 at The RAND Corporation, was based on the Princeton machine model; in 1966 it became a victim of technological obsolescence and was retired, along with a prototype JOSS station, to the Los Angeles County Museum.

entirely new design was being undertaken, however, nothing was taken for granted, and at each step of the design process all available alternatives were reevaluated and original decisions reexamined. Perhaps the only major design parameter not a candidate for reconsideration was that this was to be a hard-copy-only device, supplying a complete record of all communication to and from JOSS, and capable of producing high-quality formal output.

Throughout this memorandum, no distinction will be made between the "old" and "new" design features. The style adopted is narrative, in the hope that the reader will benefit more from the exposition of considerations made and factors weighed than from a simple bare-bones presentation of the final design. A primary purpose of the study is to indicate the extreme care that must be taken to design an acceptable console for personal use by casual users. In the words of J. C. Shaw, it's the little things that make the difference--"hundreds of them!"[1]

This work is a part of The RAND Corporation's continuing program of research in computer sciences under U.S. Air Force Project RAND.

SUMMARY

The incorporation of a familiar standard office electric typewriter as the central element of the JOSS console enables both the skilled typist and the casual user to "converse" with JOSS in an interactive fashion to solve numeric problems. The IBM Model 731 Selectric Input-Output Writer was chosen because of its excellent keyboard feel, which allows fast input; its high-quality output at a speed of 150 words per minute; its compact size; and its relatively low noise level. Although deviations from the standard typewriter were held to a minimum to avoid alienating the experienced typist, a few modifications and optional features were added: nine business symbols in the character set were replaced with symbols appropriate for numeric calculation; a pin-feed platen was chosen to feed fanfold paper in standard 8½ by 11-in. sheets; one of the operational functions, the exclusive Selectric feature <u>index</u>, was replaced by a paging mechanism designed and built at RAND; and the on/off switch was modified to give <u>ready</u> and <u>hold</u> indications.

Predominant considerations in the design of an adequate console to house the typewriter included dimensions required for operator comfort and convenience; console mobility; the packaging techniques associated with the electronic components required to implement the desired logic functions; the incorporation of the associated switches and indicator lights in a small control box; and the various dimensions of the Input-Output Writer itself.

The JOSS console logic has been designed so that control of the typewriter is proprietary: Either JOSS has control for output purposes, or the user has control for typing in to JOSS.

Which of these situations is actually the case is indicated by visual, tactile, and audible signals. The user's input of instructions and data is typed in green, and JOSS responds with output in black.

A number of console "states" are provided; these are primarily determined by the user to reflect his needs and are communicated to the central processor by a set of signals. Transmission is over a full-duplex channel, permitting the processor to verify the states of the console, even when nominal control resides with the user, as when typing in. In addition, provision is made for transmission of signals by the console even when nominal control resides with the central processor, as when typing out.

For the purposes of this memorandum, the logic of the JOSS console electronics package is divided into seven roughly independent sections. The operation of each section is described by means of a simplified diagram, with reference to a set of implementation-independent logic symbols. The first two sections cover input of both the signals to the console and the characters and operational functions to the typewriter. The remaining sections cover the various outputs from the console (characters, operational functions, signals, status reports) and the synchronizer that assigns priorities for their transmission through a single output shift register.

Detailed specifications of the typewriter modification procedure and the manufacturer's logic drawings are included as appendices. For operation of the mobile consoles within the RAND buildings, an automatic line concentrator is used to provide the connections from multiple console locations (over private cables) to the computer multiplexor. The final appendix presents a simplified diagram of this circuitry.

ACKNOWLEDGMENTS

Ideas, encouragement, and help from many sources have been important ingredients in the design of the JOSS console described in this memorandum; it is impossible to credit all individuals concerned. Thanks go above all to J. C. Shaw of RAND, JOSS's designer, who specified the stations used with the JOHNNIAC JOSS system. Most of the ideas for the present JOSS console are the outgrowth of his pioneering efforts. Ray Clewitt, also of RAND, is responsible for the design and fabrication of the prototype form-feed mechanism; it was the addition of this mechanism that made the Selectric typewriter usable for true JOSS service. Many hours of discussion with I. D. Greenwald ensured that the hardware would interface smoothly with the associated software for which he was responsible.

Much credit must also be given to the following personnel of the Digital Equipment Corporation: Alan Kotok, who implemented the author's logical design requirements with Flip Chip modules; David Nevala, who was responsible for the mechanical design of the production form-feed mechanism and physical console; and Jan Stenberg, who supervised all phases of fabrication and checkout of both the prototype and production consoles. Last, but not least, much helpful and patient assistance in interfacing the Selectric typewriter with the console logic was given by IBM'ers J. D. Whitlatch, J. C. Tarbutton, J. L. Andrews, and K. Keplar.

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I. INTRODUCTION

Thirty of the JOSS[†] consoles described in this memorandum have been in daily operation at RAND since early 1966, providing expanded JOSS service as implemented on the PDP-6 computer.[‡] Although primarily intended for use as an integral component of the JOSS system, the console has been designed as a general-purpose on-line typewriter station, and represents an attempt to remedy the various deficiencies found in currently available console equipment (e.g., Teletype models 28, 33, and 35; IBM models 1050, 2740, and 2741). The adoption of an office-style electric typewriter overcomes the objections of most typists to the "feel" of non-typewriter devices. The latter severely limit the input speed of the casual user by forcing him to an unnatural rhythm dictated by the instrument rather than adapting itself to his natural and unavoidable irregularities in typing speed.

It is evident that an on-line console should be "easy to learn" and "easy to use," and in fact, most of the above-mentioned models meet these requirements fairly well. However, a corollary at least as important, but often forgotten, is that the operation of the console must be easily and readily recalled once it has been learned. It should not be necessary for the casual user to reacquaint himself each time he approaches the console. Therefore, the entire oper-

[†]JOSS is the trademark and service mark of The RAND Corporation for its computer program and services using that program.

[‡]An overall introduction to the JOSS system is available in Ref. 3.

ation must be easy to explain (with all buttons and lights clearly and unambiguously labeled) in the vocabulary of such a casual user. For example, the turn on and turn off procedures for a Model 33 or Model 35 Teletype machine, although not particularly complicated when they are demonstrated and explained, may be difficult or even impossible to recall when the prospective user first solos--perhaps days or weeks later. In comparison, the standard office typewriter (augmented only by a self-explanatory control box) is such a familiar device that even novices have no hesitancy in approaching it.

Another deficiency to be overcome in standard devices is that they are usually adapted from one-way-at-a-time communication equipment, with little attention to the fact that on-line use implies a dialogue between man and machine. A master-slave relationship between central processor and on-line consoles can only act to the detriment of the user; in fact, the user at the console _must_ be the "master," with the processor playing the role of the "helpful assistant." Too often, on-line consoles are indeed "remote," in that they act as an independent and detached component of the system rather than as an integral extension of the service provided by the central processor.

In contrast, the JOSS console design provides for a number of "states," primarily determined by the user to reflect his needs and communicated to the central processor by a set of signals. Transmission is over a full-duplex channel, permitting signals to be sent by the console even when nominal control resides with the central processor, as when typing out. In addition, provision is made for the processor to verify the states of the console, even when nominal control resides with the user, as when typing in.

When we speak of the central processor, we mean the active supervisory program that services the console. The final hardware design, in point of fact, was arrived at only after many interactions of both console and program design. The opportunity to develop both hardware and software in parallel was an essential factor in the final design. Particular attention was given to the problem of making sure that, regardless of possible intermittent transmission difficulties, the software would be able to "stay in step" with the hardware. These console service routines, which for JOSS are collectively termed the Distributor, have been fully documented in a companion memorandum,[(4)] which should be consulted for details of this software.

As a final consideration, we wanted the console to be as convenient and comfortable to use as possible. At RAND, this meant bringing the console directly into the office of the prospective user to serve as his personal instrument, rather than locating it in a nearby "convenient" location. It is vital that the user be able to move the console himself and not have to rely on maintenance technicians nor on special tools or moving equipment. Because he is not tied to dictates of equipment location and availability, the user is once again "master" of the system.

In the remainder of this memorandum, first attention is given to describing those design features that are most apparent to a user at work with JOSS: the typewriter itself and the physical console. This is followed by an overview of the logic required to enable the user and JOSS to share the typewriter productively in an interactive conversation. Finally, although not the concern of the JOSS user, a detailed description of this logical design is given in hardware terms.

II. TYPEWRITER

The central element of the JOSS console was to be a hard-copy keyboard device with which the user and JOSS would "converse" in an interactive fashion to solve problems involving numeric calculation. Because JOSS was designed primarily for the casual user, it was important to select a familiar device for input and output.

These factors combined to rule out the ubiquitous (at least for most on-line systems today) Teletype machine. This unit, although attractive because of its availability and relatively low cost, was designed primarily for telecommunication service. Many of the functions of this device are unfamiliar to the average person, and, indeed, in most organizations Teletype machines are usually operated by specially trained personnel behind closed doors.

On the other hand, the standard office electric typewriter met our requirements handily; indeed most professionals in science, engineering, and mathematics use the typewriter regularly without special training in typing. In addition, among this group there is a gratifyingly high percentage of touch typists.

However, although JOSS itself is primarily for mathematical problem solving, we wanted a unit that could also be used for more general tasks, for example, text editing and report generation, where the primary users would be those with secretarial skills.

Matching the ease of input of the standard typewriter is the high quality of the typewritten output that is produced. Today, most written communication is by typewriter, be it letters, tables, or reports, and a large sector of the labor force in this country is dedicated full-time to the production of such typewritten documents. Another consideration is legibility, which is an important factor in a conversational system. An additional feature of the standard typewriter is that its formatted output can usually be reproduced into formal published reports without transcription (and chance of error). Finally, the console was to be used in the offices of RAND staff members, as a personal instrument, and the high noise level of non-typewriter devices was considered prohibitive.

TYPEWRITER SELECTION

The typewriter chosen was the IBM Model 731 Input-Output Writer. Basically, this unit is the standard IBM "Selectric" office typewriter, to which magnets, contacts, special cams, and covers have been added. It has excellent keyboard feel, allowing fast input, and produces high-quality typewritten output at 15 characters per second (or 150 words per minute). The relatively compact size of the machine (approximately 16 in. square), combined with the elimination of the large moving platen common to most office typewriters, make it an attractive unit for personal use. Also, the noise level is acceptably low. An important secondary benefit of the keyboard of this unit is that there are _no_ additional switches, levers, buttons, keys, or lights--any one of which would subtly but surely convey to the prospective user the message that the unit is "different" and that he must request special instruction.

The input-output part of this unit, however, is primarily designed for parallel and direct transmission of information over a relatively large number of wires (50) to a computer buffering device.[5] The JOSS typewriters, in contrast, were to be used not only throughout the RAND buildings but also in many remote locations over voice-grade dataphone channels. A serial bit-by-bit mode of signaling to and from the typewriter was therefore indicated, and this necessitated a fair investment in console logic (described in detail in Sec. VI), but this was not deemed a prohibitive price to pay for the convenience of this unit.

TYPEWRITER OPTIONS AND MODIFICATIONS

For obvious reasons it was felt that a minimum number of deviations from a standard typewriter should be made, especially if these would be apparent to the user. On the Selectric, however, there were a fair number of manufacturer's optional features to be selected or rejected. In addition, a number of modifications were necessary to make the unit completely satisfactory; these are discussed in detail on pp. 15-25. A complete list of options and detailed modification procedures are found in App. A.

In all cases, care was taken to avoid alienating the experienced touch typist (whose subconscious typing patterns are long standing and difficult to change) at the expense of marginal "improvements" designed to aid the hunt-and-peck typist.

Character Set and Type Font Selection

The standard typewriter keyboard contains 44 keys, each with upper- and lower-case, totaling 88 available characters.

This keyboard comes as close to providing a standard character set as any in the world and has been in continuous use since the introduction of the Remington keyboard in 1878. The keyboard character set finally adopted for JOSS (see Fig. 1) differs from the standard keyboard by only 9 characters; it is summarized as follows:

- Standard characters, retained in position:

Letters:	ABCDEFGHIJKLMNOPQRSTUVWXYZ	(26)
	abcdefghijklmnopqrstuvwxyz	(26)
Numerals:	1234567890	(10)
Other signs:	. , ; : / ? ( ) # - _ $	(12)

- Standard characters, position moved:

  ' " + = * (5)

- Added characters:

  ≤ ≥ < > | • ≠ [ ] (9)

- Eliminated characters:

  . , @ % ¢ & ¼ ½ ± (9)

The JOSS character set has a number of features worthy of mention. The added characters have been chosen from the usual set of mathematical symbols, while the eliminated characters are either redundant or primarily useful for business correspondence. Of the 79 characters that are retained, 74 take their usual positions. Single and double quotes have been moved to the upper-case 1 and upper-case 2 positions, respectively--an easy mnemonic device. (Note, however, that double quotes are often found in this position on manual machines.)

The redundant upper-case period and comma have been replaced with left and right square brackets, to aid in

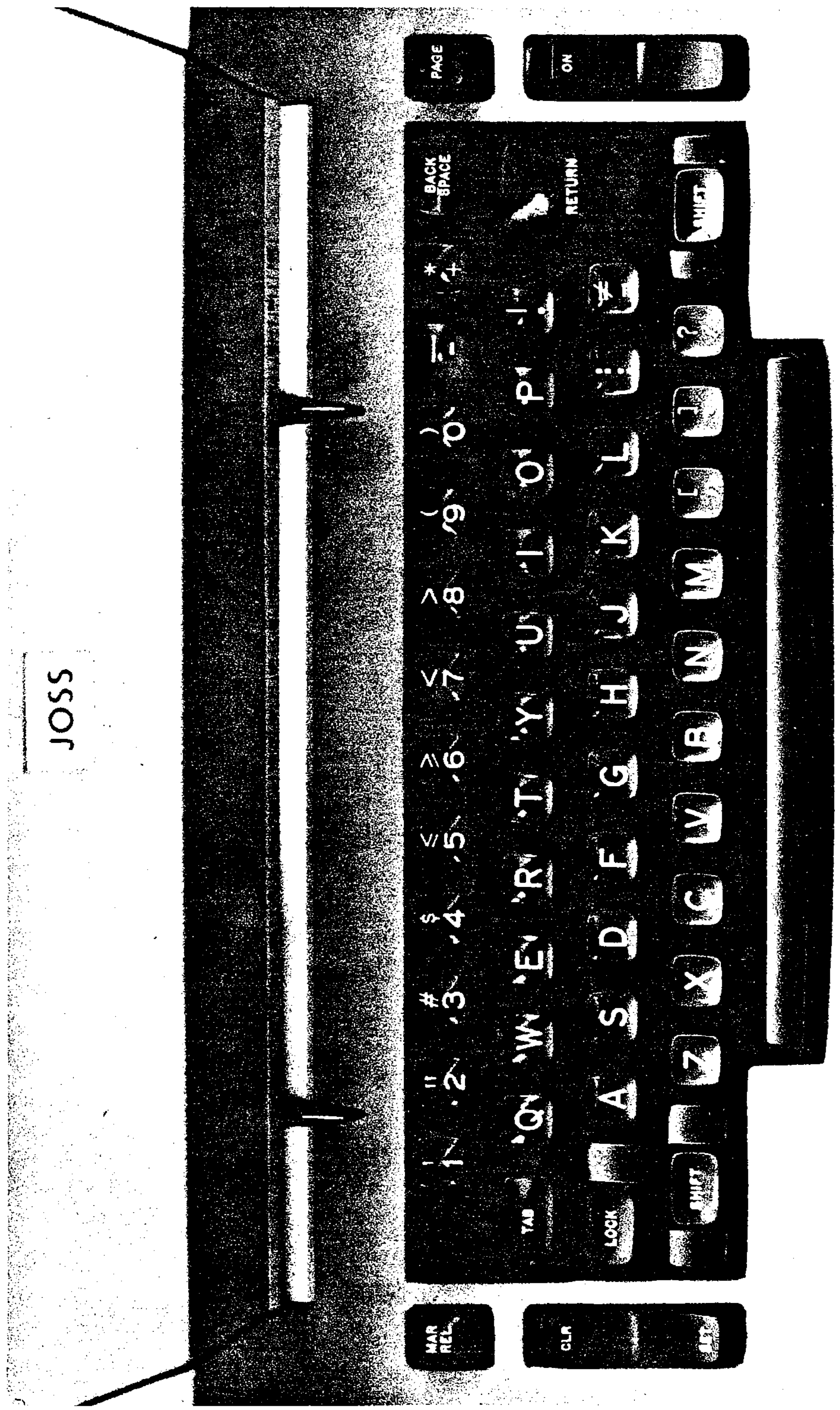


Fig. 1--The JOSS keyboard

legibility of linearized algebraic expressions requiring nested parentheses.[†] Because the remaining relational operators, ≤, ≥, <, >, might also be used as grouping operators, it is appropriate that they are also in upper-case and fall in adjacent pairs as do () and []. The final grouping operator, the added absolute value bar, is also in upper-case.

It was necessary to add only one new arithmetic character operator, the centered multiplication dot, since the five-pointed upper-case asterisk indicates exponentiation. (The selection of a five-pointed rather than a six-pointed asterisk serves to distinguish the JOSS exponentiation symbol from the Algol/Fortran multiplication sign.[‡]) The arithmetic operators, plus, minus, times, divided by, as well as the equal-to sign, are all lower-case; upper-case is more appropriate for the asterisk, denoting exponentiation, and for the not-equal-to sign.

Finally, there are adequate substitutes for all of the eliminated business characters:

"at" for "@"	"1/4" for "¼"
"o/o" for "%"	"1/2" for "½"
"¢" for "ç"	"$\underline{+}$" for "±"

[†]The changes that are the hardest for the touch typist to adjust to in learning the JOSS keyboard are the absence of the upper-case period and comma and the new position of the apostrophe (fortunately, the JOSS language has few contractions).

[‡]Through an unfortunate assembly oversight (to be corrected on future keyboards), the 5-pointed asterisk is represented on the JOSS keyboard as a 6-pointed asterisk. See Fig. 1.

The character set and keyboard layout described above have been in use for almost five years at RAND, and have proven eminently satisfactory in all respects for the JOSS language. (Only the single quote has no special use or meaning for input or output.) The skilled typist soon adjusts to the few nonstandard positions among the 88 symbols, and, at the same time, the layout is sufficiently rational that the hunt-and-peck artist finds "easy hunting."

Type Size, Style, and Font

There are two standard sizes of typewriter type available: pica, with 10 characters to the inch, and elite, with 12 characters to the inch.[†] Both styles provide 6 lines per vertical inch. Because the pica type is more legible and reproducible, it was selected for the first JOSS consoles (used with JOHNNIAC). The elite type, however, has the advantage of more characters per line, a desirable benefit in a line-at-a-time system such as JOSS.

An even more pertinent consideration, however, is that if output is to be incorporated into reports, JOSS typing should match that of the remainder of the publication. Of the thirteen departments at RAND, ten regularly use elite type, and the remaining three use pica type. It is not surprising, therefore, that a poll made of over a hundred JOSS users at RAND requesting their preference resulted in a three-to-one margin in favor of elite, and motivated the adoption of this type size. (The JOSS output in Table 1 was typed with a carbon film ribbon on bond; for Tables 2 and 3 a fabric ribbon on carbon-backed vellum was used.)

[†]The present memorandum is typed in pica type.

Table 1

INCOME SOURCES OF THE CONFEDERATE GOVERNMENT

Source	Amount (millions of $C)		Per cent of total	
Taxes [1]				
Import and export duties	3.5		0.1	
Tax in kind (estimate)	62.0		2.1	
Ordinary taxes	142.0		4.8	
	-----		----	
Subtotal, Taxes		207.5		6.9
Seizures and Donations [2]				
Federal funds	0.7		0.0	
Sequestration of alien property [3]	7.5		0.3	
Specie reserve of New Orleans banks [4]	4.2		0.1	
Donations (estimate)	2.0		0.1	
Impressments, certified by unpaid Certificates of Indebtedness (estimate) [5]	500.0		16.7	
	-----		----	
Subtotal, Seizures and Donations		514.4		17.2
Loans [6]				
Foreign (Erlanger loan)	15.0 [7]		0.5	
Domestic	697.0		23.3	
	-----		----	
Subtotal, Loans		712.0		23.8
Treasury Notes [8]		1,554.1		52.0
		-------		-----
Grand Total [9]		2,988.0		100.0

Notes: [1] Todd, p. 156.
[2] Ibid., p. 174.
[3] No estimate available for property taken over from Federal government, other than Federal funds.
[4] Confiscated upon Federal occupation of New Orleans.
[5] Not the total of impressments, but only those not paid in Treasury notes or other money.
[6] Todd, pp. 83-84.
[7] Amount realized (in foreign exchange figuring 1 pound sterling equivalent to 5 C.S. dollars) was $7.7 million (ibid., p. 184). Schwab, after deducting certain costs, estimates the proceeds at $6.25 million (p. 42).
[8] Todd, p. 120.
[9] Certain minor sources, such as profits from government enterprises (including blockade runners), appear to be omitted, in addition to the value of confiscated Federal properties already mentioned.

However, a year of experience indicates that this may have been a hasty decision. The smaller typeface is more sensitive not only to minor misadjustments in the typewriter but also to ribbons that are worn. As a consequence, the quality of the printed page is often degraded, and users preparing formal output must choose their console with care. Most of these problems, we feel, would not have arisen if we had selected the pica type size. It is possible, however, that the elite size would be acceptable with a bolder type face than "Advocate." (At the time of selection, there were only two fonts available from which to choose.)

Operational Functions

The remaining keys on the Selectric typewriter that provide the so-called operational functions divide into two groups:

1. The short functions, which take place in a single character time: space, backspace, shift up, and shift down.
2. The long functions, whose time for completion depends on the amount of typehead carrier motion involved: tab,[†] carrier return, and index.

These functions, with the exception of index, are standard typewriter functions and are retained intact for JOSS usage. Index, an exclusive feature of the Selectric typewriter, is used to advance the platen a line at a time to provide vertical paper feed. Because it was found that this

[†]The setting and clearing of tab stops is a manual procedure; each user is free to set these stops as required.

mechanism was relatively slow when the paper was advanced more than a few lines, it was replaced by a high-speed paper advance (described on p. 15).

Ribbon Color Control

To positively identify input from output typing, a two-color black and green ribbon is used in conjunction with the single-magnet color control. This provides black ribbon shift for on-line output, green for on-line input, and black for off-line typewriter use (the typist may also select manually either the green or stencil positions). A number of different ribbons have been tried; the problem is to obtain both satisfactory color distinction without "bleeding" (the absorption of black ink by the green portion) and good wearing properties. The ribbon currently in use is made by Columbia, and combines black with green #1553 in a silk gauze ribbon; however, drying of the ink in the ribbon remains a problem in the arid southern California climate.

Keyboard Lock

The energize-to-lock option is specified for the typewriters and is used to prevent the operator from interfering with typed output in the on-line mode. It is nonoperative in the off-line mode.

Typewriter Styling

The final specifications for the typewriter pertain to styling. The console mounting ring is used to mount the typewriter in the console stand; the design of this unit is detailed in the next section.

To provide the desired color scheme, units were ordered with primer paint only and were later painted a light blue. In harmony with this color, dark blue keybuttons, with matching margin indicators and platen knobs, were selected. The dark color helps protect the appearance of the unit from the damaging effects of oil and grease on the user's fingertips; discoloration of the standard light grey in the prototype typewriter was a problem.

The Paging Mechanism

In the design of the JOSS console, it was deemed imperative to provide the ability to produce, automatically, formatted output on standard 8½ by 11-in. paper. This size is universally used for correspondence, reports, and working notes, and is easily filed, reproduced, transmitted, and stored. Experience with the early JOHNNIAC console output confirmed the value of a standard paper size. The problem was how best to provide this ability in the Selectric Input-Output Writer.

For vertical paper feeding, the optional pin-feed platen, with 9 3/8-in. center-to-center pin spacing, was chosen, because fanfold continuous forms of 8½ by 11-in. sheets are readily available. Next we had to determine the positions of the top and bottom lines on each sheet of paper so that 1-in. margins (6 lines) could be preserved and synchronized with the actual physical page fold.

Since the JOSS software keeps track of the current line number on the output page, our first thought was to use the <u>index</u> feature to advance the paper the required number of lines. For merely skipping over the fold, the speed of advance provided by the <u>index</u> mechanism (7.5 lines per second) would probably suffice. The total time of 1.6 sec was deemed reasonable, since this is small compared to the $2\frac{1}{2}$ sec nominally required to type the page heading line. In formatted output, however, it is more common to skip over a much larger number of lines and to start output on a fresh page at convenient intervals. Here, the total time of over 11 sec per sheet is inordinately long. Moreover, the user is unnerved by the line-by-line start-stop motion and noise of this mode of paper advance and is quickly discouraged from using the feature.

The high-speed vertical paper advance and synchronization mechanism feature that was available for the IBM Model B typewriters used with JOHNNIAC JOSS is not provided as a feature of the Selectric Input-Output Writer. Therefore, RAND undertook to design, build, and test an acceptable mechanism that could be added to the standard typewriters. The main problems to be overcome arose from the limited amount of space available inside the typewriter covers and the desire not to interfere with either the operation or ease of maintenance of the basic unit.

In addition, some means of synchronization needs to be provided in order to ensure that the required margins are actually supplied at the paper folds and not in the middle of a page. The user must be allowed to turn the platen knobs by hand, especially when using the typewriter off-line, without disturbing this synchronization. This requires some means of <u>re</u>synchronization--at the beginning of each user session, and, preferably, at the beginning of each new sheet. The process should be automatic, with manual resynchronization necessary only when inserting a new load of continuous form paper.

The completed gearbox mechanism, shown in Fig. 2 with typewriter cover removed, provides paper advance at the rate of about $7\frac{1}{4}$ in. per second, or 1.5 sec for a full 11-in. sheet of paper. Figures 3a and 3b on pp. 23-24 present, respectively, the electrical circuit modifications to the typewriter, including the gearbox circuits discussed below, and the complete circuit for the modified unit.[†] The complete step-by-step modification procedure is given in App. A.

The paging operation is activated in two ways: (1) when the user presses page, closing a microswitch mounted beneath that keybutton (the index mechanism is disconnected and the keybutton legend is changed from index); or (2) when the console receives a page signal from the system software. Either condition causes the unit to operate as a vertical tab by energizing, through the console electronics, a small magnetic clutch to engage the gear drive unit that turns the platen. To signal the end of the paper advance, a cam follower activates a second microswitch, which is used to transfer the drive current from the magnetic clutch to the carrier-return magnet in the typewriter. This not only permits the page to be ejected in the middle of the typed line, but also allows the "carrier-return completed" interlock contacts of the Input-Output Writer to supply the necessary form-feed completed signal.

Because the operation of this mechanism is electromechanical in nature, rather than strictly mechanical as is

[†]The use of paper sensors to detect an out-of-paper condition, or paper that has jumped the sprockets, was considered at some length, but ultimately rejected, because no easily installed, reliable, noninterfering device was available. The attendant electronics was included in the console, however.

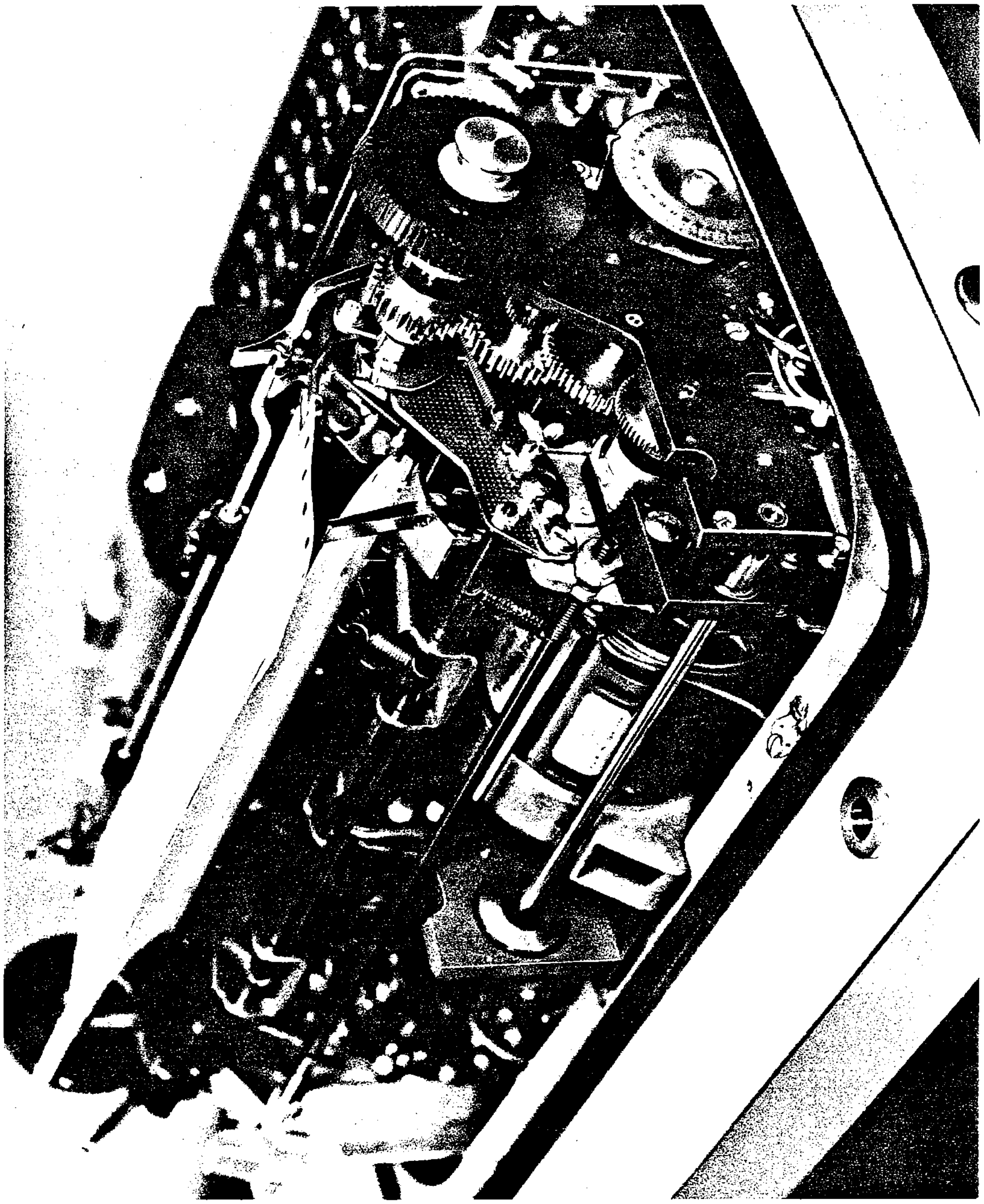


Fig. 2--The JOSS paging mechanism

the case with the remainder of the typewriter mechanism, the paging feature is inoperative in the off-line mode, when console electronics are turned off.

In order to synchronize the end-of-advance microswitch with the actual physical top of the page, the left-hand typewriter platen knob, through which the gear train actually drives the platen, includes a knob for disengaging the platen from the gear drive unit, permitting manual paper positioning without corresponding cam displacement. This also allows easy disengagement of the paper drive when required, say, for typewriter maintenance.

A year of experience with this design has proven it to be satisfactory in most respects; however, the deficiencies that have been discovered are worthy of comment. Because of the limited length of the typewriter motor shaft available, a spur gear power take-off was resorted to. This, in turn, drives several idler gears, and, as a result, the noise level of the mechanism is high compared with that of the unmodified typewriter. Frequent careful adjustment can reduce the noise to an acceptable level, which is greater than that of an idling unmodified unit but far below that of the operating typehead mechanism. A longer motor shaft will be specified in future units to permit the use of a timing belt drive with a consequent reduction in noise level. (The ability to disengage the take-off mechanism, now provided by the adjustment for gear lash, should be retained, but a suitable means for accomplishing this has not been investigated.)

Even more serious is the problem that arises because the mechanism includes no positive means of stopping the platen at the end of the paper advance. The cam that trips the synchronizing microswitch merely removes the power from the magnetic clutch used to drive the platen. At this high speed of paper advance, drive platen inertia causes difficulties, and the platen can only be made to stop reliably in position by careful adjustments to control the friction in the gear train. Once again, future units will have to overcome this drawback; experiments using a detent mechanism in the gear train appear promising.

A final, though less serious, condition occurs when the magnetic clutch slips, stalling the paper drive. This is caused by the build-up of oil and grease within the clutch and can be prevented by conscientious periodic maintenance of the units. The difficulty is easily overcome temporarily with an assist from the operator, via the platen knobs.

Several minor adjustments are necessary to permit the high-speed paper advance to operate smoothly. Normally, when a pin-feed platen is used in the typewriter, neither the feed rollers nor the paper bail (both of which hold the individual sheets tightly against the regular platen) are to be used. If the feed rollers are engaged (inadvertently), the sprocket holes are almost invariably torn out within a few pages. However, some means is needed to ensure that the paper remains securely wrapped around the platen, to prevent the extremely uneven typing that otherwise occurs at or near the natural fold of the fanfold paper. Our solution was to remove the feed rollers entirely, leaving the platen pressure plate to exert a small but constant force along the full length of the platen. The range of adjustment for the springs that are used to control the pressure was found to be insufficient; these springs were replaced by new ones, which exert slightly less force. In addition, the straight paper bail was replaced with a "stepped" bail (visible in Fig. 2), which not only helps prevent buckling when the paper is ejected at high speed, but also permits greater visibility of the three or four most-recently-typed lines, which otherwise would be hidden. As a final step, all modifications and adjustments are tested to verify smooth operation of the paging mechanism.

As a result of these modifications, all of the levers associated with the typewriter carrier and platen retain their normal, off-line, or office-use functions. The spacing lever must remain in the <u>single</u> position, unless the central processor is made aware of this repositioning (as might be the case with other than JOSS software). Appendix B summarizes the console typewriter knob settings.

<u>On/Off Switch</u>

Although it is clearly desirable for the typewriter power <u>on/off</u> switch to retain its normal function when the typewriter is to be used off-line, the user must be prevented from turning the typewriter motor off during the time JOSS (or, more generally, any software system) is transmitting output to be typed. Should this happen, serious wear or damage within the typewriter mechanism could possibly result, and certainly output characters would be lost. It seems advisable, therefore, to have the typewriter power, in the on-line mode, completely under the control of the central computing system.

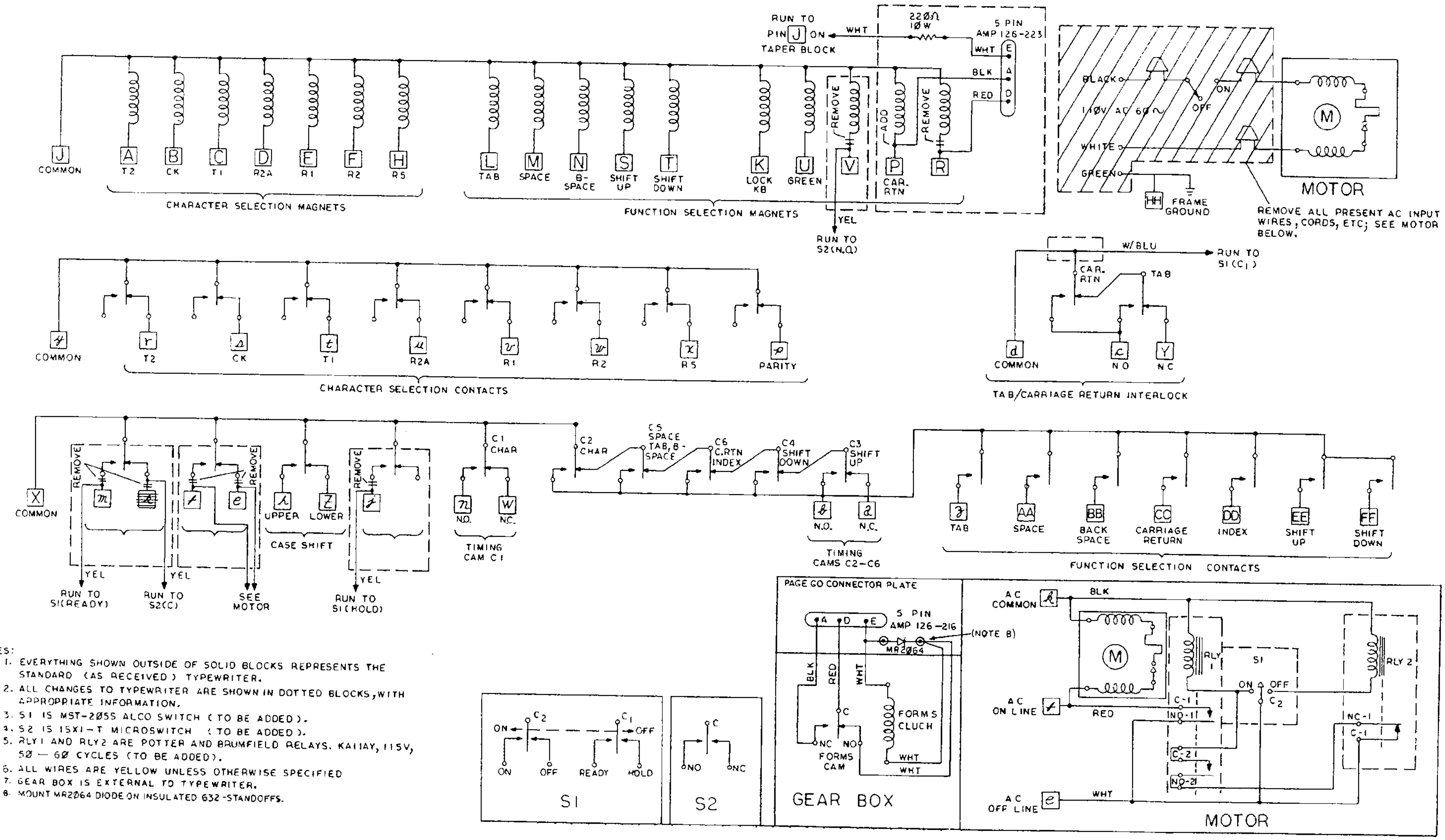
On the other hand, in the on-line mode the <u>on/off</u> switch is the natural one to use to signal the system that the user wishes the output to be held up momentarily--perhaps to answer the telephone, or to insert a new load of paper--and then to signal that the user is ready for the output to resume.

Accordingly, the circuit shown in Fig. 3 was adopted for controlling typewriter motor power, and for providing _hold_ and _ready_ indications.[†] The single-pole-single-throw snap-action switch is replaced with a double-pole-double-throw momentary action switch, S1. One set of contacts is used, in conjunction with a pair of 110-v ac relays, to provide a latching circuit for power as described below.

In the off-line mode, ac power is supplied through pins $\boxed{e}$ and $\boxed{k}$; momentary depression of S1 in the _on_ direction picks up RLY-1. One set of contacts applies power to the motor; the other set latches the relay in when the _on_ switch is released, through a set of normally closed contacts on RLY-2. To turn power off, momentary depression of S1 in the _off_ direction picks up RLY-2, whose contacts break and allow RLY-1 to drop out, removing power from the motor.

In contrast, ac power in the on-line mode is applied _directly_ to the motor, through pins $\boxed{f}$ and $\boxed{k}$ (under system software control). The relay circuit is inoperative, but the second set of contacts on S1 supply the required _ready_ and _hold_ indications.

[†]The symbol $\boxed{e}$ refers to a location in the 50-pin Amphenol connector of the Input-Output Writer. Normally, the ac power to the typewriter is supplied through a separate line cord. For JOSS console use, however, the typewriter was rewired as indicated in Fig. 3a to permit pins assigned to unused functions to be used for the new circuitry. This plug, therefore, now carries all connections to the typewriter through a single cable.



NOTES:
1. EVERYTHING SHOWN OUTSIDE OF SOLID BLOCKS REPRESENTS THE STANDARD (AS RECEIVED) TYPEWRITER.
2. ALL CHANGES TO TYPEWRITER ARE SHOWN IN DOTTED BLOCKS, WITH APPROPRIATE INFORMATION.
3. S1 IS MST-2055 ALCO SWITCH (TO BE ADDED).
4. S2 IS 15X1-T MICROSWITCH (TO BE ADDED).
5. RLY1 AND RLY2 ARE POTTER AND BRUMFIELD RELAYS. KA11AY, 115V, 50 — 60 CYCLES (TO BE ADDED).
6. ALL WIRES ARE YELLOW UNLESS OTHERWISE SPECIFIED
7. GEAR BOX IS EXTERNAL TO TYPEWRITER.
8. MOUNT MR2064 DIODE ON INSULATED 632-STANDOFFS.

Fig. 3a--Selectric Input-Output Writer modifications

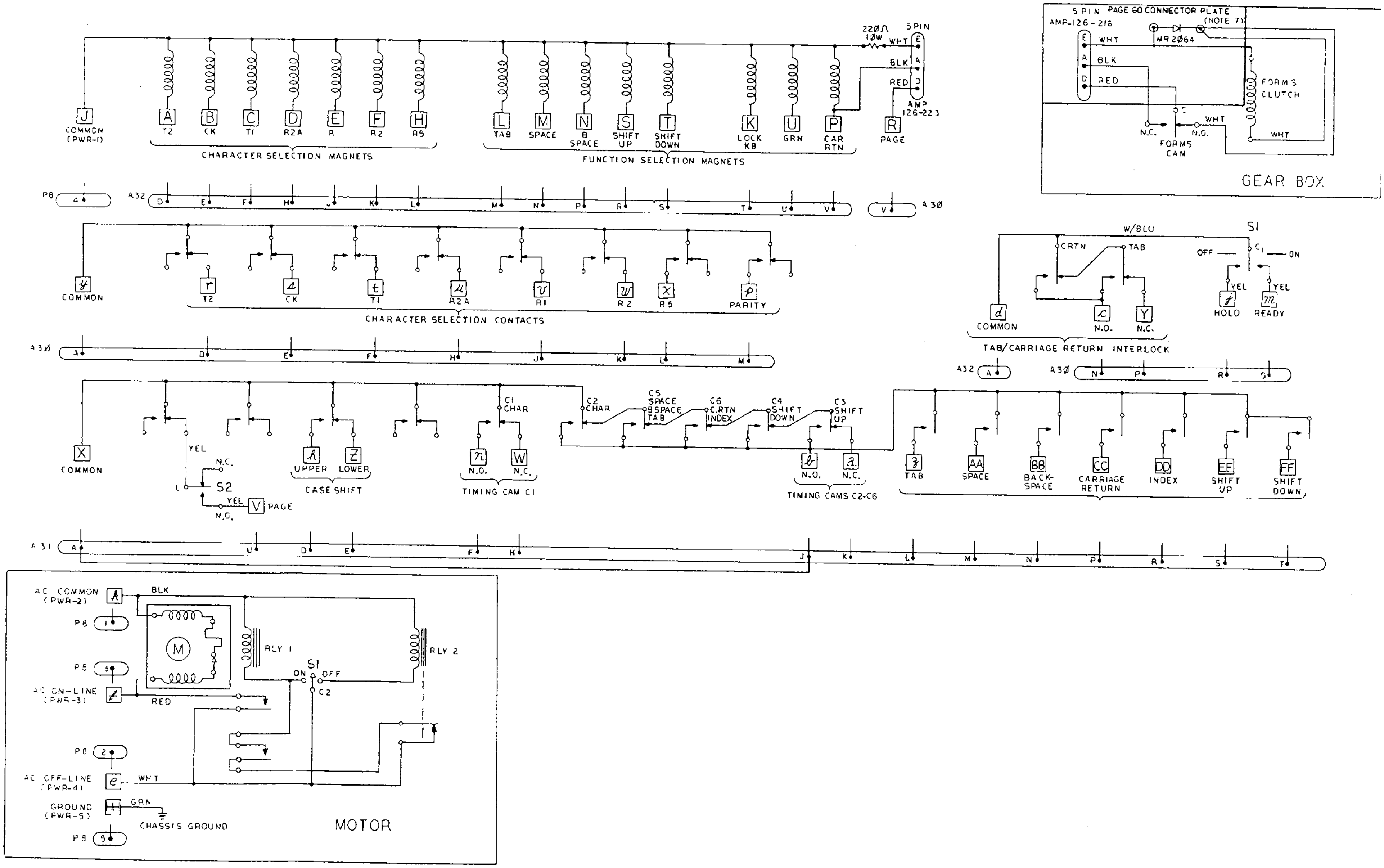


Fig. 3b--Selectric Input-Output Writer as modified

A drawback of this design is that in order to use a center neutral momentary switch, the mechanical keyboard-lock linkage normally attached to the snap-action on/off switch must be removed. Without this linkage accidental key depression when the machine is off leads to a character being stored (mechanically) in the keyboard until the typewriter is turned on, at which time the character (or function) is typed. Although this could be catastrophic if, for example, a secretary had just inserted into the typewriter a many-part manifold letterhead, it is not a serious drawback for our intended use.[†]

[†]However, the console electronics must be conditioned to ignore these spurious actions.

III. THE PHYSICAL CONSOLE

The design of an adequate console in which to house the typewriter proved to be as challenging a task as the selection and modification of the typewriter itself. Predominant considerations included the projected number and size of the electronic components required to implement the desired logic functions; their packaging techniques; the incorporation of the associated switches and indicator lights in a suitably small control box; and the various dimensions of the Input-Output Writer itself.

OPERATOR COMFORT

First on the list of requirements was that the station should be comfortable to use over an extended period of time. Recognition that the height of the typewriter keyboard was a critical parameter led to a survey of a large number of personal typewriters already in use at RAND. The height of each keyboard was measured from the floor to the top of the spacebar; also, each user was asked if he felt that his keyboard would be more comfortable at a different height.

Even if the keyboard is at the proper height, it can still be uncomfortable if there is inadequate clearance for the user's knees under the keyboard. In contrast to manual typewriters, where the spacebar is only an inch or so above the bottom surface of the typewriter, the Selectric Input-Output Writer projects 4½ in. below the console mounting surface, restricting knee room to a much greater extent.

To determine the maximum knee room that would be required, we measured the prospective user whom we felt would provide the limiting case--a 6 ft 1½ in. secretary wearing high heels.

When these data were combined, it was apparent that the console top should be 29 in. above the floor, providing 24½ in. of knee room. The typewriter, mounted with the console mounting ring, provides a spacebar height of 1½ in. above the console top. Thus, the total floor-to-keyboard dimension is 30½ in., which is at the middle of the comfort zone for those RAND users surveyed.

OPERATOR CONVENIENCE

Of course, in addition to being comfortable, the console must be convenient to use. Our primary requirement was that the console be mobile, in order to move it easily from office to office,[†] and small enough to pass through doorways and other narrow passages; it also had to fit comfortably within the user's normal work area, next to his desk. To provide the required mobility, we mounted the console on 2½-in. diameter Shepherd planetary casters. These operate well on both tile and carpeting, and permit the console not only to be moved in any direction but also, when necessary, to be squeezed into a tight "parking spot." At the same time, the casters provide sufficient stability to keep the console from skidding out from under the user, even under full-speed output conditions. (The Selectric typewriter does not have a heavy moving carriage but rather a light-weight typehead carrier.)

OVERALL SIZE REQUIREMENTS

The fundamental parameters influencing the overall size

[†]See p. 38 and App. D.

of the unit included the size of the typewriter itself (approximately 16 in. square), the size of the electronics package to be housed in the pedestal of the console, and the space requirement for the console control box. The console logic was to be implemented with Digital Equipment Corporation Flip Chip modules, which are mounted in standard 19-in. rack-and-panel module holders. Two such module panels were required, each 5½ in. high with a power supply 5 3/4 in. high. The overall depth of these units is about 6½ in. Figures 4a and 4b show front and rear views of the console with the covers removed to expose the electronic "innards;" a Flip Chip module, removed from the console, can be seen in Fig. 4a.

Consideration of all of these factors led to a pedestal 23 in. wide, 9 in. deep, and 19 in. high (including trim panels and access doors) and to a console top size of 23 in. wide by 19 in. deep.† The keyboard overhang is 10 in., which is more than adequate for typing comfort. The 19-in. pedestal height allows sufficient vertical room for the Formica-covered table top, the Shepherd casters, and for the sturdy caster mounting bars or "feet." The bars are made of solid aluminum stock and are trimmed as short as possible to prevent them from interfering with the user, but not so short as to reduce stability and resistance to tipping. They are mounted to the pedestal with sufficient give to permit the weight of the console to keep the four casters solidly on the floor at all times, even on extremely uneven surfaces. Thus, there is no annoying rocking motion requiring adjustment with matchbooks. An unexpected benefit of this

†These are not the final overall dimensions, however. See footnote, p. 36.

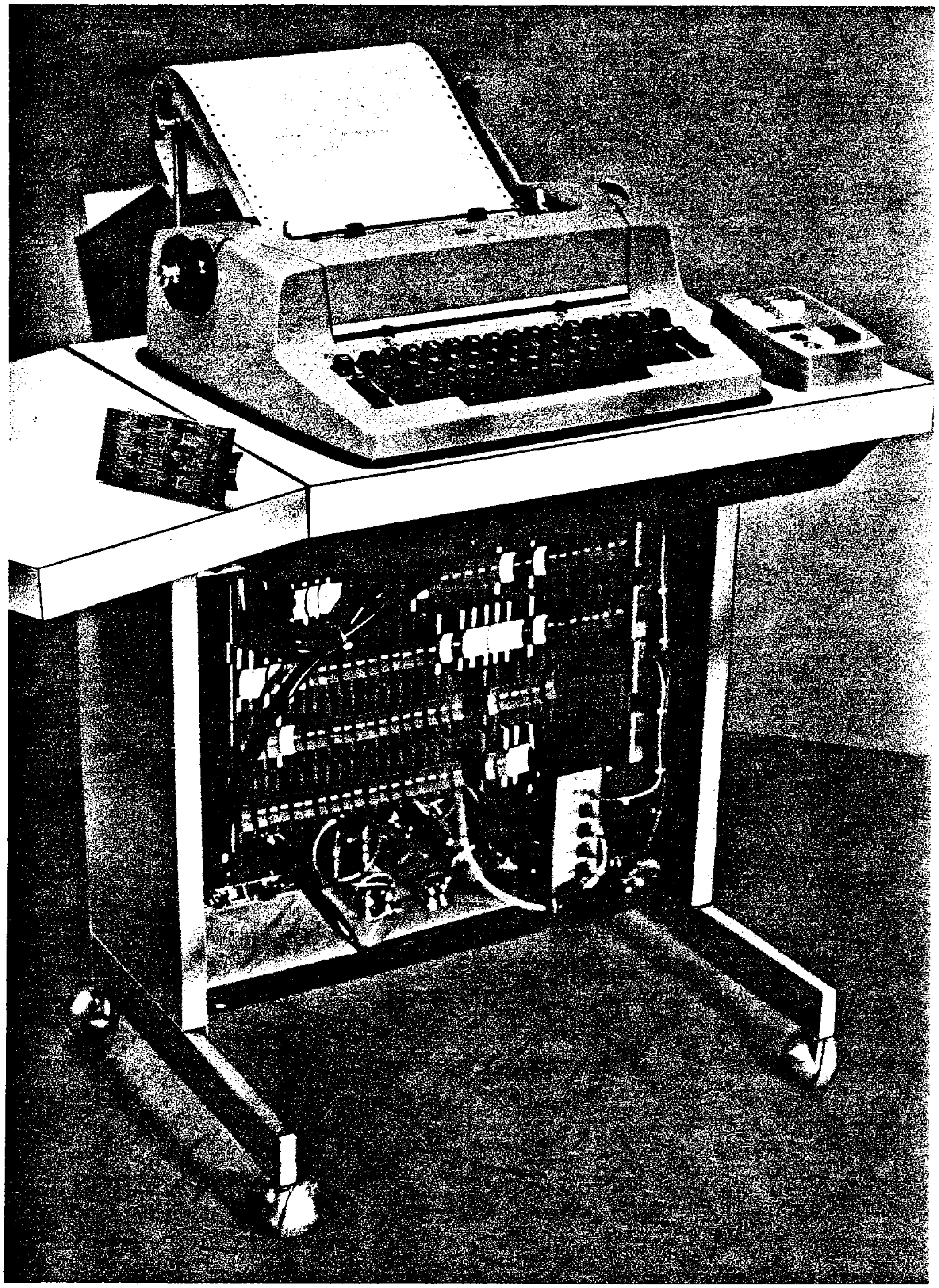


Fig. 4a--The JOSS console electronics package: front view

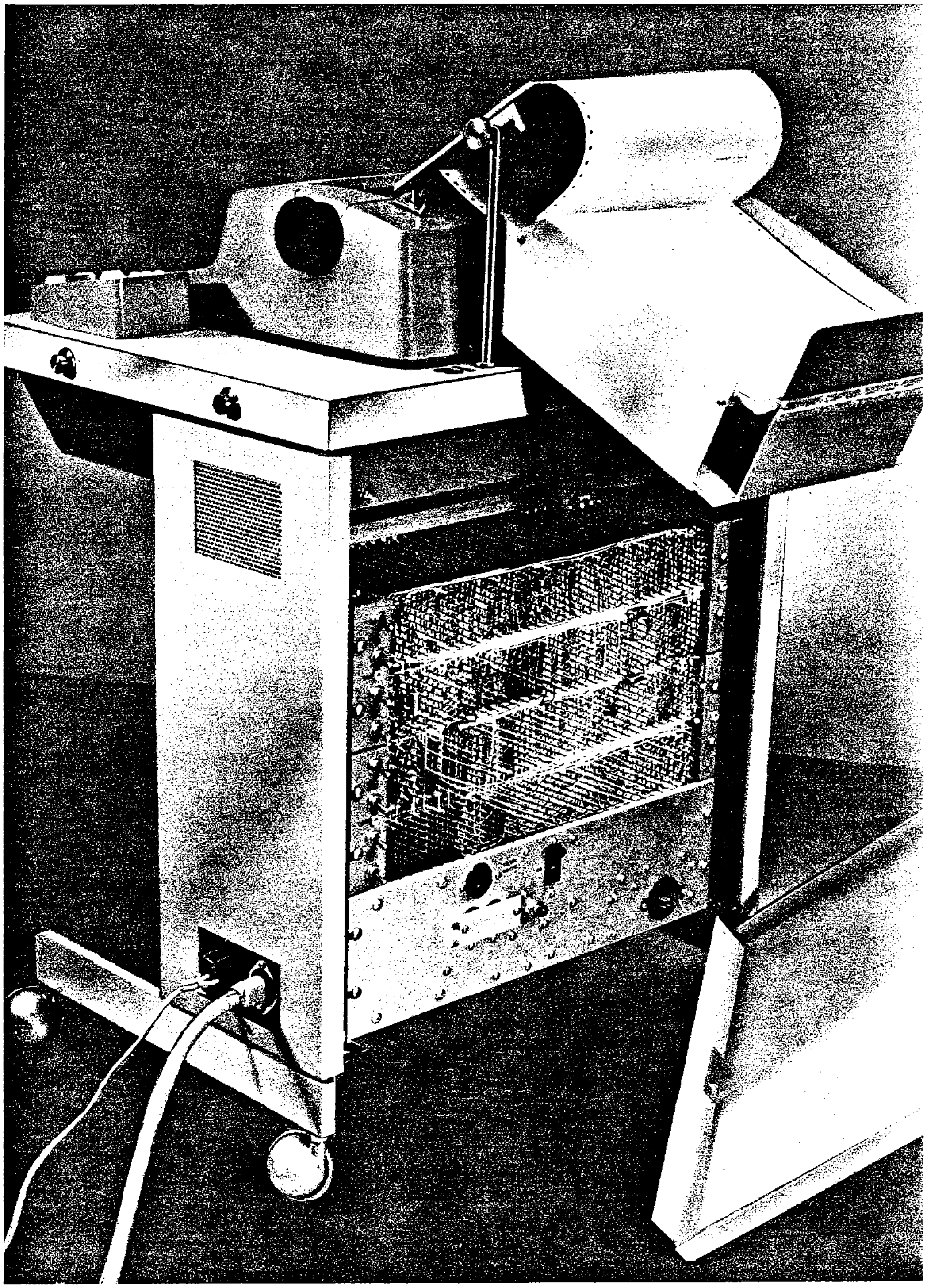


Fig. 4b--The JOSS console electronics package: rear view arrangement is that the (male) user engrossed in conversing with JOSS finds a convenient resting place for his feet as he hunches over the console; in turn his elbows rest comfortably on his knees.

To contribute further to the stability of the unit, the power supply is mounted at the bottom of the pedestal rather than at the top, as usual heat-dissipation techniques would dictate. In consequence, the pedestal was originally designed to house 3 Muffin fans to circulate sufficient air to keep the unit cool. However, these fans, operating at full speed in the prototype console, proved far too noisy for the average office, and they were ineffective when run at a speed that reduced the noise to a tolerable level. Fortunately, the heat load generated by the electronics package is not substantial and can be easily dissipated; thus, although the fans were eliminated from the production consoles, the units remain cool. (Although dissipated from the console itself, the heat still needs to be removed from the user's working environment; a small room without adequate circulation can become uncomfortably warm with the console operating continuously.)

The final overall size of the console top, 19 by 23 in., provides a more than adequate area in which to mount the typewriter by means of the console mounting ring. The cut-out into which the input-output part of the unit is recessed is offset to the left to provide space for mounting the console electronics control box. The offset was made with some misgivings, as it was felt that the asymmetry might prove annoying to the trained typist; however, this has not been the case, possibly because of the balancing effect of the control box, but more likely because there are no legs at the front corners to get in the user's way and because of the shortened caster mounting bars. Indeed, in a standard office swivel chair the user can conveniently turn back and forth from his JOSS keyboard to his desk with his working papers.

The functions of the control box itself are summarized in Table 2, p. 49; it is only important to note at this point that the box is designed to harmonize with the typewriter case and contains a minimum of lights and switches. Although during a JOSS session the control box receives infrequent use and attention, care was taken to choose reliable switches of solid touch and easily visible lights and to locate them in a nonconfusing layout. The final arrangement of this hardware, shown in Fig. 5, was selected only after

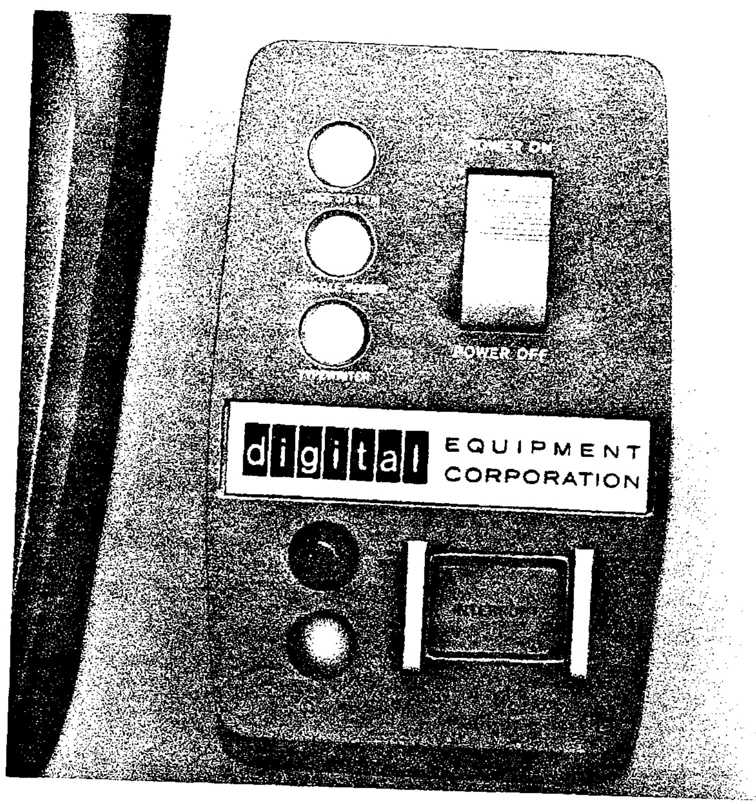


Fig. 5--The JOSS console control box

consideration of many proposed alternatives. The manufacturer's logotype was conveniently used to separate the power switch and status lights (all white) from the control lights and button (red, green, and yellow).

WORKING SPACE

To provide additional space for working papers, the table wing shown in use in Fig. 6 was adopted. The wing was designed so that it can be mounted either on the right-

Fig. 6--The JOSS console in use

or left-hand side for the convenience of both right- and left-handed users.[†] In addition, it can be mounted curving either toward the front or toward the back; or it can be removed entirely. When not in use, the wing hangs vertically, either on the right- or left-hand side of the console; rubber bumpers prevent it from rattling in this position. If necessary, a user can have a specially shaped wing made to fit his needs.

The space between the control box and the typewriter was carefully planned to provide a handy place for pens, pencils, or felt-tipped markers (and for tools during maintenance periods), and keeps these items from rolling off the console. The space behind the control box accommodates an ash tray for users who smoke, as well as the ever-present RAND coffee cup.

One defect of the side wing is that it appears much more solid than it actually is. Although the console will not tip over if the user leans against or attempts to sit on the wing, his full weight will bend the mounting fittings, which are made of fairly soft steel. Such damage is not permanent, however, as the fittings can be bent back, without tools, simply by reversing the leverage.

These fittings perform an additional duty during console maintenance: The panel containing the array of indicator lights used to troubleshoot the console electronics is designed to be mounted on this hardware during maintenance periods.

[†]The stationary control box is mounted for right-handed users; however, the manual dexterity required is low and should inconvenience no one.

PAPER TRANSPORT

Not surprisingly, the design of an adequate paper hopper and stacker assembly was one of the most vexing tasks of the project. The most recent design, seen in Figs. 4 and 6, is reasonably satisfactory in performance. It is of interest to review the stages through which this unit evolved to its present configuration.

Because the Selectric typewriter's stationary platen eliminates all of the problems associated with a moving carriage, we first thought that it would be relatively easy to design a hopper for the fanfold paper. At the same time, the stationary platen permits us to mount a paper outfeed, or platen tray, at a suitable angle and with proper size to display, for easy reference, the most recently typed page. Initial consideration was also given to eliminating the paper stacker entirely if a satisfactory unit could not be built.

In the first design, therefore, the hopper for the paper was mounted vertically at the back of the console top, with the paper feeding up and out; the paper stacker was eliminated in anticipation of poor performance. The obvious advantage of this design is that it reduces the overall depth of the console, permitting it to be used against a wall. In principle, it worked fine, and fed the first few pages without difficulty from a sheaf of about a hundred sheets. In practice, however, we required a hopper that would work well for all of the sheets fed from it, not just the first few as turned out to be the case, and it had to hold far more than a hundred sheets. (Although seemingly slow by comparison with a line printer, an on-line typewriter has a voracious appetite for paper.)

Therefore, despite the advantages of a narrow front-to-back dimension of the console, the vertical design was abandoned. The hopper was extended behind the typewriter,[†] sloping sufficiently to ensure that the paper supply would remain firmly in place.

The paper stacker provided is simply the upper deck of the hopper, hinged at the back to permit it to be swung up and back to gain access for loading paper. During this operation the console must be moved away from a wall, but since loading is infrequent the inconvenience is minimum. Paper changing actually takes only a few moments, and it is quite feasible to change from bond to vellum and back for a few pages of formal output whenever required.

The back corners of both the hopper and stacker are cut away, to prevent dirt and other foreign objects from accumulating and contaminating or damaging the paper supply.

One of the problems to be resolved was that close to the end of the sheaf of fanfold paper fed from the hopper, static electricity and paper stiffness combined to keep the last few sheets from unfolding properly; the tendency was to feed the last several pages all at once. Although the sprocket holes torn out in the paper did provide a positive indication that the paper supply was low, the entire pin-feed mechanism invariably became jammed. To circumvent this distressing tendency, a sharply upturned lip was provided at the front of the bottom of the hopper. This modification ensures that the paper is fed sheet-by-sheet to the very end.

[†]As a result, the overall width (25 in. with the wing hanging vertically) rather than the overall depth ($30\frac{1}{2}$ in. including the paper stacker) becomes the relevant dimension and determines clearances in narrow passageways.

The final feature of the paper-feed mechanism, the platen tray, is adjustable, via two knurled knobs. Thus it can accommodate slight variations of the typewriter position in the console, or be raised to the vertical so that the entire upper typewriter cover (or even the entire typewriter) can be removed for maintenance without disturbing the hopper/stacker; indeed, the stacker provides a convenient place to set this cover once it has been removed. In contrast to the several original versions, the tray that finally evolved has cutouts to avoid interference with the pin-feed sprockets. It is narrow enough to permit the typewriter cover to be opened (say, to gain access for ribbon changing) without interference from the lower edge of the platen tray.

Although the entire hopper/stacker/platen tray assembly can be removed easily when necessary (the two vertical rods simply plug into the console top), the position, size, and angle of the hopper were chosen to permit the rear access panel of the console to be removed, to facilitate maintenance procedures, without removing the assembly. In practice, therefore, the hopper/stacker seldom, if ever, needs to be removed from the console.

POWER AND SIGNAL CORDS

With a unit moved as frequently as the JOSS console, dangling power cords are often a major source of annoyance. To avoid this problem, connections to the console for power and signal cables were made through two recessed plugs in the side of the console; these are visible in Fig. 4b. When the console is to be moved, the cords are simply unplugged directly at the console. If the cords are to accompany the console, they are coiled and may be stowed conveniently in the paper stacker. In a number of offices, the power and signaling cables are left permanently in place, ready to plug into the console once it is in operating position. Thus, the user is not inconvenienced by having to find the outlets each time the console is used (at RAND, at least, these are usually found in the least accessible spot under one's office desk or table).

Within the RAND buildings, a four-wire signal cable is used. Three of these wires are for the required ground, transmitted signal, and received signal lines. The fourth wire initiates the operation of a relay-driven automatic line concentrator, which then automatically seeks out an unused channel of the PDP-6 input-output multiplexer. The line concentrator enables the mobile JOSS console to be used in any of more than 200 locations within a radius of approximately 2000 feet (as the signal cables are routed). The concentrator is comprised of standard telephone equipment, including Strowger switches and line relays: The only modification of the unit consists of the addition of transistor line-relay-driver cards. This addition is necessary to avoid excessive voltage drop on the (approximately 50-100 ohm) ground line, a condition that would result if the entire 80-ma line relay current were carried directly.

In conjunction with data set (Western Electric 103A-2 or Western Union 1183A) transmission, an eight-wire cable is used to provide the standard E.I.A. interface for data and control signal levels.

Cables for both in-house and data set use are connected through a single 10-pin plug on the JOSS console; each cable connects only to those pins actually required for that type of connection. A simplified circuit diagram for the automatic line concentrator and associated wiring is provided in App. D, along with the console-to-data set cable specifications.

IV. THE LOGICAL CONSOLE

On first thought, there seems little requirement for an extensive logic package for a remote typewriter console.[†] Indeed, the Teletype units often used for on-line work contain almost no electronics at all. But these are essentially communication devices, designed for one-way-at-a-time message transmission or reception.

Far more than simple message-sending logic is required in a truly conversational console designed for rapid and intimate interaction. If at all possible, console electronics and system software[‡] should cooperate to share the burden of this interaction; the user should not be left to cope with these tasks unassisted. For example, a control button action must be recognized whenever a user presses that button, if the action is meaningful, or ignored completely if the action is meaningless. The user should not be expected to hit a button several times until the message gets through, but on the other hand, he cannot be relied upon to refrain from pressing buttons at the wrong times, nor to avoid multiple button/switch/keystroke actions. The consequences of inadvertent actions and accidents must be minimized, for when things go awry, the user can be counted upon to punch every button and key in sight in an attempt to elicit the desired response from the console. The continued operation of Murphy's Law ensures that the most disastrous of such sequences, if one exists, will be the most probable.

[†]The necessity for a parallel-to-serial interface of the typewriter with the communication link has been discussed briefly on p. 7.

[‡]See p. 3.

This section presents the rationale for the various features that are required of the console. Detailed description of the operation of the several interrelated parts of the logic package is deferred until the following section.

CONTROL OF THE TYPEWRITER

The fundamental JOSS characteristic influencing console design is the line-at-a-time interactive mode with which the user converses with JOSS through the typewriter. The user has complete control of the typewriter while composing an input line: He may space, backspace, or strike over at will. At the conclusion of the line, the user indicates completion by a carrier return (or page), and JOSS either retains control of the typewriter for one or more complete lines of output, or immediately returns control to the user for the next input line.

The console, therefore, is always in one of two states: The state in which the user has control is termed the green state (the user is free to proceed); the contrasting state, in which JOSS has control, is termed the red state (the user must wait for green to proceed). It is vitally important for both the user and JOSS to be fully aware at each instant as to which of these states is actually in effect; much care has been taken to make sure that the user and JOSS stay in step at all times. The user is therefore provided with a red and green light pair on a small auxiliary control box, which furnishes continual feedback while the user is on-line. In addition, the two-color ribbon of the typewriter leaves a permanent, unambiguous record: All of the user's input is typed in green, while all JOSS output is in black, which is more appropriate than red for producing formal output.

STATE TRANSITIONS

The transition from one state to the other is indicated to the user in several ways. The relinquishing of control by the user is followed by carrier motion within the typewriter, locking of the typewriter keyboard to prevent conflict, and change to the red light--all of which provide positive feedback. The return of control to the user is accompanied not only by the unlocking of the keyboard and the switch to the green light, but also by a short, soft beep tone, emitted from a small loudspeaker in the console. This last audible alert is especially important, because JOSS frequently retains control for an extended period of time while performing long calculations, and then returns control to the user without further output.

Because this tone is sounded each time the console state returns to green, its characteristics must be very carefully chosen so that continued repetition does not grate on the user's nerves. The JOHNNIAC console used a mechanical doorbell chime; but the unreliability of this device, coupled with its hesitant, electromechanical response, ruled out its use for the new stations. After a number of experiments, we selected an audio tone of approximately 900-1000 hz, with a duration of 80 ms; the volume level is adjusted to be comfortable in an office environment in which the loudest noise source is that of the typewriter console itself. This soft tone has proven to be acceptable to most users over a long period of use. The feedback it provides is almost subliminal, and its short duration reinforces the feeling of rapid intimate interaction with JOSS supplied by the responsive system software and high-speed central processor.

CONTROL OF STATE TRANSITIONS

By the devices described above, the JOSS user is continually informed as to the state, red or green, of the typewriter console. In addition, the user and JOSS can, to a limited degree, exercise direct control over this state; that is, the user can always change the state from green to red, or turn control of the typewriter over to JOSS, by means of a carrier return or page. Similarly, JOSS can return control by changing the state with a switch to green signal to the console.

What is needed to complete the picture is a means whereby the user can request JOSS to relinquish control, that is, change from red to green as soon as possible (for example, to interrupt an erroneous procedure or to terminate a never-ending calculation). This capability is provided by the interrupt button, located next to the green and red light pair on the console control box. To allow JOSS to acknowledge such a request (that is, to indicate that control will be returned in an orderly fashion), the yellow interrupt button is back-illuminated, indicating by this means that the red light is about to turn to green. JOSS then extinguishes the yellow interrupt light when the change is actually made.

Finally, to enable JOSS to request the user to return control to red, when convenient, the beep tone is used. (The user cannot be expected to be constantly watching the control box, even though a flashing yellow light could be used to attract his attention.) The same audio frequency is used as with switch to green; here, however, the user is alerted by a much louder tone, whose duration is one-half second. By convention, repeated soundings of the beep, at one-second intervals, indicate to the JOSS user that there is an administrative message waiting for him. This message is printed out as a part of the page heading, and the user should hit page as soon as possible to receive it. Primarily for reasons of symmetry and generality, the console has also been designed to be responsive to a switch to red signal, by means of which the system preempts control of the typewriter. This would permit, for example, character-by-character interaction with the software; however, this device is not used in JOSS.

To summarize, the signals required by the considerations discussed above, and that must be provided by the console logic, are as follows:

From the console:

- Switch to red (carried implicitly in carrier return and page)
- Interrupt

To the console:

- Switch to green (accompanied by a short, soft beep)
- Interrupt light on
- Interrupt light off
- Beep (loud and long)
- Switch to red

OTHER CONSOLE SIGNALS

In addition to the signals used directly in conjunction with control of the red and green states described above, only a few additional signals are required to provide complete control of the console. Among these is the turn on signal which must be sent to alert the system that a user has applied power to the console and is requesting JOSS service, and the corresponding turn off signal to indicate the conclusion of a user session.

The turn on signal is normally sent automatically as soon as the console power-on sequence has been completed; the console power light on the control box is turned on at this time. In the case of transmission over dataphone circuits, the data set circuitry requires that console power be applied and a data terminal ready condition presented to the data set before the data circuits can be established. On the other hand, it is certainly necessary for the data circuits to be established before the turn on signal can be sent. To resolve this Alphonse-Gaston dilemma, therefore, the user turns on the console power on switch before the data call is placed, but the console power-on sequence is designed so that it cannot be completed until the data path has been established and a clear to send condition is presented by the data set; during the intervening period the power on light stays unlit, and the red light indicates that the console is indeed turned on. The clear to send condition also informs the console of temporary transmission outages. (See footnote, p. 80.)

It should be mentioned here that at the computer end of the telephone circuit the data sets are left in the automatic answer mode at all times. The automatic answering feature, however, will answer an incoming data call only if the data terminal ready indication is presented. The RAND PDP-6 has been modified so that this indication ("JOSS here") is generated directly by a machine instruction that must be executed at least once per second. Accordingly, the "JOSS here" instruction is used only by the JOSS software, and by this means a remote user is automatically prevented from being expensively connected to a "dead" machine; the initiate disconnect feature of the data sets automatically disconnects all users in the event of machine failure.

The JOSS system software responds to the turn on signal with a system on signal, which applies power to the console typewriter motor, conditions the console for on-line use, and lights the JOSS system light on the console control box. Placing these functions under computer control allows the user to turn on his console when the JOSS system is not in operation and avoid the annoyance of typewriter motor noise; when the system comes on the air, it can turn on the typewriter at each console waiting for service. Similarly, the system can turn off each typewriter when shutting down. Or, when desirable, the system can easily ignore one or more consoles selectively (this is useful when debugging system programs are being tested. See pp. 80-81).

When lit, the JOSS system light provides a positive indication to the user that he has been connected to a "live" central processor, a feature that is extremely reassuring under those conditions when processing delays of unknown length occur. In the case of dataphone transmission, the continued presence of the JOSS system light indicates an operating computer, as just described. By means of a fifth wire to each console within RAND, this same instantaneous indication could be offered to all users of the system. Instead of the fifth wire, however, we chose to use the software-generated "JOSS here" mechanism to transfer a single PBX telephone extension to an "off-hook" condition; to determine JOSS status a user may dial this number (days, or on a night line nights and weekends); a ringing signal indicates an operational JOSS and a busy signal indicates that the system is off the air.

As described on p. 13, the long typewriter operational functions, tab, carrier return, and page, take a variable time to complete. When one of these functions is sent to the typewriter, subsequent output must be held up until the motion of the carrier has been completed; a ready signal must then be generated and sent from the station to indicate that output may resume.

The same mechanism can also be used to permit the user to request that output be held up temporarily, and, as described in conjunction with the typewriter on/off switch modifications, a hold signal is transmitted for this purpose. Some care must be taken to allow the hold signal to be sent during (or exactly at the completion of) a long function; the transmission of the hold signal must override the signal generated by the completion of the long function, and the ready signal must not be transmitted until the user terminates the waiting period with the typewriter switch. The ready or hold condition is indicated continuously on the typewriter control box by a white typewriter light.

The only remaining signals generated by the console result from the possible coincidence of the interrupt signal with either the ready or hold signals, and are provided simply by arranging for an or of the two signals to be transmitted.

The signals described in this section are summarized as follows:

From the console:

- Turn on
- Turn off
- Ready
- Hold

- Interrupt + ready
- Interrupt + hold

To the console:

- System on
- System off

CONSOLE CONTROL BOX

All of the signaling and status mechanisms that have been described above must be presented to the user in a meaningful way, combining complete information presentation and maximum control, with a minimum of confusion and ambiguity. Figure 5, p. 32, shows a close-up of the console control box, and the functions of the individual components are summarized in Table 2.

All of the indicator lights on the console control box serve to inform the user about the various states of the console. While these lights may seem to be unnecessary, as the user is usually aware of the console states by other means (the keyboard locked or unlocked, the typewriter motor on or off, etc.), they do permit him to recognize hardware failures unambiguously, even though these may be infrequent. He can thus report these difficulties clearly and concisely to the system maintenance personnel; for example, "The keyboard doesn't lock when the console is in red" or "The system light is on, but the typewriter motor isn't running."

STATUS REPORTS

An extremely vital symmetry consideration completes the typewriter control logic requirements for an environment conducive to smooth interaction. Just as the user can at

Table 2

SUMMARY OF JOSS CONSOLE CONTROL BOX FUNCTIONS

STATUS AREA

Power On/Off:	(snap action switch, white) applies or removes power from the console electronic logic package.
Console Power:	(light, white) indicates that the console power-on sequence has been completed, and that a turn on signal has been sent from the console.
JOSS System:	(light, white) indicates that the JOSS system software has acknowledged a turn on signal with a system on signal to the console, and that the typewriter motor power has been applied.
Typewriter:	(light, white) indicates that the typewriter is in a condition to be used for input or output, i.e., ready. The motor is up to speed, the typewriter is not in the process of a long operational function, and the user has not initiated a hold condition with the typewriter off switch.

CONTROL AREA

Green:	(light) indicates that the console is in the green state; i.e., the user has control of the typewriter (for input), the keyboard is unlocked, and ribbon color is green.
Red:	(light) indicates that the console is in the red state; i.e., the JOSS system has control of the typewriter (for output), the keyboard is locked, and ribbon color is black.
Interrupt:	(button, yellow) signals (in the red state only) the JOSS system that the user is requesting control of the typewriter; i.e., a return to the green state from the red state.
Interrupt:	(light, back lights the interrupt button) indicates that the JOSS system software has acknowledged receipt of an interrupt signal with an interrupt light on signal to the console.

any time visually inspect the red and green light pair to determine the state of the console, so also must the JOSS software be given an analogous inspection ability. At first thought, this seems to be superfluous, because the software can, in theory, easily keep track of the console state as inferred from the state-changing signals that it transmits and receives. In practice, however, this is true only if one assumes that no hardware or transmission errors can occur. Such errors, if not compensated for, can easily lead to what is termed a "stare-down" condition. For instance, the console might actually be in the _red_ state, while the system, having missed a signal somewhere along the line, is assuming it to be in _green_. Thus each would be "staring down the line" waiting for the other to transmit. The user, in this case, might send an _interrupt_ signal to try to correct the situation, but such a signal is meaningless when coming from a _green_ station. If the system cannot observe that the console is in fact _red_, the signal must be ignored, and stare-down continues.

To guard against the stare-down condition, the console has been designed to allow the system software to inspect the critical states of each console by means of a _status request_ indicator, which may accompany _any_ signal (or typewriter character or operational function) sent to the console. The console electronics replies at an appropriate time (i.e., after all states are settled) with a _status report_ that the system software can inspect. By this means, JOSS and the user can always be kept in step, even in the presence of an otherwise prohibitive transmission error rate. The states that are reported are as follows:

- System light on/off
- Interrupt light on/off
- Ready/hold
- Red/green
- Incoming parity error detected at console

To allow the system to interrogate the status of the console without otherwise affecting the state, a final signal is required:

To the console:

- No op

TYPEWRITER INPUT AND OUTPUT

The final task of the console logic package, in addition to transmitting and receiving the various signals and status request and reports, is to convert the typewriter outputs, which are essentially parallel, and transform them into the same signaling pattern. Conversely, incoming signals are converted as required to control output typing. These conversions require more logic in the console than one might estimate, since the I/O writer selected is, in essence, strictly a mechanical device. Thus the speed of typing can vary from unit to unit, and some means must be taken to synchronize these speeds with the necessarily constant signaling rate to and from the console from the computer's multiplexor channels.

V. THE TRANSMITTED INFORMATION

All of the information to and from the console must, of course, be transmitted over a full-duplex[†] channel; that is, a channel in which communication is permitted in both directions simultaneously. Even in the absence of all other considerations, the user must be able to transmit an _interrupt_ signal while the console is receiving a steady stream of output information. However, given the fact that full-duplex communication links the console to the central computer, this channel can be used to great advantage in achieving rapid interaction.

INFORMATION TYPES

The information that must be encoded into an appropriate signaling code for transmission to and from the JOSS console over the full-duplex channel is of four distinct types. These are:

1. _Characters_. There are 44 character keys on the typewriter, each with an upper-case and a lower-case interpretation, for a total of 88 characters. The information is

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[†]The term "full-duplex" is often applied to a mode of operation in which the activation of the Teletype keys at the transmitting end of a communication link does not directly cause printing at that end; the receiving end must "echo" the received characters to cause printing. If signaling requires any appreciable fraction at a character time, typing becomes extremely difficult, because the auditory feedback is out of phase with the typist's inputs; the difficulty is analogous to talking over a long-distance telephone circuit with excessive echo. However, in this memorandum, "full-duplex" is used in its communication channel sense.

symmetric; that is, it is transmitted in both directions with identical interpretations.

2. Functions. There are 7 typewriter operational functions (space, backspace, etc.). Again, this information is symmetric.

3. Signals. There are 8 signals that must be transmitted to the console, and 7 signals that are transmitted by the console. The interpretation of a signal is thus dependent on the direction of transmission.

4. Status. To the console, only a single indication is necessary: send status. From the console, however, information as to the status of five different indicators must be reported, and at least one bit is required for each (if we assume errors can occur, there are no "prohibited" states).

All of the required information can be conveyed conveniently in an 8-bit encoding, allowing one bit for an odd parity check bit, one bit for a status bit, and 6 bits to convey the essentially symmetric characters, operational functions, and signals.

THE PARITY BIT

An odd parity check is carried as part of each character to or from the console. When an incoming parity error is detected at the console, the character must be ignored, and no action can be taken by the console other than to report the occurrence of the error by transmitting a status report to the system. The system software can thereupon initiate the proper recovery procedures. More elaborate procedures can be taken immediately, as necessary, when the system detects a parity error in a character received from the console.

THE STATUS BIT

A single status bit is carried as part of each character transmitted by the console. A zero bit signifies that the remaining 6 bits are to be interpreted as a character, operational function, or signal; a one bit, conversely, indicates that the remaining 6 bits are to be interpreted as reflecting the state of 6 separate console indicators (one bit is unassigned).

On information transmitted to the console, the status bit may be attached to any character, operational function, or signal, without changing the interpretation of the remaining 6 bits; a zero status bit has no effect at the console; a one status bit signifies "send a status report" (after any state changes that may result have taken place).

INFORMATION ENCODING

Table 3 presents the complete encoding of the JOSS character set, typewriter operational functions, and console signals into a 6-bit (two-octal digit) code. The details of the encoding for each group are discussed below.

The status information is encoded for the console status report by assigning one bit to each of the state pairs: incoming parity error indicator on/off; green/red; ready/hold; interrupt light on/off; and JOSS system light on/off.

Character Encoding

Character information to or from the typewriter itself is encoded in that unit's 6-bit "tilt/rotate" code, which

Table 3

JOSS CONSOLE CHARACTER, FUNCTION, AND SIGNAL ENCODING

	High-order Octal Digit	Low-order Octal Digit: 0	1	2	3	4	5	6	7
Characters (see note)	0	P p	E e	≠ =	≤ 5	: ;	D d	R r	< 7
	1	Q q	K k	I i	≥ 6	[,	C c	A a	> 8
	2	J j	T t	| ·	Z z	G g	X x	M m	' 1
	3	* +	N n	] .	" 2	F f	U u	V v	# 3
	4	Y y	H h	S s	) 0	? /	L l	O o	$ 4
	5	_ -	B b	W w	(9				
Functions	6	SHIFT DOWN	BACK SPACE	TAB	SPACE	CARR. RETN.	PAGE	SHIFT UP	ILLEGAL
Signals to Console	7	SYSTEM ON	SYSTEM OFF	INT. ON	INT. OFF	SWITCH to GREEN	SWITCH to RED	SOUND BEEP	NO OP
Signals from Console	7	TURN ON	TURN OFF	INT.		READY	HOLD	INT. + READY	INT. + HOLD

Note: Both upper-case and lower-case assignments for the characters are shown. Codes 54-57 are not generated by the typewriter; if received, the typewriter will interpret them as codes 20-23.

uses 2 bits corresponding to "tilt one" (T1) and "tilt two" (T2) to indicate one of four tilt positions for the Selectric typing element; and 4 bits corresponding to "rotate one" (R1), "rotate two" (R2), "rotate two (more)" (R2A), and "don't rotate minus five" (R5), to indicate one of eleven rotate positions (center plus five on each side of the center position). The resulting four times eleven, or 44, combinations provide the required character encoding. The 20 remaining (redundant and unused) combinations of this code are distributed throughout the possible 64, however, where they are difficult to use productively. Therefore, the encoding is transformed into the dense set 00_8 through 54_8 by negating the bits corresponding to R1 and R2A (to get $\overline{R1}$ and $\overline{R2A}$) and ordering the bits as follows: $\overline{R2A}$, R2, $\overline{R1}$, R5, T1, T2. Thus, an initial octal digit of 0 through 5 indicates an encoded character.

Operational Function Encoding

Seven operational functions are transmitted to and from the console; these are conveniently encoded into the equivalents of 60_8 through 67_8; the lead octal digit 6 thus indicates an encoded operational function.

The proper assignment of the remaining 3 bits is vital, however, since, unlike character keys, there is no interlock mechanism to prevent simultaneous (accidental or deliberate) operation of these keys (with the exception of shift up and shift down, which are opposite motions of a single key). Because two of these operational function keys, carrier return and page, also cause a state change, from green to red, precautions must be taken to avoid any adverse effects due to simultaneous operations.

By properly choosing the encoding, the simple _or_ of the individual encodings can provide a reasonable priority assignment.

However, one precaution is taken: Special circuitry is provided in the console so that depression of the _carrier return_ key overrides _all_ other functions occurring simultaneously, forcing both a _red_ condition and the sending of the _carrier return_ code. With this in mind, the following properties of the chosen encoding (see Table 3) may be noticed: No two functions can _or_ together to result in either _carrier return_ or _page_ (the state-changing functions). _Space_, _backspace_, and _tab_, in combination, result in _space_; this avoids backspacing over a preceding character in the line on input, and excessive carrier motion on output of the line. The _backspace_ key is next to the _page_ key on the typewriter, and since these can easily be hit in combination, they are given codes that result in the _page_ overriding the _backspace_; _page_ also overrides both shifts. _Page_ and _tab_ or _backspace_ result in an illegal character combination (67_8); these are relatively difficult to hit simultaneously, however, except by using two hands. In any event, the system software can detect the resulting changed (to _red_) state by requesting a status report on receipt of such an illegal character.

A Checking Mechanism for Characters and Functions

The inclusion of the illegal function code allows us to incorporate a combination hardware/software mechanism in JOSS for checking input and output to and from the console and typewriter. The encoding for _shift up_ and _space_ was chosen to make it relatively easy to _forcibly_ transmit an illegal character without state change. Any such illegal character (or any code received with incorrect parity) when encountered by the JOSS software as part of an input line, causes the line to be "echoed" to the user, with a "#" sign in place of each offending character.

Many types of character errors can occur, however, which result neither in a parity error (which is a check only on the transmission circuitry) nor in an illegal character. By providing a means for forcing an illegal character, with its consequent echo check, a user may thus quickly test for this type of error by typing a series of characters, followed by the space-shift combination, followed by carrier return, and by comparing the input (green) with the output (black) that is typed directly beneath.†

Signal Encoding

The eight signals to the console, and the seven signals generated by the console, are encoded into the codes 70_8 through 77_8. A lead octal digit of 7 therefore indicates an encoded signal; the exact interpretation depends on the direction of transmission. Some care has been taken in the selection of the bit correspondences for the signals generated at

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†Example:

```
User:  Type 2+2.
JOSS:  Eh?
User:  Type 2+2. [space/shift]
JOSS:  Typ3 2+2.##
       Sorry.  Say again:
User:  eeeeeeeeeeee  [space/shift]
JOSS:  33e3ee33e3e3##
       Sorry.  Say again:
```

The console and/or the system is getting e's and 3's mixed up on input (without the trouble being detected by parity checks). This difficulty should be reported to the system maintainers.

the console. Thus, the code for _interrupt + ready_ is the _or_ of the code for _interrupt_ with the code for _ready_. Similarly, _interrupt + hold_ is the _or_ of _interrupt_ with _hold_. In neither case is a signal lost. Finally, _ready_, when _or_'d with _hold_, leads to _hold_; and a _hold_ signal (generated in response to the user's typewriter _off_ switch) cannot be lost.

Beyond these precautions, no particular encodings are more appropriate than others. For mnemonic value, however, corresponding signals to and from the console have matching encodings, as can be seen in Table 3.

SIGNALING CODE

The signaling code adopted for the JOSS console is a two-voltage-level, 8-bit, 11-unit, 165-baud, serial Teletype code. A serial signaling method was indicated for several reasons,[†] among these were the rather slow speed (in received or transmitted bits per second) of the typewriter; our desire to avoid bulky and expensive multiwire transmission cables; and the requirement that the console should be easily interfaced with off-the-shelf data sets for long-distance transmission. Parallel signaling, on the other hand, which is easily implemented if the typewriter is to be adjacent to the computer, requires either many parallel conductors or high-priced, complicated modem equipment, and interfaces only with the more expensive and less easily installed wide-band data transmission sets.

The adoption of the 8-bit Teletype serial code was essentially determined by the multiplexer equipment available

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[†]See pp. 7 and 38.

for the PDP-6. The multiplexor, the Digital Equipment Corporation Type 630 Data Communications System, is rather easily modified to operate at the higher speed of the JOSS typewriter. More important, the 8 information bits are enough to allow inclusion of a parity bit for checking transmission to and from the console.

The voltage pattern corresponding to a single transmitted character is shown in Fig. 7. The standard DEC signal levels of 0v or -3v are used; 0v is chosen for the idle (mark) state[†] to prevent continuous spacing signals on the lines when the console is not connected or turned on. Following the 1-unit start bit, the low-order bit of the 8 information bits is transmitted first; 2 stop bits complete the 11-unit code. Figure 7 therefore indicates the transmission of the 8 bits 272_8 rather than 135_8.

As may be seen by reference to Table 3, this is the signal <u>interrupt</u> if generated by the console, or <u>interrupt light on</u> if received by the console. Since the code is received by sampling at the middle of each of the 6.06-ms pulses, and is terminated by the first stop pulse, the entire transmission is completed in 57.57 ms, although a new character cannot begin for an additional 9.10 ms.

[†]In contrast to Teletype practice, where idle corresponds to current flow.

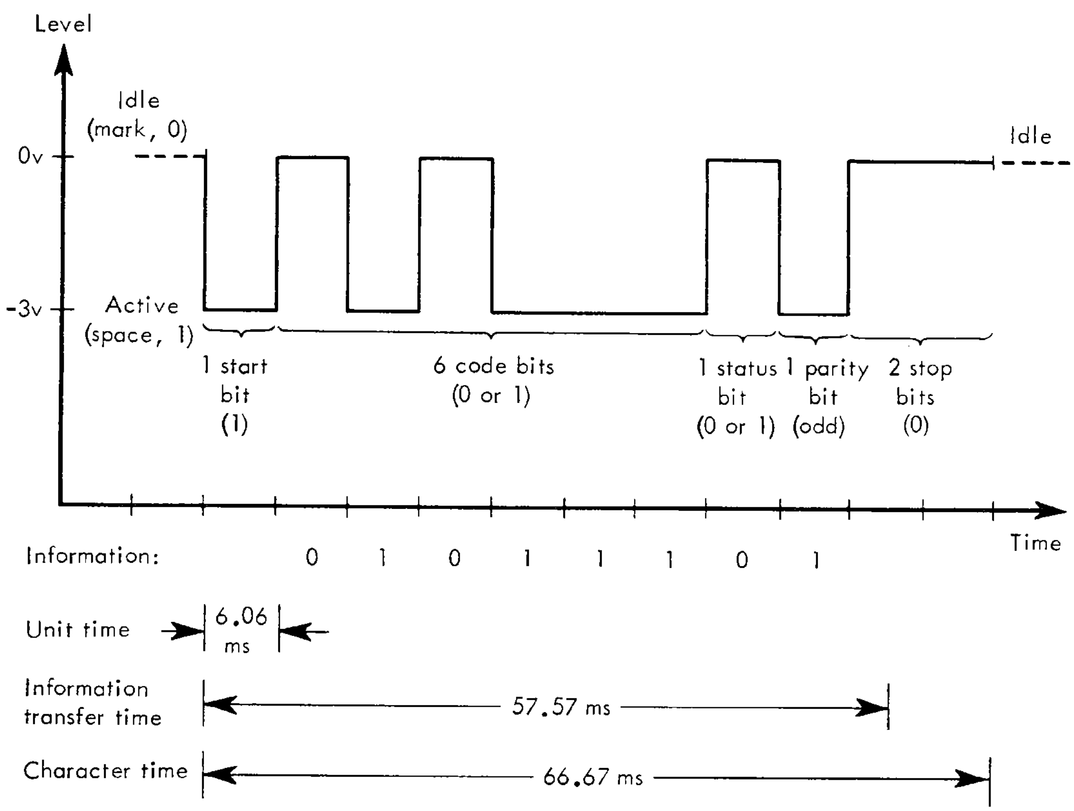


Fig. 7--The JOSS console serial signaling code

VI. CONSOLE LOGIC DESCRIPTION

The remainder of this memorandum is devoted to a description of the operation of the JOSS console electronics package. For the purpose of explanation, the logic has been divided into seven roughly independent sections; for each of these, a simplified logic diagram is presented and discussed in sufficient detail to clarify its operation. These sections are:

Input: Parity Checking, Status Bit, Signals
Input: Characters and Operational Functions
Output: Synchronization
Output: Characters
Output: Operational Functions
Output: Signals
Output: Status Reports

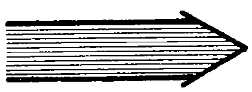
No particular significance should be attached to this order of presentation as all sections are interrelated to some degree.

SYMBOLS USED IN THE DIAGRAMS

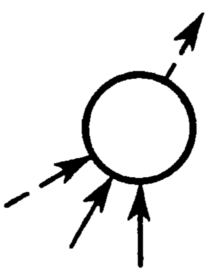
The following basic set of symbols has been adopted for the diagrams:

— — — → A path for a control pulse. All operations within the console are initiated and sequenced by such pulses; these are produced by the setting of a flip-flop to a new state, by switch or contact closures, by gates that operate on other pulses, by clocks, etc. They are used to set flip-flops, to sample flip-flop states, to begin operation of a shift register, etc.

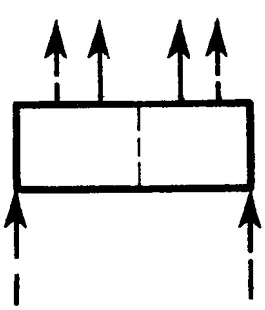
A path for control information. The states of the many flip-flops, switches, etc., are reflected by the output *levels* of these devices over such paths. These levels are used to gate control pulses; as inputs to logical operations such as *and*, *or*, and *not*; and to drive indicator lights and typewriter solenoids.



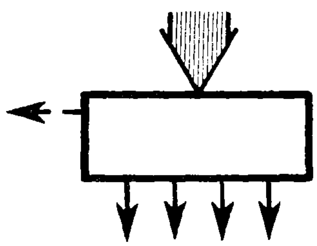
A parallel path for more than one bit of control information. Typical uses are to indicate parallel inputs or outputs to and from shift registers, buffer registers, encoders, and decoders.



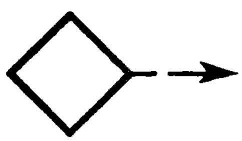
A logical operation. Inputs to these logical elements are control pulses and/or control information. If the inputs consist of information levels only, output is either continuously available, according to the indicated operation, or else a pulse occurs when the indicated condition is satisfied. If the input includes a control pulse, the output is a pulse occurring at the time of the input pulse, according to the indicated operation.



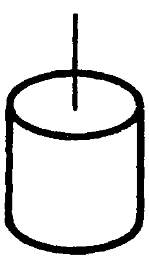
A bistable flip-flop. A flip-flop may be set to either of its two states by a control pulse directed to that half of the circuit. Output levels are continuously available corresponding to the state of the flip-flop at any instant; output pulses are generated only when the flip-flop first enters a new state. The two states of a flip-flop are contrasted by the descriptions: off/on, yes/no, 0/1, red/green, etc.



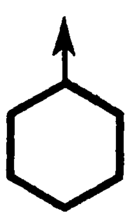
A complete, higher level logic operation. These include buffer and shift registers, encoders and decoders, etc., which usually have numerous components and a variety of inputs and outputs. The detailed operation of the registers is not presented, as it is not necessary to an understanding of the console operation.



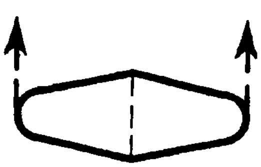
A connector indicating a control pulse path that originates from (or goes to) another logic section, with the figure number indicated.



A typewriter solenoid. All output to the typewriter is initiated by means of output levels to these magnets. Feedback cams provide the pulses to indicate the times at which magnet impulses should be discontinued.



A typewriter cam or contact. The output may be either a control pulse or an information level.



A console switch or button; also a data set condition. The outputs may be either a control pulse or an information level.

An indicator lamp on the console control box.

The console loudspeaker.

Many components appear in their entirety on more than one diagram (for example, the *outgoing shift register*) because their functions are common to, or shared by, several different console activities. Other components provide a variety of logical functions (for example, the *typewriter OK* flip-flop), and in these cases only the pertinent inputs and outputs will appear in any single diagram. Finally, still other components of the actual logic package have been eliminated from these simplified diagrams, although they are vital to the actual operation of the console; primarily, these components are concerned with timing delay circuits, which, for instance, control the power on and off sequences, account for operating speeds of both mechanical and electronic components, and avoid the various "race" conditions that inevitably occur.

INPUT: PARITY CHECKING, STATUS BIT, SIGNALS (Fig. 8a)

All communication from the central processor to the JOSS console appears, in the serial signaling code of Fig. 7, on the *incoming line*, which provides the input to the *incoming shift register*. This 11-bit register converts the serial input signal to provide a 7-bit parallel output. When an entire 11-bit character has been received, incoming parity is checked; if it is in error (even), the incoming parity error flip-flop is set. To report the error to the central processor, the incoming status bit flip-flop is set to 1, and no further action takes place in this section of the logic. If the parity is correct, however, the incoming status bit flip-flop is set to 1 only if the corresponding bit in the incoming shift register is a 1.

Note that the above parity error/status bit operations are performed on all incoming information--signals, characters, or operational functions. The incoming status bit flip-flop is continually examined by the output synchronizer circuitry (Fig. 8c, explained in detail below) to initiate a status report from the console. Both the incoming status bit flip-flop and the incoming parity error flip-flop are reset only when the transmit status pulse from the output synchronizer indicates that a status report has actually been transmitted by the console.

An and of the three high-order bits in the incoming shift register detects the presence of a signal (code $7X_8$). The no parity error pulse (the negation of the parity error pulse) is anded with this signal level, and is used to gate the three low-order bits from the incoming shift register into the 3-bit signal decoder to generate one of eight control pulses, with the results indicated in the figure. The system flip-flop, which is used to control the typewriter motor power, acts through a ½-sec delay circuit before setting the typewriter OK flip-flop to yes; this allows sufficient time for the motor to come up to speed, and for any characters accidentally stored in the keyboard (cf. p. 25) to be cleared. The state of the system flip-flop is indicated by the corresponding indicator light on the console control box, as are the

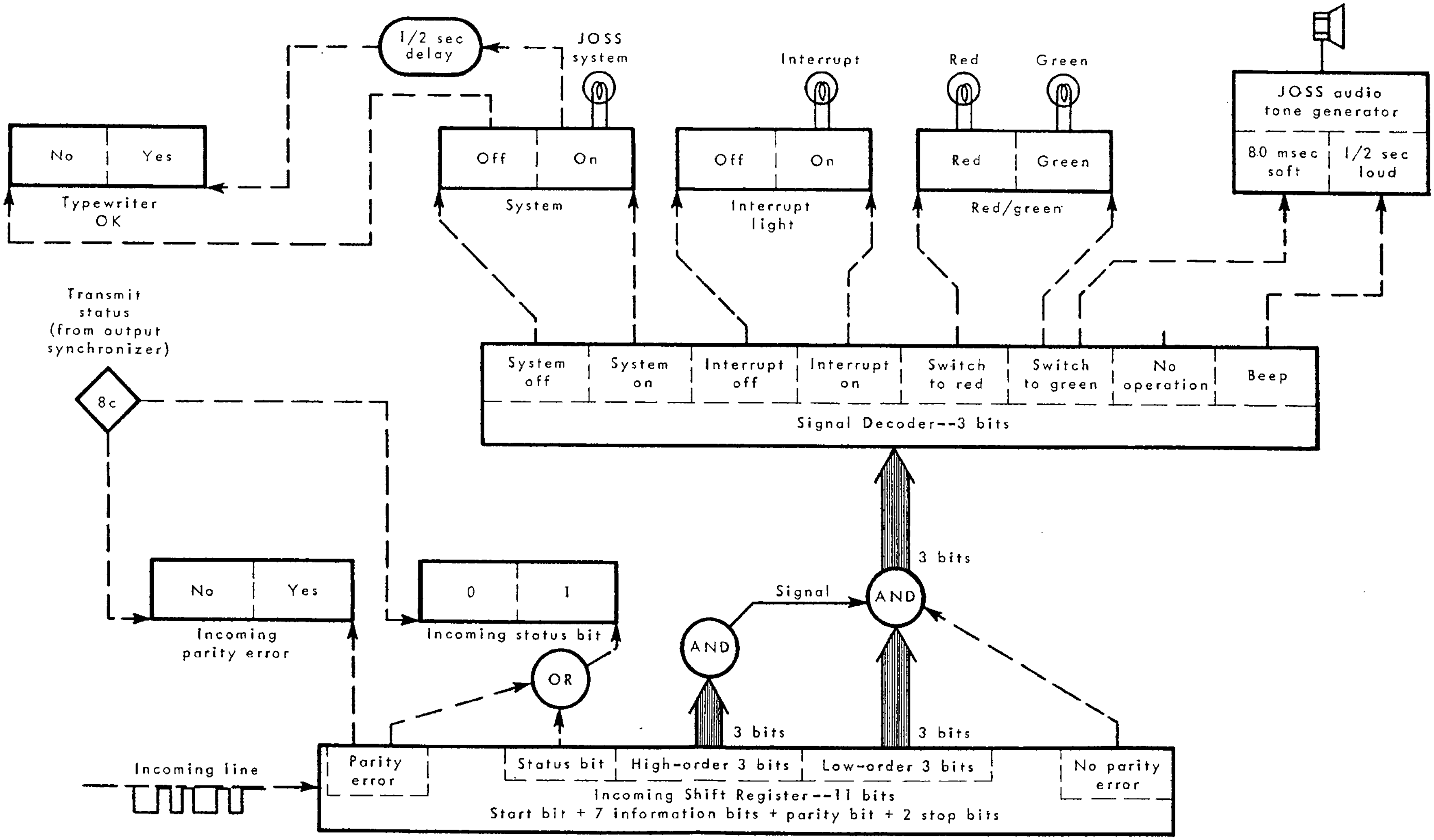


Fig. 8a--Input: parity checking, status bit, signals

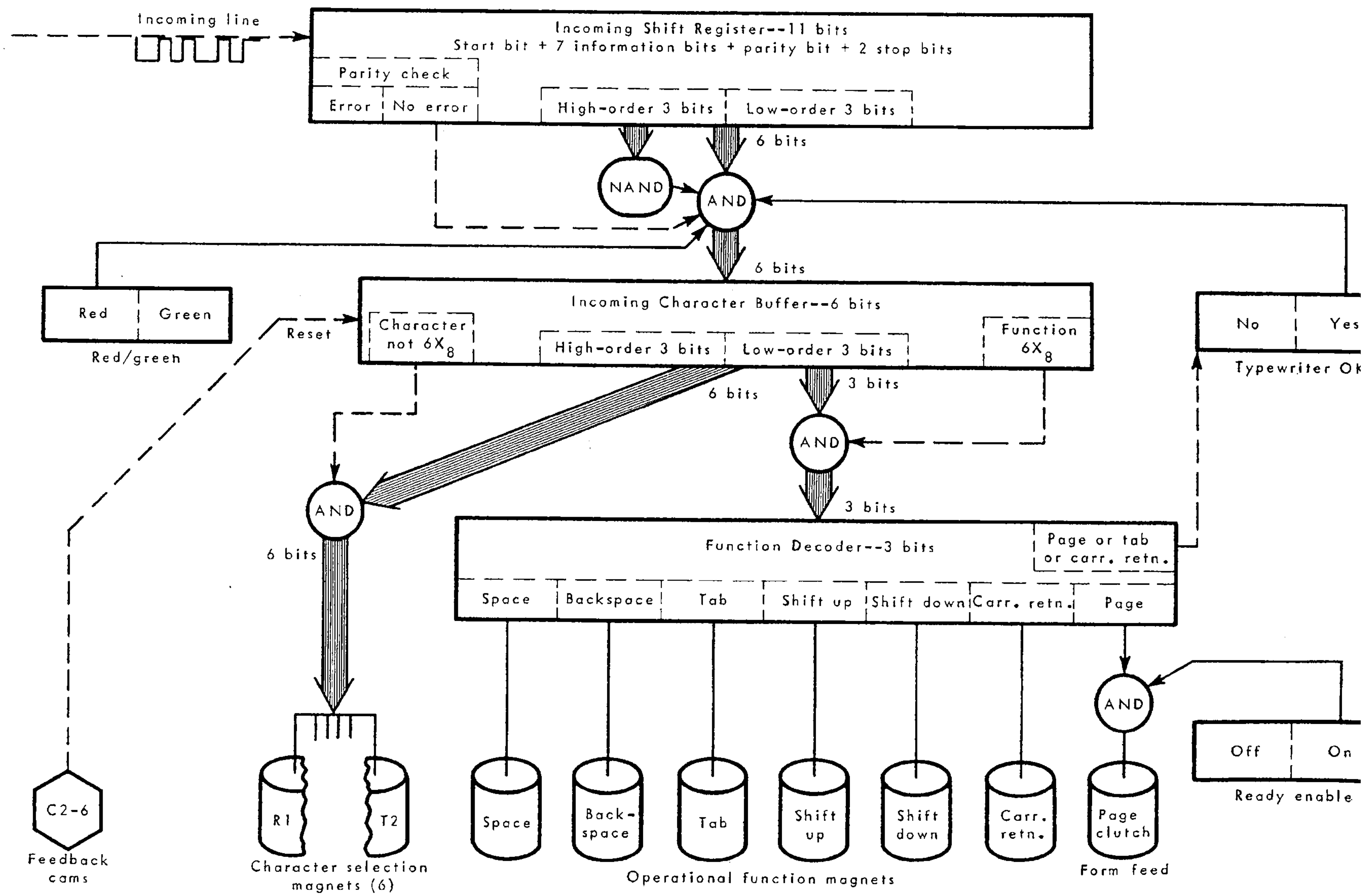


Fig. 8b--Input: characters and operational functions states of the interrupt light and the red/green flip-flops.

The switch to green signal and the beep signal both activate the JOSS audio tone generator; note the corresponding distinct durations and volumes produced.

INPUT: CHARACTERS AND OPERATIONAL FUNCTIONS (Fig. 8b)

Input information to the console for typewriter characters and operational functions is converted from serial to parallel in the incoming shift register just as for the signals described above. After the parity and status bit checks have been made, the six low-order bits of this register are transferred, in parallel, to the incoming character buffer under the following conditions:

- The parity is not in error; and
- The information is indeed a character or operational function, i.e., not a signal; and
- The typewriter OK flip-flop is set to yes; and
- The console is in the red state.

The typewriter OK flip-flop is reset to no whenever the typewriter is in such a condition that characters or operational functions should not be presented to it; that is, before the typewriter motor is fully up to speed, and when the carrier is performing any of the long functions: tab, carrier return, or page. The console red condition ensures that information erroneously transmitted to a green console will not interfere with the user's input typing.

The incoming information, once it has been loaded into the incoming character buffer, either drives the character selection magnets in the typewriter (codes 00_8-54_8),† or it drives the corresponding operational function magnet in the typewriter (codes 60_8-67_8) through a 3-bit function decoder. These solenoids are continually driven until the operation of the feedback cams (C2-6) in the typewriter indicates that the magnet pulses should be removed; at this point, the incoming character buffer is reset. (In actuality, the current that drives each magnet is effectively gated through the feedback contacts C2-6 to provide "closed-loop" operation of the typewriter. That is, the magnets are not driven immediately upon loading of the incoming character buffer; this does not occur until the feedback contacts have signaled that the previous character or operational function has been completed. See Ref. 5, p. 4.) In the case of the page function, the driving pulse is anded with the on state of the ready enable flip-flop (which is directly under user control via the typewriter on/off switch, Fig. 8f) to enable the user to "hold" the page drive in case of a paper jam.

For any long function, completion of the mechanical motion (which is normally some time after the magnet pulse that initiated the action has been removed) is indicated by the long function completed contacts (interlock) in the typewriter. The resulting pulse sets the typewriter OK flip-flop to yes, at which time the ready signal is transmitted; see the discussion of Fig. 8f below. The timing of the hardware/software interaction is discussed in detail in Ref. 6, pp. 47-51; see especially Figs. 8 and 9.

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†The necessary ordering and inversion of bits is provided, as discussed under "Character Encoding," p. 56.

It should be noted that during any long function, the incoming shift register is available to receive signals and status requests if transmitted; incoming characters and operational functions erroneously received during this period are ignored. In the case of the short functions or characters, however, there is nothing to prevent a succeeding character or operational function from being loaded into the incoming character buffer before the typewriter feedback cams (C2-6) have reset the register. The situation could have been prevented; however, experience with the typewriter indicates that this extremely rare condition is caused by a mechanical "hang up" in the mechanism, which is best cleared by presenting another character to the unit.

OUTPUT: SYNCHRONIZATION (Fig. 8c)

The JOSS console transmits three types of information: typewriter characters or operational functions, signals, and status reports. Since a single shift register is used to transmit these various outputs over a single line at a fixed rate, and since the initiation of the various types of information to be transmitted is essentially uncorrelated with this rate, some means must be provided to synchronize the console outputs. In addition, there may be competition among the types of information; for example, an incoming status bit might arrive at the same time the console was generating a ready signal. Therefore, the synchronizer must assign priorities to the different types of output and "stack" the information for orderly transmission of these through the single output shift register at the proper times. The output synchronizer thus ensures that the console is responsive at all times to the user's inputs; there are no lost characters because of unfortunate timing conflicts and repeated button pushing is eliminated.

Highest priority for output must be given to typewriter characters and operational functions, since these can be generated, by a fast series of key strokes, at essentially the same rate as the signaling process itself; the output character buffer (see Figs. 8d and 8e) must be emptied as soon as possible to allow another character to be deposited.

Secondary priority is given to the transmission of signals, with lowest priority assigned to status reports. This ensures, for example, that a ready signal will be received at the central processor before a status report containing an unexpected ready bit is encountered. Additionally, no information can be lost by holding up status reports: Multiple status requests can be satisfied with a single status report.

The three types of output are initiated as follows: by the setting of the output character buffer full flip-flop for typewriter characters or operational functions (Figs. 8d and 8e); by the setting of any one or more of the turn on, turn off, interrupt, ready, or hold signal flip-flops for signals (Fig. 8f); and by the setting of the incoming status bit flip-flop for status reports (Fig. 8a). Whenever no output activity is taking place, the outgoing shift register activity flip-flop is in the idle state. This state is used to gate a series of clock pulses (at 6.06-ms intervals) to sample the state of these output-initiating flip-flops, and thereby set (or reset) one or more priority and synchronizing flip-flops: character/function request, signal request, and status request. After a short (μs) delay to

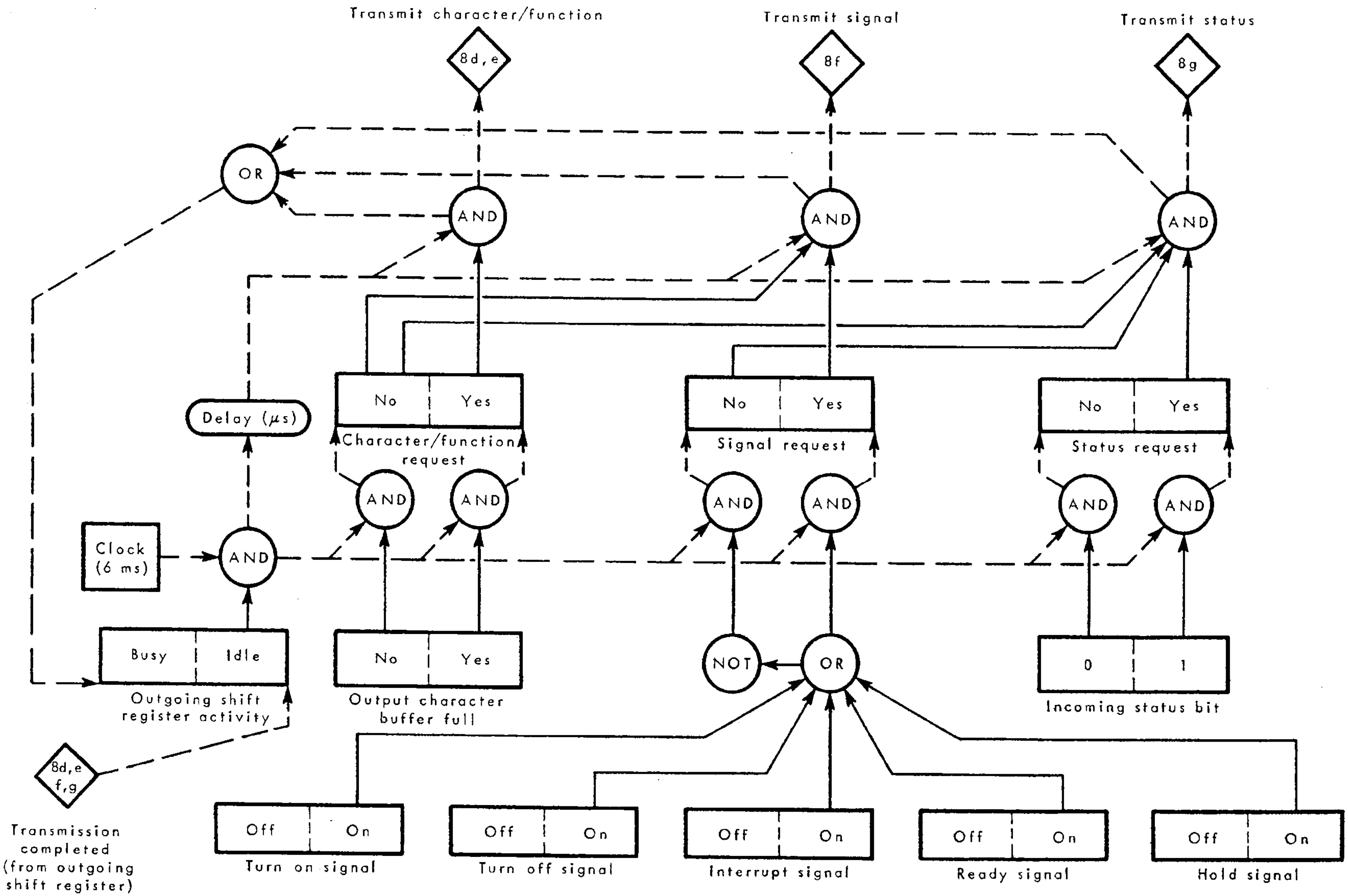

Fig. 8c--Output: synchronization

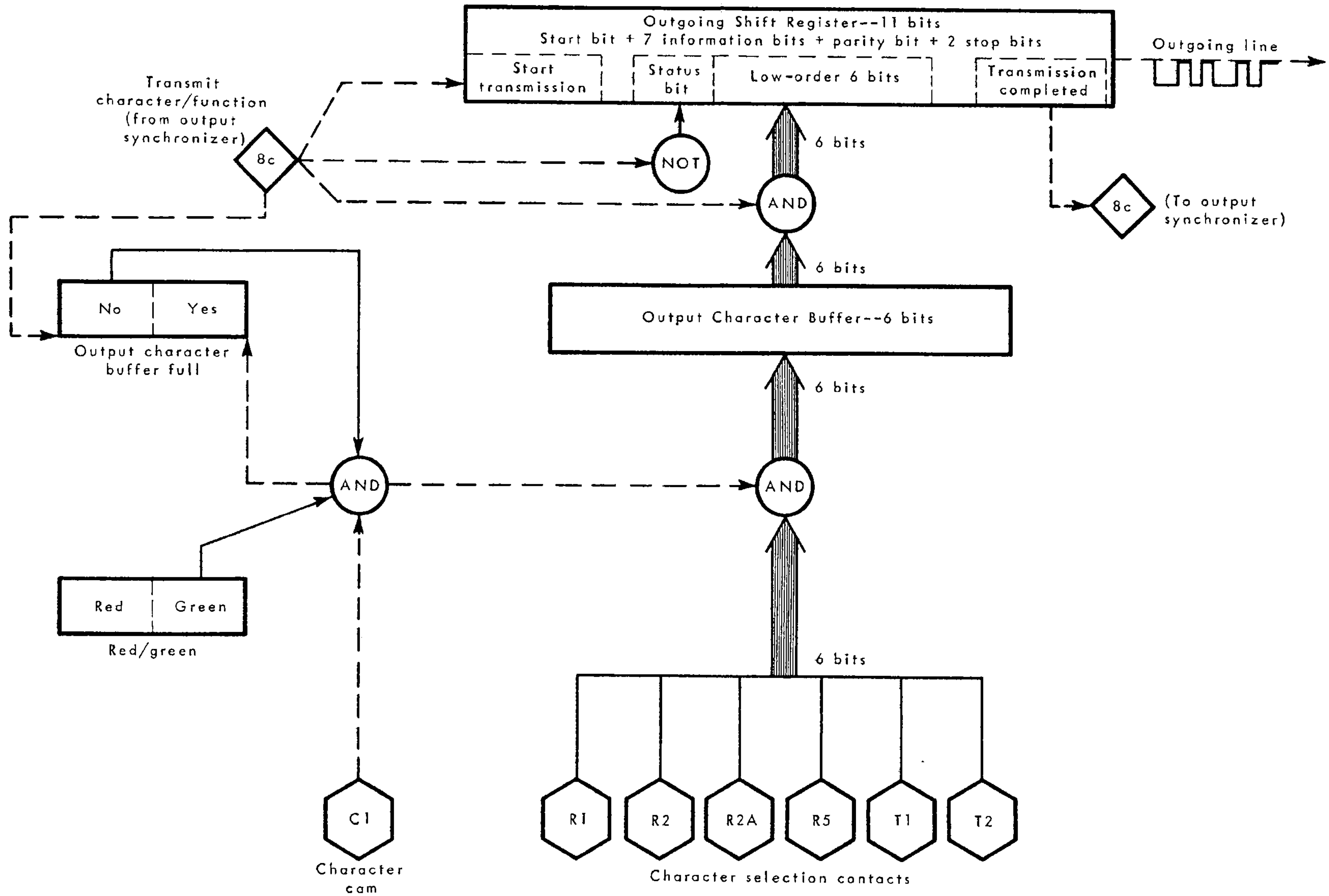

Fig. 8d--Output: characters

permit these flip-flops to settle in the proper states, their outputs are sampled, and, according to the desired priority, either the transmit character/function control pulse, the transmit signal control pulse, or the transmit status control pulse is sent to the corresponding output circuitry to begin the output process; at the same time, the outgoing shift register activity flip-flop is set to the busy state.

Notice that the transmit signal control pulse is generated only if there is no character/function request, and that the transmit status control pulse is generated only if there is neither a character/function request nor a signal request; this implements the required priority of transmission. Once any of these pulses has been generated, no further activity takes place in the output synchronizer until the transmission completed signal is returned from the outgoing shift register, which, by resetting the outgoing shift register activity flip-flop to the idle state, permits the output synchronization and priority control process to be repeated.

OUTPUT: CHARACTERS (Fig. 8d)

The output transmission for a typewriter character is initiated by the closure of the character cam (C1) in the typewriter. This pulse is anded with the green state (to guard against keyboard lock failures, or slow locking after the console enters the red state), and with the no state of the output character buffer full. The latter condition resolves possible timing conflicts from the typewriter, since the same register is used to buffer the typewriter operational functions. A first come, first served priority is therefore established for characters and operational functions. (The carrier return is "stacked," however, so that it cannot be lost. Compare pp. 57 and 79.)

If these conditions are met, the character to be transmitted is loaded into the output character buffer from the typewriter character selection contacts,[†] and, at the same time, the output character buffer full flip-flop is set to yes. This flip-flop is sampled by the output synchronizer, as discussed above. At an appropriate time, the transmit character/function pulse from this synchronizer (1) causes the status bit in the outgoing shift register to be set to zero, (2) causes the 6-bit encoded character from the output character buffer to be gated in parallel into the outgoing shift register, and (3) initiates the serial output of the character from this register over the outgoing line.

At the same time, the output character buffer full flip-flop is reset to no, so that the buffer may be loaded with a subsequent typewriter character or operational function. The transmission completed pulse generated by the outgoing shift register is returned to the output synchronizer to control further console output activity.

OUTPUT: OPERATIONAL FUNCTIONS (Fig. 8e)

The output transmission for typewriter operational functions is in most respects similar to that described for characters, in Fig. 8d, and most of the circuitry is common to both sections. Output is initiated by the closure of the function cams (C2-6) (or directly by the nonstandard

[†]The necessary ordering and inversion of bits is again provided.

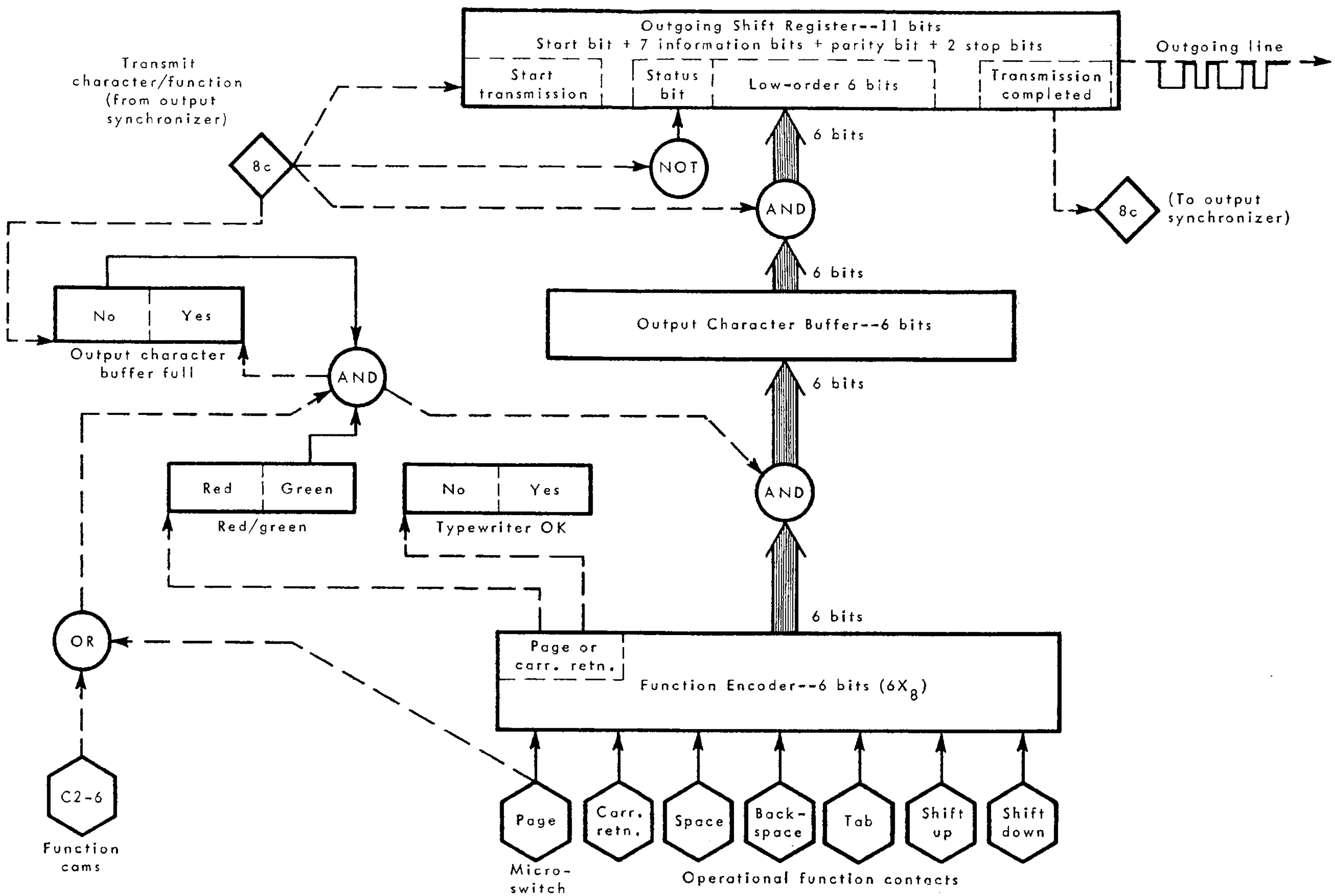

Fig. 8e--Output: operational functions

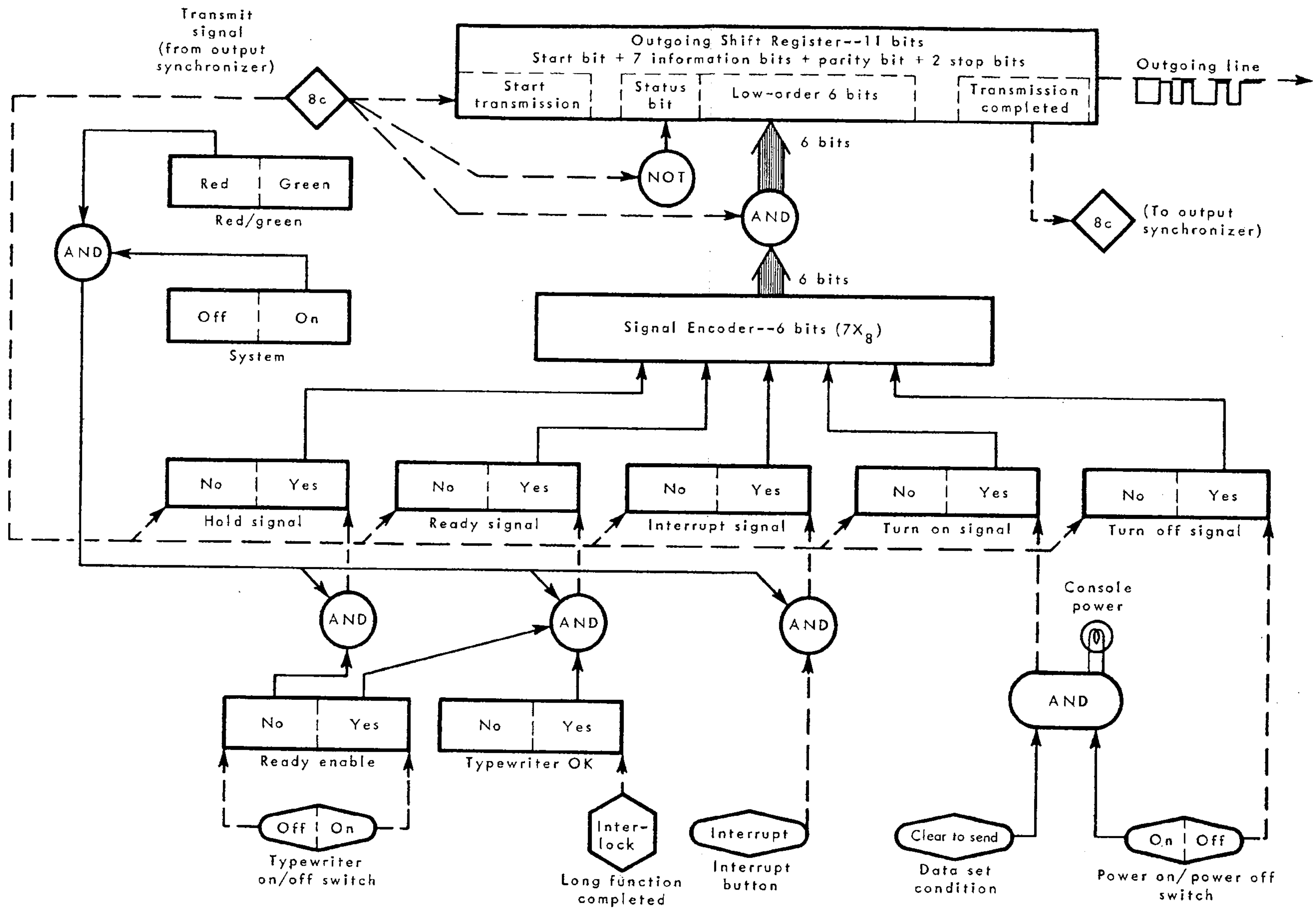

Fig. 8f--Output: signals

page key). The major differences from character output result from the fact that these function outputs from the typewriter are not encoded, but appear at individual typewriter operational function contacts; these are encoded to 6 bits by the function encoder to provide the desired encoding, as detailed previously (pp. 56-57).

The appearance of either a carrier return or page pulse causes the red/green flip-flop to be set to the red state, and the typewriter OK flip-flop to be set to no.† Because the transmission of typewriter characters and functions is on a first come, first served basis, any carrier return contact closure must be "stacked" until the output character buffer is free. The corresponding logic has been omitted from Fig. 8e.

The form-feed mechanism, which is activated by page, is not a standard function of the typewriter (see pp. 17, 19), and circuitry must be provided to activate it; this circuitry is not shown in Fig. 8e but is essentially the same as the page circuitry of Fig. 8b.

OUTPUT: SIGNALS (Fig. 8f)

Signals are transmitted from the console in much the same way as characters and operational functions. A signal can be initiated by any one of five flip-flops; an examination of the turn on signal flip-flop will serve to explain

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†The typewriter OK flip-flop is not set to the no state by a tab, since this would cause an annoying locking and unlocking of the keyboard, slowing input appreciably in many instances. No particular harm is caused if the user does type "on the fly," since the character will be transmitted correctly, but this situation seldom occurs.

the operation of the related circuitry. When the power on/ power off switch is turned on, and the data set condition clear to send indicates that signaling may begin,[†] the console power lamp is lit, and the turn on signal flip-flop is set to yes. The setting of this flip-flop, when detected by the output synchronizer, initiates the return of the transmit signal control pulse. In response, the output of the 6-bit signal encoder is gated into the outgoing shift register, the status bit in this register is set to zero, and output transmission is initiated. At the same time, the turn on signal flip-flop is reset, indicating that the signal has been transmitted. When output from the outgoing shift register is complete, the transmission completed indication is again sent to the output synchronizer. The turn off signal is sent in an exactly analogous way.

The remaining signals, interrupt, ready, and hold (and their combinations) are initiated only when the console is in the red state, and has been "enabled" by a system on signal from the central processor. Since the transmission of characters and operational functions from the typewriter is also subject to the same constraints, a console may be prevented from sending any information, except turn on and

[†]The indication presented from the data set is actually not clear to send, and therefore does not have an effect when no data set is being used. For data set operation this indication is also used to reset the entire console logic to its initial state, and thereby provides positive cessation of all console functions when a data transmission call is interrupted due to transmission line failure. In addition, when the connection is restored, a turn on signal is retransmitted, in response to which the JOSS software can reset the console to the proper state so that on-line operation may resume; at the worst, only one input line or one output line will be lost in case of line failure.

turn off signals, to any system software that wishes to ignore it. (This feature is often used to limit the number of consoles on-line at any one time, and guards against spurious signals from remote stations interfering with system software debugging.)

In addition to this limitation, a hold signal is sent only when initiated by the typewriter on/off switch off pulse, but not by a corresponding pulse from the typewriter OK flip-flop. The signal is unnecessary in the second case because the desired information is carried implicitly in the initiating long operational function or system off signal (which, since it removes power from the typewriter motor, sets the typewriter OK flip-flop to no, Fig. 8a).

On the other hand, a ready signal is initiated only when the and of both the ready enable yes state (set by the user via the typewriter on/off switch) and the typewriter OK yes state (set by either long function completed contacts in the typewriter, or by the end of the ½-sec delay following application of power to the typewriter motor via a system on signal) indicates that output to the typewriter may begin or resume.

OUTPUT: STATUS REPORTS (Fig. 8g)

Status report transmission is initiated by the examination of the incoming status bit (Fig. 8a) by the output synchronizer; the resulting transmit status control pulse sets the status bit of the outgoing shift register to one, and, along with this bit, gates the six status report bits into the same register for output transmission. No encoding is required, since one bit is used for each state to be reported on, as discussed on pp. 53 and 54. The ready state, which is the and of ready enable and typewriter OK yes states, is also used to drive the typewriter indicator lamp on the console control box.

HARDWARE IMPLEMENTATION

The symbology by means of which the foregoing description of the JOSS console logic has been presented is meant to be independent of the actual implementation in hardware (in this case by standard DEC Flip Chip modules). Our description has been, of course, influenced to some extent by this implementation; in particular, there is a great deal of correspondence between the names of signals, registers, etc., in these figures and those actually incorporated in the manufacturer's logic drawings for the console. These drawings have been reproduced (along with a summary of the logic) in App. C for the convenience of the reader. However, an exact, detailed description of the console logic (for reference or maintenance purposes) is only available in Ref. 7.

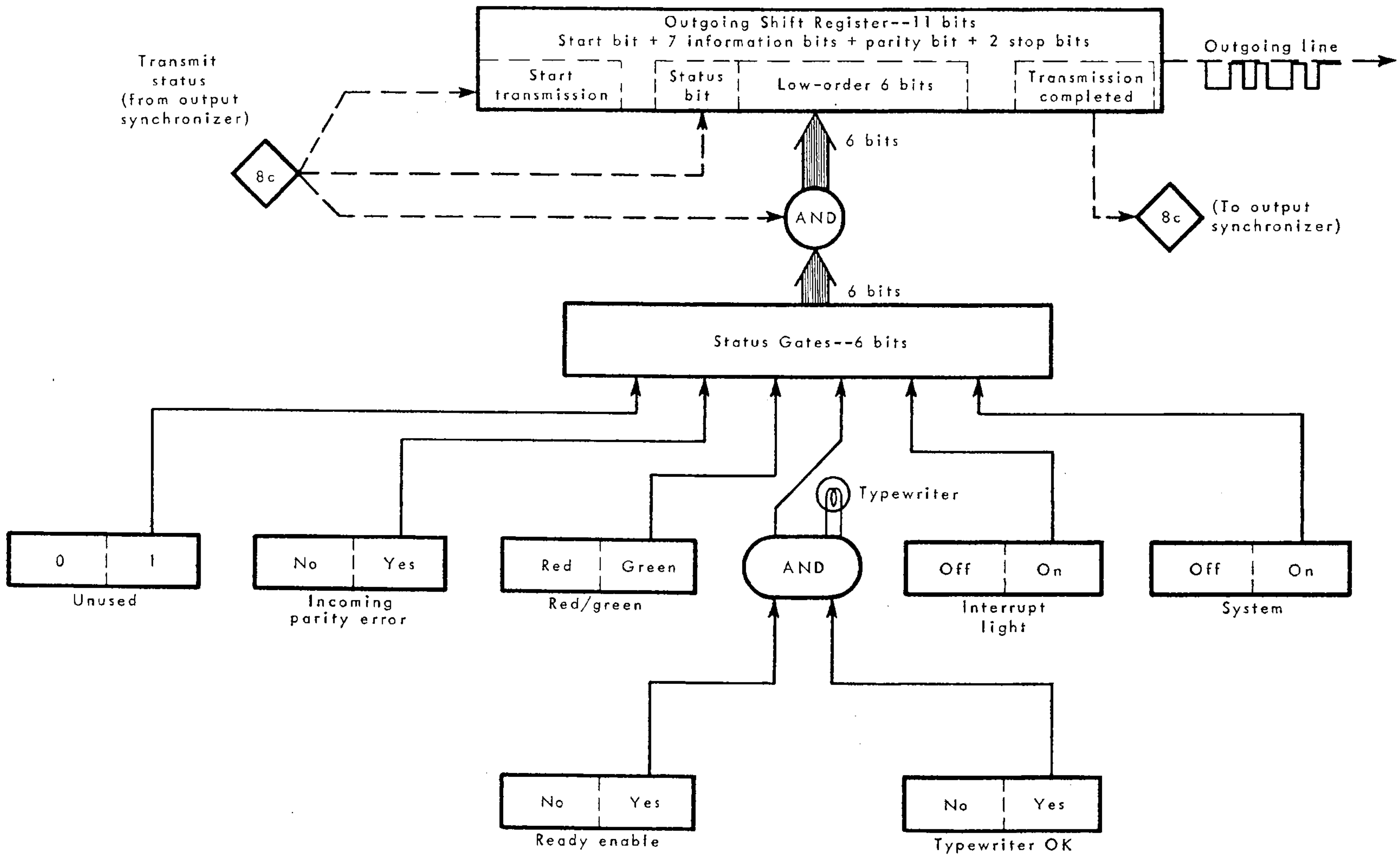

Fig. 8g--Output: status reports

Appendix A

TYPEWRITER SPECIFICATIONS AND MODIFICATION PROCEDURE

This appendix details the factory specifications (options) and subsequent modification procedures required for the JOSS typewriters.

TYPEWRITER SPECIFICATIONS

Model 731 Selectric Input-Output Writer
(compare with serial No. 4618000)

- 12-pitch, correspondence keyboard, dark blue keybuttons and knobs
- Light blue paint (special)
- JOSS type element (#1167934) with matching keybuttons
- Pin-feed platen, 9 3/8-in. pin centers
- Single-magnet color control
- Console mounting ring
- Energize-to-lock keyboard
- Mating female connector and pins
- Page keybutton in place of index keybutton
- Heavy-duty operational magnet assembly
- Chromium armature selection magnet assembly

TYPEWRITER MODIFICATION

Mechanical changes required in the Selectric typewriters are:

- Remove on/off switch keyboard-lock linkage.
- Replace on/off switch with DPDT momentary contact switch. File switch button as necessary to obtain required clearance.

- Add two <u>on/off</u> switch relays.
- Add page microswitch under <u>index</u> key, disconnect indexing mechanism.
- Add form-feed mechanism, including mounting plate for cable connector to magnetic clutch and microswitch cam follower.
- Install new left-hand platen knob.
- Change pressure plate springs, remove feed rollers, adjust tension as necessary.
- Replace straight shaft paper bail with curved shaft paper bail.

The corresponding electrical modification procedure is given below. The resulting changes in the 50-pin Amphenol connector wiring are:

Pin	New Function	Old Function
$\boxed{R}$	Forms clutch	Index magnet
$\boxed{V}$	Page switch	Black ribbon magnet
$\boxed{e}$	Ac off-line	Not at end-of-line
$\boxed{f}$	Ac on-line	At end-of-line
$\boxed{j}$	Hold	Ribbon green
$\boxed{k}$	Ac common	Keyboard unlocked
$\boxed{m}$	Ready	Keyboard locked

All other pin connections remain unchanged.

<u>Initial Disassembly and Inspection</u>

- Disassemble typewriter. Remove case, add temporary feet, and locate all relevant parts.
- Use Fig. 3a, p. 23 (typewriter modifications) with this procedure.

- All letters in brackets [a] refer to connection pins of the 50-pin Amphenol plug mounted on the typewriter.

Ac Motor

- Remove the 50-pin Amphenol plug via the two mounting screws. Care should be taken not to lose or destroy ground leads attached.
- Remove the ac line clamp.
- Cut ac input line off and pull wires out through the rear of the typewriter.
- Remove all wires, including those going to or coming from on/off key switch, and retain the two wires going to the typewriter motor. Cut the two wires going to the motor leads 5 in. from the crimp-connections so that they can extend to the relay contacts.
- Run one of the ac motor leads to both sides of the relay coils.
- Run the other ac motor lead to the c-1 contact of RLY-1.
- Remove wire from [k] to nc contact. Run wire from nc contact to c of S2. Run [k] to motor and both relay coils; use black awg 20 wire.
- Remove wire from [f] to no. contact and run [f] to c-1 contact of RLY-1; use red awg wire.
- Remove wire from [e] to nc contact.
- Run [e] to no.-1 of RLY-1, c-1 of RLY-2, and c-2 of S1; use white awg 20 wire.
- Run other end of RLY-1 coil to c-2 of RLY-1 and on of S1; use white awg 20 wire.
- Run no.-2 of RLY-1 to nc-1 of RLY-2; use white awg 20 wire.

- Run other end of RLY-2 coil to off of S1; use white awg 20 wire.

S1 Switch

- Remove no. contact end of [m].
- Run [m] to ready of S1.
- Remove no. contact end of [j].
- Run [j] to hold of S1.
- Trace [d] to center arm of carrier return interlock switch. Connect a white/blue awg 22 wire from the center arm to c-1 of S1.

S2 Switch

- Remove coil end of [V].
- Run [V] wire to no. of S2.

5-Pin Amphenol 126-223 Socket

- Wrap all wires in black tubing and make cable 10 in. long.
- Run pin A (black wire) to coil end of [P] and connect as follows: Remove [P] connection end at taper-pin block. Connect (via jumper) available taper-pin contacts (the 3 horizontal contacts located directly below [P] contact) to the point from which [P] was removed; insert [P] into the new position and add black awg 20 wire from pin A.
- Remove wire from [R] to coil connection.
- Run pin D (awg 22 red wire) to [R].
- Run pin E (awg 22 white wire) to one end of a 220-ohm, 10-w resistor mounted as follows: The resistor is

mounted on the clip that is supplied with the resistor from stock. Enlarge the clip mounting hole to fit a 6-32 screw; mount the clip with ¼-in. 6-32 screws in existing holes directly below the 50-pin Amphenol plug mounting holes.

- Trace pin [J] to its taper-pin block connection and do the following: Remove [J] connection end at taper-pin block. Connect (via jumper) available taper-pin contacts (the 3 vertical contacts located directly below [J] contact) to the point from which [J] was removed; insert [J] into the new position and add white awg 22 wire to other end of the 220-ohm, 10-w resistor.

Final Inspection and Reassembly

- Clean up, cable, and route all wires left dangling.
- Reinstall the 50-pin Amphenol plug and ground leads.
- Make sure all ac input wires are connected correctly. Use multimeter and make a thorough check.
- Reassemble all parts of the typewriter.

Appendix B

JOSS CONSOLE TYPEWRITER KNOB SETTINGS†

The levers and knobs associated with the JOSS typewriter platen and carrier all perform their normal functions in JOSS console service. However, because of the high speed with which the added form-feed mechanism operates, certain precautions should be taken to ensure smooth operation and clear, legible typing:

- Multiple-copy control lever (p. 2; at left back of typewriter): in the middle position.
- Line space lever (p. 3; at right back of typewriter): in the forward position, opposite "—", not opposite "=".
- Paper release lever (p. 3; at right back of typewriter): forward while inserting paper, back normally.
- Paper bail (p. 2; in front of platen): rollers against paper.
- Platen clutch release knob (not in Ref. 8; knob is inset in the left end of platen): pull out to disengage page drive; adjust the paper to desired position; push in to engage page drive.
- Impression selection lever (p. 10; at right of type ball): set at 3 (middle position).

The most foolproof method of adjusting the position of the page heading line to synchronize it with the paper fold is as follows:

- Depress page.

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†Page references are to Ref. 8.

- Wait until page heading is typed and the console returns green.
- Pull platen clutch release knob _out_.
- Turn platen knob(s) _up_ until the paper fold is just visible beyond the top of the paper bail.
- Push platen clutch release knob _in_.
- Depress _page_ to check that heading line prints just below the fold.
- Adjust up or down one line if necessary.

Most paper feeding troubles will disappear if these settings are made. To facilitate typewriter maintenance, however, the _page_ button, which is not a standard typewriter feature, is inoperable unless the console is on-line. To feed paper when the console is off-line, simply turn the platen knob(s) to feed as much paper as necessary. _Do not_ turn the platen knob to advance paper while the console is on-line. JOSS cannot sense that you are doing this and will fail to give you a new page at the proper time. Use _return_ or _page_ to advance the paper.

Appendix C

JOSS CONSOLE MANUFACTURER'S LOGIC DRAWINGS

This appendix documents the production implementation, in Digital Equipment Flip Chip Logic Modules,[†] of the console logic design as presented in Secs. IV, V, and VI of the present memorandum. Table C1 summarizes the implementation in terms of the numbers of circuits of various types (gates, decoders, flip-flops, etc.) employed in each console. Table C2 breaks down the summary information of Table C1 to give the Flip Chip modules used by manufacturer's type number and quantity of each used.

It should be noted, however, that no conscious attempt was made to minimize the number of logic components; for the limited production run of 30 consoles, the cost of the engineering manhours required for this minimization would far outweigh any savings in hardware cost. Additionally, major circuit elements such as shift and buffer registers have been built up from individual Flip Chip modules. Precisely because these modules are designed to be used as building blocks for experimental circuit design and limited-run production, a fair share of the components on each card is devoted to converting to and from standard DEC voltage levels, pulses, and speeds. Thus, many components would be eliminated in any redesign for a long production run, and the information in Tables C1 and C2 must be interpreted with the above factors in mind.

[†]See Ref. 9 for a comprehensive introduction to this line of logic modules.

Table C1

JOSS CONSOLE LOGIC SUMMARY

Function	Total Circuits	Total Q	Total Diodes	Total Reference Diodes
Gates and Gated Inverters	79	79	418	72
Binary to Octal Decoders	2	16	96	8
Flip-Flops	66	132	1554	140
Single Shots	12	54	196	56
Clocks	12	18	32	14
Pulse Amplifiers	20	40	270	32
Bus Drivers	1	3	7	5
Indicator and Solenoid Drivers	25	39	115	2
Trigger and Switch Filter	20	30	77	46
Level Converter	5	11	33	20
Oscillator and Amplifier	2	9	10	4
Total	244	431	2808	399

In Figs. C2a through C2i, we have reproduced (with permission) the actual Digital Equipment Corporation production logic drawings. A summary of the symbols appearing in these drawings is presented in Fig. C1.

It should be emphasized that Figs. C1 and C2 have been included in the present memorandum for reference purposes only, and that a complete detailed description of console operation is available only in Ref. 7.

Table C2

JOSS CONSOLE LOGIC FLIP CHIP IMPLEMENTATION

Module	Function (per Module)	Modules Used	Total ckts	Q per ckt	Total Q	Logic Diodes per ckt	Total Diodes	Reference Diodes per Module	Total Reference Diodes
R001	Diode (7)	1 2/7	(9)	--	--	1	9	--	--
R002	Diode Gate (5)	6	(30)	--	--	2	60	--	--
R107	Inverter (7)	6 4/7	46	1	46	4	184	4	28
R111	Gated Inverter (3)	11	33	1	33	5	165	4	44
R151	Binary to Octal Decoder (1)	2	2	8	16	48	96	4	8
R201	Flip-Flop (1)	7	7	2	14	35	245	4	28
R202	Flip-Flop (2)	20 1/2	41	2	82	23	943	4	84
R203	Flip-Flop (3)	4	12	2	24	16	192	4	16
R205	Flip-Flop (2)	3	6	2	12	29	174	4	12
R302	Single Shot (2)	5 1/2	11	4	44	16	176	8	48
R303	Integrating Single Shot (1)	1	1	10	10	20	20	8	8
R401	Variable Clock (1)	1	1	9	9	15	15	10	10
R405	Crystal Clock (1)	1	11	9	9	17	17	4	4

Table C2--continued

Module	Function (per Module)	Modules Used	Total ckts	Q per ckt	Total Q	Logic Diodes per ckt	Total Diodes	Reference Diodes per Module	Total Reference Diodes
R602	Pulse Amplifier (2)	1	1	2	2	23	23	4	4
R603	Pulse Amplifier (3)	6 1/3	19	2	38	13	247	4	28
R650	Bus Driver (2)	1/2	1	3	3	7	7	5	5
W040	Solenoid Driver (2)	9	18	2	32	6	108	--	--
W050	Indicator Driver (7)	1	7	1	7	1	7	2	2
W501	Trigger (1)	6	6	4	24	7	42	4	24
W504	Transient Det. (1)	1	1	6	6	9	9	4	4
W510	Level Converter (3)	1	3	1	3	9	27	4	4
W602	Level Converter (3)	2/3	2	4	8	3	6	16	16
W700	Switch Filter (6)	2 1/6	13	--	--	2	26	6	18
G981	Audio Oscillator (1)	1	1	2	2	--	--	--	--
G982	Audio Amplifier (1)	1	1	7	7	10	10	4	4
Total		105	244		431		2808		399

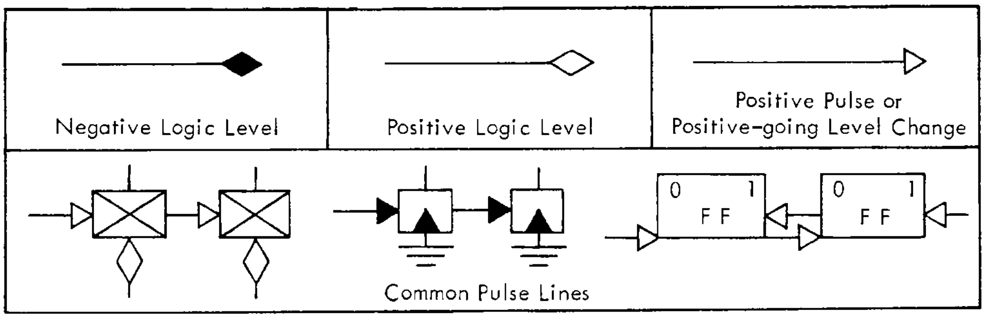


Fig. C1a--Symbols for DEC standard signals

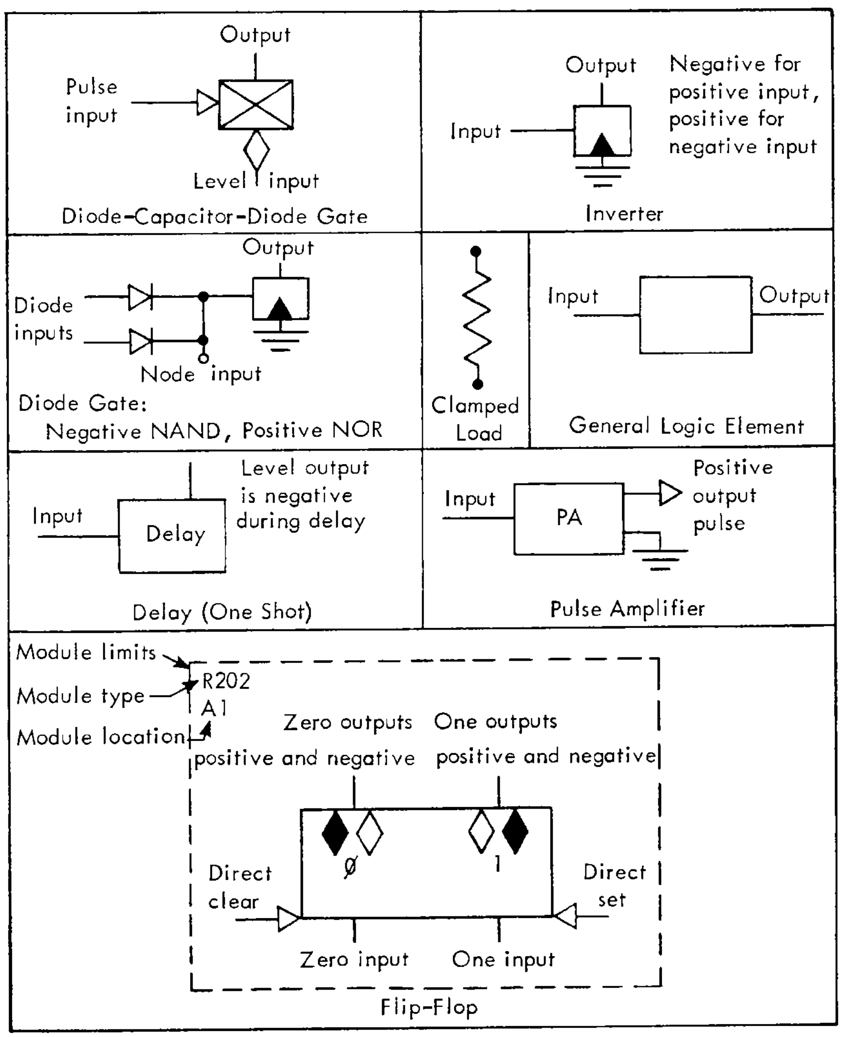


Fig. C1b--DEC device symbols

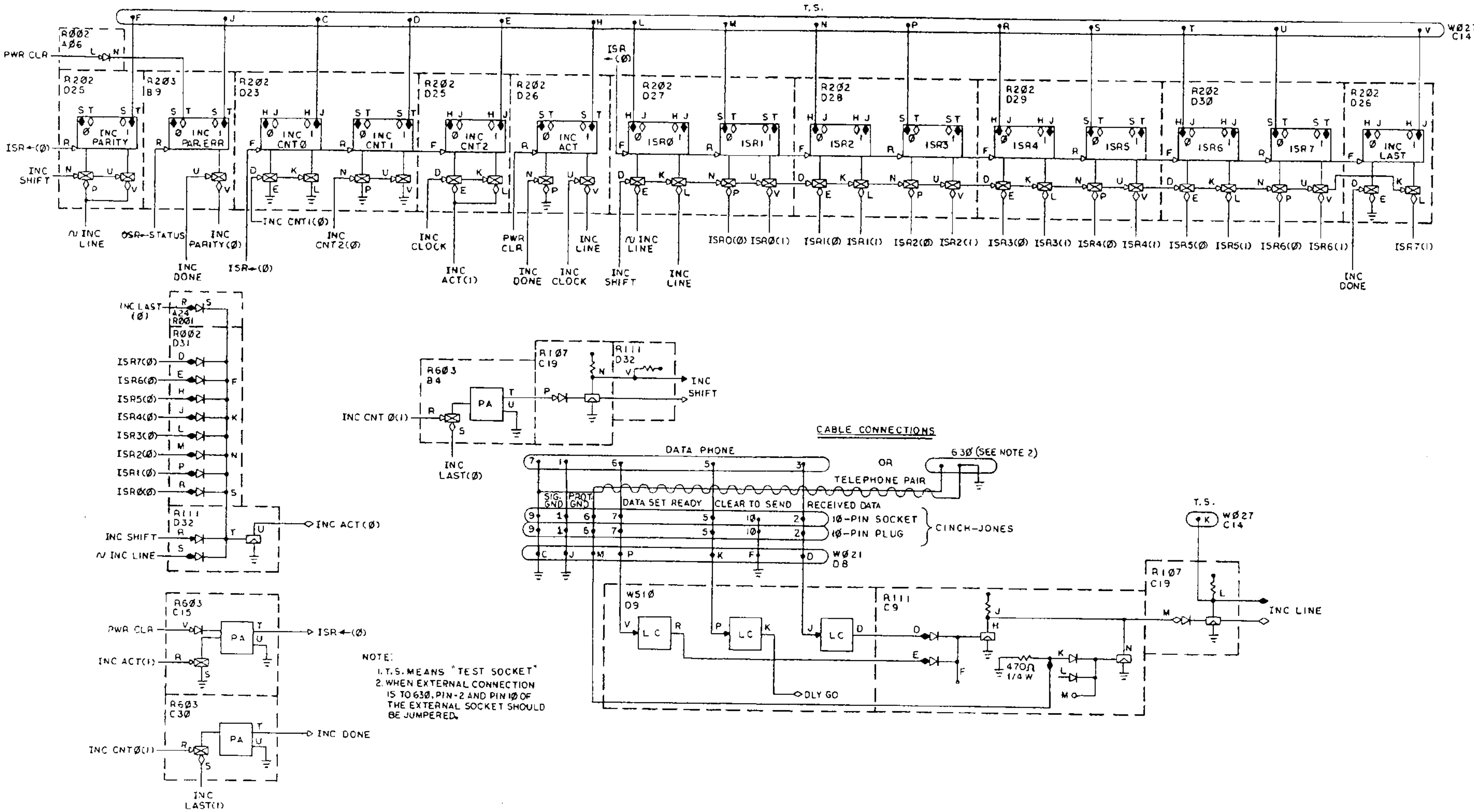


Fig. C2a--Incoming line unit

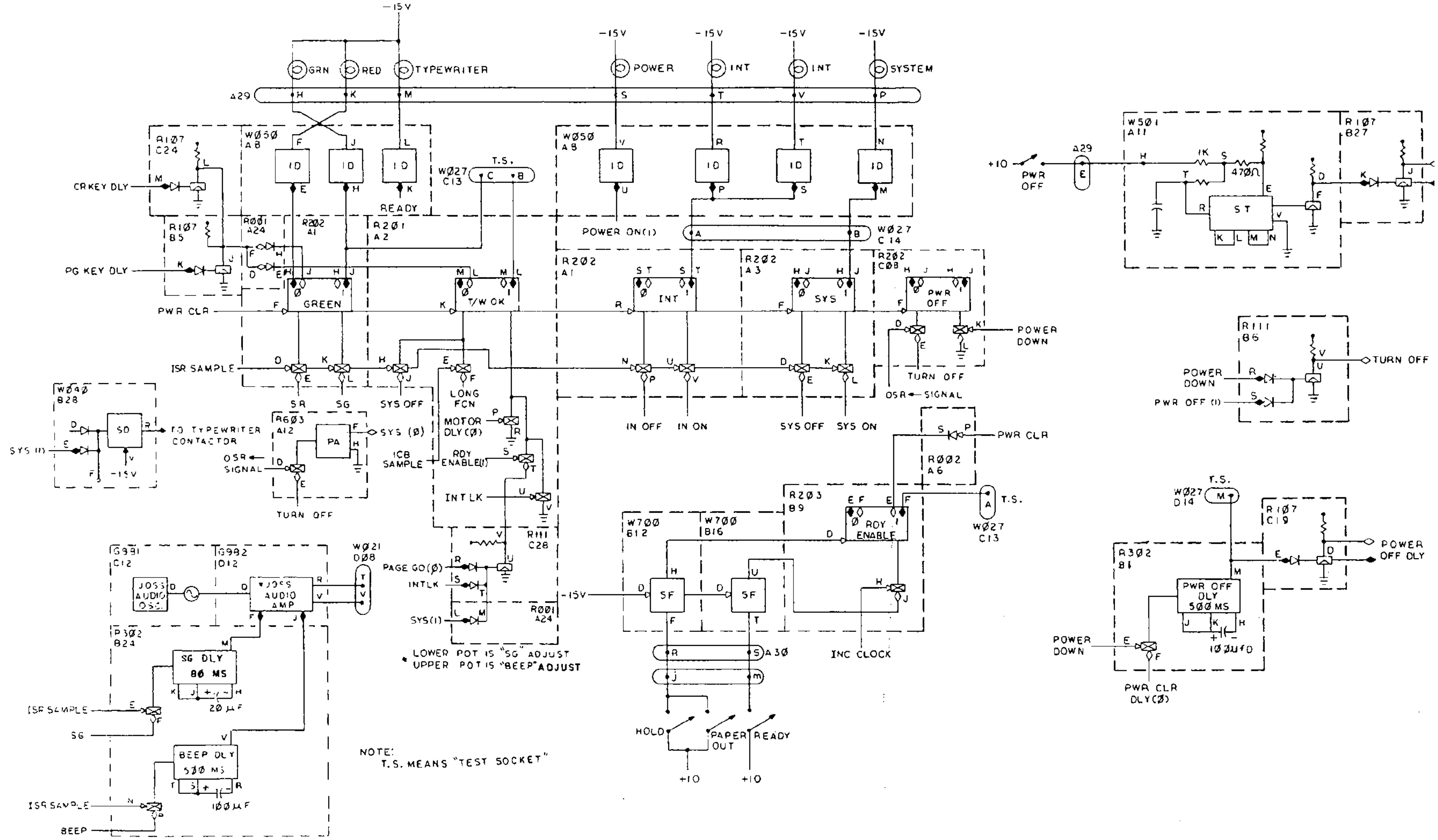
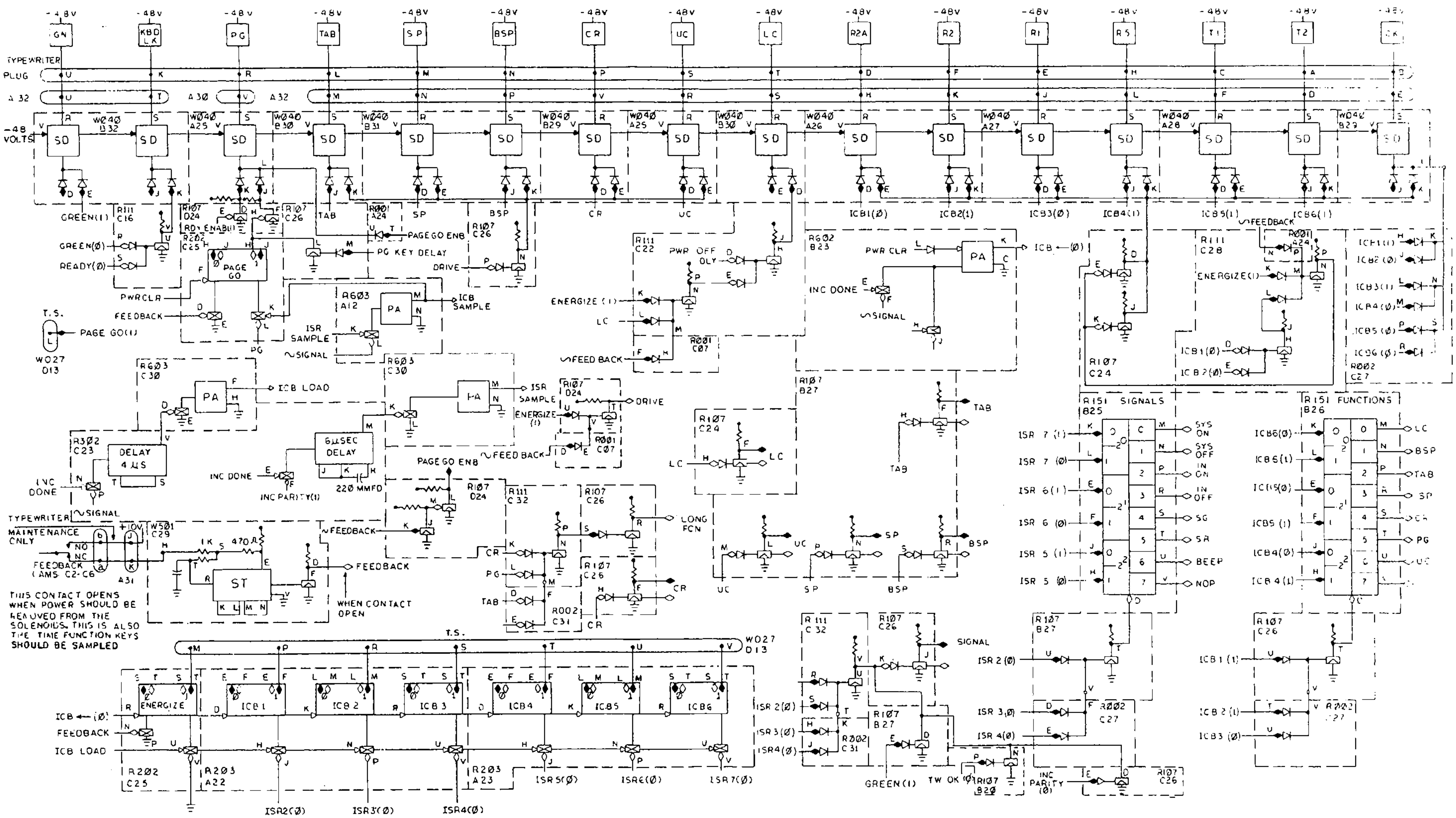


Fig. C2b--Master control



NOTE:
T.S. MEANS "TEST SOCKET"

Fig. C2c--Typewriter driver

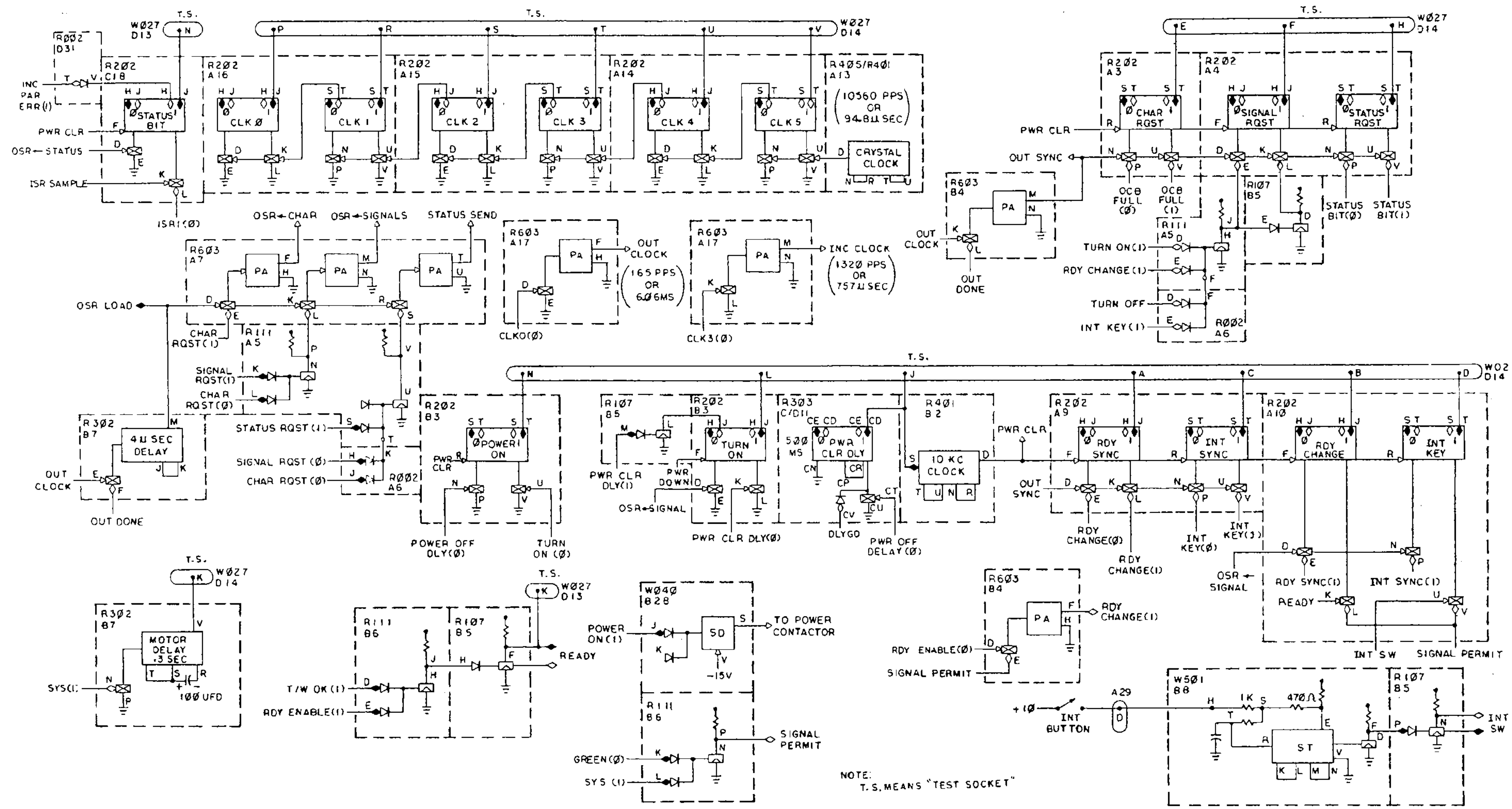


Fig. C2d--Output synchronizer

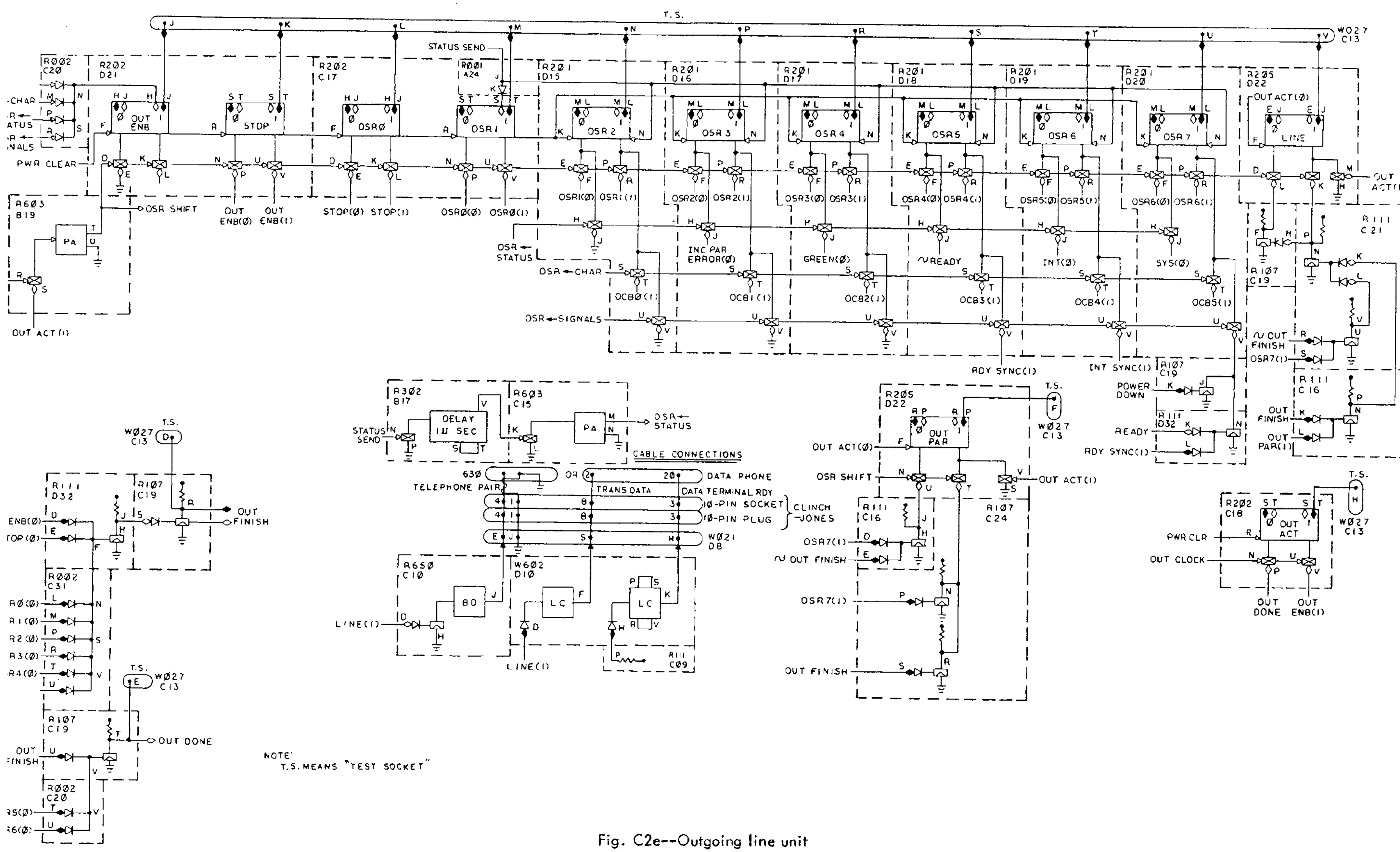


Fig. C2e--Outgoing line unit

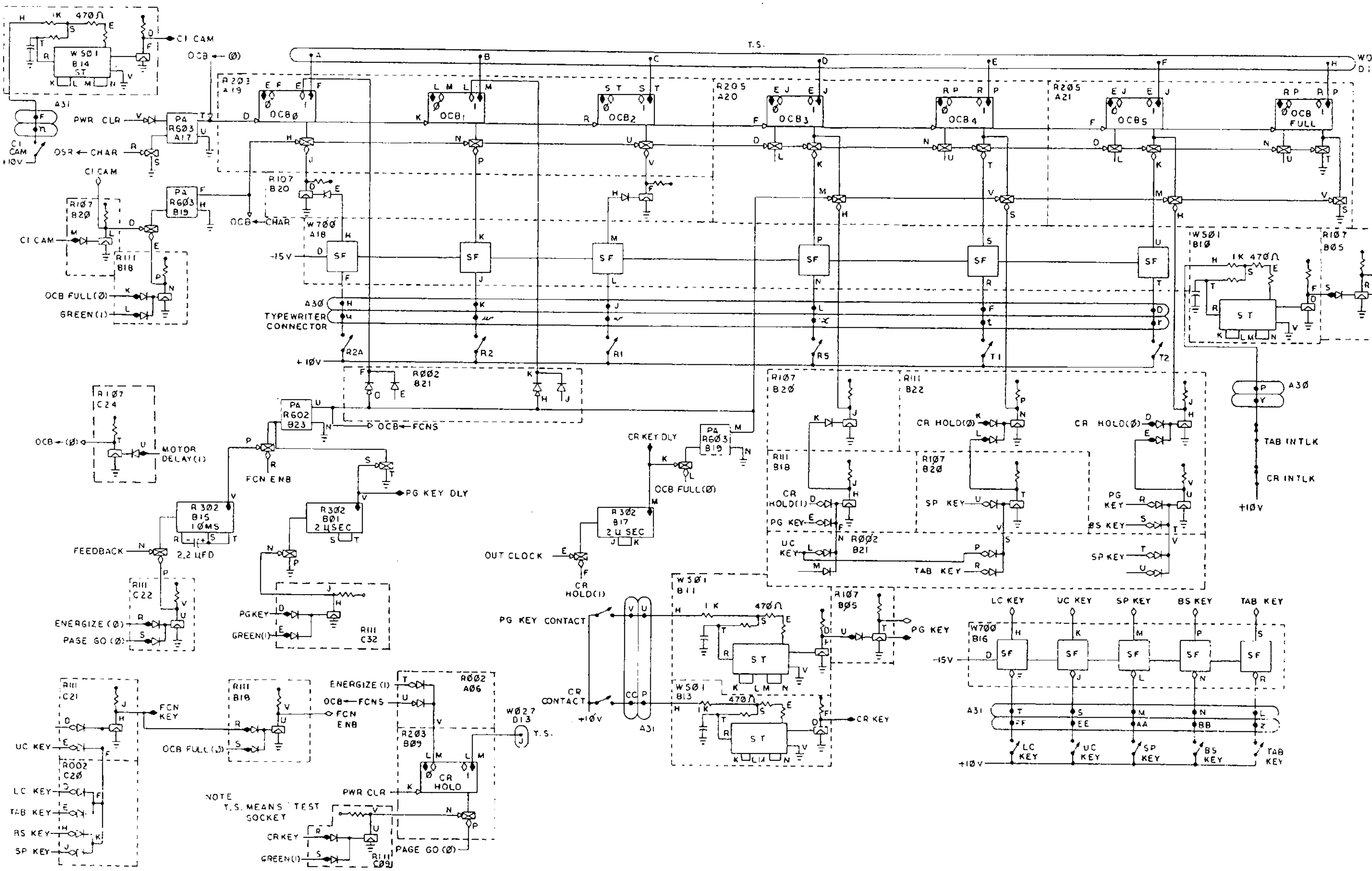


Fig. C2f--Typewriter keyboard

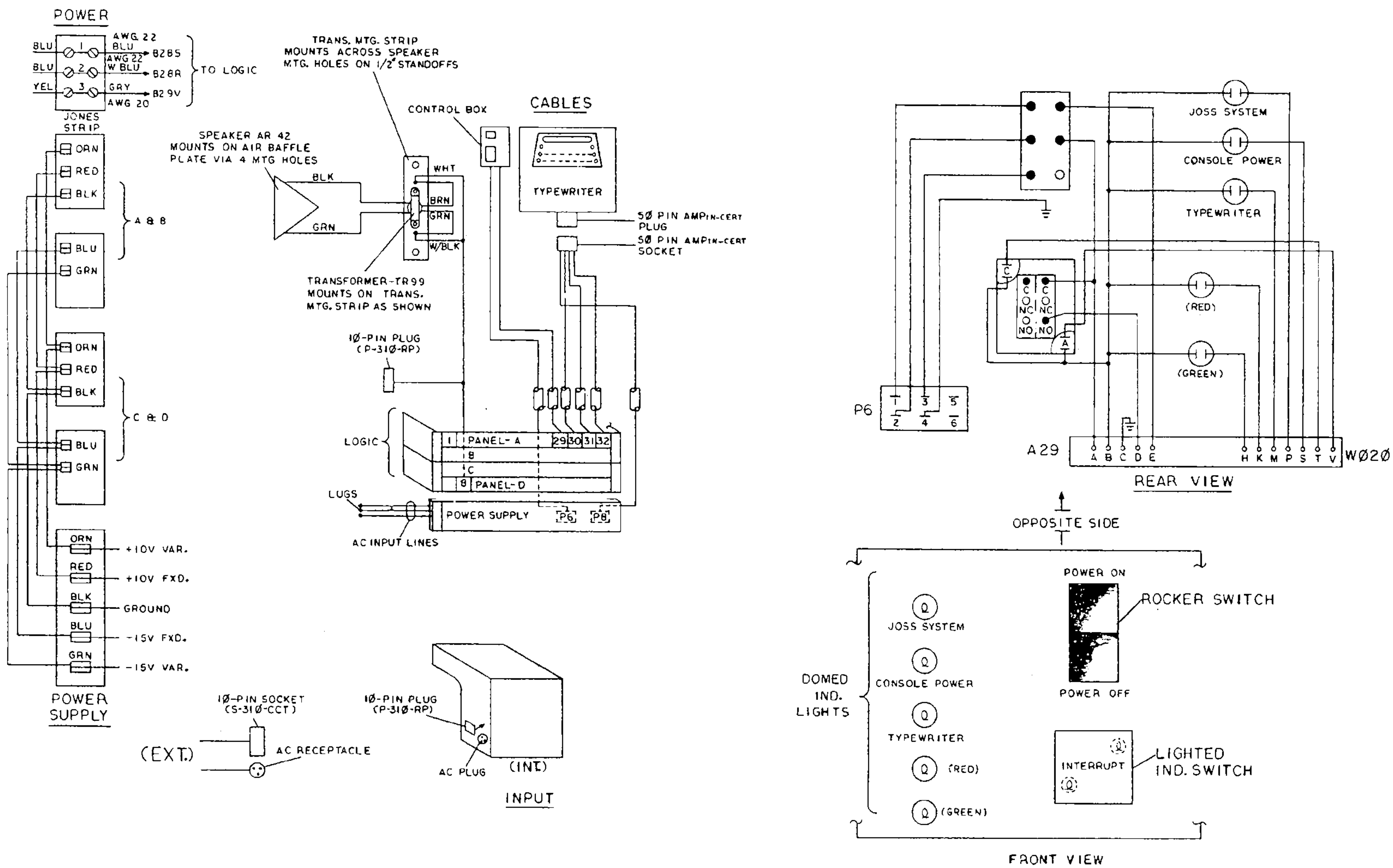


Fig. C2g--Cable connections

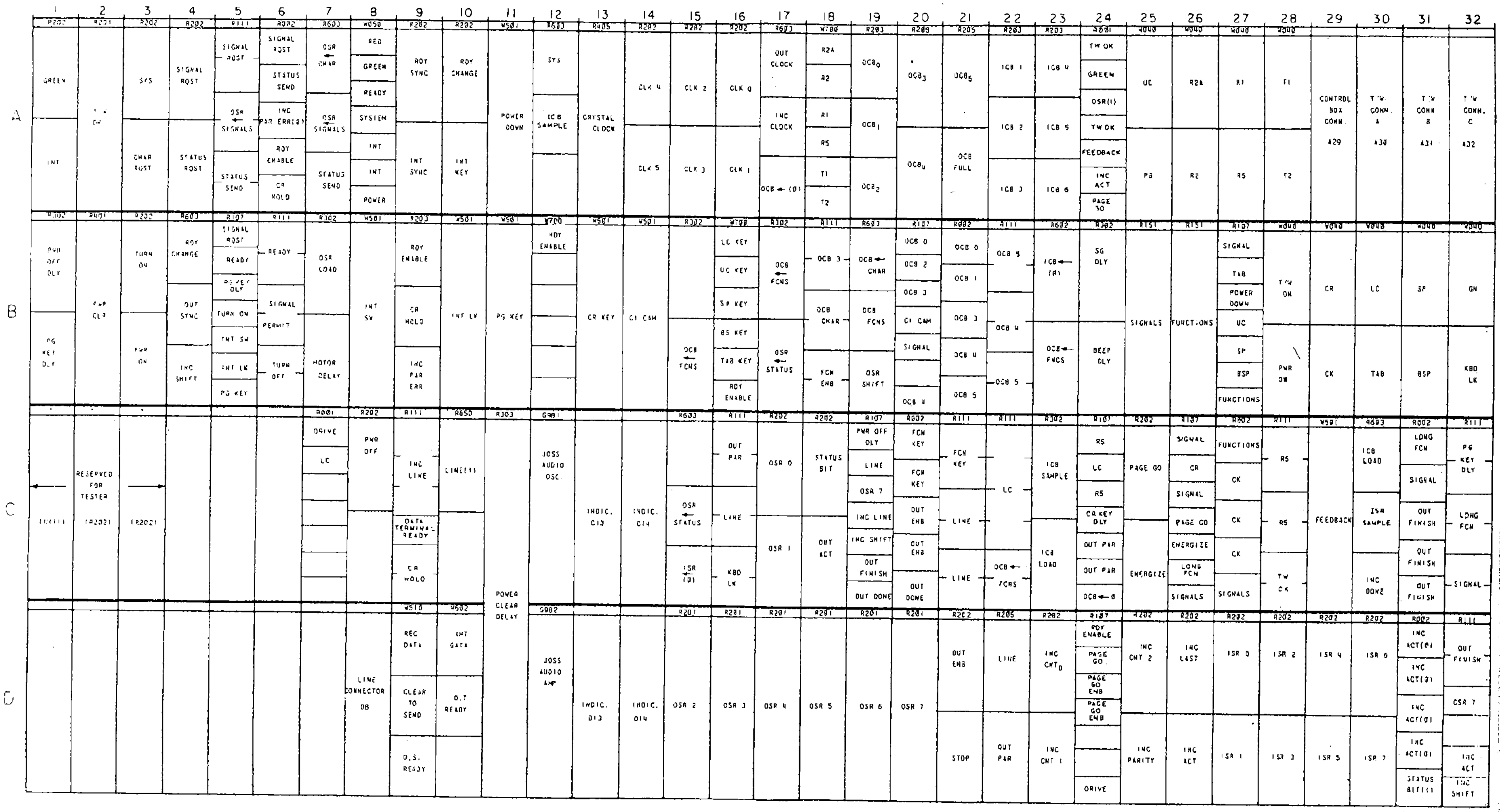


Fig. C2h--Logic module locations

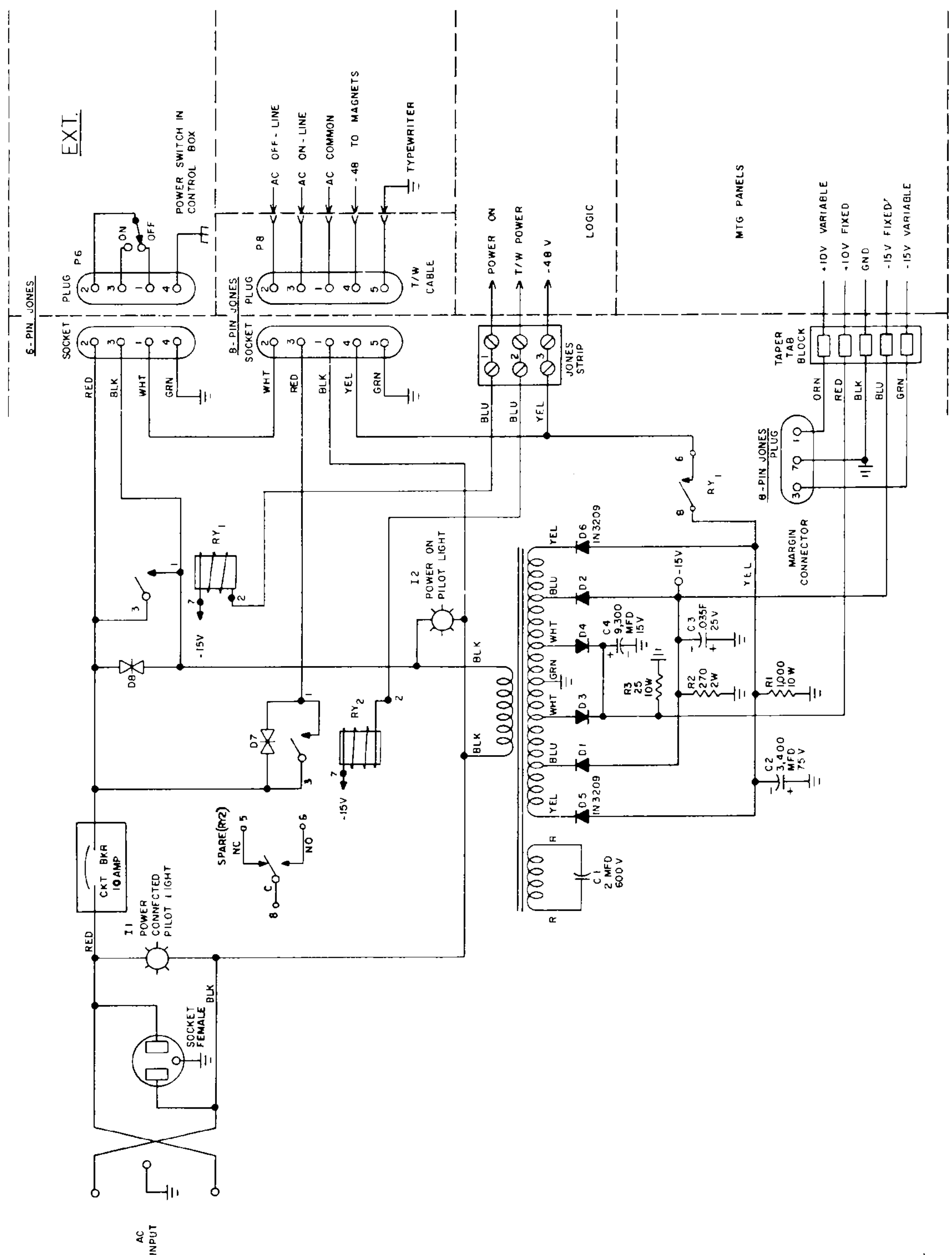


Fig. C2i--Power supply

Appendix D

JOSS CONSOLE CABLES AND AUTOMATIC LINE CONCENTRATOR

For operation within the RAND buildings, private cables and an automatic line concentrator provide the connections from multiple console locations to the DEC Type 630 Data Communications System (multiplexor). A simplified diagram of this circuitry is shown in Fig. D1. Figure D2 of this appendix presents the connections necessary to interface the JOSS console with a data set for common carrier or leased-line communication.

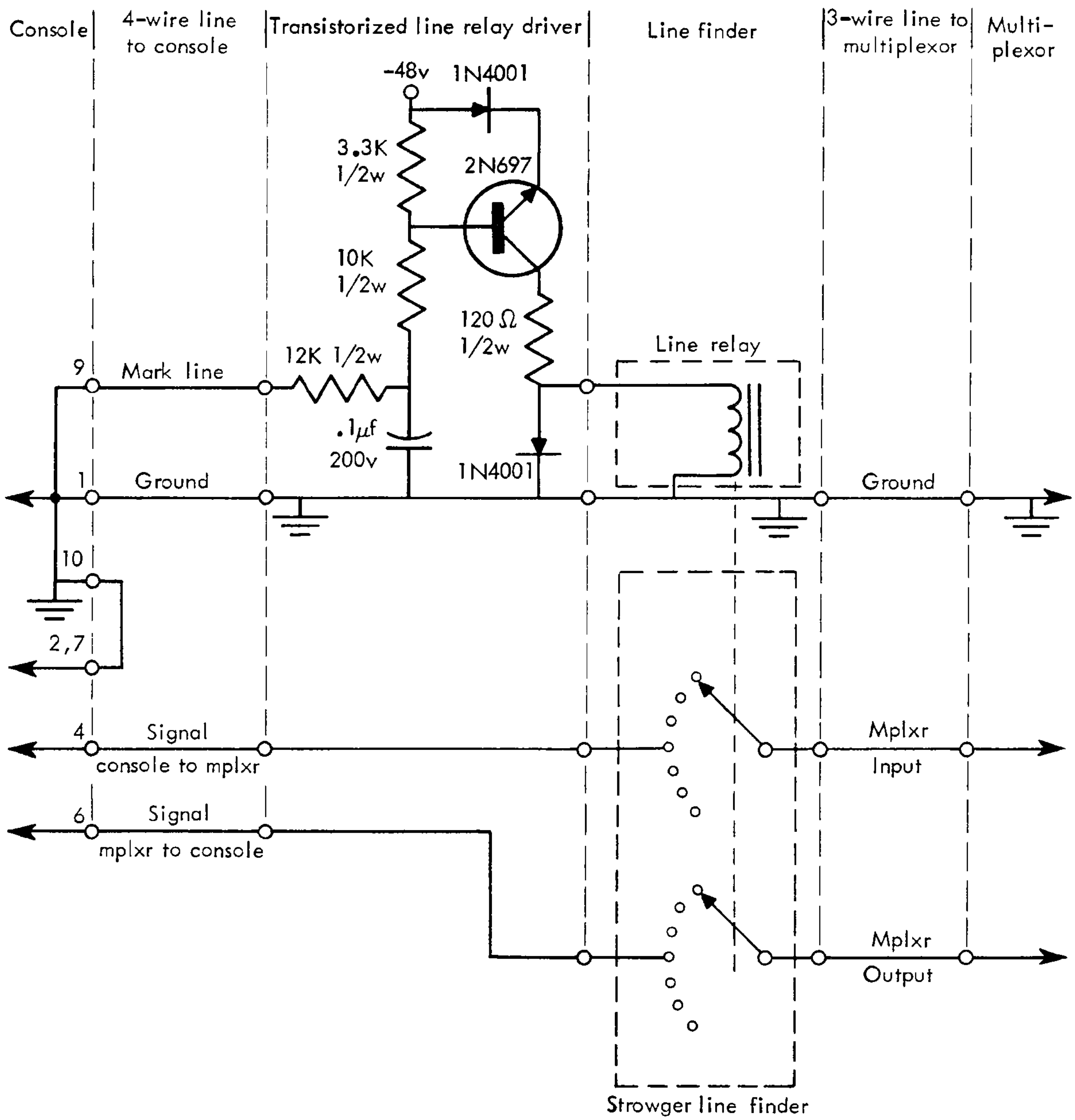
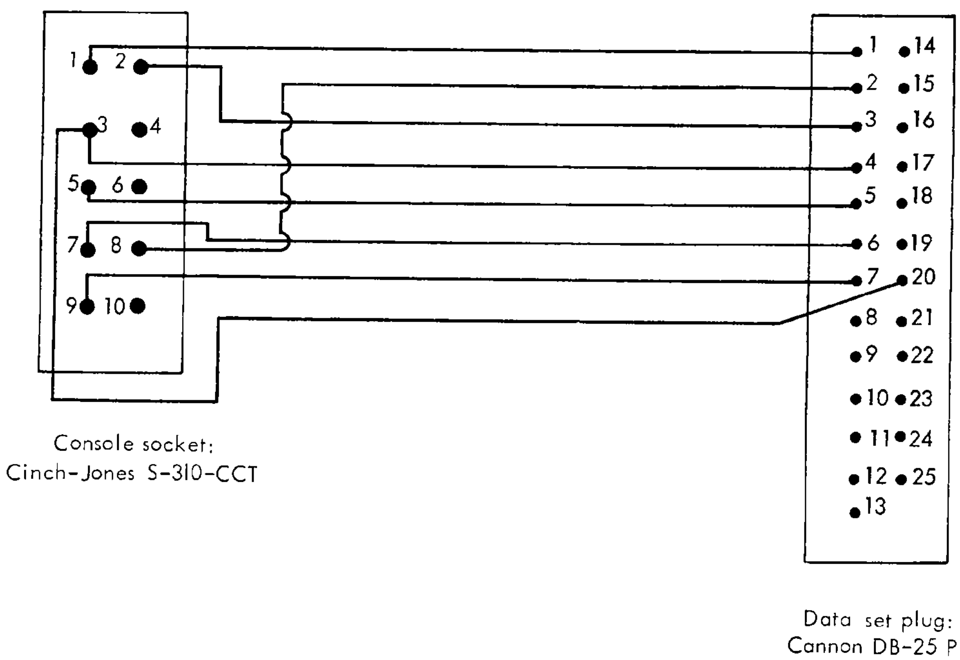


Fig. D1--Simplified circuit: JOSS automatic line concentrator



Wire	Function
1–1	Protective ground
8–2	Transmitted data (station to multiplexor)
2–3	Received data (multiplexor to station)
3–4	Request to send
5–5	Clear to send
7–6	Data set ready
9–7	Signal ground
3–20	Data terminal ready

Fig. D2--Cable connections: JOSS console to E.I.A. data set interface

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