INTERDEPARTMENTAL

MASSACHUSETTS INSTITUTE OF TECHNOLOGY *CAMBRIDGE, MASS. 02139*

from the office of

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From: J. H. Saltzer

At my request, Ken Pogran examined the potential difficulties arising from the lack of an automatic disconnect feature on the Bell System model 113A dataset. He put his observations down in the form of a memo, the first draft of which I am distributing, since Ken is on vacation. Your comments on his suggestions are welcomed.

Solving the 113A Data Set Problem

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The introduction of the 113A data set at MIT as a simpler, less expensive replacement for the standard 103A data set used for time-sharing consoles has resulted in an annoying problem, when the user of the data set forgets to "hang up" the set after completing his time sharing console session. This paper describes the problem, suggests two solutions, and discusses one considered the more feasible in some depth.

Implication of Differences Between the 113A Data Set and the 103A

The 113A data set is offered by the telephone company as a lower cost alternative for users who do not need all the features of the 103A data set. Features ommitted include the automatic answer capability, and indicator lights. More significantly, the data set is powered from the phone line, and so does not contain relays, which usually require more current than is available from the phone line. Also missing from the 113A is the "long space disconnect" feature which causes the data set to initiate a disconnect when it receives a long space signal from the modem at the other end of the connection. With a 103A data set, when a user ends a console session, the computer he is communicating with causes its modem to transmit a long space signal, causing the user's data set to drop the connection and restore itself to an idle state. The user thus need take no action other than turning off his console.

With the 113A data set, however, the user must explicitly hang up the data set by pushing the "TALK/CLEAR" button, as the unit ignores the long space disconnect signal. Users conditioned by long experience with the 103A data set often forget to push the "TALK/CLEAR" button, leaving the data set off hook in data mode, connected through the switching system to the computer's data set, which has been hung up by the computer.

This is not a major problem if a common control switching system is used to connect the user's data set to the computer's, as the system will detect the calling-party-off-hook, called-party-on-hook condition and release the connection after a brief period, freeing the computer port and returning the calling data set to dial tone, and, eventually, permanent signal tone.

This is not the case, however, in a step-by-step switching system. No timing capability is available in a step-by-step system, and connector circuits and trunk circuits, which supervise calls, are designed to be "calling-party-release" -- meaning that the path between calling and called parties is maintained until the calling party hangs up. This arrangement is appropriate for normal, voice telephone calls, but is clearly unsuited to the data communications situation described above.

In such a system -- which is the type in use at MIT -- regardless of whether the computer's data set is on or off hook, as long as the caller's data set is left off hook, perhaps inadvertantly, the connection between the two will be maintained and the computer port will be tied up. If many forgetful (or uneducated) users leave data sets in this state, the switching system and many computer ports become clogged, resulting in a situation which could be termed "creeping paralysis".

If one assumes that a user education program cannot be 100% effective, finding a solution to this problem becomes imperative, especially as larger numbers of 113A data sets are put into service on the campus.

Potential Solutions

There are a number of potential solutions to the problem:

1) The 113A data set could be modified; this solution is explored in detail below.
2) Appropriate circuits in the PBX could be modified; this solution is also explored in detail.
3) We could ask New England Telephone to come up with a "fix" for the problem on their own; however, it is uncertain whether NET&T would be willing to do this; also, the "response time", should they agree to find a solution, could be quite long.
4) We could obtain data sets which did not have this problem from another manufacturer; this would involve purchasing the data sets, and the risks that course of action entails.
5) We could turn off the PBX every morning at 6:00 AM,

dropping all connections; this has obvious disadvantages should there be any legitimate calls in progress.

7) When a build-up of "paralyzed" trunks occurs, we could trace the calls through the PBX and notify whoever is responsible for the terminal, or send someone out to hang up the data set.

8) We could provide sufficient computer ports and trunks, so that there are always enough trunks available. This solution is, of course, terribly expensive -- almost like providing a dedicated port for each console.

The two solutions to be discussed in detail here both involve specific modificaions to hardware. The two possibilities are: 1) that circuit in the step-by-step PBX wich handles supervision of a call and controls the release of the switch train involved in the call, and 2) the 113A data set itself. A proposed solution may or may not be peculiar to the switching system configuration at MIT; the general applicability of such a solution cannot be guaranteed.

We now turn our attention to the first possibility: modifying that circuit in the PBX which controls the supervision and release of a call. There are actually two circuits involved: the connector and the trunk circuit. MIT's system is somewhat unique in that it uses auxiliary trunk circuits to allow "single digit dialling" of the computer ports. Thus, the majority of MIT data calls go through auxiliary trunk circuits. Connectors are utilized when a full four-digit number is dialled.

To accomplish some sort of "automatic disconnect" under the control of the computer -- the "called party" in the situation under consideration -- the connector and auxiliary trunk circuits must to be modified to provide"either party release", such that once a "talking connection" (*i. e.*, both calling and called parties off hook) has been established, the connection will be released when either the calling party or the called party goes on hook. In the case of an off-hook 113A data set, this would result in the data set immediately being returned to dial tone.

Connectors are a widely used circuit; although technically feasible, it would probably be impossible from an administrative standpoint to modify a small number of connector circuits at MIT. Furthermore, only a small percentage of calls to computer ports at MIT go through connectors. The auxiliary trunks, which do handle the greatest percentage of data calls at MIT, are not generally used for data service outside of MIT; their primary use is in applications where the calling party release feature is desirable. It is technically feasible to modify the auxiliary trunk circuits for either party release, at least on an experimintal basis. The ideal solution along these lines would be a new trunk circuit, specifically designed for either party release, but the development cost of such a circuit for a very limited market would probably be prohibitive. However, it should be possible to modify the circuits already installed at MIT.

Let us turn to the possibility of modifying the 113A data set itself. Figure 1 is a rough schematic diagram of the circuitry involved in a step-by-step system call in a "talking" state. This diagram will represent well enough, for our purposes, several other stages of a call.

When the call is initially dialled, the data set is in "TALK" mode and functions as an ordinary telephone set. Battery and ground are supplied through the two windings of the "A" relay of whatever switch is currently supervising the call. In the later stages of a call this is a connector switch or a trunk circuit. Ground (+) is provided on the TIP lead of the phone line, while battery (-) is supplied on the RING side of the line.

A step-by-step PBX is arranged to that when the called party answers, and remains off-hook, the polarity of battery and ground supplied to the calling party through the A relay is reversed. Thus, battery will be applied to the TIP lead and ground to the RING lead. It is at this point -- after the computer's data phone has gone off hook -- that the user will push the DATA button on the 113A data set and return the hadset to its cradle, which places the data set in DATA mode.

In DATA mode, the 113A data set maintains its "off hook" state by placing a resistive "holding bridge" across the line, to maintain the flow of loop current. Part of this current is used to provide power for the modem. One component of this holding bridge, shown in Figure 1, is a 150 ohm resistor connected to the ring side of the phone line on one end and the modem circuitry on the other.

When the "TALK/CLEAR" button is pressed, the line is switched away from the holding bridge, and unless the handset has been picked up, loop current will cease, creating an "on hook" condition to which the auxiliary trunk circuit (or connector) responds by releasing the connection.

Now suppose, however, that the data set is left in DATA mode, and the user terminates his console session without hanging up the data set. The computer's data set will be placed on hook by the computer, resulting in the reversion of battery polarity supplied to the calling party to its original state of negative battery on ring and ground on tip. Note that this is the first time during the call when the set has been in data mode with "on hook" battery polarity -- and these are the conditions under which we wish to automatically "hang up" the data set.

It would seem, then, that what we need to do is prevent current from flowing through the holding bridge of the data set under "on hook" battery polarity, for that will generate the desired on hook condition which will cause the trunk circuit to release the connection, freeing the computer port. We do want current to flow through the holding bridge under off-hook battery polarity, of course. A simple, inexpensive silicon diode, inserted in the circuit at the point shown in Figure 2, will do the job. The point in the circuit shown in Figure 2 is especially suited for field modification of the 113A data set, as installation of the diode may be easily done with a screwdriver in such a manner as to result in a neat job.

Implication of the 113A Data Set Modification

With the addition of the diode in the holding bridge circuit, the data set is effectively "on hook" when left in data mode, as opposed to the present situation of being "off hook" when left in data mode. This makes it possible for someone to call a data set which has been left in this state. Without the modification, an off-hook data set would appear "busy" to potential callers. Ringing a telephone line consists of applying 90 volts at 20 Hz, superimposed upon the -48VDC battery supply. The effect this voltage will have on the diode and the other components of the data set must be determined.

During the positive half of the 90VAC ringing current cycle, the actual voltage applied to the line will reach approximately -3 volts. The diode will not be forward biased, no current will flow, and the modem circuit should be protected. On the negative half cycle, the voltage will reach approximately -93 volts. Thus, the diode must have a peak inverse voltage greater than -100 volts. If this is the case, the modem will be protected from ringing voltage.

With the set in DATA mode, the ringer will be disconnected from the line, and there will be no indication of the incoming call. This is no great loss, however, as without the modification the data set would have been off hook, and not able to receive an incoming call.

A data set equipped with this modification would not work properly if served by a common control central office which does not reverse battery polarity on local calls, but does upon receiving answer supervision on toll calls, as the holding bridge must then be able to operate properly with both polarities of battery. If the data sets were manufactured with the diode, it would have to be strapped out for such an installation.

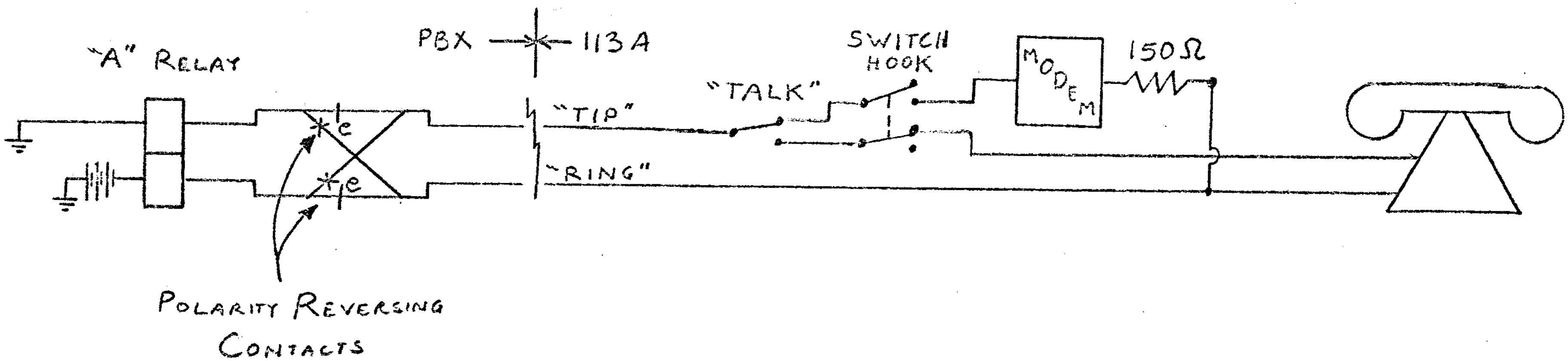

Figure 1

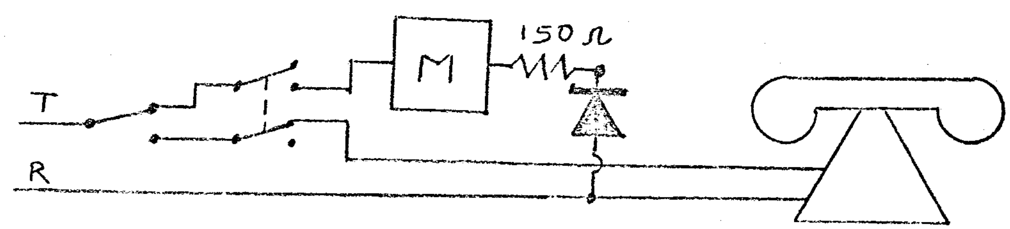

Figure 2

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