Railway
Signaling &
Communications

C & S MEETINGS

Sectional meetings of the Communication & Signal Section, AAR, were held in April and May of this year at St. Louis, Mo., and Cincinnati, Ohio. Papers were presented concerning various subjects of interest to signal and communications men. Herewith are abstracts of papers covering modular interlocking design, the role of the communications man in railroading, the testing of insulated rail joints, and practices relating to location and operation of hotbox detectors. Our thanks are extended to the Committee of Direction of the C&S Section, AAR, and to the authors for permission to publish these papers. A ready-reference guide is printed below to help you quickly locate the articles.

Modular signal design is here

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Interlockings designed on a modular or building block principle represent an entirely new concept in signal system design. To the best of our knowledge, this concept has not been applied anywhere in this country, although a similar system has been in use on some European railroads for several years. Development work in this country is currently being done by the C & S engineering staff of the New York Central, and by other companies in cooperation with or under contract to the New York Central.

Railroad signal systems really haven't changed much in the last thirty or forty years. New sophisticated supervisory control systems for CTC have appeared, along with new products as individual components in the system, but the basic signal system stands much the same as forty years ago. The last major

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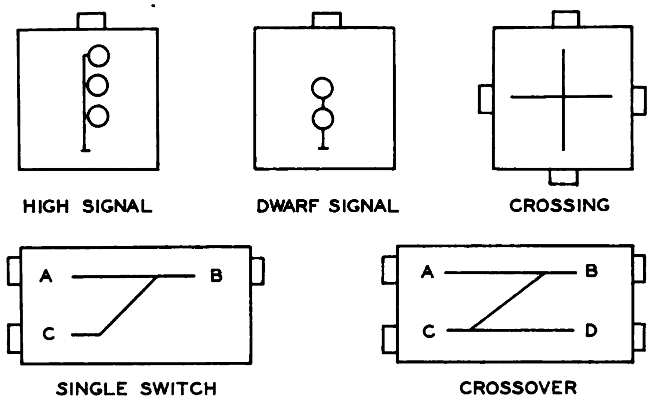


1 Types of circuit modules used and the symbols associated with them.

breakthrough in interlocking was the advent of the all-relay interlocking, using relay networks to replace the intricate mechanical locking beds.

The problem with existing signal systems is that virtually all the equipment used is designed and built exclusively for railroad signaling. As a result, components are low-volume, high-cost specialty items. Since the cost of components is so high, systems in which they are used are custom designed for each location to make the most efficient use of material. Thus not only the designing, but also the construction, installation, and testing is specially tailored to suit each individual location. This was fine in the days when labor was plentiful and wages low. The current picture shows the cost of labor increasing to the point where minimizing the material cost may no longer be the guiding factor in designing a system.

The intent of our development work is to break out of this pattern of specialty components and custom design, and to completely redesign and repackage the signal system to take maximum advantage of standard industrial material and particularly mass production techniques. This redesign encompasses the entire system from the cable terminals and power sources all the way to the signals themselves. However, our primary effort has been in the area of safety logic circuits, the actual interlocking part of an interlocking plant. We are reducing the circuits to a relatively small number of building blocks or modules that will have the following characteristics:

(1) Be universal enough to be used anywhere on the railroad;

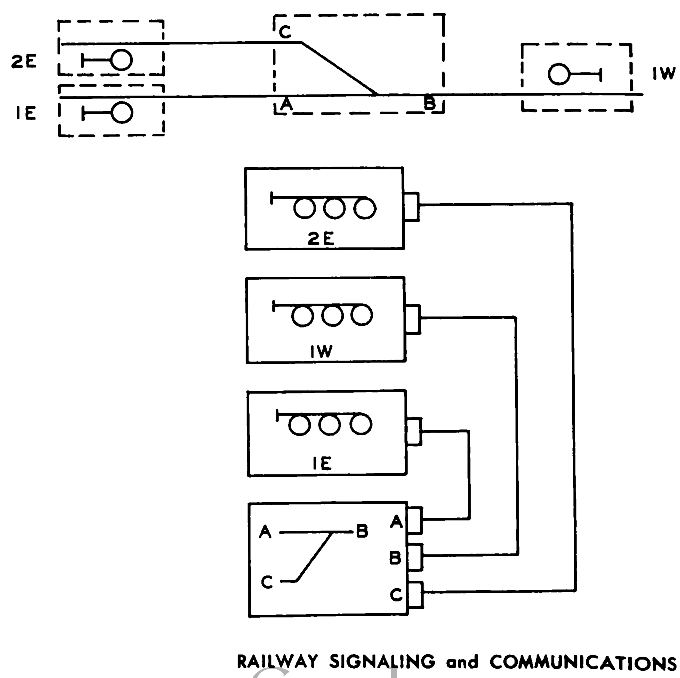
(2) Minimize the amount of field work in installation, since field labor is the least efficient form;

(3) Be readily replaceable in case of damage or malfunction;

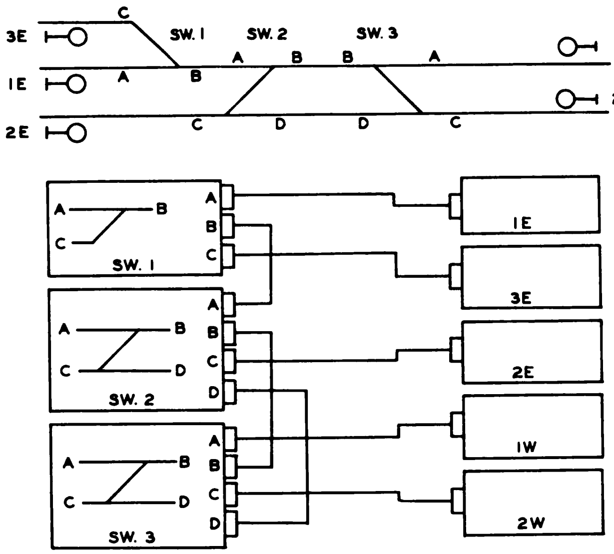
(4) Be capable of automatic test and inspection, and provide visual indications to immediately identify the area of a failure.

All the components of total system cost must be considered in any attempt to reduce overall costs. These include, for any installation, the initial cost of engineering, materials, construction labor and inspection. Also, any installation has a certain maintenance cost which includes both repairs and the periodic tests required by the ICC. Less obvious elements in total cost, but no less important are those that arise only at selected locations. One of these is revision of the system when changing traffic conditions or a change in management thinking necessitates revisions in the track layout. Relatively minor changes in track layout can require major changes in the signal system, and installation of these changes must be virtually completed without disrupting the existing system. A second cost component in the "Selected Locations" group is the cost of rebuilding an installation that is destroyed or badly damaged by a derailment or other accident. This takes in not only the cost of rebuilding the facility but also the cost of train delays over the two to six month period generally required to assemble another system. In a key location the cost of such delays and interruptions could far exceed the replacement cost of the equipment.

Any new system that is designed must meet a rather stringent set of requirements of safety and reliability. Since no system can be expected to operate indefinitely without failure, the expected frequency of failures must be considered. This is determined statistically and is a measure of the reliability of the system. Reliability concerns only the frequency of failures. Safety, on the other hand, concerns not frequency



2 A small interlocking assembled from modules.



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Module interconnections for a moderate sized interlocking.

of failures but rather the effect of any given failure on system operations. Systems are so designed that virtually all possible failure modes are considered, and no anticipated failure can cause an unsafe condition. Safety is the first consideration in signal system design, and much of the specialized equipment now used in signaling exists primarily because of this emphasis on safety.

The effectiveness of the fail-safe design techniques presently used is indicated by the record of signal system failures as reported by the ICC for all American railroads. In the fiscal year 1965, railroads in the United States reported a total of 28,082 false restrictive signal failures and 57 false proceed and potential false proceed failures. This is a ratio of about one in five hundred; two-tenths of one per cent of all signal failures were of unsafe nature while 99.8 per cent were safe failures. This emphasis on safety cannot be compromised for the sake of economy. If present performance must be compromised slightly, this compromise must be made in the area of reliability instead. This is not as serious a sacrifice as it may at first sound because the present reliability of equipment within the interlocking circuits is so high that an increase of several times in the present failure rate would have relatively little effect on the time spent in repair. By statistical evaluation of past failures we have determined an expected mean time between failures for a typical end-of-siding interlocking on single track railroad at about 130 years. Remember that this figure applies only to the interlocking circuits, not to anything outside the bungalow or to track circuit or line circuit equipment. Obviously a drop of even fifty per cent in the reliability of the interlocking equipment would not have much affect on overall maintenance. Our statistics show further that, of all false restrictive signal failures on the New York Central over a two year period, less than three per cent could be attributed to something within the interlocking circuits themselves.

Before a signal can clear over a route in an existing interlocking, the relay networks must check many operating conditions both within the interlocking and, where the signal doubles as a block signal, in the block beyond the interlocking. Within the interlocking it checks occupancy of the tracks, position and correspondence of the switches involved in the route, and absence of conflicting routes clear. The speed indicated by the signal is determined by the most restrictive portion of the chosen route. In the block beyond the interlocking the networks check block occupancy and the aspect of the next signal. As the number of routes through the interlocking increases, the data switching problem grows since the flow of information through the networks generally follows a routing similar to the geographical route through the interlocking. This fact is a first clue to the modular circuit design.

Most logic functions in the networks are associated with one of the switches or one of the signals. This fact, along with the geographical basis of data flow, led to the idea that all circuits associated with a switch be assembled into a single standard unit called a switch module. In the same manner all circuits associated with a signal would be assembled into a standard signal module. From a practical standpoint it appears that at least five different module types would be suitable. These are indicated in Figure 1 along with the routing and connection points for each. Notice that both the crossover and single switch are shown as left hand switches. This choice was purely arbitrary and of no significance. More important is the relationship of the electrical "route" through the module to the arbitrary terminal designations. For example, terminal point C on the single switch always represents the diverging route whether the switch itself is right hand or left hand. Each terminal point on the module represents a number of circuits all brought out on a plug connector. Assembling the modules into a network then requires only the tying together of various terminal points using multi-circuit cable, plug-connected. Electrical connec-

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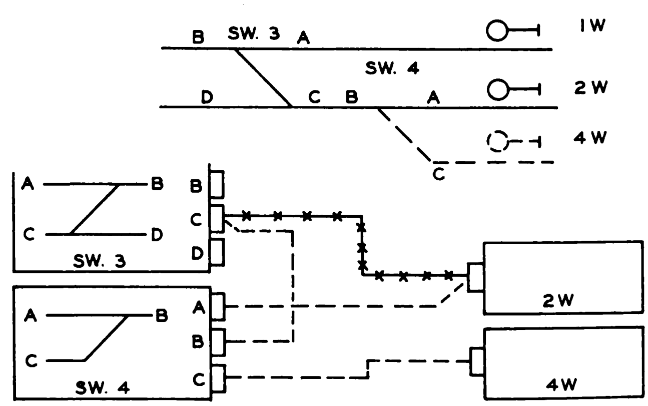
Changes that must be made to add a switch to the interlocking in figure 3. Line with "x's" is a connection to be removed.



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tions correspond exactly to the geographical layout of switches and signals. Interconnections for two typical small interlockings are shown in Figures 2 and 3. Note in particular what has to be done if a change is made in the track layout. For example, adding a switch for a second siding in the plant shown in Figure 3 would require not much more than adding one switch module and one signal module, as shown in dotted lines in Figure 4. The advantage in flexibility of a modular design over conventional practice is obvious.

Several points should be immediately apparent. One is that there are many different types of signals on any railroad with scores of different aspects, only a small portion of which will ever be used on any given signal. Being able to handle all or even most possible combinations with a single universal module requires that much more equipment be present in the module than is needed to do any one job. The selection of just what aspects will be displayed under what conditions is made by an assortment of strapping options which in effect program the module for the specific application in which it is being used. Strapping would be done on a removable plug so that if the module should be replaced, the same program can be transferred quickly to the new module. Similarly to change the program, should this be necessary, the new program can be prepared in the shop and installed in the module with a minimum of interruption. Programming, or selection of the proper strapping options, can be done from a handbook or table of instructions and requires no actual circuit engineering.

A second obvious point is that installing the strapping plugs and the interconnecting cables does not complete the installation. Additional connections must be made to tie in the modules with their respective switches and signals, with line and track circuits, with the operator or supervisory control system, and with operating power. See Figure 5. All these connections will be made on plug connectors.

Circuit operation of the modular system is quite straight forward. Each switch module contains the control and locking circuits for its switch, and checks the switch for position and correspondence. Each signal module contains all control circuits, including time locking, for its signal. It also connects to the line circuits to transmit signal aspect information back to the first approach signal, and to receive incoming line information for use by any of the opposing home signals. All the information needed to clear a signal enters the signal module from the interconnecting cable leading to the first switch in the route. Most of the information originates in the opposing signal module at the opposite end of the chosen route and is passed through each switch module in turn, being routed according to the position of the switch.

Circuits conveying the condition of the leaving block are routed intact through each switch, except that an open switch will open all circuits passing through its module. For route speed through the interlocking, separate circuits are used for each defined speed: normal, limited, medium, slow and restricted speed. All five speed circuits are present at the point of origin in the leaving signal module. As the speed circuits pass through the switch modules, each switch opens the circuit for any speed unsafe at that switch. For example, a switch lined normal will pass all speed circuits, but a number 16 switch lined reverse will open the limited-speed and normal speed circuits, passing only medium, slow and restricted speed. Given the leaving block information and the safe route speed, the signal module then determines the proper aspect to display.

Route locking is initiated at the signal being cleared, and the locking command is passed on into the switch modules. Each module in turn is locked and passes the command on to the next module, depending on switch position. There is no limit to the number of modules

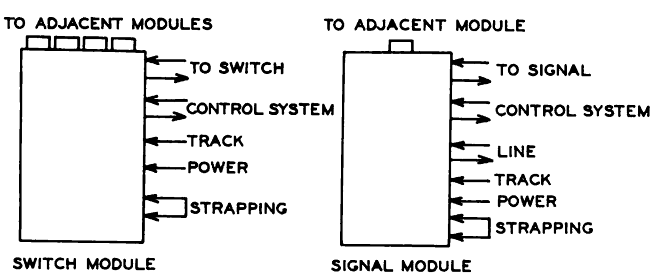

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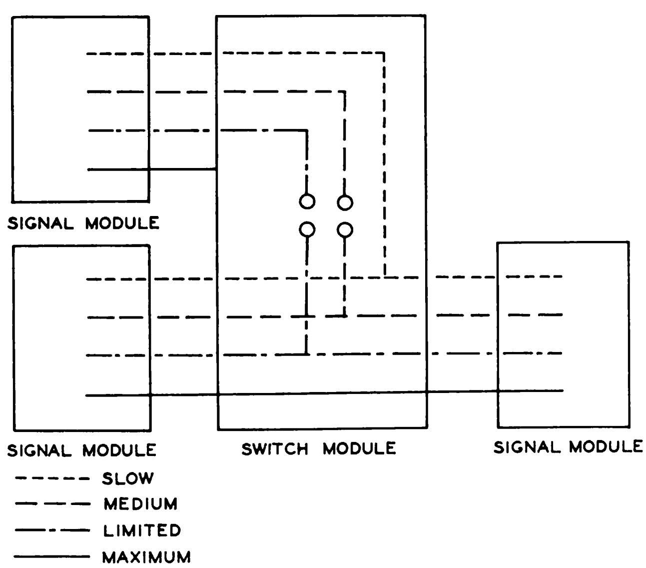
Diagram shows module connections for switches and signals.



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Route speed selection diagram. Circuit is routed according to switch position.

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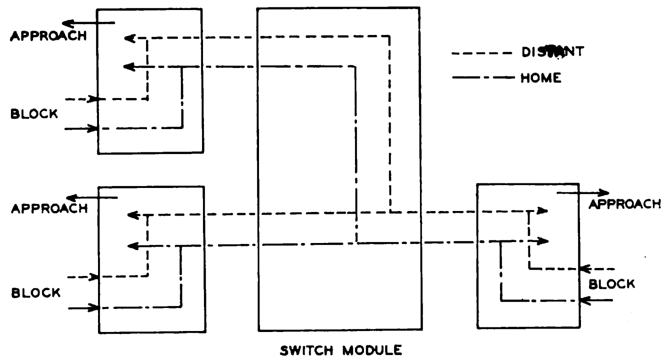

Block information is routed according to switch position.

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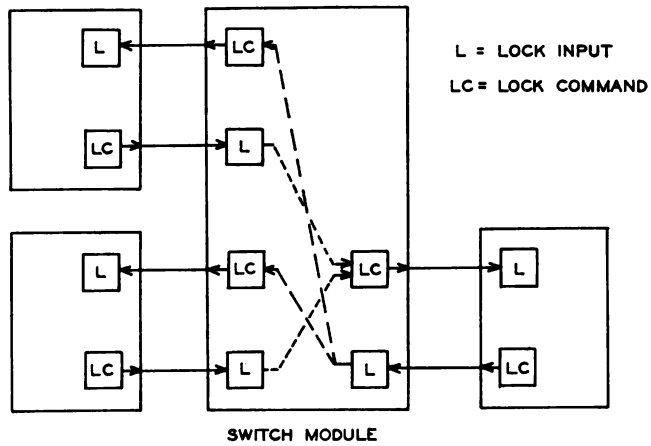


Similarly, route locking is routed according to switch position.

that can be interconnected. When the locking command reaches the opposing signal module, it locks that signal against clearing and, in the case of APB block signaling, opens the opposing line circuit to establish the direction of traffic. Each switch must indicate locked before the signal will clear.

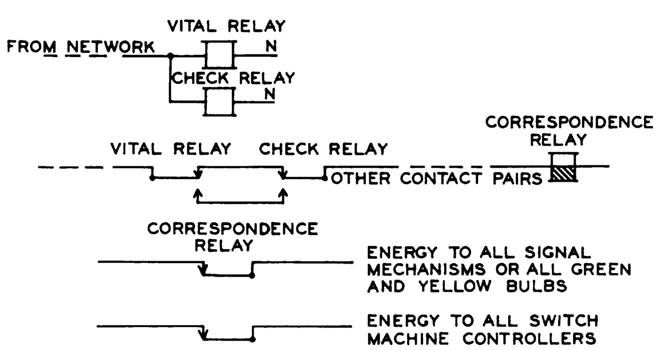
Except for increasing the number of circuits and the amount of switching performed, the basic circuit designs evolved over years of experience in signaling are retained. An illustration of some of the routing and switching concepts is given in Figures 6 and 7.

Since all modules of a given type are identical with the exception of the strapping options, an automatic test unit can be used to check out all operating functions of the module in very little time, providing a visual or printed indication if all functions are proper and the nature of the malfunction if one exists. This will eliminate a large part of the present tedious test and inspection process. Indicator lights will be used on the modules themselves to help a maintainer locate, at least down to a specific module, the cause of any system failure occurring in service.

Obviously the large increase in the number of circuits and the amount of switching, plus the excess capacity allowing for universal application, results in a substantial increase in the number of components. In general, a typical interlocking would use two to four times as many relays as with the conventional circuits. If conventional signal relays were used, the added material cost would make the job economically impossible, regardless of what savings were achieved in labor. Thus conventional relays are ruled out.

This leaves the task of selecting a suitable substitute. The major distinguishing feature of the conventional signal relay other than overall sturdiness is the carbon contact material which makes it virtually impossible to fuse a contact in the energized position regardless of the degree of overload. A suitable substitute could be either a smaller, less pretentious relay with similar contact material, or a conventional metallic contact relay used in combination with more positive surge protection to keep lightning out and with some form of back contact proving to assure a restrictive condition in the event a contact should fuse despite the added protection. This last method is used quite extensively in Europe where the need for safety is certainly no less than in this country. We are pushing actively in both directions right now; several relay manufacturers are working with us in trying to develop a small, low-cost, non-fusing relay, and we are also evaluating various different forms of contact proving for use with standard commercial relays. One potentially useful form of contact proving is illustrated in Figure 8. Each vital relay coil has in parallel with it the coil of a small "check" relay. Contact position of the two relays must agree to maintain a closed circuit through a checking loop which verifies all vital relays in the system. Since the check relays are not used in any working circuits, their contacts could not be fused from the outside. The result of the series check of all relays is a single master correspondence relay with conventional carbon contacts. De-energizing this relay will put all signals to stop and lock all switches.

Parallel with this effort, a leading manufacturer of solid state equipment has undertaken the design of a modular interlocking system based on the use of integrated circuits. Given a truly fail-safe design, suitable interface equipment and positive protection against hostile en-



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Contact proving is made by use of an independent check relay.

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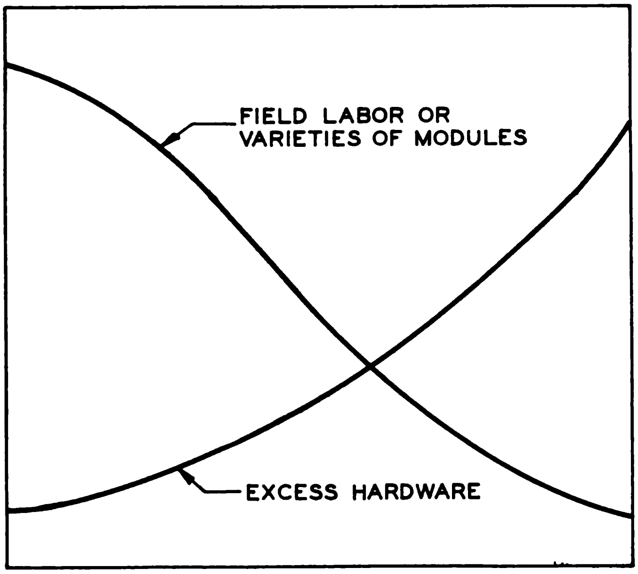

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Economic trade-off is indicated in this chart of relative costs.

vironment, a solid state system may well meet the requirements. The developer has agreed to be bound by the specifications regarding safety, reliability and environment which were based on statistical evaluation of the performance of present systems.

A big question still to be resolved is the economic trade-off between the amount of excess equipment needed to make the modules truly universal and either of two possible alternatives as indicated in Figure 9. One alternative would be to eliminate some of the less common options from the modules themselves, and leave provision for wiring these options externally in the field. This offsets the decreased module cost by increasing the average field labor cost per installation to handle the occasional need for custom wiring. The other alternative would be to increase the number of varieties of modules either by breaking down the package as presently conceived into smaller submodules or by designing more specialized types to handle certain types of signals or certain combinations of aspects. Pursuing each of these to the ultimate, in the first case you end up with the existing signal relay as the ultimate module; in the second case you come to a completely wired interlocking designed for a specific application. The first requires much field labor to install. Both tend to defeat mass production and automatic testing, and create problems in inventory of spare equipment. In a sense, both cases are approximations of the present system.

The real optimum design point lies somewhere between these extremes. Selection of the optimum depends on two factors, neither of which is fully resolved at this time. The first is the relative cost of material, production line labor and field labor. The second is the type of interlocking, the type of signals and the probable choice of aspects to be used by the railroad.

Despite uncertainty in both of these areas at the moment, design work on the modular interlocking system is progressing. The possibilities of the system are sufficiently promising that perhaps the optimum point need not be found before a railroad is able to take good economic advantage of this new approach to interlocking design. **RS&C**

Spacing set at 30 miles for N & W hb detectors

By J. D. Wimmer
Electronics Engineer
Signals & Communications
Norfolk & Western

Norfolk & Western has presently around 38 detectors installed and with tentative authority for around 90 additional installations. We employ GE, Servo and GRS types in line-of-road installations with GE and Servo detectors used for yard inspection.

Our line of road installations are normally spaced around 30 miles apart with special consideration given to the protection of bridges and tunnels. Detector information is transmitted over open wire by FM carriers back to some signal control location where we have trained personnel to read the recorders. Our recorder tapes are read on a relative basis. We compare any given indication with the others received on car in question and also with the rest of tape on the train. With the present art of hotbox detection, it is our belief that you cannot do without the human factor needed in reading recorder tapes.

The economies involved in any program is always a major consideration. The question always being, are you offering the most effective equipment at the best economical price. It is felt on the N&W that we have made progress in this direction.

It was seen early in our detector program that at certain double track locations we would have double installations in order to receive adequate protection. To avoid this extra expense, we designed switching circuits controlled by the signal system which allows two sets of track side equipment to be switched to one set of wayside housing equipment. This has worked very well on all three types of detectors and for an additional cost of $6,000 to $8,-

000, we received double track coverage with the one limitation being that only one train can be scanned at a time. We presently have seven such systems in operation and authority to add double track scan to four existing detectors.

There is another unnecessary expense in our detector program which we are presently trying to correct, this being the cost of recorder paper. We modified three heat stylus recorders to ink stylus and purchased a special plain recorder paper. These recorders were evaluated for six months while in operation and no problems were encountered. We presently have around 20 recorders modified to ink and authority to change all existing recorders on the system. The cost of the new paper is around 19¢ a roll which will bring about an anticipated savings of $25, 000 on the first year that all detectors have been converted. There are also a couple of additional features received in changing to ink stylus recorders. These being that all heat stylus recorders will inherently skip on extremely high fast indications which is not true with the ink stylus type and by having no lines on recorder paper, the system is read on a more relative basis, which we strongly recommend.

One of the most rewarding phases of our detector program has been the evaluation of hotbox detector sites to general detection centers. Back in 1963, we started to include at every detector site, loose wheel and dragging equipment detectors at an additional cost of around $1,000. This additional protection at such a low cost is achieved by using the hotbox detector and its affiliated equipment to display the loose wheel and dragging equipment indication. One full scale deflection on both rails of recorder chart indicates a loose wheel and occurs upon the axle in question. More than one full scale deflection occuring on both rails and within one car length of area in question represents a dragging equipment indication.

At the present time we have around 35 loose wheel detectors and 20 dragging equipment detectors installed. We intend to make all of our detector sites into general detection centers. This is also standard equipment in all new installations. We are presently using a loose wheel detector developed on our railroad. The dragging detectors are purchased from Hanlon & Wilson Company. During the first year that records were kept, we set out over 20 loose wheels and numerous cars with dragging equipment. These devices are playing a major role in wreck prevention.

It is very gratifying to read the weekly detector performance records and realize the possible wrecks which have been prevented. Our detection centers are doing a most rewarding job. **RS&C**

StL-SF has 16 hotbox detectors in service

By J. S. Downs
Assistant to Gen. Supt.
Communication & Signals
St. Louis-San Francisco

The Frisco has 16 hot box detectors in service and 2 in the process of installation at this time. Nine of these detectors are bi-directional, the rest are one direction only. Seventeen are on single track CTC territory, one is on single track ABS territory. Eight are in close approach to yards, the remaining are on line of road.

Most of our detectors are extended to the readout locations via carrier over CTC code lines. The longest extension is about 150 miles. Our installations consist of seven GE on GE carrier, one Servo on GRS carrier, two Servo on US&S carrier and seven GRS on GRS carrier. In addition, one installation utilizes figure 8 cable between the scanner location and the field printed readout location. An "H" indicator, automatically controlled, is associated with this one direction scanner. One other location is also equipped with an "H" indicator controlled by the dispatcher. A step in the CTC code is used for this control.

The readout locations are primarily in 24 hour attended car inspector foremen's offices at our major terminals. These locations are equipped with recorder charts. Two readout locations are in telegraph offices. These two locations are equipped with both a recorder chart and a printed readout with alarm.

Our present instructions are to stop a train passing a Servo or GE installation if a friction or solid bearing shows a differential of 8 mm. A roller-bearing car is stopped on 15 mm differential. On the GRS hub scanner, we stop a train on 10 mm deflection, not differential.

When a hot journal is indicated, the dispatcher is immediately contacted and he takes action to stop the train at the nearest control point. This isn't too satisfactory since control points are not always conveniently located with respect to the scanner location. Perhaps a better arrangement would be a combination of automatic "H" indicators, flashing beacons and train-to-wayside radio, providing all trains are radio equipped.

The selection of a hotbox detector location is determined through the joint efforts of the mechanical, transportation and C&S departments. Our mechanical department has prepared a system map showing by direction the locations where cars have been set out with defective journals or where journals have failed. This chart represents records for the past five years. Using this chart, selection is made taking in to consideration grade, curvature, accessibility, signaling and train operation.

PERFORMANCE IN 1965

During the year 1965, a total of 788 journals were discovered which required attention. Of this total, 505 were detected by our hotbox detectors and set out in terminals. On line of road, 252 cars were set out with defective journals. In addition 31 journal failures occurred. Our records on those set out on line of road and those with journal failures do not reflect which were discovered by detectors, nor do we have records of false indications. To properly evaluate our hotbox detector performance, it will be necessary that a better system of records is established.

OVERTIME CALLS

During 1965, overtime calls due to defective hotbox detectors amounted to 385 hours. Complete records were not available detailing maintenance hours required during regular working hours. Suffice it to say, several hours were consumed. Hotbox detector equipment is certainly not trouble free and it does require considerable attention. To this end, it is recommended that the suppliers concern themselves with better quality control of their products, better and more complete maintenance manuals including complete parts references and design of equipment for ease and simplicity in alignment and maintenance.

Our plans for this year contemplate the installation of six additional detectors, moving six further out from our terminals and converting these six to bi-directional scanners. In addition a close look will be taken toward centralization of readouts at Springfield, Mo. We believe there are many benefits to be derived by centralized readout. **RS&C**

SOU put in hotbox detectors in '58

By R. C. Pace
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Signal & Electrical Dept.
Southern Railway System

Hotbox detectors were first installed on the Southern Railway System in 1958. The purpose of the first detectors was to inspect trains immediately prior to their arrival at terminal points in order that necessary action could be taken on hotboxes or journal boxes with abnormally high temperatures. The wayside detectors were located approximately 30 minutes from the terminal points with the information transmitted to a graphic recorder in the general car foreman's office at the terminal point by carrier imposed on existing line wires. Radio communications were used to stop the train if a journal was shown to be in imminent danger. The detectors were calibrated with the graphic tapes to indicate an 18 mm pip when the journal box was 100° F. above ambient temperature. Trains with a friction bearing journal showing a temperature of this magnitude or higher were instructed to stop immediately and check the journal. Trains with roller bearing journals showing a pip height of 25 mm were instructed to stop. All journals with indications of temperatures above the average of the other journals in the same train were inspected upon arrival of the train at the terminal point. Since the installation of microwave on the Southern Railway, practically all of the telemetering of journal information and voice communications have been changed from line carrier to microwave. There were approximately 50 of these detectors installed originally and there are now approximately 54 in service.

An additional system, utilizing approximately 80 wayside detectors, was started in 1960. This system was designed to inspect trains periodically as they moved from point to point along the railroad. This information was telemetered from the outlying detectors, located at points over the entire Southern System, to a central recorder room located in Atlanta, Ga. A vast system of carrier was installed on existing line wires to establish this communications and voice communications between each detector location and the central recorder room. Each detector, lying outside of a perimeter formed by four switching plants located at strategic points around and approximately 100 to 150 miles from the central recorder room in Atlanta, had a single channel carrier extending from the detector to a grouping point from which a multichannel carrier extended to one of the four switching plants. There were approximately 10 carrier channels between each switching plant and the central recorder room in Atlanta. Each detector lying within the perimeter of the four switching plants, had a single channel carrier extending to the central recorder office. There were approximately 40 recorders installed in the central recorder office which averaged about one recorder for two detectors. This does not mean that each recorder was assigned to any two detectors. The selection of recorders was assigned in proportion to the probability of the necessity of their use.

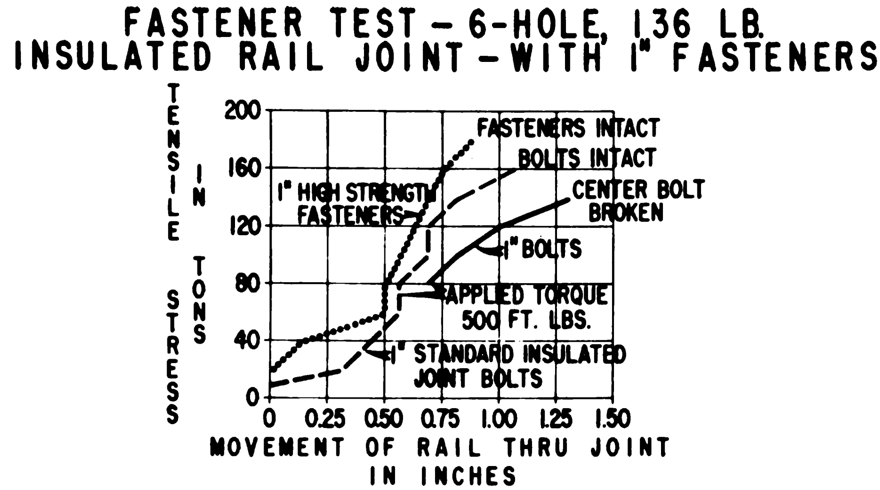
The recorders were equipped with three styli, one each for journal boxes on the No. 1 and No. 2 rails and one to indicate both the location of the transmitting detector and the direction of the train movement. Radio transmitters and receivers were installed at each detector with an antenna installed on a 100 ft tower erected at each site. Trains with journal boxes indicated to be in distress were notified immediately by the tape reader from the central recorder office.

This system has expanded to 128 detectors, and additional detectors are proposed. The data transmision has also been changed from line carrier to microwave. All detectors now have a microwave channel to the Atlanta central recorder office with a single switching plant in Atlanta for recorder selection.

In non-signalled territory, dragging equipment detectors were installed at each hotbox detector location and the detection of dragging equipment was transmitted to the central office recorder room by a series of five high pulses on the hotbox detector channel. As the five high pulses would obliterate the hotbox scanner signal, trainmen were instructed to inspect the car for hotboxes as well as dragging equipment when this signal was received.

Santa Fe tests insulated joints

By F. H. Smith
Assistant Engineer
Santa Fe Railway System



This is a graph of rail movement through an insulated joint plotted against the force which caused the movement. There are three fasteners shown on the graph. The dotted line shows action of a joint with six high strength fasteners applied with over 60,000 lb. of tension in each fastener. The dashed line shows a joint with six original equipment bolts torqued to 500 ft lb. or about 30,000 lb. of tension. The solid line shows an inferior set of one-inch bolts applied in the same manner as standard bolts. Note that as fasteners improve, resistance to bending and breakage also improve.

The subject of this discussion is testing of insulated rail joints and components with procedures developed on the Santa Fe. The most frequent failure on the Santa Fe was insulating bushings, with end posts a poor second, and other failures somewhat rare, at least comparatively speaking. Problems on other roads will not necessarily be the same because of differences in climate, materials and methods.

The Santa Fe began testing insulating material in 1956, using field test methods and various materials, all of which had impressive physical properties. These tests were carried out by my predecessors, R. G. Garland and E. L. Honath, in cooperation with various suppliers. Although these tests did not result in finding a new material, they did eliminate several products and provided a very good background for later tests. The problem of providing a bushing to resist the forces developed between the bolt and the bar, and an end post to function between the planes of the rail ends had proved anything but simple. Also, the handicaps of field testing were very evident. In order to obtain a good evaluation, it was necessary to use sizeable samples, to find suitable test locations, to arrange for installations and subsequent inspections, and to provide documentation based on the memories and willingness of local people. These tests were expensive and slow to provide reasonable evaluations. Both the supplier and the railway company were faced with a one to three year wait for results which were of questionable accuracy.

My first test in 1962 involved a small sample of polyurethane bushings and end posts. This test was documented with rail temperature, joint gap measurement, trade name of the material and very little else. This material survived a one-year field test with flying colors. The following year, a larger sample was installed and the material flopped miserably. I was disgusted with the inaccuracy of the original test. Two years had elapsed and we had nothing to show for our efforts except the elimination of one more product. We suggested to the manufacturer that he might obtain better distribution of stress on his material by using a steel shielding. The manufacturer quickly provided the new shielded bushings and end posts and we were again faced with the necessity to test this new product and several others in which we were interested.

Just prior to the scheduled start of this series of tests, I became involved in the rescue of a hydraulic rail puller from discard in the manufacturer's attic. Some very successful experiments in welded rail end behavior were conducted on our Plains Division and the usefullness and effectiveness of the puller were proved. These experiments provided a basis for determining stress to be placed on rail joint components for test out-of-track and the rail puller provided the means of imposing and measuring this stress.

Instead of starting a second series of field tests, I decided to run preliminary tests out-of-track using the puller to impose a tension load on rails, connected by our test joint, much as stress is imposed by cooling of rail in the field. There was some concern at first, lest absence of live load and environmental conditions of temperature and moisture would invalidate test results. However, we were able to reproduce field failures of bushings so closely as to defy detection. End posts were tested in a press at 250 tons imposed on the full face of the material. This test proved too lenient. While end posts which failed this test could not have succeeded in the field, some of those which passed it had earlier failed field trial. Of seven materials tried in a three day period, only one was accepted for field test.

FEWER FIELD TESTS

Thus the need for expensive field testing was enormously reduced and much added impetus was given to testing of the successful product. These tests, with some modification, are an excellent preliminary qualification trial for experimental joints and components and have reduced evaluation time from a matter of years, to only a few days. They have also accelerated product development, since test samples are available to the manufacturer and quick changes in design have resulted. Ad-

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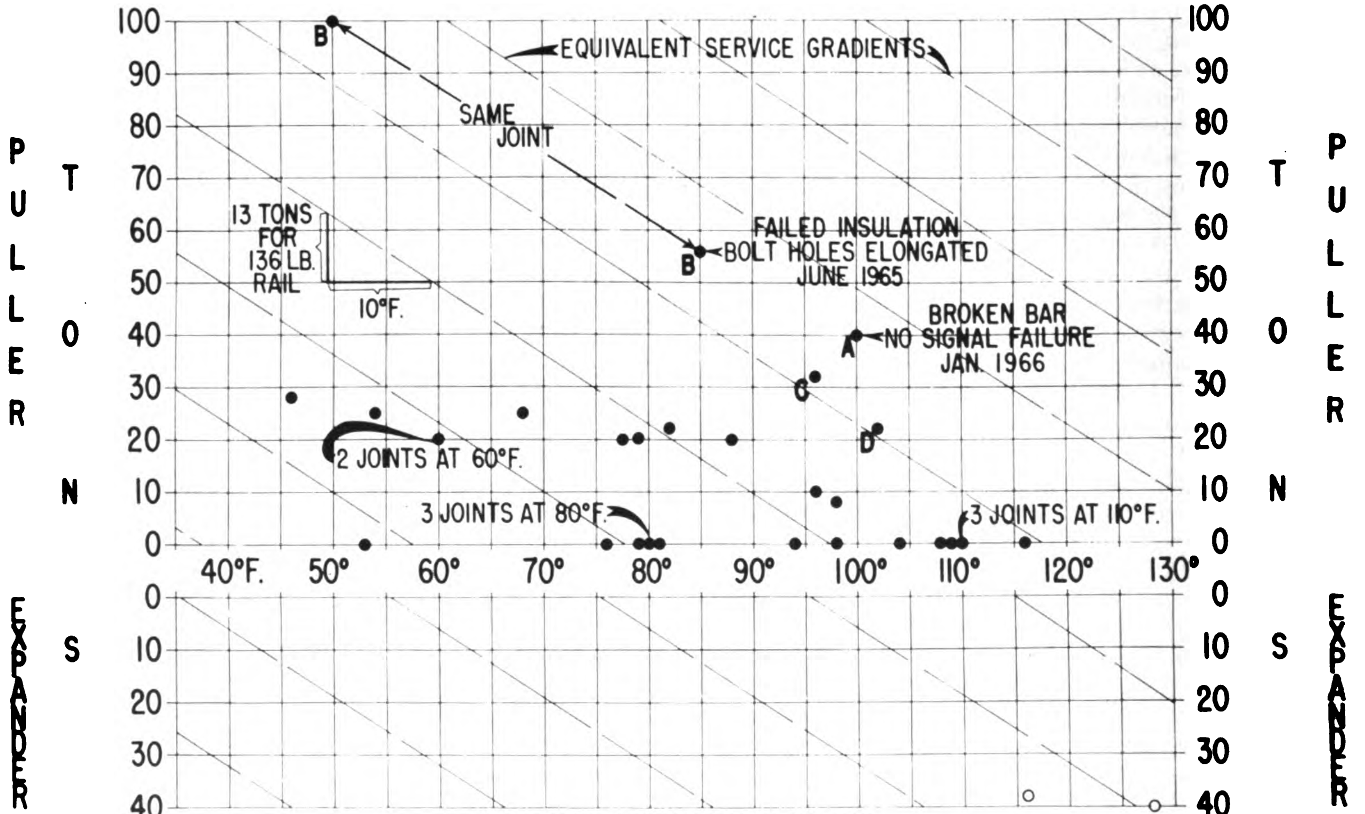
ditional tests for bolt strength and frictional resistance to rail movement through joints also provide valuable information.

During progress of the first simulated tests using a 120-ton rail puller, it was determined that capacity of the device was inadequate for test of 6-hole joints completely assembled with six bolts. Most of the early tests were conducted with only a single bolt on each side of the joint gap. Bolt and bushing tests are still made with only two bolts in order to eliminate as many variables as possible. In order to be able to test complete joints when desired, we collaborated with the puller manufacturer to build a 200-ton hydraulic rail puller-expander. With this new device, we established minimum approval values of 180 tons tension stress for complete joints which must be replaced in their entirety upon failure, 50 tons per bolt for replaceable insulating components and about 60 tons sheer stress, in the joint, for each bolt or fastener. Since we find low temperature closure pressures in excess of 120 tons in the field, these values are deemed entirely reasonable.

At this same time, we raised end

INSTALLATION DATA
RAIL JOINT INSULATION TESTS
FALL OF 1964



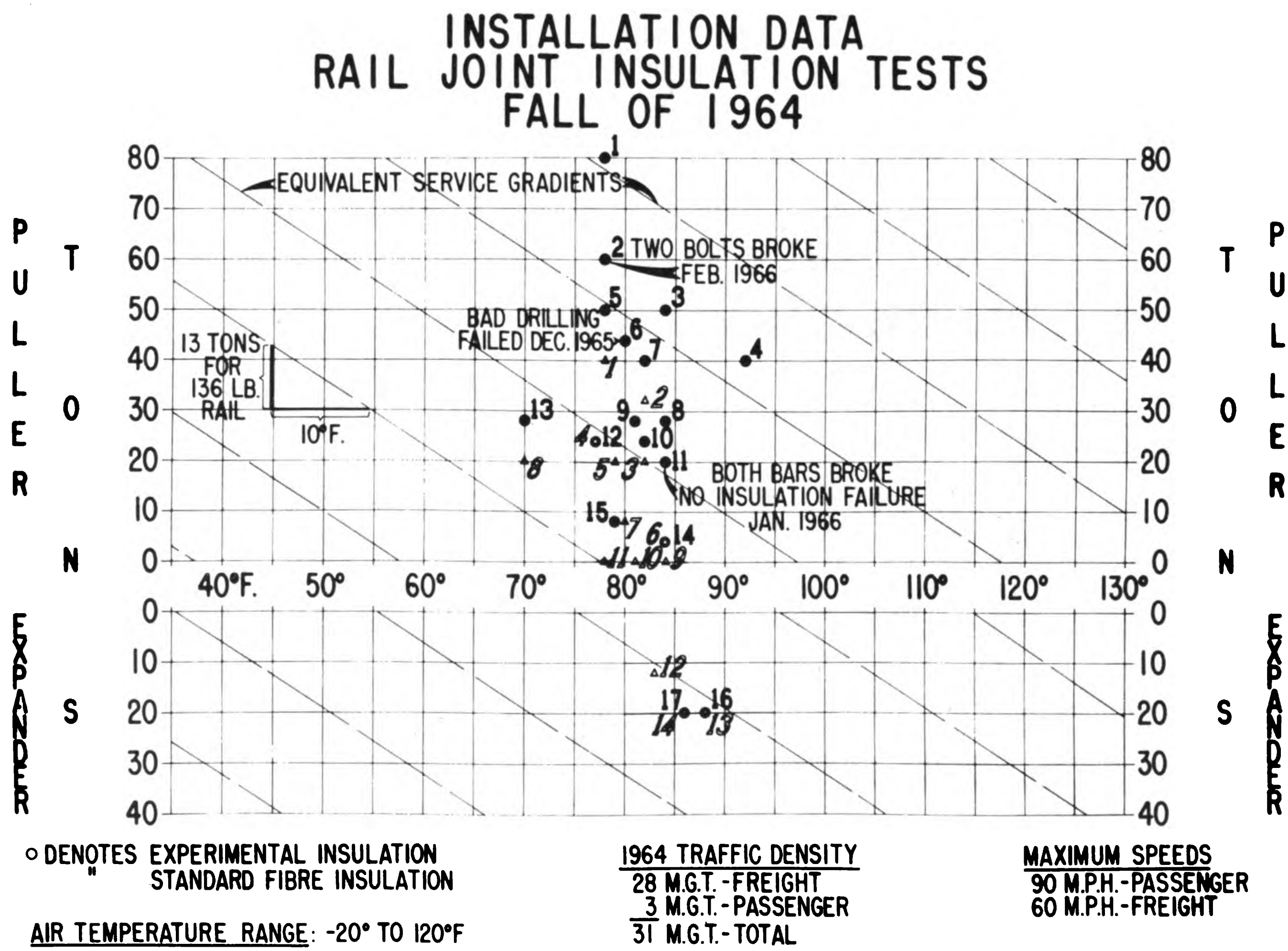
EXPECTED CLOSING FORCE AT -10°F.

JOINT	FORCE REQUIRED
A	183 TONS
B	178 "
C	170 "
D	168 "

This is another graph of a field test installation. The circles indicate experimental insulation installed in a rail joint in 136 lb. welded rail at the indicated rail temperature and adjustment pressure. Again, we have shown the Equivalent Service Gradients for 136 lb. rail. Joints A, B, C and D have very severe low temperature service as indicated in the table of expected closure pressures at 10 deg. below zero shown below the graph. It is interesting to note that the two readings on joint B are parallel to the Equivalent Service Gradient just as we said they should be. It is also important that the test insulation is failing in the range where steel parts are damaged. Rail end stresses in the range shown for joints A, B, C and D are excessive and should be corrected since they are abusive to rail end drilling, bolts, insulation and bars. Of the 33 test joints, very few would survive with fibre insulation.

post qualification standards to 10 cycles of 300 tons on head area only. Posts should survive this test in serviceable condition in order to warrant field trial. Of three complete joints of new design offered, two have been rejected and one has tentatively been accepted for field trial. Of 19 bushings tested, 16 have been rejected, two are scheduled for further testing and one is now being used as standard equipment. Of 36 end posts tested, 33 have been rejected, two are scheduled for further testing and one is now being used as standard equipment. Correlation between the end post qualification test and field tests is not as good as is the bushing test. The largest force we have measured in the field tests is 60 tons compression load on the end post. Remember, we said tension loads in excess of 120 tons and a compression load of 60 tons. It is clear that much of the damage to end posts comes from live loads and environment rather than one application of temperature stress. Else, we would not have to test at 300 tons, or five times the maximum force expected in the field.

Our efforts to document our tests do not end with preliminary qualification tests. Required data for field test now includes: rail end gap prior to adjustment, rail temperature and measurement of force necessary to adjust rail end gap to ⅜-inch. It is clear from data collected thus far, that rail joint behavior is predictable on the basis of our data, plus requirements that drilling be accurate and bolt strengths be reasonably uniform and adequate. Bad drilling or a weak bolt cause failures at less



This is a graph of a field test installation involving experimental bushings, end posts and head and base pieces shown by circles and standard fibre insulation shown by triangular symbols. It shows the rail temperature at joint as the test was installed and the force necessary to adjust the rail end gap to ⅜ inch by means of a hydraulic rail puller-expander. The slanting lines on the graph, labeled Equivalent Service Gradients, are based on the stress change in completely restrained rail due to temperature change. This stress change amounts to 195 lb. per sq. in. of steel per deg. of temperature change. Since these tests are in 136 lb. welded rail with a rail end area of 13.35 sq. in., the gradient on this graph shows a force change of 13 tons for a 10 deg. temperature change. In simple terms, all joints which fall on the same slanting line resist the same stresses when their temperatures are equal. All of this enables us to predict much of the abuse to which a joint will be subjected at various temperatures through out the year. Results of this particular test after one year, were 16 failures in 10 of the fibre equipped joints and no failures in the 17 experimental joints, even though, as can be seen on the graph, low temperature service for the experimental joints was much more severe. Certainly, this test shows that the experimental bushings will survive where fibre will not. Note that this test was in high speed main line with 90 mph passenger and 60 mph freight speeds, 31 million gross tons of traffic, 136 lb. welded rail and an ambient temperature range of 140 deg. We asked our people to test in the worst joints they could find, and the graph shows that they did.

than expected stress.

Credit for our testing program really belongs to our Chief Engineer R. H. Beeder and our Assistant Chief Engineer H. E. Wilson. They believed that testing was advisable and that a better insulating medium could be found to take the brutal punishment given bushings and end posts. They provided all of the equipment, aid and advice required to keep the program going and appeared to have far more faith in our chances of finding better materials than I did.

Just one word of caution. If any of you decide to conduct tests such as these, bear in mind that the forces we are using are rather large. During end post tests, wear goggles and stand out of the line of fire. Many materials virtually explode under pressure. During bushing tests, use caution around heavily loaded components and approach from a safe angle away from rail ends. **RS&C**

Communications approach to managements' needs

By Robert J. Maher
Staff Representative-Sales
American Telephone & Telegraph Co.

The interdependence of systems people and the communications engineer cannot be over-emphasized. However, the recognition of the mutual needs and wants of these two groups is only part of the story.

The overriding important question which must be answered is, "What does management want?" Operating or middle management people will have some ideas as to what the overall policy is—or should be—but in the final analysis you will agree that it is the prerogative of top management to delineate policy and the objectives of a business. Once these policies and objectives have been established, it then becomes the responsibility of the various department heads to achieve these objectives, and in the present and future scheme of things the man responsible for communications must play a key role in determining how the objectives are going to be met.

In recognition of the problems of rating and routing a company was recently formed in the Midwest to provide computer updating service to the large shippers and also to provide such other services as rate searches and remote preparation of bills of lading, and freight bills. The bills of lading preparation has been demonstrated to several shippers and transportation groups. This is how the proposed system would work:

A shipper would transmit coded information to the computer center by means of TWX, Telex, Data-Phone Service or private line data or teletypewriter service. The computer would then search its files and the output would contain a completed, routed (as established by the shipper), rated—including divisions—combined bill of lading/freight bill. This information is transmitted from the computer to a teletypewriter or business machine equipped with multi-part forms located at the loading dock. In addition, the information can be routed directly to the carrier (highway, air freight, water or railroad) and received there on paper tape—for advance preparation of freight bills or waybills. A memo copy of the bill of lading can be sent to the destination. Another aspect of the system which shows great promise is the inclusion of a bank in the distribution. From the information contained in the bill of lading the bank can debit the shippers account and credit the accounts of the carriers. The need for billing could virtually be eliminated and transfer of funds could be verified through the bank statement.

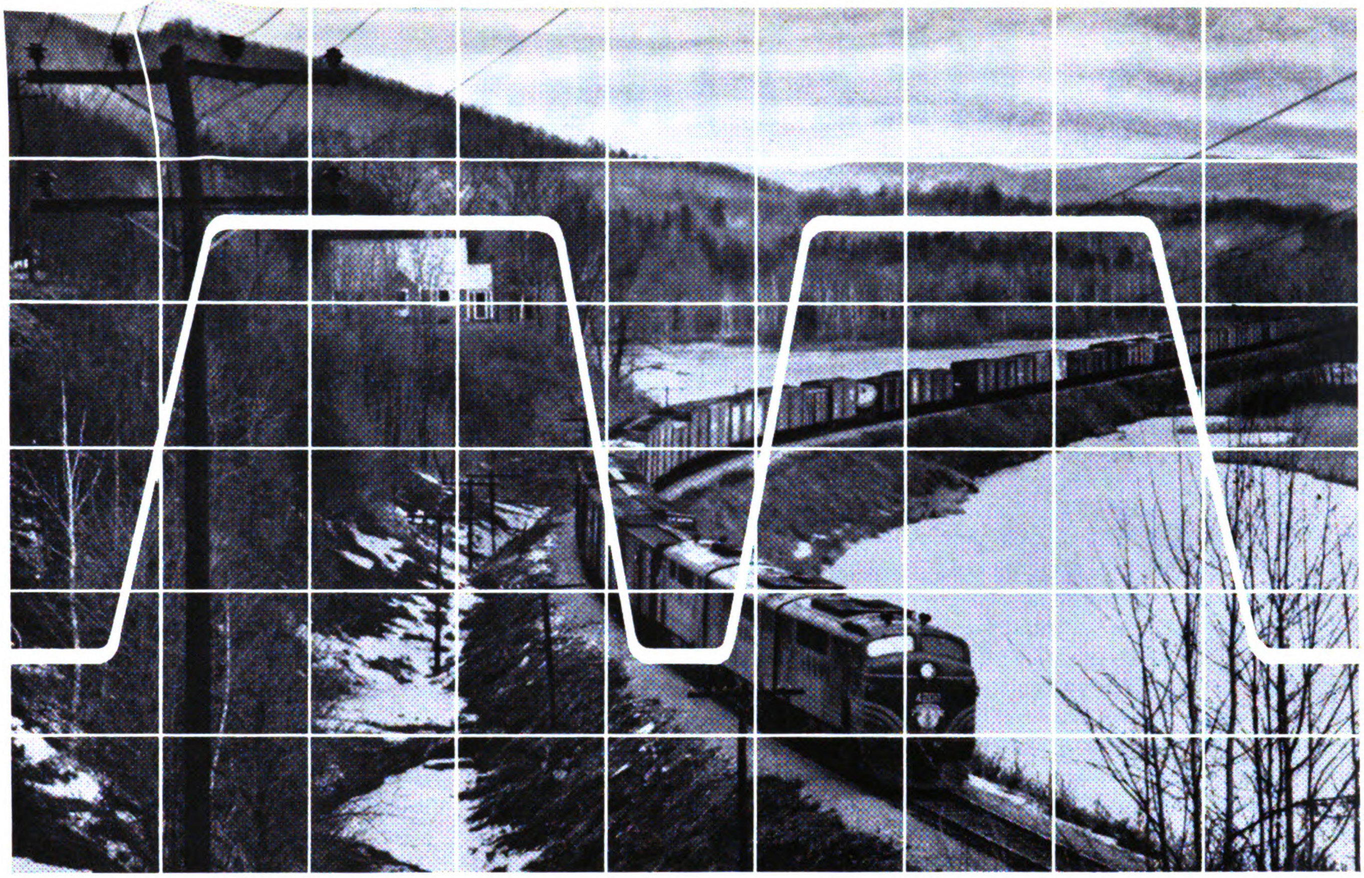
The other area which will affect transportation is shipper access to car movement information. Production and distribution have long been closely allied with transportation. In those cases (automobile assembly lines for instance) where delivery of components has been closely integrated with production, local arrangements have been worked out between the carrier and the manufacturer to insure continuity of supply.

In a great many industries such tight control was considered unnecessary and the usual procedure was for the shipper to advise the consignee that a shipment "was on the way." However, with the sharply increasing costs of storage, distribution and handling, the users of products became more insistent that they be advised as to the progress of all shipments. This placed a terrific burden on the shipper and as a consequence the demands were transferred to the carrier. If the railroad had a good car reporting system—and the movement was local—the shipper was able to keep close tabs on the shipment. The problem was not so easy to solve on an interline movement because the car information between carriers was keyed to the accounting and operational requirements of the carriers themselves and general car movement information for the shippers needs was not too readily available. In some cases, elaborate tracing bureaus were established to fulfill the needs of special customers.

Several railroads who have reached the stage of sophistication in the control of car movement—data communications linked with computerization—have offered a service whereby a shipper or car fleet owner has direct access to the railroads car movement inventory. On some roads the shipper initiates the request and on others a status report is automatically transmitted by the carrier.

In the first arrangement, the shipper accesses the railroad's compu-

(Please turn to page 30)



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(Continued from page 28)

ter by means of TWX, Telex, Data-Phone service or private line. When the computer receives the request (with proper identification codes) it automatically searches its memory and transmits the required information—which can be the entire history of a move or the most recent move as desired by the shipper.

The second arrangement does not require an inquiry by the shipper. An automatic calling unit associated with the computer places a call to the shipper either on a timed basis or whenever there is a move of interest to a consignor, consignee, car owner or freight forwarder.

A third system, which is as far as I can determine, still in the planning stage, utilizes a digital input voice answer concept. In this arrangement a dial through unit such as a Touch Tone telephone would be used to access the computer memory. The voice answer arrangement would provide the greatest flexibility and would open a number of possibilities to freight sales people shippers, freight agents, car owners and so on.

The carriers offering shippers direct access to car movement information are finding that the service is expanding at a fast pace. And therein lies a tough communications problem. As you can imagine, other carriers are taking advantage of this service—particularly those who interchange cars. The situation would be complex enough if access was limited to carriers operating in the same mode—but as intermodal carriage expands, all carriers would be forced to offer this service to all comers at great expense for the additional computer and communications capacity which would have to be provided.

The answer would seem to be in the establishment of regional clearing houses owned by the carriers. Each carrier would transmit to these clearing houses all records of moves and the clearing house in turn would advise the shippers and other carriers of the progress of shipments. The payoffs of such an arrangement would be manifold—since all the efficiencies of a good information system would be made available to the shippers and carriers alike. The carriers would benefit through better utilization of available capacity and control of their units particularly when they are away from their properties. The shippers in turn would have tighter control of production and distribution with the inherent savings of manpower and space in being able to know where their shipment is and when it will arrive at its destination.

NEW HORIZONS AHEAD

There are many other areas in transportation where the combination of data processing and communications are opening up new horizons. In the not too distant future, transportation, terminal and maintenance managers will be better able to plan and predict their operations with the aid of computers which can simulate an activity and when certain variables are incorporated in a program the computer can point out in detail the best course of action to be followed. These computers will have massive storage capabilities and access to this information will be gained through data communications operating on a real or semi-real time basis.

The close bond between data processing and data communications will be further strengthened in the coming years. The two can be brought even closer together to create a more effective information system than either can produce on its own. There will be an increase of on-line real-time data transmission systems in use. (The airlines reservations system is a good example of an on-line real-time system.) However, for the next five to ten years most systems will probably use the batch processing and transmission techniques. Real-time systems are both complex and expensive and their use may not be justified in all areas of transportation.

Since people are the final controlling link in an information system it would seem appropriate to make terminal equipments easier to operate. From some of my observations, however, I find the opposite to have been true. Before the advent of high capacity communications and computers, it seemed to be the best course to build in as much sophistication at the outlying stations as possible. And in transportation many of the outlying stations are in remote and inaccessible locations with the result that information systems are sensitive to breakdowns occurring at several source locations. The trend seems to be turning now and several of the control functions which were formerly handled "in the field" are being transferred to the computer. This has the real advantage of not only reducing the complexity of the outlying equipment but also reducing its cost. Of course, this makes the computer installation more expensive but where many outlying stations are involved, the increased cost at the computer will be more than offset by the reduction at the outlying terminals.

In further efforts at simplification at terminals, several carriers are using high speed facsimile. The high speed transmission of graphics is now practical with the use of wideband communications and expensive station equipment. Considerable work is underway to enable the transmission of high speed facsimile over regular voice grade channels.

The years ahead will see a growing complexity in data communications. No matter how large or fast or expensive computers become, scientists see no end to the need for more advanced machines and more refined systems. Developing new computer techniques and programs to fill current needs often results in methods that lead to the solution of other related problems. The mathematics used to solve military logistics problems, for example, could be applied to warehousing, transportation and distribution in industry. As electronic data processing develops and improves, so also do data communications. Our whole way of life is destined to be noticeably affected by computers and data communications.

The challenges of an integrated transportation information system, to the systems people and the communications engineers are manifest. In some cases a complete "new look" has to be taken at the methods of operating and informing. **RS&C**