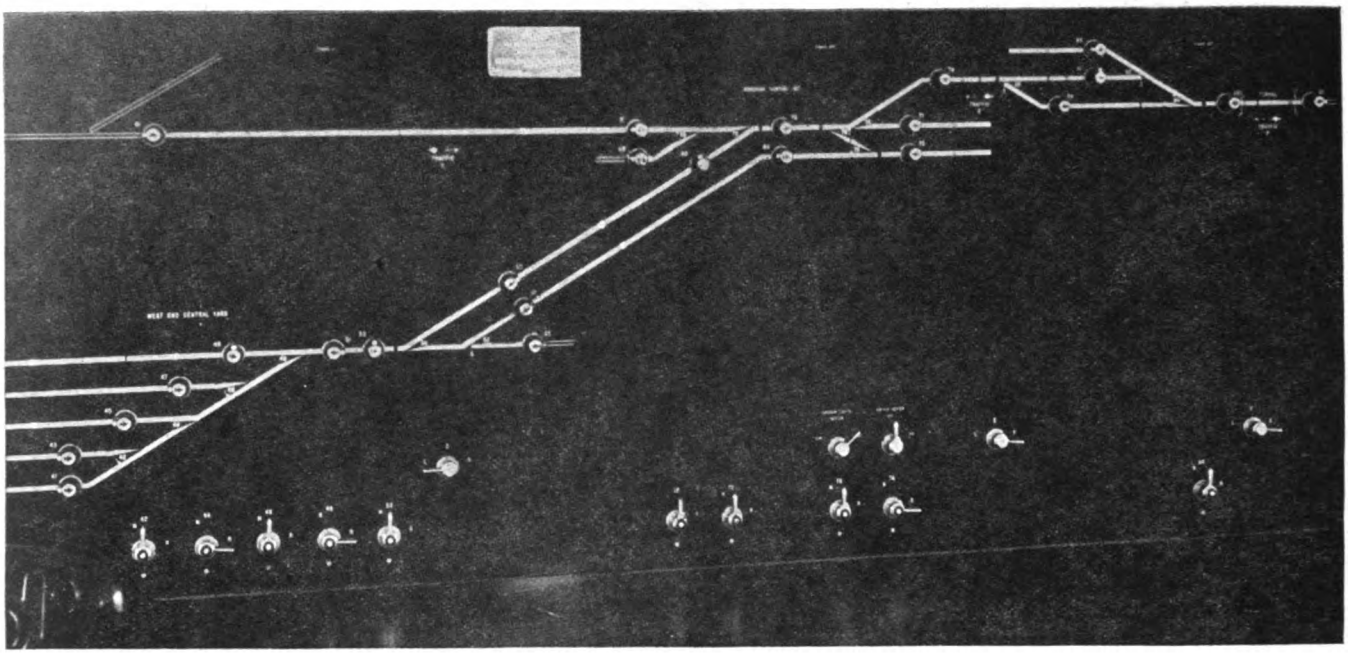


The control machine for the installation has separate switch, signal and traffic levers

Modern Interlocking Applied to *Ore Transportation*

By R. J. CORFIELD

Electrical Engineer, Utah Copper Division
Kennecott Copper Corporation
Garfield, Utah

Installation at large copper mine in Bingham Canyon, Utah, featuring miniature-lever control machine, searchlight signals and power switches, increases safety of mine train operation, and places one man in control of train movements in and out of one end of assembly yard

THE transportation of millions of tons of ore from the mine of Kennecott Copper Corporation, Utah Copper Division, at Bingham Canyon, Utah, one of the largest open pit mines in the world, together with an equal or greater tonnage of waste over-burden, requires the most modern loading and transportation equipment available. For this purpose a fleet of 41 5-cu. yd. full-revolving electric shovels are in operation loading ore and waste, and 64 85-ton electric locomotives are used to transport this material to either waste dumps or assembly yards. The property involved in this transportation problem, shown in accompanying photographs, consists of standard gage track running over the territory to be mined in a series of switchbacks, having a maximum grade of 4 per cent, and level tail tracks. A number of bridges, overpasses and tunnels are used to expedite traffic.

Under general operating procedure, all ore above elevation 6190 is brought down "off the hill" over surface lines, consisting of tracks along the various levels connected by switchbacks, and all ore below elevation 6190 is brought out of the pit through the 6040 tunnel, which are driven into the pit below its lowest rim to eliminate uphill haulage of pit ores. The route through the tunnel is shown in the accompanying diagram of the track and signal layout.

A normal downhill train is made up of 20 loaded steel gondolas, weighing about 116 tons each, and a normal uphill train consists of 15 empty gondolas, weighing 24 tons each. Speeds are maintained at approximately 10 m.p.h. up grade and 15 m.p.h. down grade. Waste trains use part of the track in the signaled territory, and there is also considerable movement of work trains and speeders. No definite preference is given to any particular type of train under normal operation. However, conditions may arise where it becomes necessary to give empties or loads definite preference in cases of emergency, and the signaling is arranged to take care of such a condition.

Prior to the installation of this signal system, switch tenders and flagmen were stationed at principal switch

locations, and telephone communication was used to route trains over the territory. While this system was quite satisfactory, it lacked positive safety and economy. The decision to signal the territory was based on safety rather than economy. Operation to date indicates, however, that there will be a saving due to the fact that, with one man in control of all train movements to the central assembly yard, trains are moved much faster. It is also evident that the train crews work with more confidence under signal protection.

The Control Machine

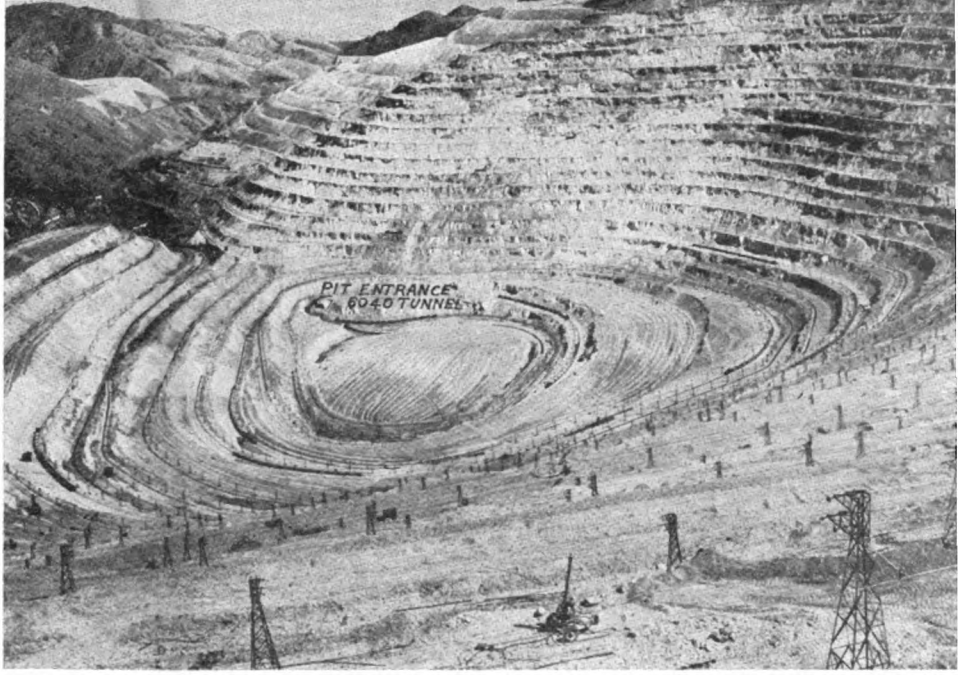
The control machine selected for this installation has a panel with separate switch, signal and traffic levers. There are 10 switch levers, 24 signal levers and 3 traffic levers. Track occupancy and switch positions are indicated to the operator, and directional routing permits preferential train operation. All switches are electrically heated, this feature being handled by one lever on the control panel, which controls contactors housed in the instrument cases at principal switch locations. The control machine operator has a public address system at his disposal to transmit any verbal orders to train crews, either approaching or in the assembly yard, as it is often necessary to double over with both empty and load trains.

Switch Levers

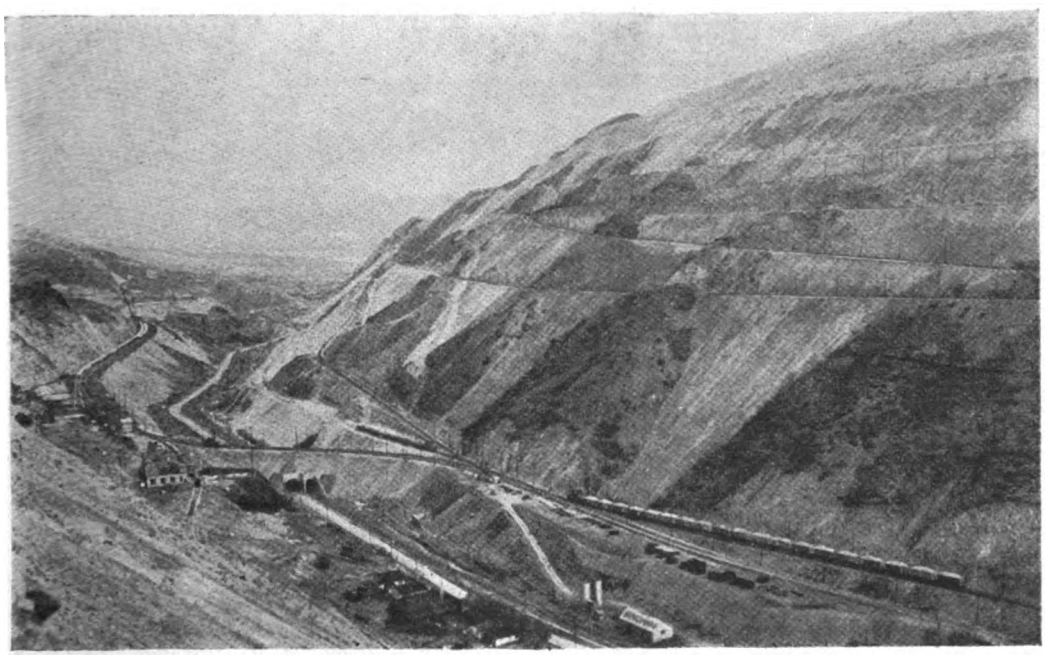
The switch levers are in a row below the diagram. They have two operating positions, normal and reverse, corresponding with the letters N and R engraved on the control panel at the lever. The lever for a particular switch is located below the location of its movable point indicator on the track diagram. The position of a switch is indicated by its movable point indicator, which is located in the track diagram at a point corresponding to the location of the switch on the ground. It is in the normal position when set to indicate a main-line route.

Correspondence lights are white, and are located directly below each switch lever. This light is illuminated whenever the switch machine is in motion, and while the position of the switch lever and the switch do not correspond. While this light is out, the switch and its movable point indicator are in the position called for by the lever. Red lock lights are located in the stem of each switch lever which, when illuminated, indicate that the switch is electrically locked.

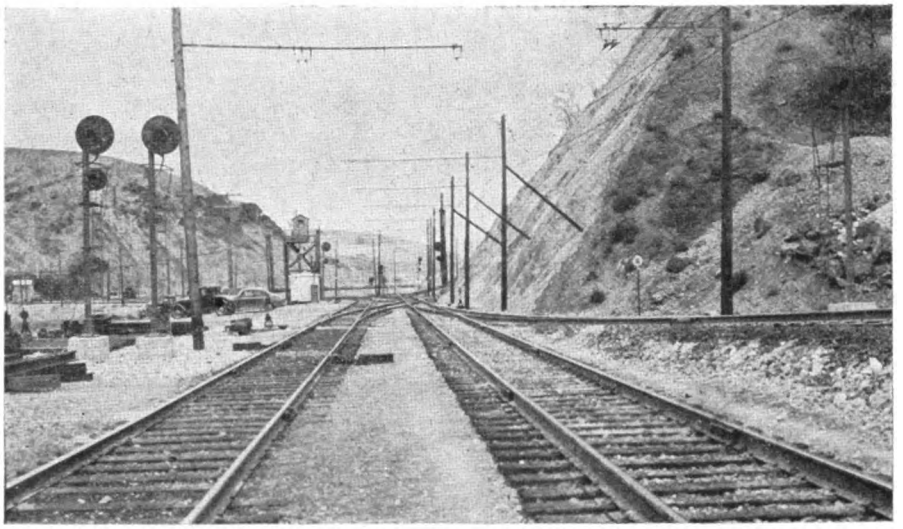
The signal levers are the rotary knob type. They are black and have a dark fixed arrow in the end to indicate the direction for which the corresponding signal can be cleared for train movements. These knobs are located at points on the track diagram corresponding to the location of wayside signals. In their normal position, a small white bead marker behind the fixed arrow on the knob is in line with the track. The top arm of a two-arm signal may be cleared by rotating the knob so that the white marker moves 90 deg. to a position above the track. The bottom or call-on arm of a two-arm signal may be cleared by rotating the knob so that the white marker moves 90 deg. to a position below



The mine pit, showing entrance into 6040 tunnel



General view of signaled territory in Bingham Canyon, showing switchbacks and tail tracks. The central assembly yard is shown at the extreme left



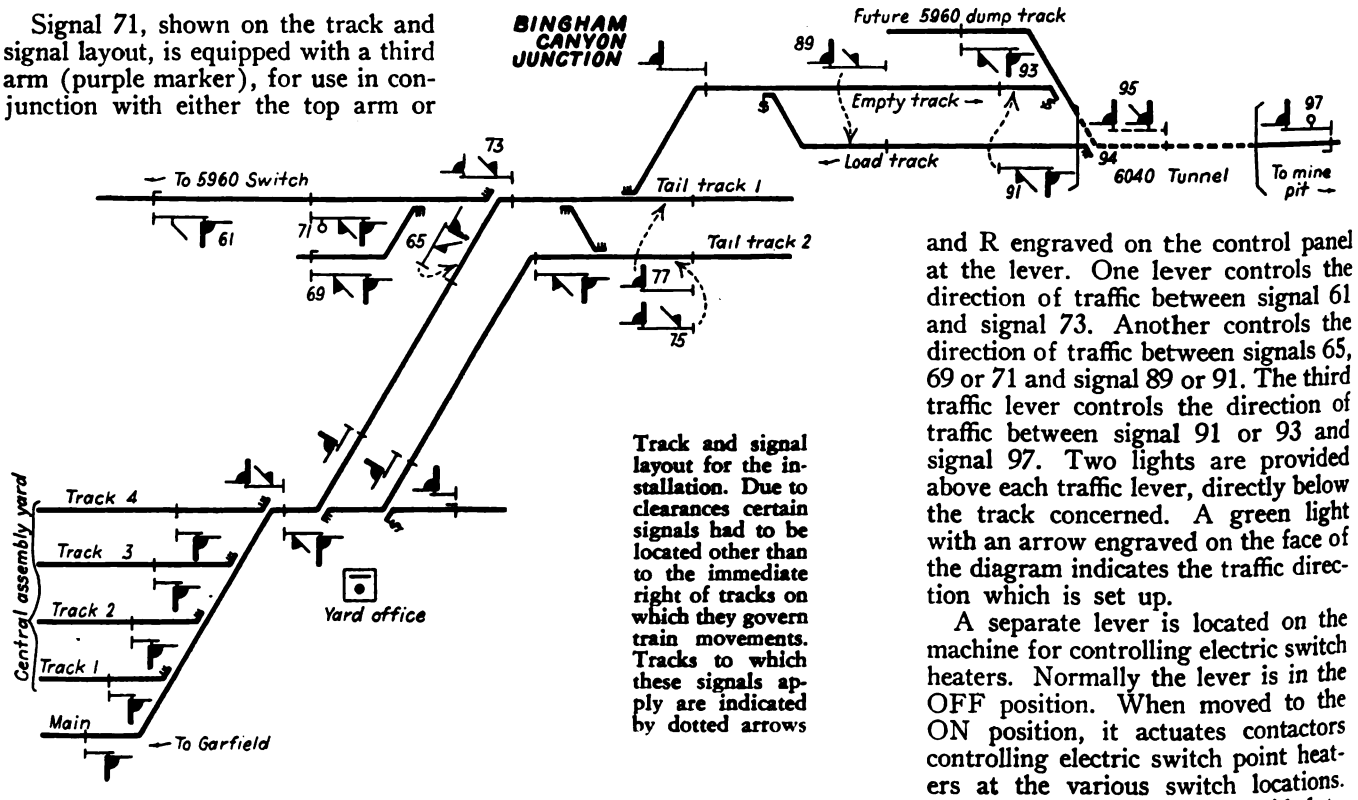
The signals on this project are the Type SA searchlight

the track. This call-on indication can only be displayed to advance empty trains or light engines into a block occupied by a preceding train beyond the opposing signal. One-arm dwarf signals may be cleared by rotating the knobs 90 deg. upward.

Special Signal Aspects

Signal 71, shown on the track and signal layout, is equipped with a third arm (purple marker), for use in conjunction with either the top arm or second arm to indicate that a train accepting this signal must move into the clear beyond signal 75 or signal 77. This indication may be displayed by rotating the knob either 90 deg. upward or 90 deg. downward and then pushing the knob.

All signals, except the lower arm of signal 61 are stick controlled and are placed at Stop by the passage of a train into the block. Signals may also be restored to Stop by rotating the knob back to the normal position, in which case, however, a time interval must elapse before the route may be changed or the opposing signal cleared. The lower arm of signal 61, once cleared, will continue to display the call-on indication until it is restored to Stop by rotating the knob back to the normal position.



Track and signal layout for the installation. Due to clearances certain signals had to be located other than to the immediate right of tracks on which they govern train movements. Tracks to which these signals apply are indicated by dotted arrows

Other Lamps on Control Machine

An opal lamp is provided in the stem of each signal knob, and when lighted, indicates that the signal is clear, except in the case of the knob for signal 71, where a steady opal light indicates that either a green or call-on indication is being displayed and where a flashing opal light indicates that the bottom arm (purple marker) is being displayed in addition to either a green or call-on indication.

In the solid white track lines on the track diagram are lights which indicate the occupancy of the particular track section in which the light is located. The presence of a train causes the display of a red light for track sections in which switches are located, and an opal light for track sections in which no switches are located. Three lights are marked "Power Off" are provided near the top edge of the track diagram, and when lighted, indicate power failures at signal 97, instrument case 95 or 89; signal 61 or instrument house; or at the yard office.

Traffic Levers

Three traffic levers are located in a row above the switch levers. They have two operating positions, left and right, corresponding to the letters L and R engraved on the control panel at the lever. One lever controls the direction of traffic between signal 61 and signal 73. Another controls the direction of traffic between signals 65, 69 or 71 and signal 89 or 91. The third traffic lever controls the direction of traffic between signal 91 or 93 and signal 97. Two lights are provided above each traffic lever, directly below the track concerned. A green light with an arrow engraved on the face of the diagram indicates the traffic direction which is set up.

A separate lever is located on the machine for controlling electric switch heaters. Normally the lever is in the OFF position. When moved to the ON position, it actuates contactors controlling electric switch point heaters at the various switch locations. Another single lever is provided to control the brilliancy of the lights on the control panel. The normal position of the lever is vertical or medium. When this lever is rotated to the left, lights are dimmed, and when rotated to the right, maximum brilliancy is provided.

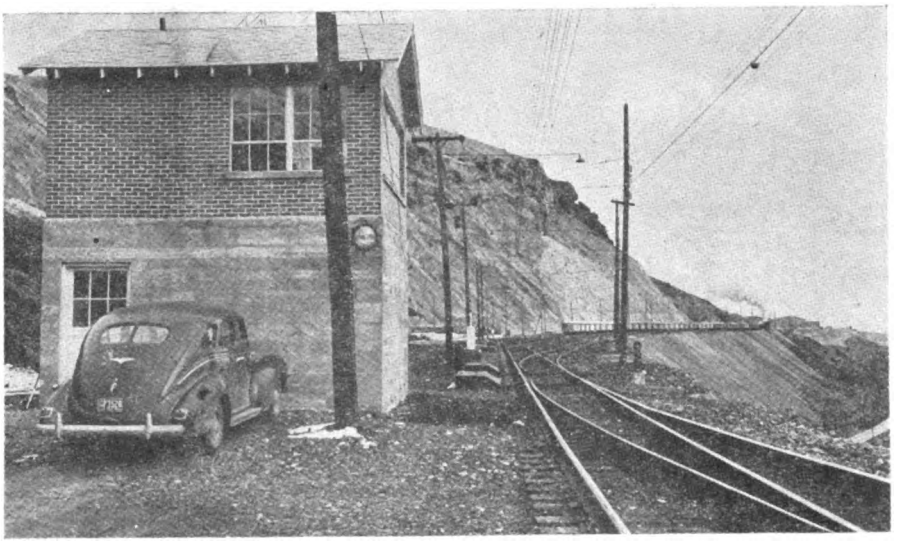
The control machine is located in a new tower at the west end of the assembly yard. Relay racks, terminal

boards, batteries and charging equipment are on the first floor, and the control machine, telephones and public address system equipment are on the second floor. Marine-view windows are provided on three sides, providing excellent visibility. The building is electrically heated and is arranged for natural ventilation rather than air conditioning.

Special Circuits

Signal circuits have been maintained as standard as possible special circuits being used only where necessary. One special circuit, governing operation through the tunnel, provides three timing circuits arranged to limit the speed of a loaded train down the 2-per cent tunnel grade. This 2-per cent grade breaks into a 4-per cent at the lower end of the tunnel, and should a train get out of control in the tunnel, it must be prevented from continuing down the 4-per cent grade. Switch 94, controlling a through movement down the 4-per cent grade, cannot be lined unless all timing relays have functioned properly. If proper speed has not been maintained through the tunnel, a Stop indication is given by signal 95 at the tunnel exit, and, if the train is under control, it must wait until timing is completed before the signal will clear. If out of control, and the Stop signal is over-run, the train is diverted over a tail track having a sharp adverse grade with sufficient length to bring the train under control. This track is designated as the future 5960 dump track on the accompanying diagram.

In order that operation of the central yard may be continued without interruption in case of power line failure, inverters are provided to feed the two track sections in which yard switches in the vicinity of the tower are located. The inverters operate from the main tower battery when the power-transfer relay is de-energized, thus supplying 220-volt energy to the primaries of the transformers feeding the track sections involved.



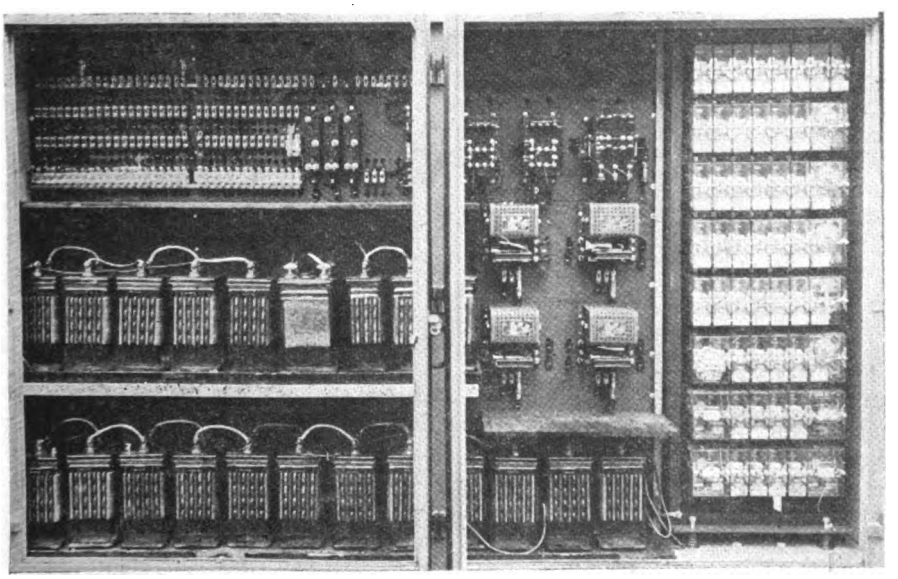
The new tower with the central assembly yard in the background

All signals, except signals 71, 95 and 97, display two or three principal aspects. These include a single green light (top arm of two-arm signals, with bottom arm out) for Proceed; single red light (top arm of two-arm signals, with bottom arm out) for Stop; and red-over-yellow for a call-on. It is often necessary to move light equipment; such as work trains, speeders and trolley line cars over this territory rapidly in emergencies, and rather than delay these operations by requiring such trains to keep within block distance of each other, the operator is able to set up the call-on aspect on most of the signals to govern these movements. Such an indication is for follow-up movements only, and indicates to the train crews that the tracks are occupied and they must proceed with caution, prepared to stop.

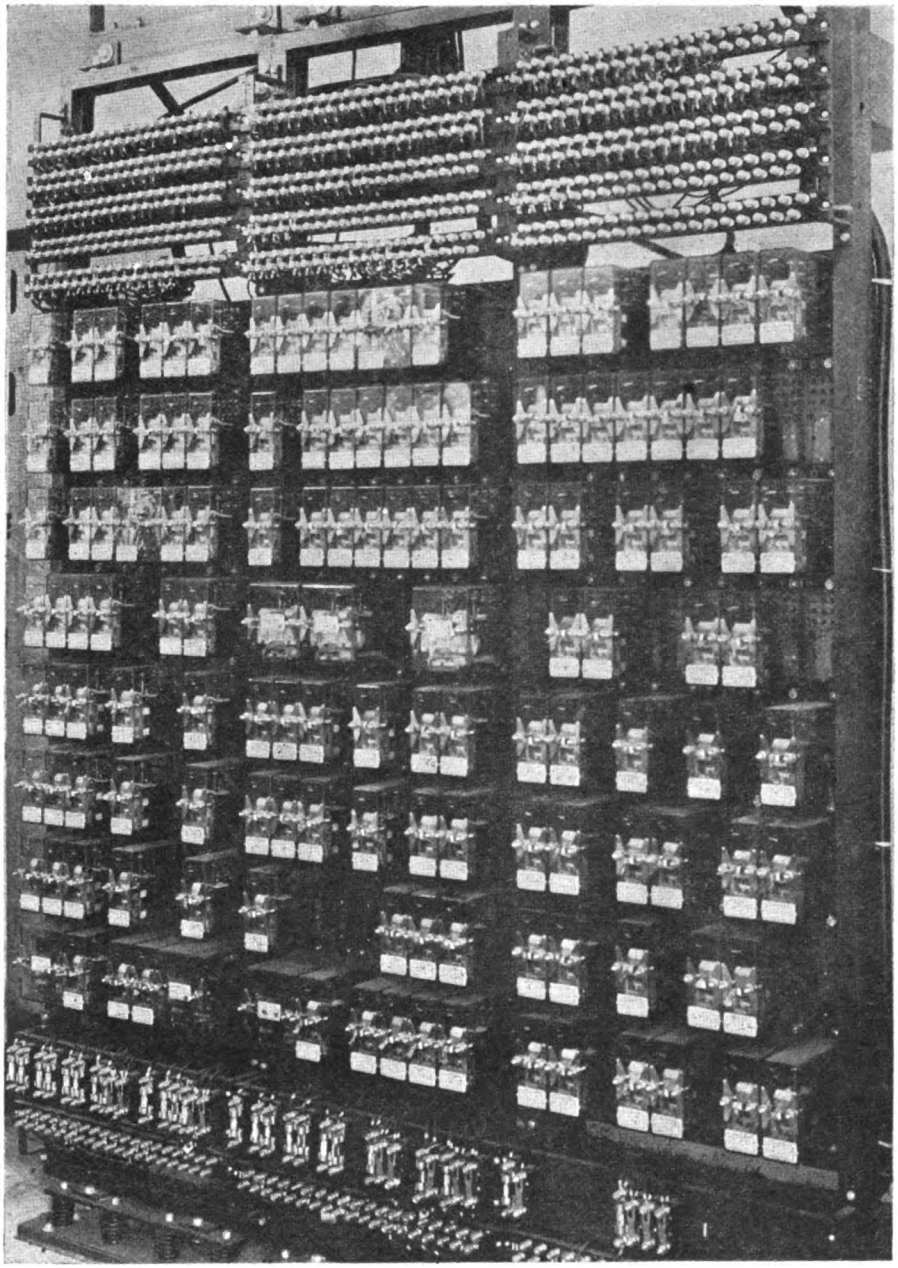
In addition to these aspects, signal 71 has a third arm (purple marker), and will display green-over-purple, indicating that a train is to proceed to tail track and clear the insulated joints at signal 75 or 77. A red-over-yellow-over-purple aspect is an indication for a train to proceed to tail track with caution-block occupied and clear the insulated joints at signal 75 or 77. Signal 95 is a two-arm signal, the top arm governing train movements to the load track and the bottom arm governing movements to the future 5960 dump track. Red-over-red indicates Stop; green-over-red, Proceed; flashing green-over-red, Proceed to signal 89 prepared to stop; red-over-green, Proceed to dump track; and red-over-yellow, Proceed to signal 89 or to dump track with caution on dump track prepared to stop.

High signals are the Type SA searchlight, either two or three position. Dwarf signals are used on yard tracks and high signals are used on main tracks. Switch machines are operated at 24 volts d.c., special attention being given to their support to assure good alinement without frequent adjustment. Insulated gage plates, 1 in. by 8 in., together with rail braces, are used. Operation from normal to reverse, including locking, requires about 10 sec.

The instrument cases and houses were factory wired, plug-in relays being generally used throughout. Overhead and underground wiring is in either single or multiple-conductor cable, having synthetic insulation and outer covering. Underground cable is buried directly in the ground and through the track ballast which is



Interior of double instrument case at signal location



Plug-in relays and rack in basement of tower

smelter slag. Aerial cables are suspended from steel messengers and supported in plastic cable rings.

Rails are of two sizes, 90-lb. and 131-lb. Standard, continuous rail joints are used and, as this is electrified territory, impedance bonds are required. All tracks are bonded with 4/0 gas weld bonds on the rail head. Bootlegs are terminated in the conventional manner. All housings are set on concrete foundations, a minimum of 12 in. above the natural ground level.

Batteries are of the lead type with Manchester plates, and have a capacity of 80 a.h. Five cells are used at signal locations and 15 for switch machine operation. All batteries are trickle charged from copper-oxide rectifiers. The primary power supply is at 2,300 volts and the secondary voltage is 220 volts. Track circuits are fed from adjustable voltage track transformers. The primary voltage is 220 volts and maximum secondary voltage is 8.5 volts.

This interlocking system has been in operation for a sufficient length of time to demonstrate reliability and efficiency in handling this particular type of traffic. The original design of the signal system was collaborated upon by H. L. Garrity, superintendent of mines, L. C. Jones, engineer of mines, and the author. Installation of the equipment was under the direct supervision of W. B. Reynolds. Operations at the mine are under the supervision of Mr. Garrity. The chief operating executive is D. D. Moffat, vice-president of the Kennecott Copper Corporation and general manager of its Utah Copper Division.

Iowa Grade Crossing Accidents

THE Iowa State Commerce Commission has issued a summary of highray railroad grade crossing accidents in that state during 1946. Following is a partial abstract of the report:

123 Crossing Accidents

During 1946 there were a total of 123 highway-railroad grade crossing accidents, in which a total of 76 persons were killed, and 109 persons were injured. Of the total number of accidents, 81 occurred during daylight hours; 42 during hours of darkness; 96 during reported clear weather; and 27 during reported inclement weather. Passenger trains were involved in 58 accidents, and freight trains in 48. Switching movements were involved in 17 accidents. Of the total number of accidents, 98 occurred at unprotected crossings; 25 at protected crossings; and 47 at crossings reported as having obstructed views. Automobile trucks were involved in 25 accidents, and vehicles ran into the side of trains in 27 accidents.

Hours of Accidents

The greatest number of the foregoing accidents occurred between 8 and 10 a.m., and between 2 and 3 p.m. Ten of the accidents occurred between 8 and 9 a.m., 11 between 9 and 10 a.m., and 10 between 2 and 3 p.m. The majority of accidents occurred during the months of February and December, 1946, when there were 16 and 18, respectively. With regard to fatalities, the biggest figure is for February, when 11 persons were killed. The most injuries occurred during December, when there were 19, followed by those in February, when there were 16.

Type of Protection

Of the 25 accidents at protected crossings, 11 occurred where flashing-light signals were provided; two where mechanical gates were in service; three where flagmen were on duty; four where wig-wag signals were in service; and five at bell-protected crossings. In one case, at a crossing protected by flashing-lights, a trainman was on the crossing giving signals with a lighted lantern. One pedestrian was involved in an accident at a crossing with mechanical-gate protection; two at crossings protected by flagmen; and one at a wig-wag protected crossing; so that 21 of these accidents involved the operation of motor vehicles.