EJ&E Uses Tone Coding to G

A unique tone coding arrangement is enabling the Elgin, Joliet & Eastern to privately operate radio systems in three yards on a single frequency. "The arrangement in effect gives us three separate radio systems while at the same time integrating all three yards on a single optimum channel utilization," says Signal Engineer W. K. Waltz.

The tone coding is achieved through use of Motorola Private-Line radio equipment, which operates on 160.260 mc. The three yards in the system are South Chicago, Gary Mill and Whiting, Ind. Each yard has its own tone code so that a message transmitted from a base station or mobile unit is received by only the other units with the same code. The key to its operation is a subaudible tone, which is transmitted along with each message and "unlocks" all properly equipped receivers. Tone codes used are: South Chicago, 179.9 cps; Gary Mill, 114.8 cps; and Whiting, 91.5 cps.

The Private-Line radio feature, reports "J" supervisors, provides maximum efficiency and utilization of the systems by eliminating the possibilities of any mix-up in orders and enabling the men to work smoothly without being disturbed by messages not intended for them.

"There is no possibility that an engine crew in another yard might re-

Left: Tone coding radio system includes footboard loudspeakers and controls on yard locomotives. **Above:** EJ&E dispatcher at hot metal office in South Chicago radios instructions to hot metal engine crew. **Right:** Walkie-talkies are also equipped to operate with the tone coding system.

Systems on One RF Channel

ond to an order not meant for it," ys V. M. Christensen, superintendent the South Chicago division. "For ample, we coordinate our 'hot metal' gines in both South Chicago and ary Mill by radio. A Gary Mill engine ew might mistakenly take a radio signment meant for a South Chicago ew. The results could mean delay in tting the job done, an engine crew asting vital time going to the wrong b, and much general confusion. This nnot happen with tone-coding, for e Gary Mill men do not hear the ders for the South Chicago crews. 'e also eliminate the necessity of veryone listening to each and every essage transmitted to make sure they on't miss anything for them."

Installation at South Chicago includes a base station with four remote ontrol points—the slab yard office, P&O yards, assistant supervisor's office and hot metal yardmaster's office. line locomotives are radio-equipped.)f these, five are used for yard work, he other four are on the hot metal uns. The locomotives have radio control inside the cab and also on the front nd back of the engine to provide the rew foreman with communication fa-ilities. The South Chicago installation lso includes a radio-equipped wrecker truck, a supervisory vehicle and five Handie-Talkie portable radios, used for ield work.

The Gary Mill system ties in eight diesel locomotives with remote control points at the hot metal yardmaster's office, coke plant yard office and assistant superintendent's office. Three walkie-talkies are used by trainmasters. At Whiting two locomotives are radio-equipped and controlled from one location. EJ&E has also ordered a number of spare radio units, including base stations for all three yards.

Main uses of the radio network, according to railroad officials, are: (1) to provide for the safety of the men; (2) to expedite customer service and provide pinpoint scheduling; and (3) to handle emergencies swiftly.

Instant radio contact makes possible fast aid in the event of an injury. The engine crew is able to radio a remote control point immediately to request first aid. "With this system we are also able to immediately reach a man to notify him of any important messages," Mr. Christensen explained. "We can move fast to send a man on his way home, for example, should there be an illness in the family. At the same time, we are lining up his replacement on the job."

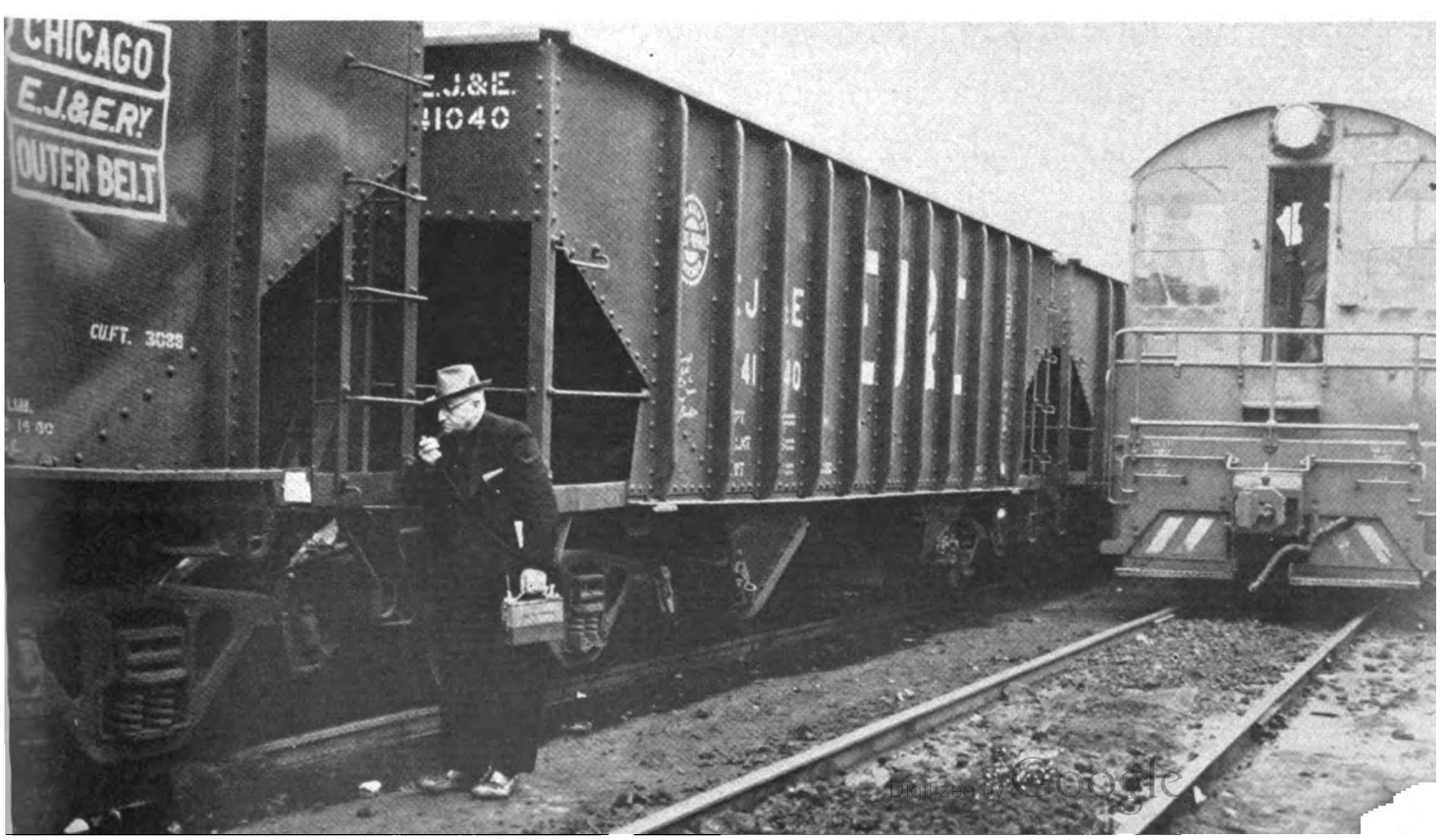
Immediate and steady contact with the engine crews enables the company to set up pinpoint scheduling programs. Timing is critical in hot metal work. When a furnace is ready an engine must be at the location as soon as possible. With radio, the yardmaster quickly contacts an engine to handle the assignment. This makes for improved customer service in all areas.

In case of a derailment of a car, the wrecker unit can wait until the last possible minute before radioing for an engine to pull the car back on the rails. Previously, an engine would often have to stand by until needed.

Supervisory personnel use the walkie-talkies to maintain constant contact with engines and the various offices. They can radio instructions and are always available to provide solutions to problems or be alerted to handle emergencies. The portables are also used when making air tests and for field observation work.

Private line radio operation is achieved by means of a unique squelch system which silences the audio section of the receiver. The squelch is not operated by the carrier and noise reduction, as is usually the case, but by a low-frequency audio tone which constantly modulates the carrier. This audio tone is below the voice range of 300-3,000 cps, however, and special filters are used to eliminate it in the audio stages of the receiver. By means of highly selective circuits and a high-Q vibrating reed, the squelch is made insensitive to all frequencies except that one to which it is tuned.

(Please turn to page 20)



An advantage of Private Line radio systems is that the equipment is continuously operated at full squelch sensitivity. With the conventional squelch system the sensitivity of a receiver squelch is subject to the setting of the squelch control. With the correct setting of this control, a weak signal will open the squelch. If the squelch control is advanced too far, however, the squelch sensitivity is lowered and this same signal may not be strong enough to open the squelch circuit.

The tone-operated squelch permits the sensitivity of the receiver to remain at its full value; the squelch setting is not adjustable. In Private-Line radio operation, the squelch will always be open for the weakest signal that is readable.

With his receiver squelched and in the absence of the carrier with its correct squelch tone, the operator is not only relieved from the necessity of listening to other signals on the same channel, he is also oblivious of interference signals, intermodulation and image response. Such "interference" may still be taking place in the receiver circuits, for this portion of the receiver is operating at all times, but the speaker is silenced and the operator does not hear it. As soon as his receiver is activated, by the correct carrier and tone squelch, however, it will operate in a normal manner, being subject to all the interference signals listed above.

Fig. 1 shows the block diagram of a Private Line transmitter which is designed to operate in the high band (160.260 mc on the EJ&E, for example).

The tone oscillator generates a low frequency audio tone (91.5 cps, 114.8 cps and 179.9 cps are the tone frequencies used on the "J"). The exact frequency is determined by the reed installed. This oscillator reed is called a Vibrasender.

The tone oscillator output is applied to the phase modulator together with audio modulation. Hence, the coding tone will be present at the transmitter output as long as the equipment is on the air.

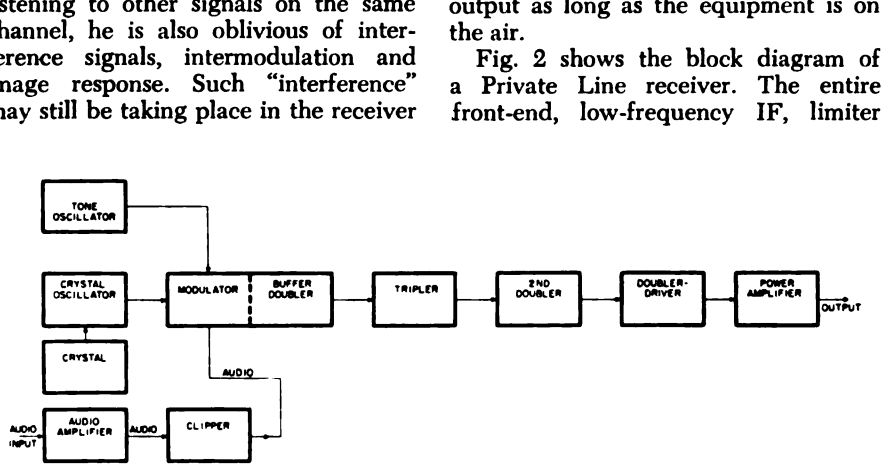
Fig. 2 shows the block diagram of a Private Line receiver. The entire front-end, low-frequency IF, limiter and discriminator sections of the receiver are the same as for a conventional receiver. The point of difference in this Private Line receiver, however, is to be found in the squelch circuitry. The discriminator output contains the audio message which is to be reproduced; it also contains the Private Line tone signal. This output is applied both to the low-pass amplifier and to the audio amplifier. Filters in the low-pass amplifier reject the higher audio signals, passing only those frequencies below 300 cps. The coding tone thus reaches the limiter amplifier where it is further amplified. The amplification is sufficient to properly drive the resonant reed, which is called the Vibrasponder.

When the correct tone is received the reed is energized, closing contacts so as to apply the negative DC bias voltage from the limiter to the grid of the DC amplifier stage. This negative voltage disables the squelch, allowing the receiver audio section to operate normally. When the correct tone is not present to operate the Vibrasponder, the negative voltage from the limiter does not reach the DC amplifier, the squelch is closed, and the receiver is silent. Thus, the only time that the receiver audio section is operative is when a tone of the proper frequency is received.

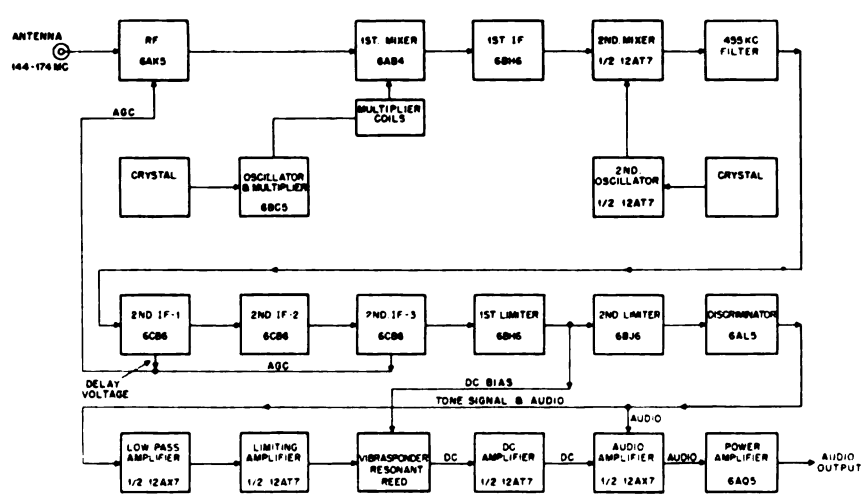
The highest frequency used for the audio tone (179.9 cps) is considerably lower than the audio range used in two-way communications (300-3,000 cps). It is therefore improbable that any normal voice transmission will open the squelch of the Private Line receiver.

When a transmission is completed and there is no longer any carrier present to provide quieting, the squelch might be expected to close, silencing the receiver. It is true that as soon as the squelch circuit goes into operation the receiver is silenced, but in actual practice the time constants of the squelch circuitry will keep the audio section of the receiver open for a short period of time after the carrier is removed. In the absence of a carrier to provide quieting and with the squelch still open, the typical FM noise reaches the speaker. This short burst of noise which is heard in the speaker as the carrier is removed is known as "squelch tail".

One simple way to eliminate squelch tail in Private Line radio is to remove the tone modulation at the transmitter a short time before the carrier is discontinued. During the period that the squelch requires to close, the carrier is present to provide quieting. By the time the carrier goes off the air, the receiver is already silenced by the squelch. RSC



HIGH-BAND "PRIVATE LINE" TRANSMITTER
FIGURE 1



HIGH-BAND "PRIVATE LINE" RECEIVER
FIGURE 2