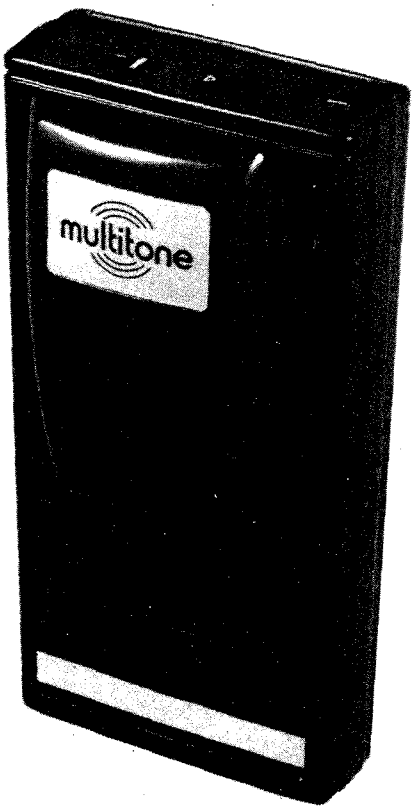
ALL ABOUT

PAGERS



Pocket pagers keep you from missing important calls, even when you're miles away from your phone. Here's a look at how pagers and paging systems operate.

PETE DeHAAN

YOU'RE IN A CROWDED RESTAURANT, there's talk and laughter all around you, when suddenly a *BEEP, BEEP, BEEP* fills the room. The roar subsides as curious heads turn to find the source. *"Mr. Jones,"* says a disembodied voice, *"please call your office."*

As Mr. Jones gets up and heads toward a phone, the talk at your table turns to the merits of pocket pagers—beepers, as they are sometimes called. You start to add your opinion, when you stop short. What exactly *is* a pager, anyway?

If you look about you, you're sure to spot them—carried by doctors, salespeople, maintenance crews, computer technicians, and others. Even your favorite TV crime-fighter may "pack" a pager on occasion. Let's examine how pagers work.

Basically, a pager is an FM receiver with a tone decoder and audio amplifier. In order to activate or set off a pager, some additional equipment is needed: a transmitter to signal the pager, a controller to turn on the transmitter and encode the signaling information, and a means for input to the transmitter. Before we discuss paging equipment, let's take a fast look at the radio frequencies used by paging services.

Frequencies used

The FCC (*F*ederal *C*ommunications *C*ommission) permits paging within several bands of frequencies in the RF spectrum. Those bands, however, are used for other purposes in addition to paging. The bands are divided and allocated by the FCC for such diverse functions as public safety, industrial communications, land transportation, public radio, etc.

One group of frequencies where paging is permitted is in the VHF (*V*ery *H*igh *F*requency) range and is commonly referred to as "low band;" it covers 30 to 50 MHz. Also in the VHF area is the "high band," with a range of 147 to 175 MHz. Farther up the frequency spectrum are the UHF (*U*ltra *H*igh *F*requency) band segments allocated for for paging: 406 to 420 MHz, 450 to 512 MHz, and areas in the 800-MHz band. Also being considered for paging are frequencies in the 900-MHz range. Again, those bands are not used exclusively for paging; many other types of transmissions are FCC-authorized for those frequencies.

As you can easily see, there are many frequencies that can be used for paging, and there are a number of different paging systems as well. They range from private business in-house systems to the offerings of RCC's (*R*adio *C*ommon *C*arriers), which are available to the public. Even though private users (industry, business,

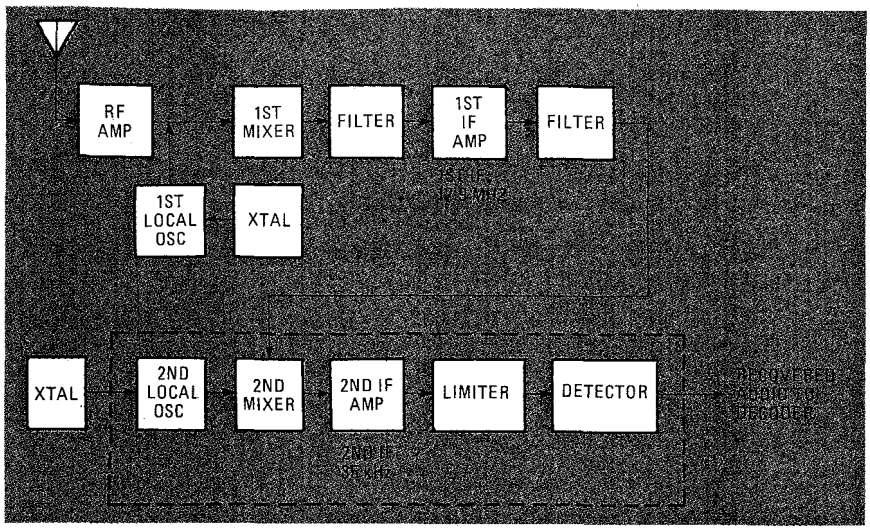


FIG. 1—RECEIVER USES TWO IF-STAGES (17.9 MHz and 35 kHz) to step signal down to a frequency where it can easily be limited and demodulated.

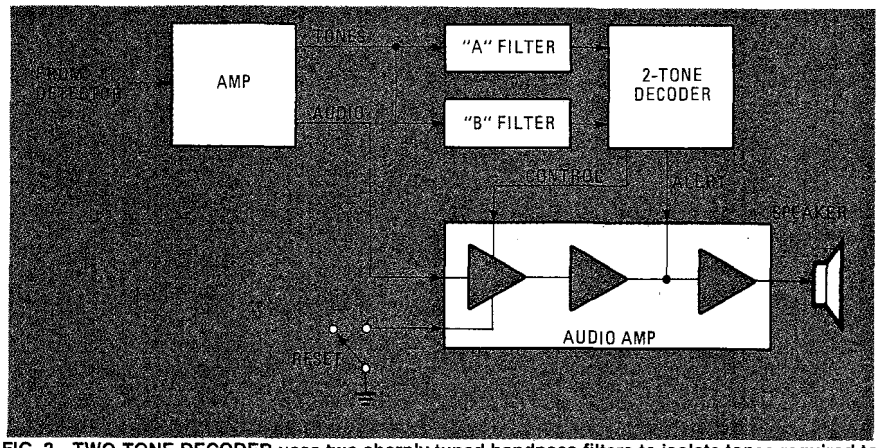


FIG. 2—TWO-TONE DECODER uses two sharply tuned bandpass filters to isolate tones required to activate pager. First stage of audio amplifier is not keyed unless tones are successfully decoded.

etc.) are permitted to own their own paging systems, they often choose not to. The reason is that they must file for, and be granted, a license by the FCC. They must also purchase and maintain their own equipment. Since that is both expensive and time consuming, many potential private users have, instead, sought the services of a local RCC. In that case, the user generally pays a fixed monthly rate to the RCC, which is, in turn, responsible for all equipment and licensing. For that and other reasons, independent RCC's across the country serve about 85% of the paging market. The most common frequencies of the RCC's are two VHF high-band frequencies referred to by the industry as P-5 and P-6—152.24 and 158.7 MHz, respectively.

Because of its widespread use, we will concentrate on the RCC format and examine the operation of a typical VHF high-band pager.

The pager receiver

As stated earlier, a pager is simply an FM receiver with a tone decoder and audio amplifier. The receiver portion is a dual-conversion FM receiver. It must not only be very sensitive, to provide wide-range coverage, but must also be highly selective to reject unwanted and interfering signals.

Figure 1 shows a block diagram of a typical pager. When a signal arrives at the pager's antenna, it is coupled to the input of the RF amplifier. The RF amplifier must have a high gain-factor because, at times, the RF signal level at its input may be only slightly higher than the noise level. The RF amplifier will amplify both the wanted and unwanted signals; however that stage's high gain will greatly increase the difference between them. The relationship of the two signals within the receiver is referred to as its signal-to-noise ratio, and is an indication of the receiver's sensitivity. The output of the RF amplifier is fed to a stage called the *first mixer*.

Also fed to the first mixer is the output of the *first local oscillator*. Its frequency is established by a crystal, and is 17.9 MHz lower than the frequency the receiver is tuned to (also crystal-controlled). The purpose of the mixer is to combine the two input frequencies. The result is four signals at the mixer's output; one is the original input signal, another the local-oscillator signal, and the others the sum and the difference of those two.

Both the sum and the difference signals contain the same modulation information as the original signal, but it is only the 17.5-MHz difference signal that is needed for the *conversion* process. (The signal is converted to a lower frequency because it is easier to work with there than at a higher one.) A crystal filter is used in a bandpass configuration to attenuate the three unneeded signals and pass the modulated 17.9-MHz difference-signal. That leaves a signal having a lower frequency, with the original modulation intact, and accomplishes the first (or high) conversion of the dual-conversion process.

The difference-frequency of 17.9 MHz is referred to as the *first intermediate-frequency* (first IF). The signal is then further amplified by the first-IF amplifier and filtered a second time to further improve IF selectivity (the rejection of the three unwanted signals).

The conversion process is then performed a second time. That step is referred to as *low conversion*. The amplified and filtered first-IF signal is fed to the second mixer, along with the output of the crystal-controlled second oscillator. The second mixer produces a difference frequency of 35 kHz, which is amplified and fed to the limiter. That stage limits the amplitude of the signal to a constant level, as required by the detector. The detector removes the 35-kHz second-IF carrier, recovering from it the modulated audio. The recovered audio is then passed on to the decoder and audio-amplifier circuitry. The process of recovering the audio from the modulated second-IF signal is called *demodulation*.

Decoder operation

The decoder, shown in block form in Fig. 2, must check for a series of received and demodulated audio tones. Each pager in a system will respond to one, and only one, specific group of tones. Not only does the decoder check for a particular series of tones, but it also looks for them to appear in a specific sequence.

Since the audio recovered from the FM signal is low in level, it must be amplified before being fed to the decoder filters and the audio amplifier. If the pager is in its normal (STANDBY or RESET) mode, it is waiting for the audio tones that will enable it and cause it to "sound off." In the case of the decoder shown in Fig. 2, only two tones are needed to make it decode successfully.

In the RESET mode all of the audio (tones and speech) may be present at the inputs of both the audio amplifier and the two filters. The filters, which are highly

selective bandpass arrangements, will not pass any speech, since they require steady tones at the frequencies to which they are tuned in order to produce an output from the decoder.

The first stage of the audio-amplifier IC is normally off. When a tone matching the frequency of the "A" filter is received, that filter passes the signal to the decoder. The decoder is then enabled. If the proper "B" tone follows, the "B" filter will pass it on the decoder. The decoder will recognize the "match" and will produce an "alert" signal that is fed to the last amplifier-stage of the audio IC. That amplifier, which is always on, will drive the speaker, and the familiar *"beep, beep, beep"* will be heard. Once the alert has sounded, the CONTROL line enables the first section of the audio-amplifier IC and the voice message is received. When the caller has finished speaking, the amplifier is reset to mute the speaker. The pager is then back in the RESET or STAND-BY mode, awating another page.

Some pagers, known as *tone-alert* pagers, do not have the capability of handling a voice message. They merely output an alert tone that informs the user to call some pre-arranged number, such as his office, answering service, home, etc. The tone-alert pager circuitry is similar to that of the tone-plus-voice model, but the audio amplifier is configured differently to handle only an alert tone and there is no provision for processing a voice signal.

A second decoding method, the *five-tone* format, uses five distinct audio tones transmitted as a rapid pulse-train. There, the decoding process can be compared to the two-tone format, though the circuits are much more complex. There are two advantages to the five-tone format. The first is that there are more than a million unique encode/decode combinations. The other is that the decoding information can be transmitted in approximately half a second, while the two-tone format requires up to four seconds. That adds up to quite a time saving for systems that are heavily used.

The paging process

Now that we know what's inside a pager, let's see how paging works. Refer to Fig. 3 as we discuss just what is involved in the paging progress.

In most cases RCC customers can reach a pager on a direct-dial basis (although sometimes a dispatcher must be called; he will, in turn, manually process the paging). A person wishing to page someone merely has to dial a telephone number; each pager is assigned its own, along with the unique set of audio tones required to activate it.

The phone call is channeled through the phone company's central office and then on to the RCC's paging-control equipment. The controller searches its memory for the frequencies of the audio tones required to activate the pager

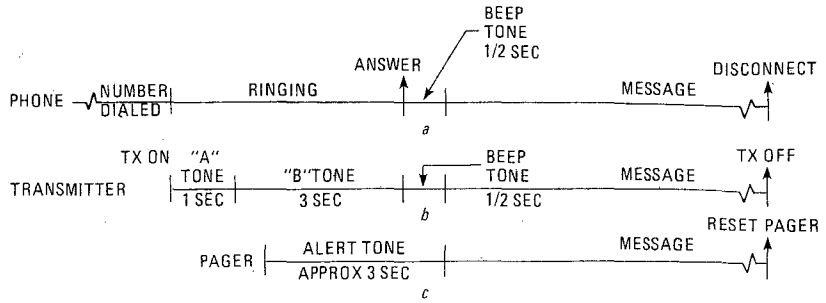


FIG. 3—SEQUENCE OF EVENTS involved in making a page as they occur at (*a*) telephone, (*b*) transmitter, and (*c*) pager.

associated with the number dialed. That information is found within milliseconds and the paging controller turns on the transmitter. It also generates the proper tones, which it sends to the transmitter. The transmitter modulates its RF carrier with those tones, transmitting the page-signal.

If the pager is within range of the transmitter, it decodes the signal and emits an alert tone. At the same time, the paging controller "answers" the line and returns to the calling party a short beep tone, which is a signal to the caller to begin speaking. The length of his message can vary from system to system, but is usually about ten seconds. Although that seems short, it is really quite adequate to repeat a short message or phone number two or three times. It is just a matter of seconds from the time a number is dialed until the pager user receives a message.

Some pagers—the tone-alert models—are not able to handle voice messages; instead, they merely beep. With that type of system, the caller hears a beep tone that indicates that the page has been processed, and then receives an interrupted busy tone.

Pros and cons

A pager can be a great time and money saver to its user. A page can prevent a wasted trip, or ask the user to make an extra stop before returning home or to the office. It is also invaluable to someone who may be away from the office when an important customer, or a patient needing immediate attention, calls.

In these days of economic downturn, pagers are enjoying an increase in popularity. Businesses have been forced to cut costs and to search out and eliminate inefficiencies. Many firms have found that pagers save time—and, therefore, money amounting to many times the monthly pager-rental fee. I'm sure you'll agree that an investment with that kind of return is rare today.

One shortcoming of pagers is their relatively short range—typically 15 to 25 miles. Range can vary with transmitter power, terrain, and atmospheric conditions, and is sometimes related to the number of times the pager has been dropped! Pages may be difficult to receive in some rural areas. To reduce the problem, many RCC's are, or soon will be, simulcasting their pages from several strategically placed transmitters. That naturally increases a device's useful range.

For instance, many RCC's in the state of Michigan and from nearby areas have devised an inexpensive manual wide-area paging system. While the details are too involved to go into here, you can now have a pager in Michigan that will be useful and effective over most of the state.

Finally, a preliminary agreement has been reached to form a national radio-paging system using geosynchronous satellites. The participating companies are National Public Radio and Mobile Communications Corporation of America. Under the proposed system, users would phone pages into their local paging companies as usual. Those companies would then relay the pages to National Public Radio's Washington D.C. control center. From there, they would be uplinked to Westar IV and downlinked to the appropriate ground station. The ground station would then relay the page to the appropriate local paging company which transmits it in the usual manner. **R-E**