—ELECTRONIC MUSIC

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AT one time or another, every musically inclined communications engineer has connected a laboratory oscillator to a speaker and twiddled the frequency dial to play himself a tune. But did anyone ever provide four people with four oscillators, so that they might play like a barber-shop quartet?

Here is a facet of electronics which up to now, so far as the author has been able to discover, has been left unexplored. The question occurred to him while searching for a novelty to entertain members of a glee club at their annual party. The results of preliminary research (conducted in the author's cellar, since it was not an official company project) were received so enthusiastically that improved models were designed (in the same cellar), playing techniques were improved, and concert experience was obtained before several surprised and delighted audiences.

The present state of the art is represented by the "wobble organ" described in this article. It uses inexpensive radio parts, and offers interesting possibilities for home recreation of the participation kind, as well as for various entertainment fields involving large groups.

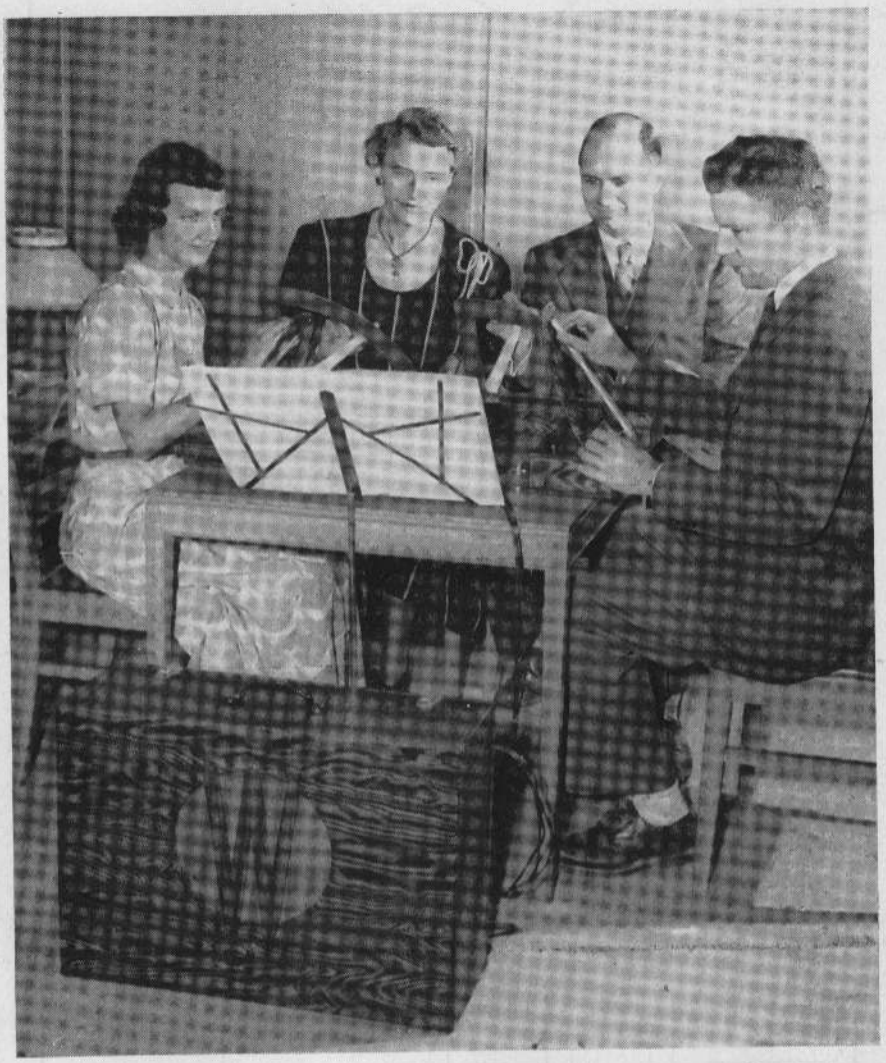

FIG. 1—The wobble organ and its first four players: Ann Codington, Phyllis Taylor, the author and B. McMillan, all of Bell Labs

TIME OUT TO PLAY

AUTHOR TO EDITORS: "Once in awhile we engineers need a light touch in the midst of our serious striving for progress and profit. With this in mind, it seems to me that the attached paper would not be out of place in ELECTRONICS."

EDITORS TO AUTHOR: *When we first read your paper it immediately created a desire to build a wobble organ in our own basement. So here it is in print. We think it will create the same desire among many of our readers*

The four players sit around three sides of a card table, as shown in Fig. 1. The fourth side is turned toward the audience, and may conveniently be faced by a music rack if desired. In front of each player is a small "playing console". On the floor near the table is a cabinet containing a power supply, an amplifier, and a speaker. Pairs of consoles which are adjacent to one another are plugged together mechanically (see Fig. 2), and electrically, the whole set of four being connected to the speaker cabinet by a single 6-conductor cable.

Each console contains a thyratron sawtooth oscillator, with suitable control circuits and a simple waveform-shaping network which emphasizes or suppresses various harmonics in the complex sawtooth wave and thus affords a distinctive and different tone quality for each player. The physical arrangement of a console is shown in Fig. 3. The main control device is the "wobble arm", carried on a potentiometer shaft which extends through the sloping front. This control is designed to vary the pitch over a range of about 2½ octaves (about 6-to-1 in frequency). The range is at least that of the human voice,

for FOUR

Novel "wobble organ" has separate soprano, alto, tenor and bass oscillators and a common power pack, amplifier and loudspeaker. The instrument plays anything from barbershop ballads to Bach with a pleasing vibrato quality from which it gets its name

and in the present model is located differently on the frequency spectrum for each console, so that the four of them cover the vocal ranges of soprano, alto, tenor and bass respectively. (A male quartet model could be obtained merely by changing capacitance values.) The pitch control, or wobble arm, is operated by the right hand of the player in relation to the musical scale designations on the sloping scale quadrant. These designations need be used only as a rough guide, but they are of great value even to an experienced player in making rapid and accurate changes over large musical intervals, and they are indispensable to a beginner.

Operation of the tone source or oscillator is not continuous; each console can be turned on and off at will by the individual performer. The four consoles are normally silent. Oscillation is started by a slight downward pressure of the player's left hand on the knob at the left front of the console. This pressure closes a contact applying plate voltage to the oscillator. Thus the player may use a "portamento" between notes (leaving the tone on) or "detache" (momentarily interrupting it) as desired. The volume of sound delivered by the individual console to the common speaker is also under the control of this same knob, which may be turned as well as pressed by the player's left hand. The rotation can be calibrated in musical symbols, *pp*, *p*, *mp*, *mf*, *f*, and *ff*, indicating different degrees of loudness from pianissimo to fortissimo, but in the present model this is left to the musical taste of the player and only *p* and *f* are marked as rough guides near the opposite ends of the range. The

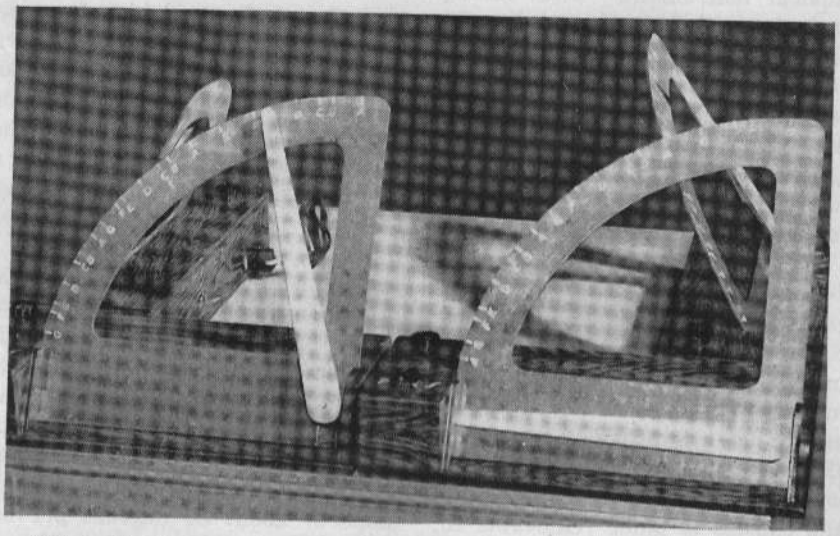

FIG. 2—The four-man (or woman) instrument from the players' point of view

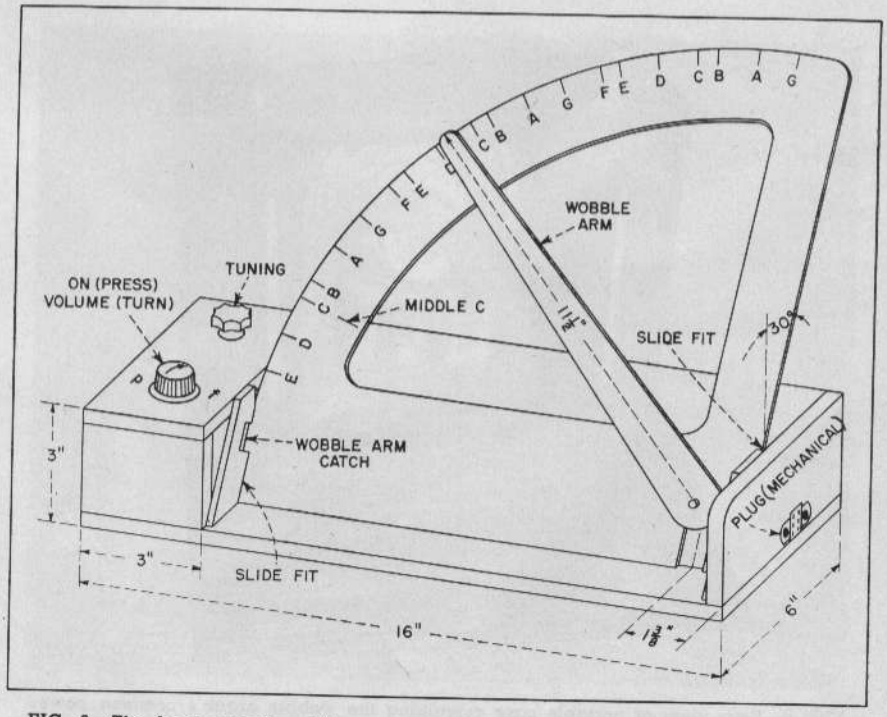

FIG. 3—The bass console. Others are similar mechanically except for calibration of the scale quadrant and placement of interconnecting plugs

switch action mentioned above is obtained very simply by mounting the potentiometer near the free end of a flat cantilever spring, the fixed end of which is screwed to the underside of the console top. A downward motion of about 3/32-inch brings the free end into electrical contact with a fixed metal contact that also limits travel.

One other control, a tuning adjustment to compensate for such variables as temperature and aging, is required, as in almost any other musical instrument. This tuning knob is initially adjusted by the player's left hand while the corresponding wrist presses down the "on" knob and his right hand aligns the wobble arm with a scale mark (such as middle C) corresponding to the pitch of the reference source to which he wishes to tune.

The present consoles are made of 3/8-inch plywood, with scale quadrants of 1/8-inch pressed hardboard. Each scale quadrant is made removable to facilitate storage, being mounted in slides at its edges. A simple catch is provided to support the free end of the wobble arm when not in use. The bottom of the console is made removable for access to component parts. Principal dimensions are shown in Fig. 3.

The layout of the speaker cabinet is conventional, the only novel feature being the provision of storage space for the four consoles, two at each side of the loudspeaker as shown in Fig. 4.

Circuits

Complete schematics are given of the consoles in Fig. 5 and the power supply and amplifier in Fig. 6. The thyratron relaxation oscillator in each console is of the type commonly used in oscilloscope sweep circuits, with the variable timing resistance used for the main pitch control and the grid bias for tuning. Different timing capacitors and waveform-shaping networks are shown (terminals *A*, *B*, *C*) for the respective consoles. When the consoles are plugged together a common shielded path is formed from the networks to the amplifier input.

The use of a 1-megohm logarithmic potentiometer in series with a fixed 10,000-ohm resistor for each frequency control provides a relationship between shaft angle and musical pitch which is substantially linear over a resistance range of 16,000 to 450,000 ohms, with a slope of about 30 degrees per octave. Accordingly, each half-tone occupies 2.5 degrees and each whole tone 5 degrees. The wobble arm swings over more than 75 degrees, giving the desired 2½ octaves, and is set on its shaft so that the minimum total resistance actually used is 75,000 ohms. The potentiometer should have a molded carbon element or equivalent so as to minimize effects of mechanical wear on scale calibration.

A voltage divider across the 150-volt supply (resistors R_1 and R_2 in Fig. 5) is arranged to hold the plate of the thyratron at about 40 volts above cathode potential while the "on" contact is open. The tube does not conduct in this condition, because its firing point for normal tuning is designed to be near 80 volts. The effect of the bias is to make the d-c potential at point *A*, while the oscillation is off, substantially equal to the d-c component of the sawtooth wave at the same point when it is on. Figure 7 shows how the bias eliminates a starting transient in the sawtooth wave as it is delivered to the input of the shaping network. If present, the transient would give a noticeable thump at the beginning of each note, particularly if the volume were turned up until excessive initial voltage rise overloaded the final stage of the amplifier.

A voltage-doubling selenium-rectifier type of power supply (Fig. 6) delivers 100 milliamperes at 250 volts, and two voltage regulators are arranged in series to provide stable plate and bias potentials. This regulation is quite important, not only to avoid fluctuations of pitch with line voltage, but to keep the four consoles independent of one another in spite of the fact that their mean plate currents change as they are started and stopped or as their pitches are varied.

The audio amplifier is conventional; it includes a volume control, allowing the over-all instrument to be adjusted to a room of any size.

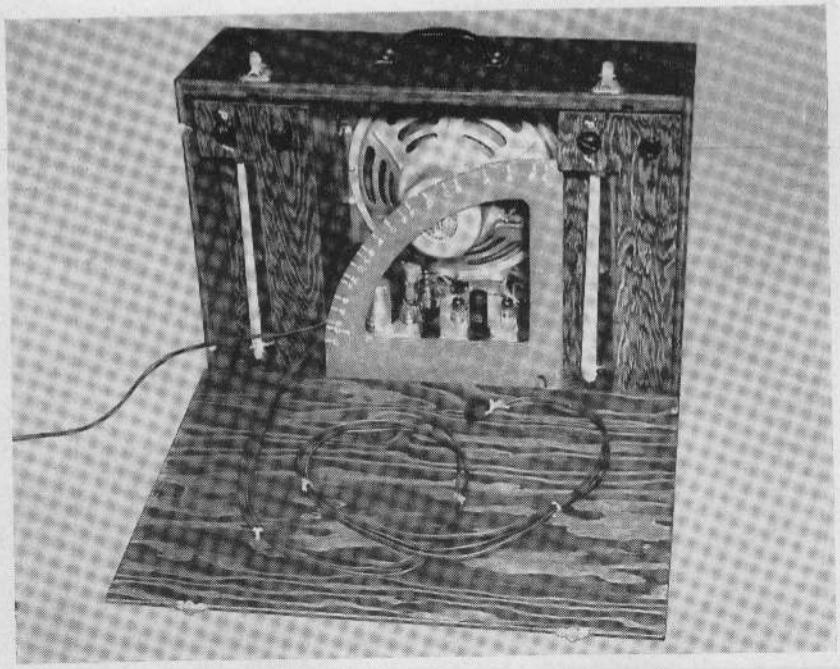

FIG. 4—Rear view of portable case containing the wobble organ's common power supply, speaker and amplifier, with the four individual consoles knocked down and stowed away

Playing Techniques

Several interesting facts have developed from playing and experimenting on this instrument. First, although steady tones, without vibrato, are desirable in some kinds of music, a much more live effect can be obtained by wobbling the pitch control smoothly through a small range above and below the

position of true intonation. This corresponds to the vibrato used in playing a violin or trombone, or occurring naturally in the human voice. All who have learned to play thus far agree that a vibrato of small extent (less than a quarter tone peak-to-peak) and at a rate of about 4 or 5 per second is desirable. This motion, as may be guessed, accounts for choice of the name wobble organ.

To allow the player's right hand to produce vibrato with a comfortable wrist motion the notes should be spaced well apart on the dial. A spacing of about one inch per whole tone appears to be a reasonable minimum. This figure, taken with the potentiometer calibration of 5 degrees per whole tone noted earlier, leads to a figure of about one foot for the length of the wobble arm.

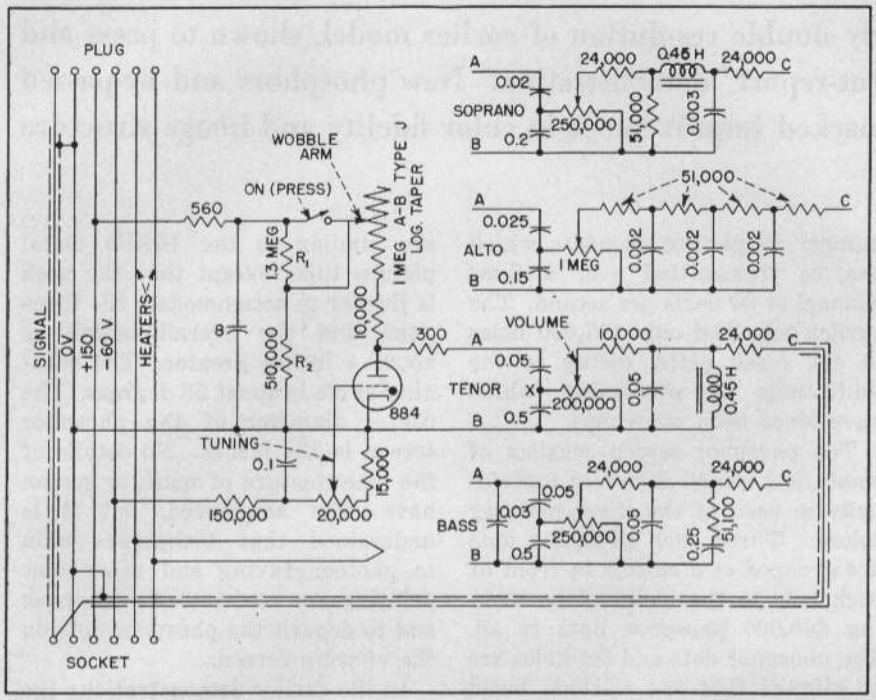

FIG. 5—Circuit of one of the four consoles, in this case the tenor console. The other three are identical electrically except for timing and waveform-shaping networks. Component-part values and circuits are shown for the soprano, alto and bass units

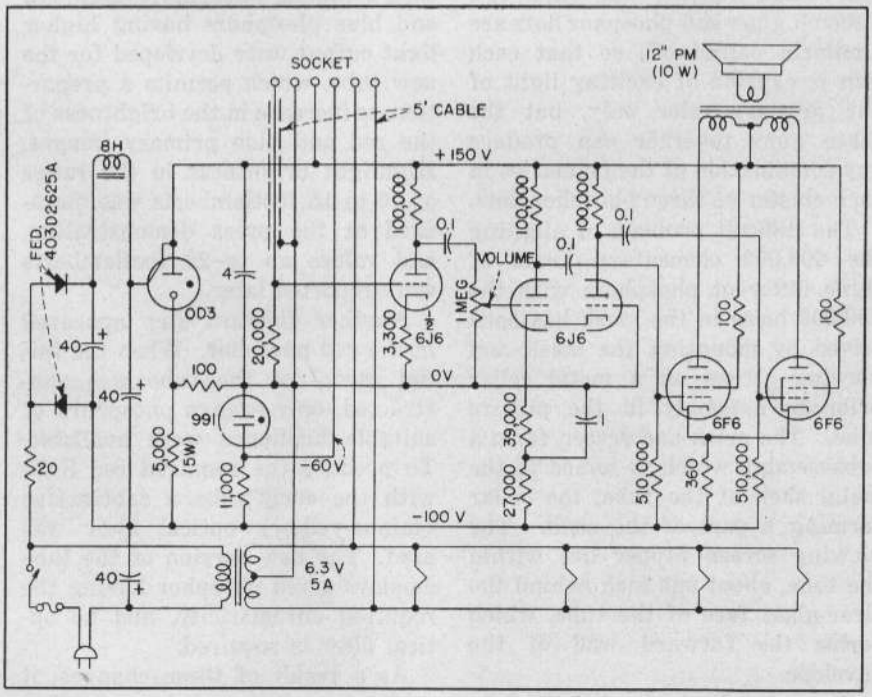

FIG. 6—Circuit of the common power supply, amplifier and loudspeaker unit

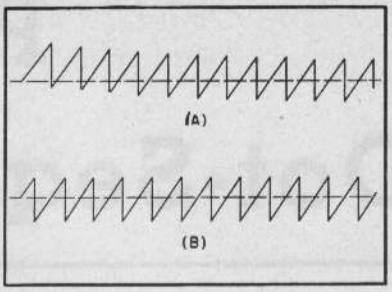

FIG. 7—Waveform at point X of Fig. 5 at start of oscillation (A) without bias derived from the bleeder R_1 R_2 and (B) with the bias

It may be noticed in Fig. 3 that the scale quadrant (in this bass console) is calibrated with high notes toward the left and low notes toward the right. This comes about because logarithmic potentiometers having a left-handed taper are not commonly stocked in suitable sizes. Although players quickly become accustomed to this arrangement, it has been found that most of them would prefer to have the scale reversed to match the convention of the piano keyboard.

Experience has been obtained both with family groups playing for their own entertainment, and with quartets well rehearsed for public performance. Some solo work has also been done using a single console with piano accompaniment. In every case enjoyment and recreation value have been strikingly evident. Even two professional symphony players who took part in one of the quartets were highly entertained and, incidentally, behaved like the amateurs in that they played awkwardly at first but improved very rapidly.

The music used has varied from simple "rounds" and folk songs to Bach chorales. Although no suggestion is intended that the wobble organ may ever join the ranks of the serious musical instruments, nevertheless it can do things with Bach that are actually rather satisfying. It has a voice-like quality, and yet overcomes certain vocal restrictions. The soprano never strains for high passages, the alto cannot possibly run short of breath, the tenor never cracks and the bass has power at his command for his very lowest note.

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Wobble Organ

DEAR SIRS:

IN the article, Electronic Music For Four (Feb. 1951), the "wobble organ" is described as being representative of the present state of the art. Actually, it would be more appropriate to say that the monophonic electronic musical instrument of the crank-operated, continuously-tuned oscillator type built by the author represents the state of the art approximately 20 years ago. Except for the name, there is little if anything new in the "wobble organ".

In this connection, your attention may be directed to Péchadre's U. S. patent No. 1,791,374, corresponding to French patent No. 672,-968 (1929). The differences between Meachem's and Péchadre's structures are very minor and Péchadre's device may even be superior with respect to practical operation.

Another good example of electronic musical instruments of the crank-controlled type is described in Mager's German patent No. 536,-855 (1928). Bertrand's "Dynaphon", described in French patent No. 664,305 (1929) likewise employs a crank-type operating mechanism for a continuously-tuned audio oscillator.

Nor is Mr. Meachem the first one who has assigned an individual oscillator to each of four or more performers to produce polyphonic music. As far back as in 1932, the writer organized and directed the five-piece Emicon Electronic Or-

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BACKTALK

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chestra, which gave two chamber music concerts daily at the Philadelphia Radio Show of the same year. The performers were members of the Philadelphia Orchestra. Even this early attempt could hardly claim to be the first one as it was antedated by Theremin's concert at the Carnegie Hall, New York City, during the early part of 1931. The same period witnessed numerous similar concerts in Europe, featuring ensembles of electronic solo musical instruments developed by Martenot and Bertrand in France and by Mager, Lertes and Helberger, and Trautwein in Germany. Incidentally, Trautwein's electronic solo instrument, the "Trautonium", had the distinction of having special music written for it by Paul Hindemith, the well-known modern composer.

That the crank-operated solo instruments of the type described by Meachem were not commercially successful was probably due to the fact that they are not suitable for the execution of rapid musical passages. They were quickly superseded by solo instruments in which the selection of pitch is accomplished by keyboard control, as in the writer's Emicon, manufactured by Pratt, Read & Co. in Deep River, Conn. in 1932-33, or by displacement of a finger on a string, as in the Trautonium, manufactured by the Telefunken Company of Berlin, Germany in about the same period. Both of these early attempts were commercial failures, due to a variety of reasons. In the first place, the resistance of musicians, both professional and amateur, against an instrument requiring a completely non-conventional, although relatively simple, playing technique, was considerable. In the second place, the selling price of the instruments twenty years ago, when the quantity production of electronic devices was still in its infancy, was too high to permit reaching a sufficiently broad segment of the public. Finally, the development, manufacture and distribution of a practical and commercial electronic instrument of this type requires an unusual combination of electronic and musical talent which was impossible to find within the

same organization twenty years ago. However, it may well be that, apart from the present emergency, a similar venture may have better prospects for success at the present time.

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Author Replies

DEAR SIRS:

THANK YOU FOR your invitation to reply to the comments of Nicholas Langer on my article "Electronic Music for Four" published in the February issue of ELECTRONICS.

I am grateful to Langer for his contribution of historical background. Not long ago I was hunting for such information, and although acquainted with Theremin's and Péchadre's patent, I found little else pertaining to instruments using continuously tuned oscillators.

If we assume it to be true, as Langer points out, that what I have lightly referred to as "the present state of the art" is actually similar to efforts of twenty years ago, then we must ask why there has been so little advance in these twenty years. The answer appears to be that efforts to establish "crank-controlled" devices as serious musical instruments met early discouragement, which caused interest to shift over to the keyboard type of control. The resulting electronic organ was quite successful and captured almost all the subsequent development effort. If this shift of interest had not occurred, the field would surely have been covered more thoroughly. Perhaps it is because it did occur that the Patent Office has found it possible to allow my application, Patent No. 2,544,466, which includes as one of its claims, "An electronic musical instrument comprising a plurality of self-oscillating electronic sources of electric waves, rotary manual means for independent frequency variation of each of said sources over a continuous range of at least one octave, means for independent amplitude variation of each of said sources, means for independent interruption of each of said sources,

means for combining the electric waves of said sources, and an electromechanical transducer for converting the sum of said waves into sound, whereby a plurality of players, respectively controlling said sources, may produce polyphonic music". Incidentally the patents referred to by Langer do not show an ensemble type of instrument.

It seems to me that the most significant thing I have happened to come across in this matter is a surprisingly encouraging response by various samples of the public. The wobble organ started as a joke—a rather horrible novelty—and produced happy enthusiasm. People have asked where they might obtain one. They have made serious comments on such things as the "sympathetic" quality of the vibrato and blending. They have speculated on uses in hospitals and rehabilitation centers, and in musical education. This observed phenomenon is what has led me to carry the wobble organ up to the stage of an ELECTRONICS article.

Let's not be too serious about it. Let's never mention it in the same breath with the symphony or the pipe organ or the string quartet. Nevertheless, here it is for what can be made of it. Maybe the development of twenty years ago should be resumed.

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Electronics Quiz

THIS month's quiz was furnished by Emil M. Anderson of Detroit, Michigan. For his contribution, Anderson will receive our check for five dollars, as will all contributors whose problems are published.

This Month's Problem

Assume a superheterodyne receiver with a signal input to the converter of frequency f, and a local oscillator input of frequency (5/4)f. Then, in accordance with established principles of converter action, its output will contain the two input frequencies f and (5/4)f, and the sum and difference frequencies (9/4)f and ¼f. The intermediate frequency amplifier is, as usual, tuned to pass only the