[redacted]

COMMERCIAL RADIO

January
1935

20 cents
the copy

Velocity Microphone

Ship News

Loudness and Pitch

Broadcast Station News

Assignments

Police Radio

A MONTHLY JOURNAL DEVOTED TO THE COMMERCIAL RADIO & ALLIED FIELD

PUBLICATION OFFICE

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VOLUME IV NO. 4

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EXCEPTIONS were filed by:
Western Union
Postal Telegraph
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R. C. A. Communications
Commercial Cable
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to Federal Communications Commission order No. 14. This order was issued in connection with the issuance of telegraph franks and the giving of free telegraph service, and was dated Dec. 19, 1934.

On Jan. 2, 1935, the Commission issued an amendment to order No. 14, in the form of 4 (a), which reads as follows:

"No frank or franks shall be issued by any carrier purporting to authorize any person to send messages the regular charges on which in the aggregate would exceed $10.00 in any calendar year; nor shall any person use or attempt to use in any calendar year any frank or franks issued by one carrier for the sending of messages the aggregate charges on which, at regular rates, would exceed $10.00 in any calendar year."

Since certain general officers from General Freight Agent on up to Presidents are now allowed to receive franks, the chief sufferers appear to be the captains and radio operators on board 1,264 ships, who over a period of nine months from Jan. 1, 1934, were supposed to have used about $22,000 worth of free messages.

Federal Communications Commission No. 14 will be of utmost importance to any man shipping to sea, and also to any other radio operator where toll charges are made, and every man is urged to get this fully explained to him if he has not already been properly instructed on the points of this order.

COMMERCIAL RADIO

(FORMERLY "C-Q")

The Only Magazine in America Devoted Entirely to the Commercial Radio Man

Contents for January, 1935

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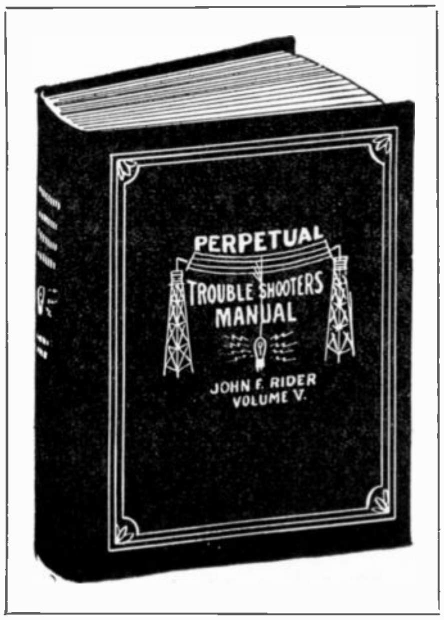

Rider's Manual Volume V

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Allied	21	International	19
Ansley	5	Kingston	10
Atwater-Kent	36	Lafayette	26
Audiola	11	Lang	5
Autocrat	6	Larkin	3
Balkeit	7	Lewol	5
Belmont	16	Mission-Bell	6
Bosch	19	Montgomery-Ward	13
Colonial	16	Noblitt-Sparks	11
Crosley	25	Philco	19
Detrola	7	Pilot	10
Dewald	24	Radolek	13
Echophone	6	RCA-Victor	63
Edison-Bell	7	R. K. Labs	4
Elec. Spec. Export	5	Sears Roebuck	56
Emerson	13	Sentinel	26
Empire	8	Sparton	16
Erla	12	Stewart-Warner	38
Fairbanks-Morse	22	Supreme Inst.	9
Federated		Tatro	5
Purchaser	27	Webster	8
Ford Motor	4	T. C. A.	12
Fordson	7	Wells Gardner	12
General Electric	40	Westinghouse	11
Gilfillan	13	Weston Inst.	20
Grunow	19	Wilcox Gay	13
Halson	6	Wurlitzer	8
Horn	5	Zenith	21

NEVER before in the history of Radio has such a stupendous compilation of technical servicing material been collected between two covers. ¶ Expense was not spared to make Rider's Volume V all-embracing in its scope. ¶ Sets are explained even more lucidly than those of yesteryear, for complications galore are incorporated in 1935 receivers. ¶ Seeing is believing—prove to yourself that Rider's Volume V is without doubt the servicing sensation of the year—better than any other manual—the absolute peer!

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Perfect Reproduction With the Velocity Microphone

By A. BARBIERI

REPRODUCTION without peaks—no background noises—its resistance to temperature, humidity, and age, and the ease with which it eliminates acoustic feed back are the reasons for the increasing popularity of the velocity microphone. It is capable of uniformly excellent operation for many years without service—even if roughly handled.

The Velocity Microphone consists of a light duralumin ribbon hand hammered to .00015" thick and suspended in a magnetic field. Sound waves create unequal pressures on the two sides of the ribbon—causing it to vibrate. The vibrations generate an induced voltage of

$$E = B\,l\,x \quad \begin{array}{l} B \text{ — Flux density} \\ l \text{ — Length of ribbon} \\ x \text{ — Velocity of ribbon} \end{array}$$

The controlling factors in a microphone are mass of the mechanical system and stiffness. The lightly suspended ribbon has a period below the audio range, therefore is not affected by any frequencies to be reproduced. The only remaining controlling factor is mass, which is made so small as to be negligible. We can assume that the velocity of the ribbon is the same as particle velocity. Particle velocity is the velocity of a hypothetical particle of matter that has no mass, suspended in air, and carried back and forth by the sound waves. The ribbon may be considered as a number of such particles alined in a plane—the velocity being constant at all frequencies.

Since B and l are constant in the above formula, voltage E will be directly proportionally to the velocity only, therefore, the name Velocity Microphone. Having no mass or stiffness, the Velocity Microphone has no resonant points, or peaks. (Fig. 1.)

One of the outstanding and misunderstood properties of the Velocity Microphone is its directional quality. A sound at A (Fig. 2) will give approximately 0.8 x the loudness as the same sound at B. And at C will give 0.5 x the loudness as at B. In the plane D, the response is zero. Undesirable sources of noise should be in the plane D.

Another exceedingly important point to remember is that any note from 30 to 10,000 cycles will be reproduced at A or C to the same degree. In other words, there is no frequency discrimination at various angles as experienced with diaphragm microphones. If instruments are played at an angle with a diaphragm type microphone, frequency discrimination will result. Several microphones must, therefore, be used for large ensembles. A large orchestra, however, can be placed around a single ribbon microphone—the instruments being placed at a distance and angle depending only on their loudness and not their frequency range.

The Velocity Microphone can always be depended upon since it is not affected by temperature, altitude, moisture, or even age. Microphone service and its accompanying costs are entirely eliminated. Microphones, of course, should be handled with care. Should a Velocity accidentally fall ten to twenty feet, you will find after picking it up that it is still ready for service. It is in reality most rugged and will stand the heaviest duty.

Another general misconception about the Velocity Microphones is the effect of wind. It is impossible to damage a good ribbon by blowing into the microphone, even a 45-mile gale will not affect it.

The output of the Velocity Microphone is approximately -65 db. on open line (-90 db. under average load). Two stages of pre-amplification are required to bring it up to that of a carbon microphone. Either battery or A.C. operated tubes can be used. The battery operated pre-amplifier is exceptionally simple to build. It is merely important to be careful as to the parts used. Transformer should cover the frequency range of the microphone itself (30 to 12,000 cycles) with maximum variation of +2 db.

A little experience and technique is required to build an A.C. pre-amplifier with good output and a hum level below audibility. Hum level should be in the order of −100 db. By using a hum bucker as shown in Fig. 3, the problem of hum elimination is greatly simplified. Six-volt tubes are selected for two reasons. They offer a minimum level of thermalagitation noises, and the lower heater current creates a much weaker field around the cathode.

Should hum present itself, make sure the pre-amplifier and power supply are shielded with a 1/16" steel case—aluminum will not do. The pre-amplifier should be at least three feet from the power transformer. Grounding of the center tap of the line to grid (L.G.) transformer often helps. If no center tap is available, the primary should not be grounded because grounding of either side of the microphone leads will result in lower output and high frequency cut off. A poor ground will give a higher hum level than no ground at all.

The position of the L.G. transformer is very important. By rotating it, the position of minimum hum can easily be found.

Amplifiers built even ten years ago had a fairly good frequency response. It was the microphones that introduced the peaks—created an unnatural impression. Now that a microphone with a flat response over the entire audible range is within the reach of everyone, any installation can be greatly improved at low cost.

Leopold Stokowski, an excellent acous-

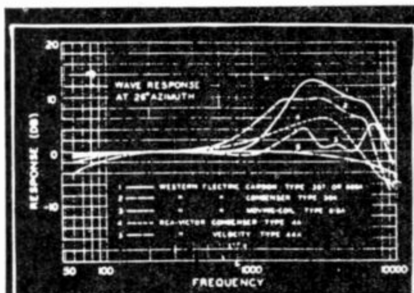


Figure 1—Frequency response characteristics for several standard commercial types of microphones (Ballantine).

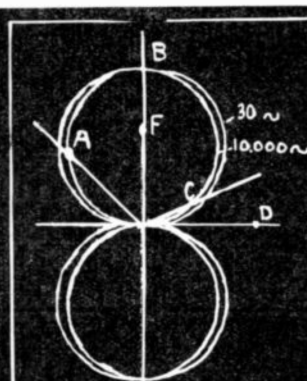


FIG. 2. Response of the Velocity Microphone with the sound source at various angles.

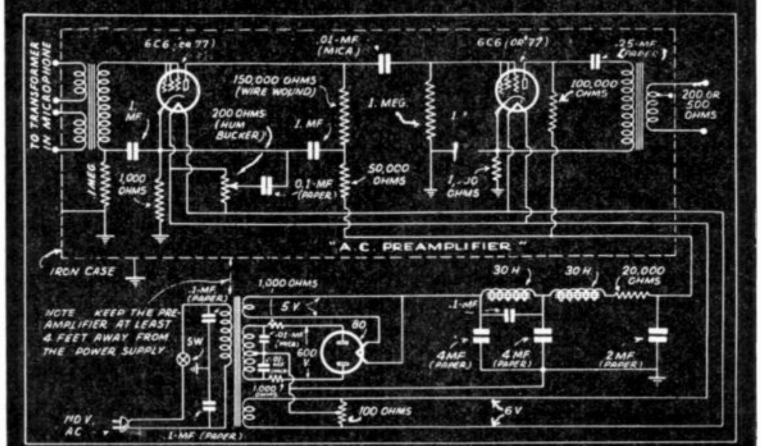
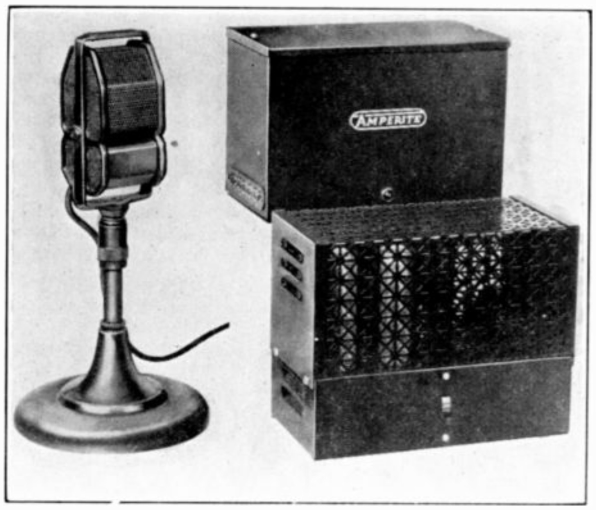


Fig. 3. A Humless A.C. Pre-amplifier.

tic engineer as well as premier maestro, writes of new vistas in radio in the Atlantic Monthly for January, 1935. He states that perfect reproduction of music can be obtained if the frequency response is uniform from 30 to 13,000 cycles. A well-designed Velocity Microphone, good transformers in the amplifier, and matched speakers, make this now possible. It means that men like Stokowski can be satisfied. It means that orchestra leaders will no longer object to reinforcing their orchestra, permitting a much wider range of volume and interpretation. It means a tremendously new and limitless field for the public address engineer. It means perfect reproduction.



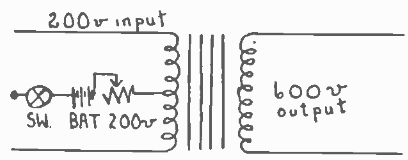
A WRINKLE FROM WIBX

By LAWRENCE W. BRIGGS

As per your request of October 11th I am enclosing a little wrinkle from our station here. In sending in this wrinkle I wish to give credit to our chief engineer, Robert Snider, for this as he was the one who worked it out, I only send it in to you in order that we may help along.

This is a very simple wrinkle, but may help some stations that are still using carbon mikes for remotes. We used a mike to line job of this type for quite some time. Had very good luck with it, the length of the line being about one and one-half mile long. If any of the boys at the smaller stations get caught with a remote, and no amplifier just dig into the junk box and, presto! the day is saved. We used to have several around as they are light and anyone with radio experience can set them up. They have a fair gain, much higher than one would imagine.

Below you will find a diagram which



is self explanatory. For mike current we use two dry cells. We have not used an amplifier of this type at our station now for some time but it may be a great help to some operators in the smaller stations, especially for short lines.

HOW SANTA FE GOT ITS RADIO

By TOM NICHOLSON

POLICE Radio Station KGPF is now on the air one year. It is a Collins Type 32C, 25-watt transmitter.

The history of this little one-horse town police department and how it bought its transmitter is as unique as could be possibly found in any town its size in this country. We don't believe any other police department in the U. S. A. can brag about buying their own transmitter and radio equipment, yet through the efforts of the chief of police and his officers, transmitter, receivers for the cars, installation, etc., without the aid of the City of Santa Fe's fund were paid for by money raised.

You will say, how? Well, here goes! We needed a police radio transmitter badly to be up-to-date in our work, even though our department is small, so we got together and figured a way to buy it ourselves.

The City Council couldn't see our plight whatsoever and business men said the town was too small, although a good argument couldn't be given for not having the transmitter. The police department knew its merits and how badly it was needed, so with a great deal of figuring and work, a plan was started to get the money.

Officers of the department went to the local picture show owner and presented their case, in how he could make money on a quiet night and at the same time help the police department buy the transmitter. The plan was OK and besides a $100 donation received to start the ball a-rolling. Seventy-five per cent of the gross receipts of the evening, shows of both large theaters were to be given and all advertising money from the runners on the screen given.

The next step in our plan was to buy a car, which we did, on credit. A Buick sedan was purchased, tickets and advertising matter bought and the plan went ahead.

Advertising was sold to local dealers, who gave a ticket away on the new Buick car which was to be raffled at the theater, for every cash dollars worth of business. The plan went over big and the tickets were in great demand. A huge crowd for all of the shows the night of the drawing was had.

The picture shows made more money that night than they would have had otherwise. The merchants handling the tickets did a very large cash business and, greater still, the Santa Fe Police Department took in a great share of the money, which fell short a little bit, and was made up by a large after-theater dance.

The transmitter and radio receiving equipment was presented to the City of Santa Fe by its police department and to date has made Santa Fe a better place to live in.

Yours for better police methods.

A QUESTION AND AN ANSWER

Dear Sirs:

I wonder if you will be kind enough to provide a little information of vital importance to me. To help you, I have enclosed a stamped, self-addressed envelope.

I am studying radio theory and code under several well-known correspondence schools, with the end in view of securing a second class commercial radio-telegraph license.

Suppose that in a few months I am able to secure my license. Will I then be able to get a job? Will the companies hire an inexperienced second class operator?

Also, I would like to know what you think of the future of the code operator. Does the ever-increasing number of hams threaten to cause a hopeless overcrowding of his profession? Does the rapid development of automatic transmission and reception, fascimile transmission or other inventions threaten to displace manual operation of the key?

Having conducted a campaign against the racketeering radio schools, you must understand their agility in evading the issue of overcrowdedness and leading the student to the black end of a blind alley.

Believing you are honest, I am prepared to listen to whatever you tell me. Please remember that what you say is likely to be of inestimable value to me!

Also, send latest "Commercial Radio" subscription rates.

73 and Tnx, fm
(Signed) "J. M."

Dear "J. M."

Fighting your way into a job in radio today is probably harder than it ever was before. Even the most optimistic correspondence schools are taking a much more cautious attitude on promising a job than ever before. Of course even the mildest promise means practically nothing, when it comes to performance.

Ship and land station jobs are being handed out, it is true, but then there are veterans of many summers on the waiting list. What do you think you would do in the event you had a job to give out and you were faced with this situation? Right, you are; the old-timers are getting the few berths available.

Now in the broadcast field when a great deal of technical experience is naturally expected, but of course there are more different points that a chap can apply for a job, it is about the same. Forty fighting for every job available. Once in a while the old order is excepted, and for personal reasons, either friendship or the requirements of the moment the job goes to a newcomer. Why there are even a great many men in this field who if it were not for the "code" would be working for nothing, just to get experience. The "code," thank goodness, corrected all this, though, and even that entry is closed to newcomers. Any old-timer out of work, of which there are many, will be glad to give you the story.

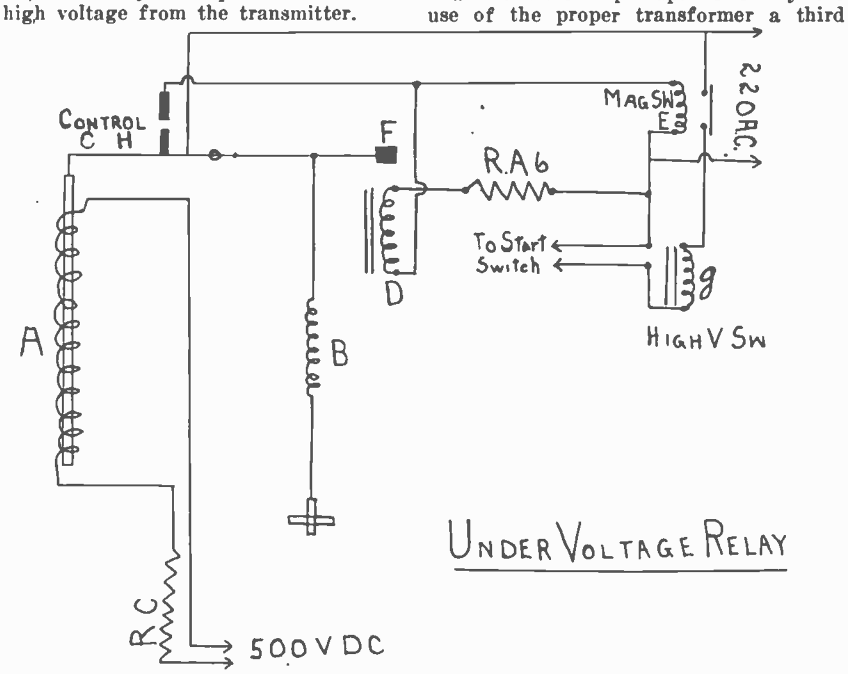
Description of an Under Voltage Relay for Tube Transmitters

By ALBERT MEYER, Chief Engineer KGBZ

THIS under voltage relay is a protective device and can be readily applied to tube transmitters that are not so equipped. Its main function is in the bias supply. If for any reason the bias supply becomes inoperative this relay will remove the high voltage supply from the transmitter. This will protect the power tubes from sudden overloads.

This relay consists of a solenoid "A" and a movable core inside of the solenoid on which is mounted a lever pivoted at the center. The control contact "H" and the armature "F" are mounted on this lever. The movement of the core is controlled by the DC current through the solenoid "A", partly by the tension of spring "B" and the magnetic force acting on the armature "F". This magnetic force is supplied by the coil "D" and the force acting on the armature can be increased or decreased by the adjustment of the movable core in coil "D" which is done by means of a screw and locknut. The resistor RC is a limiting resistor and limits the DC current through the solenoid. The resistor RAG limits the AC current through coil "D". When the proper voltage is applied between the terminals of the solenoid the core moves upward, closing the control contact "H", completing the circuit through the mag switch and also the mag switch contacts which completes the circuit through the holding coil "G" of the high voltage switch which can now be closed at will.

The purpose of coil "D" is to prevent the relay from operating under small DC voltage variations. When the proper adjustments of spring "B" and the movable core in coil "D" are made the relay will work with snap action. The relay can be set so that when the DC voltage varies over 5% the relay will open and remove the high voltage from the transmitter.



UNDER VOLTAGE RELAY

Here is a wrinkle that may prove interesting to station engineers where economy is a necessity. A goodly number of studio installations have only a three-position mixer. With the addition of a transformer and a D.P.D.T. switch the mixer can be converted to a four-position mixer. In the usual three-position mixer two microphones are used and one electric pickup. Then by the use of the proper transformer a third microphone or remote line can be switched in place of the electric pickup by the D.P.D.T. switch. No circuit detail is necessary as all mixer circuits are well known.

The San Bernardino Police Radio

By R. Carl Anderson
Radio Engineer, KGZY

OUR transmitter is entirely composite, designed and constructed by myself, on a labor basis. All parts were purchased with the object of economy in view, but reliability was not sacrificed. This economizing was necessary due to the extremely close budgeting of the police funds, most of the investment being secured through the diligent and persistent efforts of our Chief of Police, Daniel G. Murdock. The transmitter components and three automobile receivers were purchased at a cost of approximately $600. Most of this amount was secured through public donations and a benefit dance arranged by the Chief of Police.

The transmitter is constructed in two racks, one comprising all AC power units, the other, all radio and audio frequency circuits well isolated.

The power unit contains three power supplies: one 1,000 volts using 866A rectifiers, two 400 volts using 5Z3 rectifiers. The high voltage supply powers the modulators, last buffer and class "C" stage. One low voltage supply is utilized on the lower radio frequency stages, the other, on the speech amplifier stages. All bias, at the present time, is supplied by batteries.

The radio frequency section consists of a '47 crystal controlled oscillator, '46 first buffer, '10 second buffer and 203A class "C" amplifier with quarter wave Marconi antenna.

The audio portion consists of a double button carbon microphone, two resistance coupled '56's, two push pull 245's and two 845's operating as class "A" modulators, giving 100% modulation capability easily.

The transmitter has been operating eight hours per day for ten months with no replacements, filaments on steadily at normal voltage. The only difficulty yet encountered has been that caused by the crystal and temperature control equipment which has required careful watching. The crystal has developed two peaks about 400 cycles apart, but despite this condition we have been able to maintain our frequency well within the .04% deviation tolerance.

At the present time four cars and one motorcycle are radio equipped. No trouble is experienced with dead spots, although one of our streets has the interesting peculiarity of weak spots every few feet for its entire length of a mile and a half.

The present service covers only about twenty square miles, but the transmitter has proven its capability of consistently covering 150 square miles. The sheriff's office of the county of San Bernardino, comprising about 20,000 square miles, are investigating the possibility of adding a 500-watt linear, class "B" amplifier, to the present installation.

The time required to have police officers at any address in our city of 40,000 inhabitants averages less than three minutes from the time the call is placed. An extension on one of the police desk phones serves for intercommunication to the transmitter room.

The relief operator is Theodore T. Emm, who under the present schedule of eight-hour operation works one day per week.

The composite nature of the transmitter permits accessibility and improvements are made from time to time, during operating hours.

The effectiveness of this system has been proven by the abrupt increase in the number of arrests at its inception and the subsequent dropping off as the results impressed the potential criminals.

Airway Notes

Three good radio reports have been published by the Department of Commerce, and are worth the reading of every radio operator. They are: First Report of Liaision Committee on Aeronautic Radio Research; Second Report of Liasion Committee on Aeronautic Radio Research; and Third Report of Liasion Committee on Aeronautic Radio Research.

Broadcast Chain President Speaks Up

William S. Paley

WILLIAM S. PALEY, President of the Columbia Broadcasting System, made the following statement:

Radio broadcasting in 1934 has been a vital force in the nation's orderly march into new adjustments. By making possible, on a more democratic basis than in any other nation, exhaustive public discussion of every vital problem of the day, American radio has attained a new and fundamental importance in the nation's life.

The year just closed has been one in which public discussion of economic, political and social relations has been more widespread than during any other modern period.

Moreover, this discussion has been an orderly one without undue social stress. And I believe that greater interest in the discussion itself—and the absence of social stress—owe much to radio, with its facilities for rapid interchange of thought not merely between leaders and the people, but also between the many diverse sections of the country with their varying interests.

Most important organs for the expression of American public opinion have identified themselves with some certain political or economic creed. Radio broadcasting, however, does not itself editorialize. In the periods it daily devotes to serious discussion of current issues, radio acts essentially as a great open forum, impartially available for national discussion of the most divergent views, aims, and philosophies. It thereby serves as a public voice for every responsible group with a message or issue of import to place before the people. The result is that our democracy of millions has recently been functioning as efficiently in studying its problems and making swift decisions, as did the democracy of Athens which consisted of only a few thousand free men.

Thus in 1934 the Columbia Broadcasting System has brought to its microphones labor leaders and financiers; spokesmen for the political minorities as well as for the government; economists of every shade of thought; religious leaders of all the major faiths and creeds.

To present a background of general information, against which judgments can be more accurately formed, Columbia has cooperated with many scientific, educational, medical, civic and social organizations to present informative programs consisting both of lectures and of dramatized events. The scientific frontiers of radio have extended from the stratosphere to the sea depths, from the far north to the south pole.

Likewise, international broadcasts have been frequently arranged to give our people an insight into the ways of living in foreign lands, and an understanding of the thought of foreign leaders. Leaders and makers of policy in most of the great nations of the world have spoken into Columbia microphones during 1934.

This policy of the open forum, maintained in close cooperation with hundreds of representative groups, is to be continued and broadened by Columbia in 1935. As a nation we are still aware of certain domestic tensions; we are likewise painfully conscious of international stress and strain. In such an era a public hearing for any thesis, deserving the people's thoughtful consideration, that is presented in fair, free and unimpassioned discussion is the finest safeguard of our essential national unity.

Columbia in 1935 will extend, at the same time, its schedule of educational and cultural broadcasts, for adults and children alike. It has been said that entertainment is the first function of radio. It is equally true, however, that there are many levels of comprehension and taste; that delight for one listener is boredom to another; that entertainment for a national audience consists necessarily of a great variety of broadcasts. A familiar example is the symphonic music, which under the leadership of great directors Columbia is now broadcasting in greater quantity than ever before: such music is sheer recreation and enjoyment for part of the radio audience, while serving as an educational and cultural force for others who have not previously learned to appreciate its intricacies.

As an audience is led to appreciate and seek higher or finer forms of entertainment, the national cultural level becomes appreciably raised. To this extent, even programs of pure entertainment can, over an extended period, be educational in their direction. Many commercial sponsors, for instance, have in recent months broadcast, at huge expense, programs of grand opera and symphonic music, sung by the greatest stars and played by the greatest of our musicians, largely as a result of the wider public appreciation for these things which radio has been creating.

The educational work of the American School of the Air, carried on in cooperation with educators of national eminence, will be continued during all the days of the 1935 school season.

Those planning radio programs today are well aware of the more discriminating and critical taste that has been rapidly developing among radio listeners in recent years. We welcome it; we feel indeed that our work has been contributing toward it; and our 1935 programs will take full cognizance of it.

KEX CLAIMS ONLY VERTICAL ANTENNA IN WEST

By O. R. ANDERSON, Chief Operator

BY way of information "The Oregonian" operates two broadcast transmitters which are operated from the same transmitter building, with combined studios for both stations in the Oregonian building. KGW 1000 watts 620 KC and KEX 5000 watts 1180 KC.

Both transmitters and studios incorporate latest equipment designed for the art of broadcasting. KEX utilizes a vertical antenna over 300 feet high. A wooden mast supports the copper tubing antenna and circuits to hazard lights on mast are run inside the copper tubing. This vertical antenna, recently installed for KEX, has greatly reduced fading, affording an increased ground wave. KGW has the conventional T type antenna 300 feet high.

Technical department consists of H. Singleton, engineer; E. Meisner, assistant engineer; O. R. Anderson, chief operator; C. M. Carlquist, Clyde Bruyn, Art Bean, F. Wetteland and A. Olson, operators. Carlquist and Anderson are oldtimers, having been ship operators even before the inception of broadcasting, and have been with KGW over eight years each. Carlquist, Anderson, Bean and Olson don't get enough radio at the two transmitters so have amateur stations at home to satisfy their technical pursuits.

KGW-KEX transmitters are located near the junction of the Willamette and Columbia rivers and have a ground system second to none. The site is diked land so the XMTR building is below water level.

We would be pleased to hear from any operators who operate combined XMTRS from one point. The KEX vertical radiator was designed by Engineer H. Singleton and is the only one of its kind in the West. The speech input racks for KGW-KEX at transmitter are in a copper screened room and all AC operated. No cross talk whatever is experienced.

775 AIR LINE AIRPLANES EQUIPPED WITH RADIO

There are 775 radio-equipped airplanes in commercial and private operation in the United States, according to a survey just completed by the Bureau of Air Commerce, Department of Commerce.

The scheduled air lines lead in number of radio-equipped aircraft with 345. Miscellaneous commercial operators, such as charter and taxi services, have 49. Business firms operating airplanes have 135 which are radio-equipped. Private owners with radio in their airplanes number 246.

Government-owned airplanes, such as those operated by the Army, Navy, Bureau of Air Commerce, other Federal agencies or state governments were not included in the study.

The 775 radio installations include 326 which are two-way, capable of both receiving and transmitting by radio telephone. The other 449 are one-way, and can be used only for receiving messages.

Air Commerce Regulations

Sec. 4. Radio Operator

The first pilot or copilot may serve in the capacity of radio operator. Where, because of the nature of the route, equipment or mode of operation a full-time radio operator is considered necessary, then he shall serve as a separate member of the aircraft crew.

LOUDNESS AND PITCH

By HARVEY FLETCHER

Member of the Technical Staff, Bell Telephone Laboratories

MUSICIANS employ three terms to describe different aspects of the sensation they experience when listening to musical tones. These are pitch, loudness, and timbre, although the term quality, or tone color, is sometimes substituted for timbre. Most textbooks on physics have taught that these psychological characteristics are related in a simple way to three corresponding physical quantities: frequency, intensity, and overtone structure. The relationship between pitch and frequency, and between loudness and intensity, has been thought to be one of direct correspondence: the pitch of each note corresponding to a definite frequency, and the loudness of each note to a definite intensity. The relationship between harmonic structure and timbre has had no such simple formulation, but at least the timbre has been thought to depend on overtone structure alone. Studies in these laboratories, however, have shown that no such simple relationships exist, that each of the psychological quantities—although depending chiefly on the corresponding physical quantity—actually depends on all three. That there has not been a strict one-to-one correspondence between loudness and intensity has been known for some time, but only recently has accurate quantitative data been obtained. Between pitch and frequency, on the other hand, it is still generally thought that there is a strict one-to-one correspondence.

Frequency is the number of vibrations per second made by the sound source, such as a tuning fork or a violin string. Most musical tones, however, are composed of a series of frequencies which are multiples of the lowest or fundamental. For such tones the frequency of the fundamental is considered as the frequency of the tone, while the number and magnitude of the harmonics produce the overtone structure that results in the perception of a definite timbre. The intensity of the tone is the power content of the air vibrations at the position where the listener hears the tone.

Among musicians loudness is roughly gauged in seven steps running from *ppp* to *fff*. Such a scale is entirely inadequate for scientific studies, both because the steps are too large and because there is no definitely established reference loudness. To provide a more suitable measuring scale, it has been the practice for some time in these laboratories to measure loudness in terms of the power intensity of a pure tone at a frequency of 1000 cycles per second. Because of the wide range of intensities to which the ear responds, it has been convenient to use a logarithmic scale of values. The use of such a scale is further justified because the minimum change in intensity that the ear can detect seems to follow more nearly a logarithmic than an arithmetic law. Moreover, since it is convenient to establish the zero of the scale near the lowest loudness that can be detected, zero loudness is taken as that caused by the smallest audible intensity at a frequency of 1000 cycles, which is 10^{-16} watts per square centimeter in a free air wave.

At 1000 cycles the loudness level of a tone is defined as the logarithm of the ratio of the intensity of the tone to the basic intensity of 10^{-16} watts per square centimeter. Thus if L is the loudness level of a 1000-cycle tone and I its intensity in watts per square centimeter, $L = \log I - \log(10^{-16})$ or more briefly $L = [\log I + 16]$. For an intensity of 10^{-14} watts per square centimeter at 1000 cycles, therefore, the loudness level would be +2, and for one of 10^{-4} watts it would be +12, which is about the greatest intensity that the ear can tolerate without pain. Since the loudness level is defined as the logarithm of the ratio of two powers, the unit is the bel, and thus the loudness scale runs from 0 to 12 bels, or from 0 to 120 decibels.

Intensity level is measured in exactly the same manner, and at 1000 cycles, intensity level and loudness level are, by definition, the same. At any other frequency, the loudness level is defined as equal to the intensity level of a 1000-cycle tone that would be judged equally loud by the average listener. Some of the relationships between loudness and intensity levels for pure tones, which have been determined during the recent studies, are shown in Figure 1. The heavy straight line running up at an angle of 45° to the right represents a tone of 1000 cycles where by definition loudness level and intensity level are the same. This equality also holds very closely for all frequencies between 800 and 1800, and for frequencies from 500 to 6000 cycles there is no very great difference between the loudness level and intensity level. At 30 cycles, however, the intensity must be raised to 64 db before the tone is audible, and above this the loudness increases rapidly—a 36 db increase in intensity causing a 100 db increase in loudness.

To study the relationship between pitch and frequency, scales of pitch and frequency levels were established somewhat analogous to those of loudness and intensity. There is no natural scale of intensity, and thus logarithms to the base ten were employed, with the result that an intensity of level 4 represents 10 times the power of one of level 3. With pitch the situation is different, because there is a natural pitch scale—the octave. The pure tones of the same loudness will be judged to be an octave apart when one frequency is double that of the other. Thus for these scales it seemed desirable to use logarithms to the base 2. As in defining loudness a constant frequency was selected for the reference tone, so in defining pitch a constant loudness level, that of 40 db has been selected. In selecting a zero level of loudness, the lowest audible intensity of the test tone was chosen, and a similar procedure seemed desirable with pitch. It is also desirable to have the pitch scale based on international pitch, which assigns a frequency of 440 cycles to A above middle C, and since a tempered

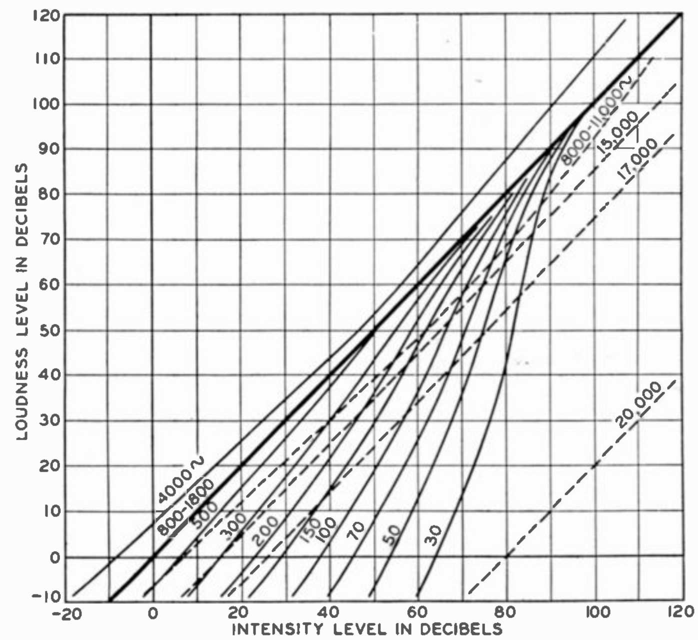


Fig. 1—(*Left*)—*Relationship between loudness and intensity levels for pure tones of various frequencies*

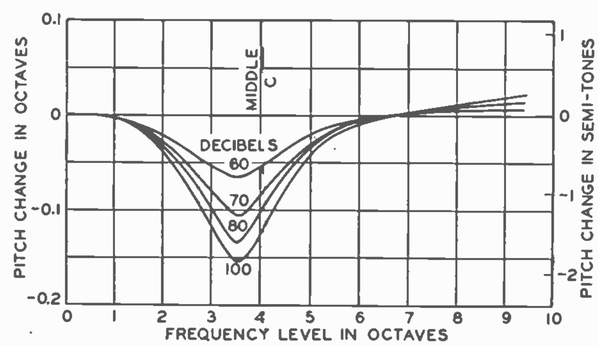


Fig. 2—(*Above*)—*Relationship between pitch change and frequency level for pure tones of various loudness*

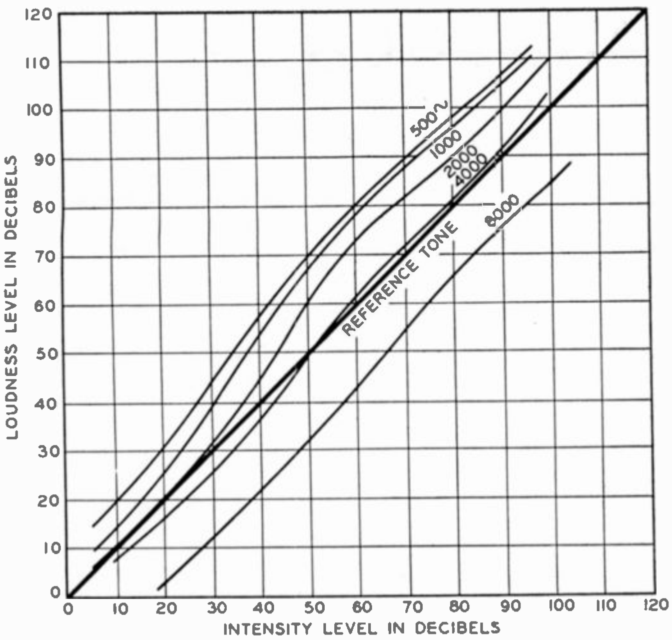


Fig. 3—*The loudness of a group of harmonic tones of equal loudness is found to be greater than the sum of the loudnesses of the individual tones*

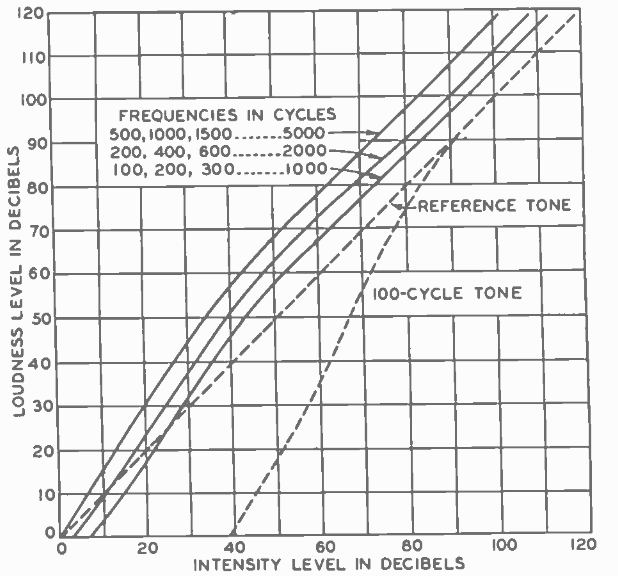


Fig. 4—*Relationships between loudness and intensities of groups of ten harmonic tones*

scale is almost universally used, C is the natural starting point. The zero of the pitch scale was thus taken as C four octaves below middle C, which corresponds to a frequency of 16.35 cycles per second. The pitch level of a tone of loudness level 40 is thus defined as the logarithm to the base 2 of the ratio of the frequency of the tone to 16.35 cycles; or if P stands for the pitch level of a tone of loudness level 40, then $P = \log_2 f - \log_2 16.35$.

Frequency level, F, is defined in a similar manner; $F = \log_2 f - \log_2 16.35$. As loudness level at a frequency of one thousand cycles is defined as equal to the intensity level, so pitch level at 40 db loudness level is defined as equal to the frequency level. At any other loudness level, pitch level is defined as the frequency level of a tone of 40 db, loudness level, that is judged equal to it in pitch. Since for both the frequency and pitch scales, logarithms to the base 2 are employed, the unit is the octave rather than the bel, and the audible scale covers a range of about ten octaves.

Until recently accurate studies of pitch at high loudness levels have been handicapped by the lack of suitable apparatus for producing very pure tones of high intensity. Such studies are now possible, however, by use of the apparatus developed for stereophonic, or auditory perspective, reproduction. Some of the results obtained are shown in Figure 2. Here the abscissas are frequency level and the ordinates, the difference between the pitch and frequency levels. Curves are drawn for tones of various loudness; the curve for 40 db loudness would by definition lie along the line of zero pitch change.

The pitch changes indicated here are rather startling to those of us who have been accustomed to think of a definite frequency always corresponding to the same pitch. If for example middle C is sounded at a loudness level of 40, the frequency, on the international pitch scale we are using, would be 262 cycles. If this frequency were held constant but the loudness increased from 40 to 80 db, the pitch level would drop 0.1, more than a half tone, or to a pitch that at 40 db loudness level would require a frequency of 238.7 cycles. The greatest changes occur at a frequency level of about 3.5 or what roughly corresponds to a pitch of F sharp below middle C. At this frequency an increase in loudness of 50 db lowers the pitch almost a full tone. For very low notes and for those at a frequency level between 6 and 7 (corresponding to frequencies from 1050 to

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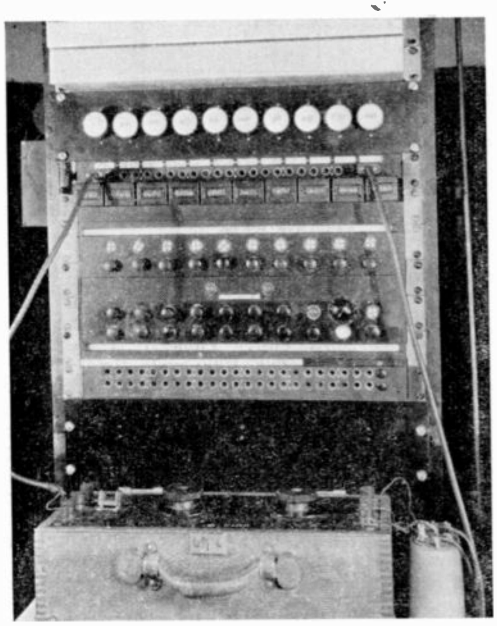

Harvey Fletcher

The apparatus at the right automatically presents a sound to be measured and a thousand-cycle comparison tone; the observer, Miss F. Torpadie, records her judgment as to which of the two sounds is the louder

The Fall of Samuel Jones

By VOLNEY G. MATHISON

SAMUEL JONES has always strenuously opposed the idea of my writing an account of his Great Fall. Once, when I casually mentioned the matter to him, he most emphatically objected, averring that he didn't want to have his private business printed in a magazine and exhibited on all the newsstands in the country, to be read and snickered at by the darn public. He declared that the said affair in question occurred many years ago, when, fresh from the turnip-patch and hayfield of a country farm, he was quite unsophisticated and wholly unversed in the deceiving ways of the fair sex; and he said he felt that Evelyn Campbell, the young lady in the case, made quite enough of a jackass out of him at the time, without my rubbing it in by writing a fool story about it. Hence, I was obliged to desist.

However, since just this morning, I was casually informed by the radio inspector that Samuel Jones has lately departed on a big freighter, off on a six months' voyage to Madagascar with a cargo of prunes and windmills, I have resolved to take advantage of his absence to slip you the story of his Great Fall.

Once upon a time, in the dim Achaean age of the wireless game when shellbacks were greenhorns and the straight-gap roared supreme, the chunky little steam-schooner "Wapama" pulled away from a San Francisco pier, one cloudy autumn afternoon with a full list of passengers—about twenty—and a cargo of lumber. The cargo had been brought down from the Columbia River, the passengers recruited at San Francisco, and the "Wapama" was bound for San Pedro, where she would be relieved of lumber and landlubbers, alike.

As the good ship rambled out through the Golden Gate, Samuel Jones, the chief wireless operator of the vessel, settled himself at his operating desk, as comfortably as the cramped combined wireless cabin and sleeping room would permit, and resigned himself to the necessity of standing watch until midnight, when he would be relieved by his assistant, Jimmie Morrow. With the phones resting loosely on his tow-headed cranium, he extended a long arm and dragged out a large musty volume from beneath the old-fashioned condenser rack. Hitching his chair around a few times until he was able to wrap his long, lanky legs around the motor generator in a manner to his satisfaction, he hunted for the place in the book where he had read last.

The book, which bore the weighty title, "Thrilling Adventures Among the Red-Headed Wild-Men of Bonga Tonga, by the famous missionary-explorer, Sir Sigismund Athanasius Mugfoot," clearly held a special attraction for Samuel Jones. Scarcely six months away from the adventureless environs of a country farm, he was intensely interested in the account of the perils braved by Sir Sigismund in his invincible determination to convince the cannibals of Bonga Tonga that canned horse-meat was better for the soul than fresh man-chops.

Samuel Jones had fallen into the habit of reading aloud for the benefit of his second operator, when he came to the more thrilling passages in the book. Jimmie Morrow had long since resigned himself to this business, and customarily listened to the stirring accounts of butcheries and battles with a callous indifference. Jimmie's main ambition was to sleep as much as possible, whether on or off watch.

"By jiminy, ol' Mugfoot sure had a excitin' time of it, all right," exclaimed Samuel Jones, for the thousandth time, addressing himself to Jimmy, who lay half dozing in his bunk—a narrow, crib-like affair, just above and a little to one side of the operating desk. "Here he tells how he got shipwrecked goin' from Bonga Tonga to Kinanakaluli, an' gets captured, along with eleven more of his gang, by enemy cannibals. The savages puts 'em all in a cave, an' the chief scoffs one every week, until ol' Mugfoot was the only one left; an' the chief wouldn't eat him because he was too darn tough an' skinny. He was tryin' to fatten him up a little, when a trader comes along an' the skipper of the trader gets the chief to swap the scraggly ol' missionary fer three drinks of rum. I reckon the chief thought he was gettin' a lot the best of the bargain at that, but, anyway, that's how Mugfoot got saved from the ol' stew-pot. That sure must'a been a great life, eh Jimmie?"

Jimmie's only comment was a grunt, as he turned his face to the wall and tried to sleep.

"By jiminy, soon's I get a couple years' time in on this job, I'm goin' to strike the chief fer a big tramp steamer, an' go all over the world, an' see some adventures like that myself, eh Jimmie?"

"Aw, fer th' love of Mike, lay off that adventure racket, will yuh!" grumbled Jimmie, growing peevish at being thus constrained from peaceful slumber. "You'd ought'a be thinkin' about gettin' married an' settlin' down."

Now this was an unfortunate remark, as Jimmie promptly discovered, for it brought upon him a long and brilliant lecture, in which the numberless advantages and incalculable value of travel was reviewed and enthusiastically dwelt upon, while matrimony and married life in general was scathingly disparaged and condemned to perdition.

"There's nothin' like travelin' an' adventure to learn a fellow somethin'," concluded Samuel Jones, earnestly, "an' travelin' an' marryin' don't mix. Course, I don't mind talkin' to the girls an' explainin' to 'em about the set, an' all that stuff, but you don't catch me fallin' in love with 'em—none of 'em! No darn woman's goin' to drag me up to a preacher like a fish on a hook an' spoil my c'reer with matrimony—no sirree—!"

Just at this moment, the chief wireless operator's dissertation was interrupted by a distant silvery laugh, a sound of light footsteps tripping across the deck, and the appearance of a picture of feminine beauty in the doorway.

"O-o-o-o-h! This is the wireless, isn't it?" trilled the fair one, resting a daintily manicured hand upon the door. "Please, may I come in?"

"Yes, sure, come right in an' have a seat," exclaimed Samuel Jones, gallantly, arising and offering his chair to the charming visitor. Six months of wireless operating and explaining radio to lady passengers unnumbered had rather thoroughly broken Samuel Jones of his original countrified shyness.

With a sweet "Thank you," Evelyn Campbell stepped into the radio cabin and accepted the chief wireless operator's chair. As she did so, Samuel Jones could not help noticing that she was attractive—charmingly, seductively, irresistibly attractive. There had been many fair young visitors in the radio shack at different times, but the little beauty who now sat in the chief wireless operator's chair and smiled so alluringly at him, certainly outclassed anything yet. Samuel Jones was a trifle embarrassed.

"So this is a wireless, and you are a real wireless man, aren't you?" she bubbled with a glance of her glorious eyes that shot through Samuel Jones like a thousand arrows and made his heart palpitate strangely. "I'm just awfully interested in radio—please tell me about it, won't you?"

This was the chief wireless operator's cue; he promptly plunged into an explanation of wireless telegraphy that covered everything from motor-generator to buzzer-tester; appended with a history of the art, beginning with the discovery by Hertz of wiggly wave-motions, and winding up with the latest dope concerning a fellow who was dreaming about a queer thing that he called an audion.

"You must be just wonderful to know so much," rippled Evelyn Campbell, with another entrancing smile. "It must have taken you years and years to learn it all, didn't it, Mr. Jones?"

"Oh, I don't know; it only takes about four or five years, if a fellow's got any brains a'tall," answered Samuel Jones, modestly, as he put on the phones and proceeded to impress his fair visitor by throwing a lot of switches in and out, accompanied by a skillful twirling of miscellaneous knobs and dials on the antiquated tuner.

"Of course, the wireless game's gettin' a little harder all the time," he added, slamming up the plunger of the rickety underload-breaker and frowning thoughtfully at the storage-battery voltmeter; "they're gettin' a good many of them new quenched sets an' arc outfits out on the ships nowadays, an' a fellow's got to study a lot to keep up to date. But it don't take most operators more'n eight or nine years to learn to handle even them newest sets—"

The chief wireless operator paused as the "Wapama" slamming her bluff bows into the heavy seas running on the bar, began to roll and pitch, sickeningly.

"Oh, dear, I'm getting seasick," gasped Evelyn Campbell, rising. "I'd better go."

Expressing his sincere sympathy, Samuel Jones solicitously assisted the fair maiden to her stateroom.

Returning to the radio shack, the chief wireless operator reseated himself, hung the phones over one ear, and took up the book of adventure. Locating the place where he had been interrupted, he began to read. He went scarcely a page, however, when he realized that the book had somehow become strangely stale and flat. Evelyn Campbell seemed to smile alluringly at him from between every line; his attention was distracted by unbidden thoughts of her shapely figure, her dainty hands, her seductively glorious eyes. With a sigh, Samuel Jones closed the book and shoved it back underneath the condenser rack. As he did so, he heard something that sounded suspiciously like a snicker. He glanced up sharply at Jimmie Morrow, who was still lying in his bunk, but the second operator apparently was dozing peacefully as usual.

Clamping down his phones, the chief wireless operator adjusted the carborundum detector and listened in. He heard the usual crash of traffic and he essayed to enter upon his favorite pastime: to take note of some particular signal and read it through all interference by sheer concentration—and failed. Wireless had become as stale and dead as the book of Bonga Tonga.

Samuel Jones had fallen. His fall had been sudden, headlong, and complete. He was subconsciously aware of the fact that he had fallen a victim to Cupid, but he firmly refused to admit any such thing—not even to himself.

The retarding wind that the "Wapama" met at the Golden Gate increased in strength and was attended by a choppy swell, in which the steam-schooner tossed and pitched wearily all through the night. Morning found her diving wildly into towering seas and barely holding her own with the gale.

The storm continued through the day. Evelyn Campbell was very seasick, and Samuel Jones worried a good deal about her. The chief wireless operator, recognizing his sympathetic anxiety for the fair traveler as something wholly unprecedented and altogether unbefitting one destined to a life of adventure on the high seas, strove with a vague uneasiness to stifle his thoughts by turning his attention to other things. But with poor success, however.

Toward nightfall the gale suddenly moderated somewhat. Samuel Jones happened around to Evelyn Campbell's stateroom, for the simple reason that he couldn't keep away; although he probably would have indignantly denied it, had anybody so insinuated. The charming passenger was not feeling much better, despite the abatement of the storm, but she did indicate a desire to get out on the upper deck and rest in a steamer-chair. Samuel Jones eagerly, yet rather diffidently, assisted her to a comfortable chair, which he placed behind a stack of life-rafts near the lee rail, where she would be sheltered from the wind. As he awkwardly proceeded to wrap her up in a warm deck blanket, to protect her from the chilly air, his hand touched hers once, and he experienced a wild, sharp thrill that left him quite confused afterward.

"It's awfully good of you to be so nice to me," said Evelyn Campbell, sweetly, when the chief wireless operator, having made her as snug and comfortable as he knew how, stood wavering, uncertain whether to go away or to hang around; "and, if you're not too busy, won't you stay and talk to me a little while, please?"

Samuel Jones was not too busy, and he stayed. Half an hour later, the "Wapama" had occasion to alter her course a few points, bringing the heavy sea directly abeam. The result was immediately noticeable. As the old ship laid over on her very beam ends, from somewhere below there arose a terrific crashing, slam-banging of upsetting cans and buckets, followed by great streams of heartfelt profanity from the engine-room gang.

"Oh, oh," moaned the seasick beauty, as the vessel lunged, gaspingly and sickeningly. "If I had to endure such misery very long, I would jump right overboard."

"I'll go an' get you a glass of salt water an' a hunk'a stale bread," said Samuel Jones, anxiously arising at once. "That's good for seasick people."

He hastened down a companionway to the galley, which was two decks below. As he filled a tumbler with water and stirred a little salt into it, the "Wapama" was unexpectedly caught up by a succession of unusually high and sharp-crested waves, in which she rolled more wildly than ever. Thinking to himself that this would make his fair protege even sicker than she was, the chief wireless operator glanced out through a galley port-hole at the heaving waters, hardly visible in the increasing darkness; and, just as he looked, he saw something—a dark huddled object, a brief flash of white—fall by the open port and vanish noiselessly into the sea.

For a moment, Samuel Jones stood bewildered. Then his brain reacted to the testimony of his eyes with a terrifying recollection of Evelyn Campbell's threat to end her seasickness—to commit suicide. What he had seen had fallen from directly above—from the very place on the upper deck where he had left Evelyn in her steamer-chair. His imagination swiftly reconstructed what he had seen falling—the little dark figure, the flash of white petticoats! And, as this awful conviction laid hold of Samuel Jones with an icy grip, with it there came like a crash of lightning the burning realization that he loved Evelyn Campbell—that he loved her deeply, intensely, mightily. It was a crystallization of feeling under stress of catastrophe, and in its dazzling revelation Samuel Jones was electrified to action. Throwing aside the tumbler of water, he sprang up the companionway to the poop deck.

"She's overboard!" he shouted to the officer on the bridge. "She's overboard! Stop the ship! Quick! Stop her! Stop her!" His breaking voice rose in wild anguish above the thumping of the engines and the churning of the propeller.

Almost instantly, the engine-telegraph clanged sharply; with a squeal and a jerk the throbbing pistons came to a sudden stop. People seemed to spring from nowhere from out the darkness; anxious questions were hurled back and forth; up on the pilot house the ship's searchlight sputtered into action. Coming out of his cabin, the captain of the "Wapama" saw the crowd gathered on the poop and he hastened aft. Incoherently, Samuel Jones began to tell of what he had seen go by the galley porthole. Before he could finish, a loud guffaw broke in on his stumbling words. It was a rude, coarse laugh, altogether out of keeping with the tense and dramatic situation. Everybody turned. Under a deck light stood a brawny wiper, clad in greasy overalls. In his hands was a big chunk of waste, with which he was wiping lubricating oil from his face and forearms.

"Shure, an' I knows what yiz saen, fur I wuz here an' haeved it ouver mesilf!" he asserted, in his strong brogue. "Didn' yiz hear th' ile cans upsittin' whin th' ould gurrl took that beam-inder a bit ago? I jist claened up the worst av th' dirthy mess an' brung up th' swabbins. 'Twas a sack av greasy rags yiz saen chicked ouver th' side, an' naught ilse, begorrah!"

Somehow, Samuel Jones managed to escape from the crowd. Going up the second companionway to the upper deck, he went behind the stack of life-rafts to the place where he had left Evelyn Campbell. He found her just as he had left her snuggled warmly in the blanket he had put around her. She was fast asleep.

Of course, Samuel Jones suffered a severe reprimand from the captain, and all the ship made him a victim of merciless jibes. He bore it all, however, without flinching. He didn't really care. The incident, absurd as it was, had brought him conscious realization that he was deeply enamored of Evelyn Campbell; thereafter nothing else mattered. From that time on to the end of the voyage he hovered over his fair lady with a tender solicitude that seemed blissful and sublime to him; although it was ludicrously funny to everybody else. He attended to her every trifling wish that it was in his power to gratify, he stole fruits and delicacies from the ship's icebox for her, he bribed indifferent stewards to prepare appetizing broths and tempting salads—and the stewards saw to it that his bribes were substantial.

As he had no time to sleep, he stood his watches in a comatose condition, in which he dreamed of matrimonial blisses and pictured himself living in a second Paradise with his Eve. In his waking moments, he thumbed a home-builder's catalogue that he had unearthed somewhere; or pondered on the rather knotty problem how he was going to feed his fair lady all the bacon and beefsteak she wanted; how he was going to furnish her with expensive silk stockings and, er—other needful things; and how, at the same time, he was going to pay installments on a four or five thousand dollar bungalow for her to dwell in—all on his salary of thirty-seven dollars and fifty cents a month. (Remember, dear reader, this was not 1935.) Although it hardly seemed workable in figures, Samuel Jones knew that, according to the service regulations of the wireless company, he soon would be entitled to an increase in salary of two dollars and fifty cents a month; which would help some, anyway.

The heavy weather stayed on all through the trip and Evelyn Campbell (purposely, perhaps) remained more or less seasick. Samuel Jones was at her side as much of the time as possible, stoically indifferent to the open ridicule of the ship's company and the caustic comments of the captain.

The fourth night out, the much-delayed "Wapama" rounded Point Arguello and entered the smooth water of the Santa Barbara channel. Evelyn Campbell became well immediately. In the morning, when the little steamer made fast at the San Pedro wharf, the fair beauty was almost the first one down the gangway.

Samuel Jones was half way through the laborious process of changing into his "shore clothes," when he chanced to look out through his cabin window and saw her going. Frantically, he hunted for a mislaid back collar button; not finding it, he desperately stuck his collar on without. Throwing an awry half-hitch into his necktie, he grabbed his hat and sallied forth. Striding down the gangway, he hurried to where Evelyn Campbell stood waiting for a steward to bring her suitcases ashore.

As Samuel Jones came rushing up, he suddenly noticed that a hard and solid-looking male person was standing near

(Continued on Page 22)

GALVANOMETRY IN VACUO

By W. B. ELLWOOD

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By its association with the science of hurling missiles, the word "ballistic" describes a certain type of galvanometer very graphically. When a charge of electricity is shot through such a galvanometer, the instrument measures the amount of that charge. Theoretically, indeed, the more nearly the charge is compressed into a single projectile-like packet, the more accurately the galvanometer will measure it.

Practically, of course, the charge flows through the galvanometer during a small but appreciable period of time. Its passage constitutes a pulse of current, and it is the task of the galvanometer to integrate or sum up the instantaneous current values of this pulse and indicate the result of this integration accurately in its deflection. The galvanometer accomplishes this best if its period of swing is so long that the charge has completely passed through it before it begins to move appreciably.

Such a galvanometer forms a convenient means for studying the magnetic properties of materials. A sample of a material is placed in a magnetic field and a suitable coil about the sample is connected to the galvanometer. When the field is suddenly removed or reversed, the magnetic flux which it had established in the material cuts through the coil, inducing a voltage in it which drives a charge of electricity through the galvanometer. The galvanometer reading is thus a measure of the flux which the field had established, and such readings can be used, together with the known values of the field strengths, as a basis for drawing the familiar curves relating field strengths to the fluxes they produce. Because of the low field strengths and fluxes frequently utilized in communication apparatus, the investigation of magnetic materials in these laboratories requires unusually sensitive and accurate measuring equipment.

Ballistic measurements can be made with suitably constructed galvanometers of either of two general types; that in which the charge passes through a fixed coil and the resulting magnetic field moves a permanent magnet, or that in which the charge passes through a movable coil and the induced field reacts with the field of a fixed magnet to move the coil. For measurements on magnetic materials at low flux densities, the moving-magnet type can be made amply sensitive, but it is inaccurate because it cannot readily be shielded from the effects of external fields and does not accurately integrate pulses of current of appreciable duration. Commercial moving-coil galvanometers, on the other hand, while better integrators, are still inadequate both in this respect and in sensitivity for extremely delicate measurements.

Fortunately there is a principle, stated by Maxwell, whereby the effective sensitivity of a ballistic galvanometer can be considerably increased; and the application of this, together with other principles tending to improve both the sensitivity and the accuracy of integration, are embodied in a new moving-coil galvanometer recently developed in these laboratories. The principle is that, if the charge to be measured can be sent repeatedly through the galvanometer, timed in proper relation to the natural period of its swing, the amplitude of the swings will increase to a steady value which is proportional to the charge and which is greater the smaller the damping. Air damping is eliminated by suspending the moving-coil in a vacuum, and elastic hysteresis in the suspension is minimized by the use of a flat tape so thin as to approach a bifilar suspension of metal in the neighborhood of the coil, in its properties. By avoiding the use eddy currents and hysteresis losses in the galvanometer are also minimized, and the accuracy is correspondingly improved.

The construction of the galvanometer is shown in simplified form in Figure 2. The moving-coil C, two centimeters in diameter, consists of thirty-six turns of enameled wire, held together by enamel. It can be clamped or released by the glass hooks H and the wire W, which expands when heated electrically, and

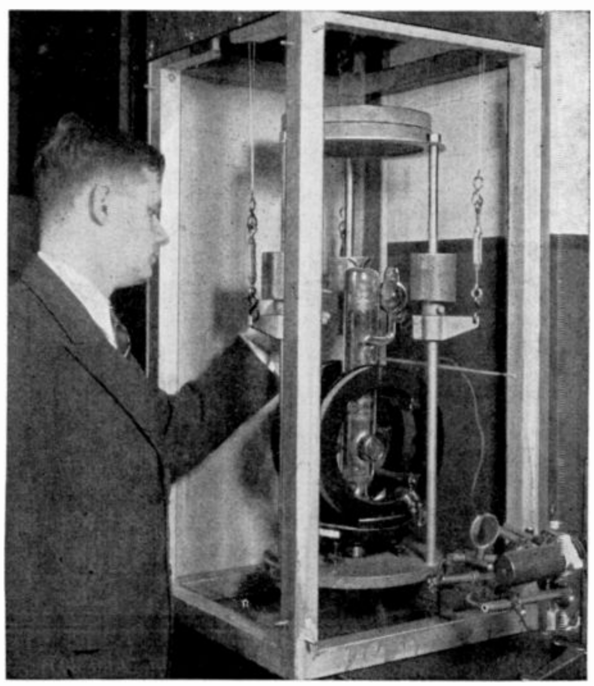


Fig. 1—(*Left*)—*In the new ballistic galvanometer, the moving element is a fine coil suspended in a highly evacuated glass tube*

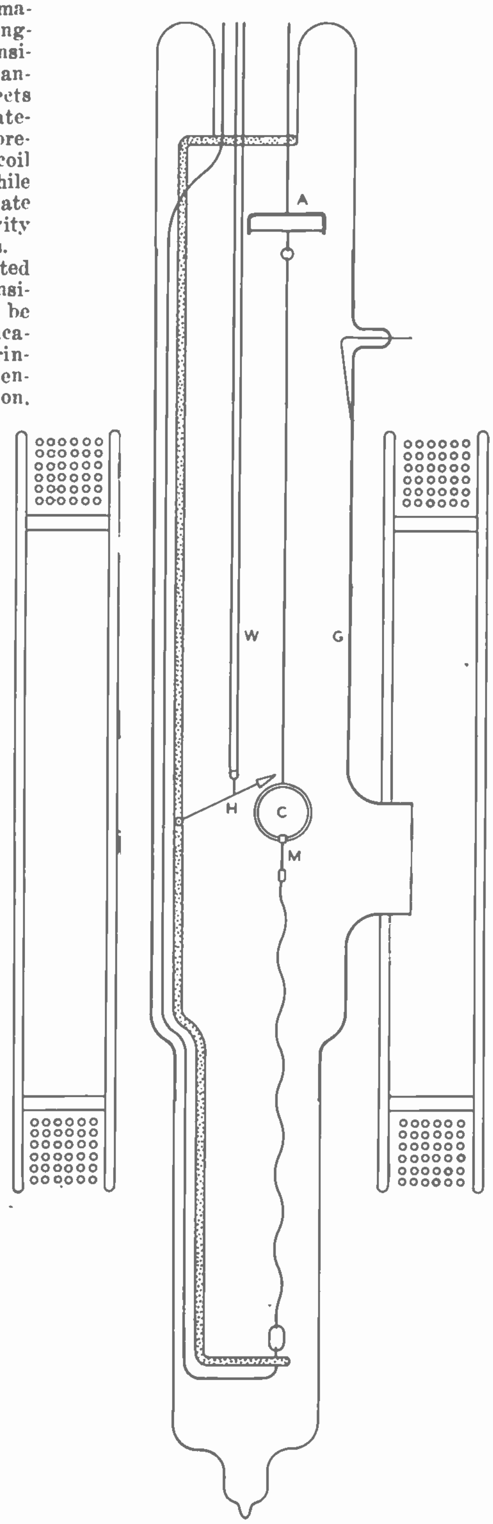


Fig. 2—(*Right*)—*In the new ballistic galvanometer a moving coil, carrying the pulse of current to be measured, turns in a magnetic field which is produced by a pair of Helmholtz coils*

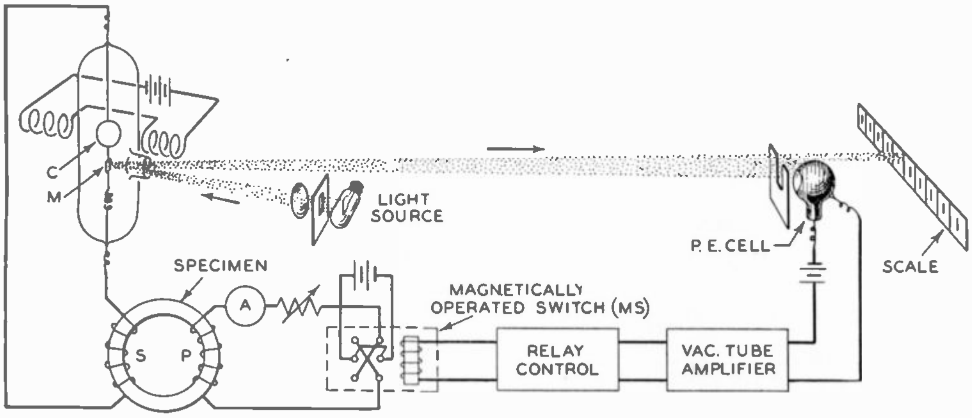


Fig. 3—*Every time the galvanometer coil swings through its zero position, a beam of light acts through a photoelectric cell to reverse the current through the primary winding, of the transformer under test, and thus passes another pulse of current through the galvanometer, in a direction tending to increase its swing*

W. B. Ellwood

can be set at any azimuth by the magnetically controllable armature A. The mirror M is a gold-plated glass strip, perpendicular to the coil and attached to it by an isolantite saddle. The upper suspension, attached to the coil by a bit of metal held in a similar saddle, is a flat strip of copper only three-thousandths millimeter thick and less than one-tenth millimeter wide, and a similar strip coiled into a spiral forms the lower suspension. Copper was chosen as the material presenting the best combination of low resistivity and low coefficient of internal friction.

All these parts are supported on a glass stem sealed into a glass tube which was baked, exhausted, and sealed at an extremely low pressure.* Since the baking temperature of the assembly is limited by the suspension fiber to 100 degrees Centigrade, the coil and tube were prebaked at 300 degrees. A transparent conducting film of gold G, connected at one terminal of the suspension and grounded, affords electrostatic shielding. A pair of large Helmholtz coils outside the tube provides the necessary field in which the coil turns. The strength of the field is about 40 oersteds when the coils are connected to a 135-volt battery. The whole instrument is mounted on a vibration-absorbing suspension.

Outside the tube a light source and a photoelectric cell are so placed, behind s'its, that the mirror reflects a beam of light into the photoelectric cell when the galvanometer is undeflected, as shown in Figure 3. The magnetic material to be investigated is made up into a toroidal transformer, whose secondary winding is connected to the galvanometer and whose primary is connected to a battery through a reversing switch. When the switch is operated, the flux through the transformer core is reversed and a momentary voltage is induced in the secondary winding, deflecting the galvanometer. When the coil swings back through its zero position, the photoelectric cell receives a light impulse and acts through an amplifier and relays to throw the switch and reverse the flux again, passing another momentary current through the galvanometer in a direction tending to increase its swing. Once started, the instrument can be left to operate in this fashion, until, *in about a half hour*, the deflection has so nearly reached its ultimate value that it can be satisfactorily taken as the measurement. The ultimate deflection is about 33 times the initial deflection. It is important for the accuracy of the final reading that the successive impulses be accurately timed to occur while the coil is passing through its zero position.

The deflection of such a galvanometer is limited by both electrical and mechanical factors. Of the latter the most important are the viscous drag of the air and of the coil suspension, which have been reduced by evacuation and by the use of a thin tape suspension. As for the electrical factor, it can be shown that there is a relation connecting the deflection of the coil with the number of turns of wire in it, the area enclosed by it, its resistance, the strength of the fixed field, and the sum of all other damping factors. After the galvanometer has been constructed, all these features are constant except the strength of the field produced by the Helmholtz coils, and there is a certain strength at which the deflection will be a maximum for all measurements, as shown in Figure 4.

The galvanometer is actually operated at a field strength somewhat higher than the optimum, in order to reduce the time constant of the galvanometer so that the swings will increase in amplitude sufficiently rapidly to permit readings within a reasonable time. The period of the swings remains sufficiently long to fulfill the classical requirement for accuracy of integration: that the charge to be measured should pass through the galvanometer before it moves appreciably. Within the half hour ordinarily consumed in a measurement, the galvanometer executes about a hundred swings and the deflection reaches about 99 per cent of its ultimate value. Calibration shows the response of the galvanometer to be strictly linear: always proportional to the amount of the charge which has passed through it.

The qualities of the new galvanometer have made it almost indispensable in magnetic measurements where the available change in flux is small. The curve of field against flux for the toroidal iron-

(Continued on Page 22)

*About 10^{-5} mm. Hg. There is no advantage in evacuation unless it is carried to the point where the mean free path of the gas molecules is comparable to the diameter of the coil.

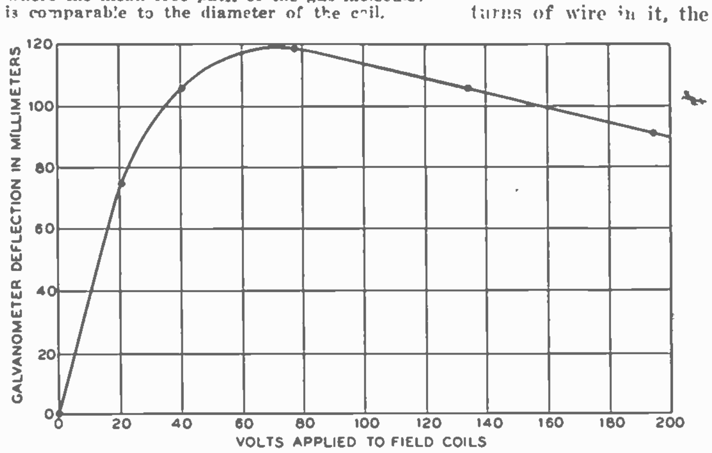


Fig. 4—*There is a definite external field strength at which the deflection of the galvanometer will be a maximum*

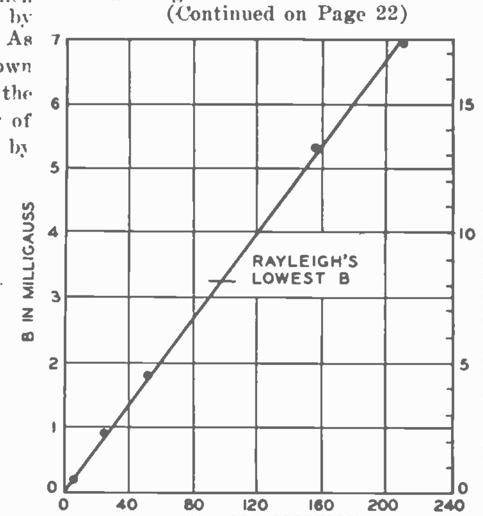


Fig. 5—*With the new galvanometer it has been possible to measure the fluxes produced in iron-dust cores by very weak fields, carrying the investigation into flux ranges far lower than those of Rayleigh's classical researches*

The Six-String Oscillograph

By A. M. CURTIS

Member of the Technical Staff, Bell Telephone Laboratories

WHEN the first model of the rapid record oscillograph was designed in 1929, it appeared that an instrument capable of recording simultaneously three currents of any frequency in the commercial speech band extending to 3000 cycles per second would probably answer most needs, and that the higher frequencies would be studied by the cathode-ray oscillograph. But almost as soon as members of the laboratories became accustomed to the convenience of the new instrument they began complaining that it was not good enough. One wanted to see what went on in the 4800-7600 cycle carrier band in his apparatus; why did the oscillograph have to stop at 3000 cycles? Another wanted to push a button on the front of a panel and see what happened on the oscillograph back of the row of racks, and he couldn't be on both sides at once. Still another wanted to watch a wave which was supposed to be continuous but sometimes wasn't, without using a mile of paper in the process.

First we tried shortening the string of the oscillograph galvanometer and pushed its frequency up to 6000 cycles, when we happened to have a good batch of wire. This required a lens of greater magnification in order to get the same deflection as before on the paper, which meant a thicker string image and less light where we needed more; and we could use only two strings where some customers wanted four or six.

Then we enlisted the help of mathe-

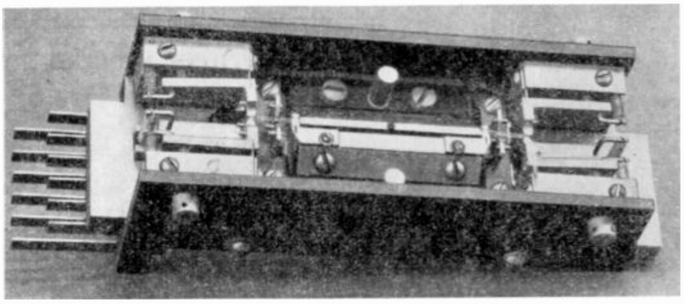


Fig. 1—*In the galvanometer of the six-string oscillograph, the six strings pass across a small hole in the pole piece, through which light shines to form their images on the light-sensitive tape*

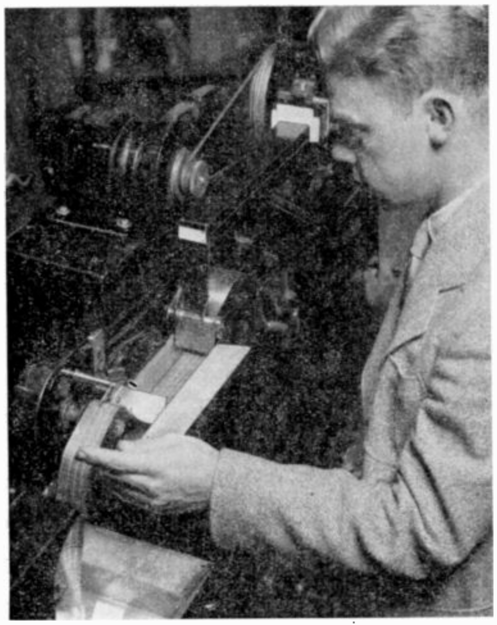


Fig. 2—*(At Left)—A record being inspected, as the oscillograph takes it, by T. L. Tuffnell*

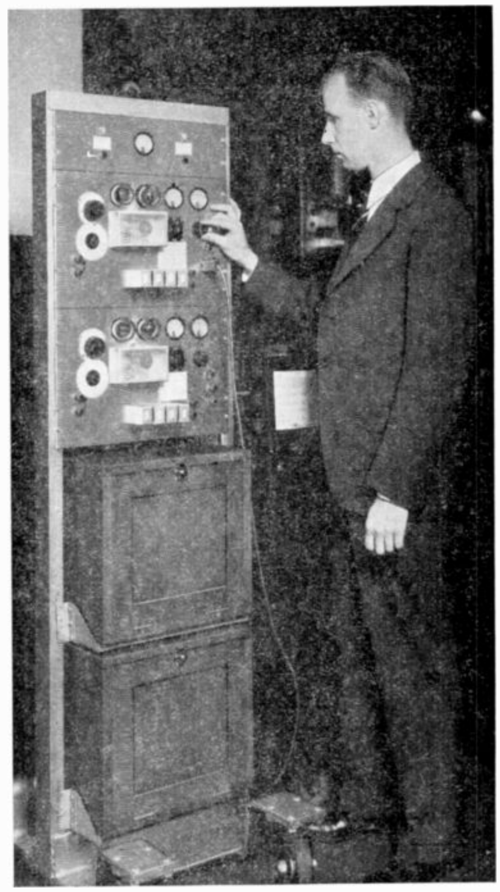


Fig. 4—*(At Right)—The new amplifier for use with the rapid record oscillograph, being operated by A. E. Melhose*

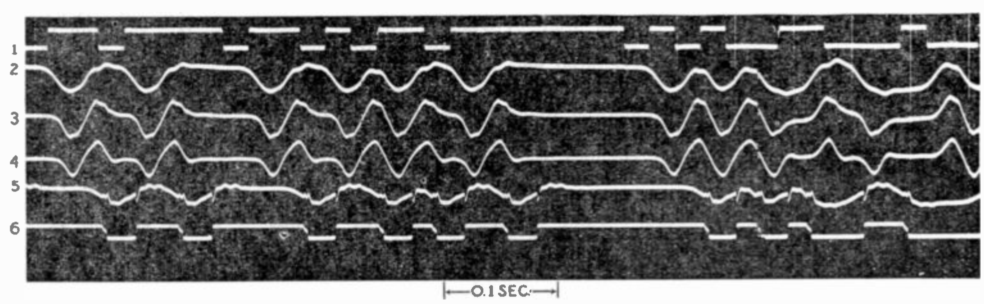
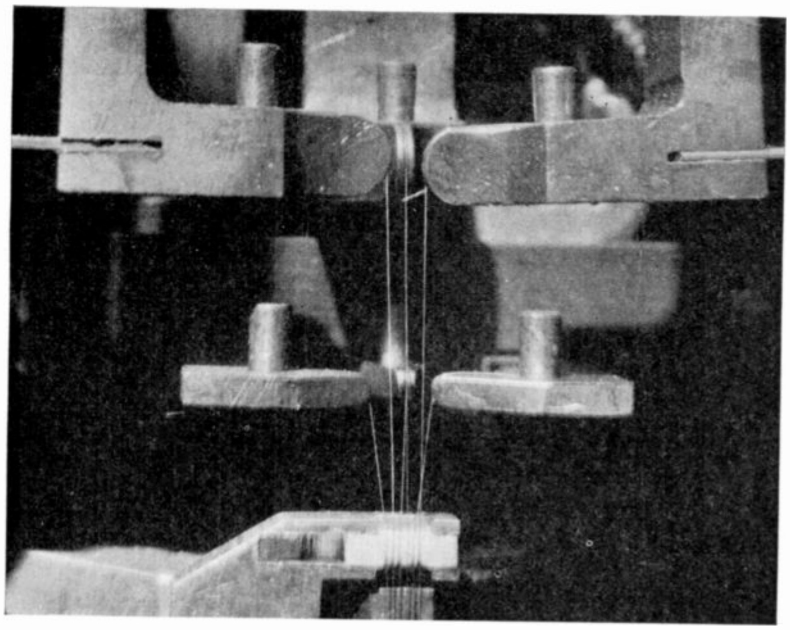


Fig. 3—*This oscillogram of an experimental telegraph repeater system shows (1) the sending voltage, (2) the current at the output of the first 100-mile line, (3) the current at the input of the second line, (4) the disturbance (amplified) which it creates there across a telephone circuit at the composite set (5) the current in the winding of the receiving relay, and (6) the current in the receiving subscriber's loop*



matics. E. L. Norton designed a network which would equalize the 6000-cycle string up to 9000 cycles. The network served as long as we had the spool of wire which was used in the galvanometer in obtaining the characteristics to be equalized, but unfortunately the wire on the next spool was so soft that it couldn't be stretched to a frequency of 6000 cycles. A new equalizer had to be designed, based on a natural frequency of 4500, and improved design let us push the range to 10,000 cycles. Strings in an oscillograph used by a dozen different engineers break in a dozen mysterious ways, and soon that spool of wire was gone. The next wire was nice and strong, and could be pulled to 8000 cycles, but its resistance was 25 per cent higher than

A. M. Curtis

the first lot and wouldn't fit either equalizer.

After obtaining a dozen or so batches of wire, we found that we could never expect it to be the same twice in succession. Making duralumin wire 0.0008 inch in diameter is no snap, but we must have it, low in resistance, high in tensile strength, free from tight curls and uniform in all respects. Apparently the problem of improving the frequency range of the oscillograph reduced itself to finding out how to make fine duralumin wire. The metallurgists in the chemical laboratories could heat-treat duralumin and draw it down to 0.001 inch, but their draw bench ran at too high a speed for smaller sizes, and dust caused by the remodeling of Section H of the laboratories building interfered with their work.

A draw bench was built by E. Lund at the Canal Street branch of the laboratories, according to designs by A. E. Melhose, who then tried to find out how to tease the wire made by H. T. Reeve's group down to 0.0008 inch. We began to wonder what duralumin was: why one sample would draw quite easily, but be weak and low in resistance, and another sample from the same ingot would draw with great difficulty but turn out strong and high in resistance. In a series of experiments, J. W. Nalencz heat-treated and drew down to 0.002 inch several different alloys all called duralumin which were then drawn to the final size and tested in the oscillograph by A. E. Melhose. We finally found that one alloy, when heat-treated exactly thus and so, and drawn at a certain speed and no faster (deadly slowly as a matter of fact) would come out straight and strong and low in resistance all at the same time, if the dies were absolutely clean and the wire wasn't allowed to oxidize between passes at the small sizes.

At first it was rare for a piece a foot long to get through the die without breaking, and each break required that the end of the wire, already thinner than the finest needle point, be ground down to a long point and pushed through a hole, visible only with the aid of a microscope, in a diamond die. Later the technique was improved until the wire would often run a hundred feet without a break, and eventually two thousand feet of uniform wire were stored under an evacuated bell jar.

Careful inspection of the older samples showed spontaneous breakages of the wire on the spools, and the microscope showed localized corrosion, accompanied by the formation of minute white crystals. The corrosion of the purchased wire, wound on molded bakelite spools, was considerably worse than on the turned spools we had made ourselves. The trouble was evidently due to some chemical in the molding compound, and the remedy was to rewind all the wire on aluminum spools.

At first the demand for this wire was

(Continued on Page 21)

BROADCAST STATION NEWS

NEW STATIONS APPLIED FOR

Brothers & England, Mansfield, O. 100 watts, on 1370 kc.

Broadcasters of Penna., Inc., Erie, Pa. 100 watts, on 1420 kc.

I. J. and J. Kohn, Nashville, Tenn. 100 watts, on 1370 kc.

Big Springs Broadcasting Co., Big Springs, Tex. 100 watts, on 1210 kc.

KWIL Broadcasting Co., Williston, N. D. 100 watts, on 1500 kc.

Tem-Bel Broadcasting Co., Temple, Tex. 100 watts, on 1310 kc.

James R. Doss, Jr., Decatur, Ala. 100 watts, on 1370 kc.

Denton Broadcasting Co., Denton, Tex. 100 watts, on 1420 kc.

Paul Sullivan Andrews, Lewiston, Me. 250 watts, on 560 kc.

WDRC, Inc., Hartford, Conn. 100 watts, on 1200 kc.

Hazelwood, Inc., West Palm Beach, Fla. 100 watts, on 1420 kc.

Jesse H. Jay, Miami, Fla. 100 watts, on 1200 kc.

Paris Broadcasting Co., Paris, Tex. 100 watts, on 1500 kc.

The Journal Co., Milwaukee, Wis. 1 kw on 1010 kc.

Eagle Rock Broadcasting Co., Eagle Rock, Cal. 250 watts, on 1160 kc.

J. L. Scroggin, St. Joseph, Mo. 100 watts, on 1500 kc.

Brothers & England, Lovain, O. 100 watts, on 1200 kc.

Palm Beach Broadcasting Service, West Palm Beach, Fla. 100 watts, on 1370 kc.

Joplin Broadcasting Co., Pittsburg, Kans. 100 watts, on 1200 kc.

Trust. of Golden Empire Broad. Co., Ltd., Chico, Cal. 250 watts, on 950 kc.

The Ashland Broad. Co., Ashland, Ky. 100 watts, on 1310 kc.

Siever, Bayless & Steele, Duncan, Okla. 100 watts, on 1500 kc.

East Texas Broad. Co., Dallas, Tex. 100 watts, on 1500 kc.

Homer York, Lufkin, Tex., 250 watts, on 1340 kc.

Lakeland Broad. Co., Lakeland, Fla. 100 watts, on 1200 kc.

Wm. A. Schall, Omaha, Neb. 100 watts, on 1500 kc.

Springfield Newspapers, Inc., Springfield, Mo. 250 watts, on 1120 kc.

Mississippi Valley Broad. Co., Inc., Jefferson City, Mo. 100 watts, on 1310 kc.

Omaha Broadcasting Co., Omaha, Neb. 100 watts, on 1210 kc.

J. C. & E. W. Lee, Riverside, Cal. 100 watts, on 820 kc.

Dallas Radio Research Engineers, Dallas, Tex. 1 kw, on 1550 kc.

William S. Smullin, Salem, Ore. 500 watts, on 1330 kc.

Worcester Broad. Co., Worcester, Mass. 100 watts, on 1200 kc.

(Continued on Page 20)

NEW APPARATUS

THE NEW MODEL "M" VELOCITY MICROPHONE

THE new Bruno Velocity Microphone De Luxe Model "M" has been designed to meet the requirements of broadcasting studios, recording studios, sound equipment companies and public address users. It is manufactured by Bruno Radio Laboratories, 22 West 22nd St., New York City.

It affords a high degree of fidelity due to the exceptionally wide range of frequency response brought about by the material used and the correctly designed case in which it is enclosed.

Two powerful cobalt magnets are used to produce a strong magnetic field in which is suspended a specially treated aluminum alloy ribbon. Cavity resonances have been entirely eliminated by the correct placement of the magnetic assembly. It is a well-known fact that any obstructions in the back of the ribbon will cause reverberations which tends to distort and emphasize some particular frequency. In the construction of the Bruno microphones, the magnets are placed vertically, end on end, and the ribbon is suspended in the most dense portion of the powerful magnetic field produced by the cobalt magnets. A sound wave striking the ribbon will then continue to travel without impediment and will not be reflected back by the inner portion of the horseshoe magnets as in the case of poorly-designed velocity microphones.

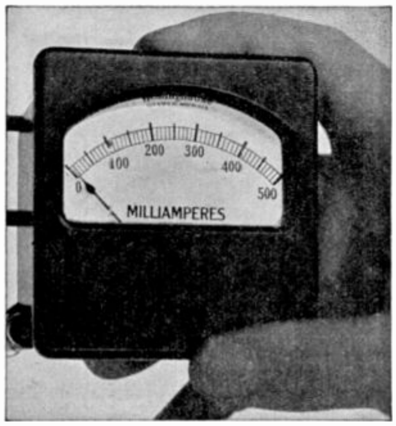
While handsome in appearance, it is ruggedly constructed and has a flat frequency response curve from 30 to 14,000 cps. It is characteristically directional, enabling the reduction of acoustic feed back. It is not subject to variations of humidity and temperature. The coupling transformer used in these units are wound on "permalloy" cores with an impedance output of either 200 or 500 ohms, but other ohmages can be supplied. A universal ball swivel joint is furnished with this microphone, enabling the user to focus it in the most suitable direction. Ten feet of shielded rubber covered cable is supplied with each unit.

NEW MINIATURE RECTANGULAR INSTRUMENTS

A LINE of moderately priced direct current, radio-frequency and rectox miniature instruments designed to harmonize with radio and communication equipment is announced by Westinghouse Electric and Manufacturing Company. Only one large hole in the panel is required for mounting and all visible mounting screws are eliminated by using mounting clamps. For ease in connecting and to save space, soldering clips are standard for electrical terminals of these instruments. These RX instruments have a scale length of 2.4 inches, are accurate within 2 per cent (rectox types 5 per cent) and flange dimensions measure 3x3⅛ inches with zero adjusters on the outside. Vertical decorative lines give the dull matte Moldarta cases distinctive appearance.

The d'Arsonval, or permanent-magnet moving-coil principle of operation is used. Numerous refinements in the design of this movement have been made; such as, soft iron pole tips welded to the permanent magnet in accurately aligned fixtures; improved springs; and an entirely new method of supporting the iron core in a die-cast bracket which also supports the jewel bearings in perfect alignment. Provision is made for the use of extremely strong cobalt-steel magnets for super-sensitive microammeters.

The permanent magnets are made of high-quality tungsten steel or cobalt steel, properly heat-treated and aged. The soft-iron pole tips are accurately aligned and fastened to the permanent magnet by an electrical welding process, thus assuring perfect alignment and uniform air gap for the moving coil. The iron core



is accurately aligned by a die-cast bracket which supports the sapphire jewel bearings. These features of construction assure extremely accurate air gaps with the convenience of removal of the moving element from the pole pieces as a complete unit for easy repairing. This provides uniform scale distribution except when used with thermo-couples or rectox units and reduces the amount of energy consumed by the movement, making possible a super-sensitive instrument in the miniature size.

Standard dials are finished in matte silver, with black figures. The number of scale divisions and the size of the figures have been selected for greatest ease in reading and best appearance. Provision is made for multi-scale markings where necessary.

All standard RX instruments are furnished with a new type solder terminal. A notch is provided to wrap the wire around the terminal. The connection is then soldered. These solder clips project straight out the side of the base and are made of flat brass. This makes possible the mounting of instruments in shields, close to the base without interference with connections to the terminals. If desired the solder clips may be bent straight back from the base for convenience in wiring.

Type RX instrument can be furnished special with stud type terminals, same as supplied on round miniature panel instruments.

Rectox instruments are used for the measurement of alternating currents when low-energy consumption is necessary. A copper-oxide, full-wave rectifier is mounted inside the instrument case, and connected to feed full-wave rectified current to the moving coil. The d'Arsonval instrument element deflects proportional to the average value of the rectified wave. The dial is calibrated in terms of effective or root-mean-square values. A sensitivity of from 1000 to 5000 ohms per volt can be obtained with rectifier-type instruments.

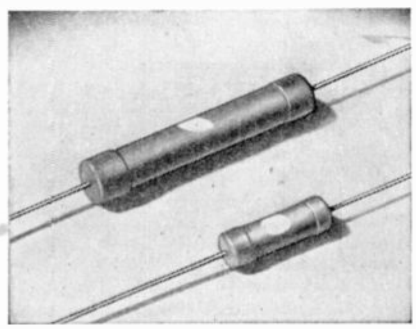
Range of ratings available:

Direct Current—
- Ammeters—1 to 8 amperes
- Milliammeters—1 to 800 m.a.
- Microammeters—20 to 800 micro. amps.
- Voltmeters—1 to 5000 volts (200 ohms per volt)
- Voltmeters—1 to 1000 volts (1000 ohms per volt)

Radiofrequency—
- Ammeters—1 to 8 amperes
- Milliammeters—100 to 800 m.a.
- External thermocouples—1 to 50 amps.

Rectox—
- Microammeters—200 to 500
- Milliammeters—1 to 10
- Voltmeters—4 to 150 (1000 ohms per volt)
- Voltmeters—1 to 3 (2000 ohms per volt)
- Voltmeters—½ to 1 (5000 ohms per volt)

RESISTORS OF FULL CROSS-SECTION CONDUCTION



DEFINITE departure from established resistor art now makes available an inexpensive extruded resistor capable of a performance heretofore identified with wire-wound units. Developed and now offered by Henry L. Crowley & Co., West Orange, N. J., the novelty of the new resistor rests on the production of a solid, homogeneous, full cross-section conduction body comprising a background or bulk material of high-resistance value, with a greater or less admixture of another resistive material of lower value to obtain desired ohmage in mass of fixed length and diameter. The entire cross-section is uniformly current-carrying—no conducting film or coating, no isolated conducting particles, no uncertain contacts between adjacent particles, being used. To complete the perfect contact throughout the mass, the ends of the extruded length are coated with metal and capped with ferrules to which pigtails are integrally attached.

Crolite resistors have a smooth, rock-hard, black body, solid and uniform

(Continued on Page 20)

ASSIGNMENTS

Following Radio Officers have been assigned to Mackay Radio and Telegraph Company ships in New York District between November 1st and 27th:

Radio Officer — Vessel

Stanley Oliver (Jr.)—Shawnee
Pietro Rametta (Jr.)—Exochorda
George Orgera (3rd)—Manhattan
Vernon Hopkins—Cities Service Empire
Emile Fazulak—Florida
Sol Lenkowsky—Oneida
Donald Thomas—Broad Arrow
C. A. Luckenbach (Jr.)—Cherokee
Paul Girard (Jr.)—Henry R. Mallory
Gerald Travis—Osage
Walter Weber (Jr.)—Excalibur
Robert Brown—Norfolk
Mauro Sabando (Jr.)—Edouard Jeramec
Edward Rocks (Chief)—Edouard Jeramec
Abraham Eisenberg—Black Heron

Following were assigned between November 27th and December 27th, to Mackay Radio controlled ships:

R. Annett—Yorba Linda
M. Greenblatt (Chief)—Scanyork
R. C. Williams (Jr.)—Scanyork
H. Leatherman (Chief)—Henry R. Mallory
D. Hoey (Jr.)—San Jacinto
J. Bianca (Jr.)—Iroquois
E. Tabakman (Chief)—Iroquois
R. Jacks—Haiti
R. P. Brown (Chief)—Cherokee
J. Finzimer—Norfolk
H. Weinstein—Agwidale
E. Cole (Jr.)—Seminole
I. Finver—Yorba Linda
E. Rocks (Relief)—Black Hawk
R. Mathers—Edward Pierce
L. Rose (Jr.)—Henry R. Mallory
C. J. Sheblak (Chief)—Scanpenn
E. Rocks—Black Gull
R. Wilson—Queen Anne

RADIOMARINE CORP., NEW YORK

Radio Officer — Vessel

G. H. Ellis—H. M. Flagler
W. I. McKinley—Beaconhill
A. Cohen—George Washington
F. Howe—Potter
C. O. Ehrensperger—Cristobal
A. J. Jensen—Santa Elisa
Loya—Oriente
J. Stengard—Cerro Ebana
T. C. Ault—Santa Maria
C. Stewart—Western World
R. H. Cooke—Western World
S. Hakam—Paul H. Harwood
B. Dove—Pennsylvania
J. Sonyk—Watertown
J. J. Delaney—Steel Mariner
H. A. Musgrave—Benj. Brewster
W. A. Smith—Siboney
J. Potts—Santa Cecilia
A. Rzuri—George Washington
C. C. Berger—Paulsboro
T. F. Reynolds—R. G. Stewart
D. K. Megaffin—City of New York
H. Baxter—Pan Bolivar
E. Witkowski—Pan Bolivar
W. Gordon—Culfwax
G. Fitzsimmons—George Washington
H. S. Kutcha—Craigsmere
J. Simon—Standard
E. Ellsworth—Swiftscout
G. Silverman—Veedol No. 2
K. E. Goss—Sagaporack

A. D. Jackson—Robert Luckenbach
J. Strumph—Exporter
A. G. Lupien—Yorktown
F. W. Harper—Gulfprince
S. Suarez—Pan America
L. F. Sherwood—Empire State
G. N. Robinson—Chalena
J. Dudor—Aurora
R. Dekofsky—Paul Luckenbach
J. P. Kelly—Ward
G. O. Dill—Seaborn
R. H. Roberson—Paul H. Harwood
R. L. Raysbrook—C. J. Barkdull
C. A. Quinn—Concord
A. G. Lupien—Lexington
H. G. Wright—Daylight
C. R. Bismarck—E. G. Seubert
Charles Porter—George Washington
G. E. Favre—Siboney
S. Young—California
R. Bougere—Thomas H. Wheeler
N. M. Hiorns—Paulsboro
F. C. Haack—Willet
R. Kay—W. L. Steed
W. A. Smith (Jr.)—Scanstates
H. McGrath—Henry S. Grove
H. McCallum—H. H. Rogers
T. F. Murray—Hagood
R. S. Ward—Cumeo
A. Kowalski—Veedol No. 2
A. Dzuri—George Washington
W. T. Parker—San Juan
R. Kaplan—Oriente
A. Zafft—Susan A. Moran
E. B. Deturck—Zarembo
H. W. Bell—Gulfprince
R. J. Martin—Beaconstar
R. Kay—American Banker
O. A. Fonas—Livingston Roe
Ed. Hallen—Chippewa
C. R. Seymour—Colombia
A. Charters—Colombia
S. Hakam—Steel Navigator
D. C. Mealy—Executive
S. G. Hopkins—R. G. Stewart
L. Sherwood—Oriente
M. S. Olson—Havana
A. Regelman—Anniston City
E. Bamel—Providence
O. Harwood—Widgeon
F. Bishop—T. H. Wheeler
A. Dzuri—George Washington
F. W. Robinson—S. C. Kansas
W. B. Lee—A. F. Luckenbach
F. Frohnen—Santa Maria
J. F. Smith (Jr.)—Dixie Arrow
V. C. Ellis—Western World
Charles Porter—Robert E. Lee
R. H. Cooke—Vermar
T. F. Reynolds—George H. Jones
J. Rohrich—Chincha
A. P. O'Connor—Santa Monica
G. H. Geiger—Santa Elisa
C. F. Anderson—Examiner
H. Sudborough—Chester O. Swain
G. S. Silverman—Southern Cross
F. W. Harper—West Humhaw
Arthur Finch—Henry Jaspar
Joseph Gately—Jean Jadot
W. Gray—Coamo

RADIOMARINE CORP.—BALTIMORE

D. Rodriguez—Flomar
L. Livermore—Felix Taussig
C. H. Warner—Altair
C. E. Fraser—Lake Osweya
C. C. Taylor—Santore
O. Wolf—Ensley City
T. C. Davis—Mangore
C. W. Thumm—Pennmar
W. M. Neubauer—Tuscaloosa City
W. Disney—Chattanooga City
C. R. Hahn—Charles Kurg
R. F. Woodson—W. A. McKenney
E. Gannett—Melrose
O. Theiss—Malacca
C. L. Hack—Losmar
C. E. Frazier—Selma City
F. H. Flanders—Somerset
L. R. Grisson—Chas. G. Black
J. H. Egan—Garney Hulings
J. H. Johnson—Capillo
W. E. Cunningham—Walter Miller

CALIFORNIA—EASTERN LINE

Roy Welbon—General Pershing
H. H. Schoolfield
Karl Steiner—General Sherman
K. Harris
James Crouse—General Lee
W. M. Harvey
Roy Whittington—Texas
John Robinson—Washington
Ted Toppi—Michigan
Everett Henry—Illinois
Ben Cohen—California
R. S. Bean—Iowa
A. A. Marsh—Kentucky
Howard McMahon—Oregon
Carl Anderson—New York
W. F. Mee—Wisconsin
L. K. Bradley—Pennsylvania
E. I. Garrick—San Anselmo
Frank Caldwell—San Angelo
Sydney Ferguson—San Pedro
T. W. Shultrich—San Vincente
R. L. Norgard—San Lucas
Claude Wareham—San Diego
D. E. Youngberg—San Clemente
Dallas Hughes—San Bernardino
Herbert Oliver—San Simeon
C. P. Burt—San Rafael
DeWayne Duncan—San Domingo
M. R. Darby—San Felipe
John Risley—San Marcos
James Dinsdale—San Gabriel
Edward Betts—San Julian
Ralph Derabach—Jefferson Myers
Glenn Peek—Peter Kerr

INTERESTING

The American Radio News Corp. stations at New York, Tinley Park, Ill., Carlstadt, N. J., Milwaukee, Wis., have applied to change their names to Hearst Radio, Inc.

On January 12, 52 applications for ship licenses were filed.

On January 8, 157 applications for ship licenses were filed.

On December 15, 71 applications for ship licenses were filed.

Loudness and Pitch

(Continued from Page 10)

2100) the changes in pitch with increasing loudness become negligible. For very high notes, however, for frequency levels above 8 (frequencies above 4200) the pitch level increases slightly with increase in loudness.

The results discussed above pertain to pure tones, but studies were also made of complex tones of various types. The relationships between intensity level and loudness level for complex tones having ten equally intense harmonic components are given in Figures 3 and 4. The curve labelled 1000, of Figure 3, for example, represents the results for a tone having a fundamental frequency of 1000 c.p.s. and overtones having frequencies of 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, and 10,000 c.p.s., all having the same intensity. The intensity level of the combined components is given by the abscissas and the resulting loudness level by the ordinates. By adding the nine overtones to the 1000-cycle pure tone the intensity level is raised 10 db, but the loudness level, it will be noticed, is increased nearly 30 db. In other words, increasing the overtone content of such a musical tone increases its loudness level much faster than one would expect from the increase produced upon its intensity level. It is interesting to note from Figure 4 the very large increase in the loudness level of the 100-cycle pure tone when an overtone structure is added to it. At an intensity level of 60 lb, for example, the loudness level of the pure tone is slightly over 35 db. With the addition of nine overtones, however, the intensity level is increased 10 db but the loudness level becomes 77 db—an increase of over 40 db. These results show why it is easy to increase the loudness of a musical tone by increasing its overtone content, a practice which is common in producing musical tones.

Another fact that becomes evident from these curves is that the loudness is greater the greater the separation between the harmonic frequencies. This is plainly evident in Figure 4, but in Figure 3 the higher harmonics become less important when all are of equal intensity because of the decrease in loudness at the higher frequencies as shown by the dotted curves of Figure 1.

Many interesting phenomena in connection with the pitch of complex tones were also discovered. It was found, for example, that while the pitch level of a pure tone of 200 cycles—a frequency level of 3.6—was lowered .15 octaves as the loudness level was raised from 40 to 100 db (as shown in Figure 2), the pitch level of a complex tone composed of tones of frequencies of 200, 400, 600, 800 and 1000, dropped only .03 octave. At 100 db loudness level, therefore, the pure tone was at a pitch level of 3.46 octaves and the complex tone at a level of 3.58 octaves—¾ of a tone higher, and when the two were sounded successively this difference was plainly noticeable. With this difference in pitch it would be expected that if the two were sounded together they would be discordant, but such was not found to be the fact. The effect is to strengthen the fundamental, and to lower the pitch of the resultant tone to a level of 3.54 octaves. Whether or not two tones will be harmonious when sounded together depends therefore on the frequency rather than on the pitch of the components.

Although no quantitative measurements have been made upon the timbre of a musical tone, we know that it depends not only upon the overtone structure but also upon the intensity. If a violin tone, for example, is reproduced at a very much higher intensity than that at which it is usually heard, it will be very evident that the timbre is changed. A scale for representing timbre is now being worked out and it will be interesting to see if some quantitative measurements similar to those reported under loudness and pitch can be made to describe the quality aspects of the tone. It is sufficient to say here that

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Correspondence

A MORRO CASTLE ECHO?

Federal Communications Commission,
Washington, D. C., Dec. 1, 1934.

To Licensees of Ship Telegraph Stations:

It is noted that masters of many vessels have violated, possibly unwittingly, the provision of Treaty regarding the silent period since they have obtained bearings during that period using a direction finder with apparatus which requires the disabling of the ship's regular receiving system in order that bearings may be taken.

Under the terms of the Ship Act, the equipment installed on a compulsorily equipped vessel must be in charge of "two or more persons skilled in the use of such apparatus, one or the other of whom shall be on duty at all times while the vessel is being navigated." Under the terms of paragraph 2 (1) of Article 19 of the General Radio Regulations annexed to the International Telecommunication Convention of Madrid, 1932, all ships operating on the frequencies 365 to 515 kilocycles must make provision for the maintenance of watch on 500 kilocycles during the silent period throughout their working hours.

It is entirely practicable for auxiliary receiving antennas to be installed on a majority of ships equipped with direction finding apparatus by means of which the radio operator may continue reception on the distress frequency (500 kilocycles, or 410 kilocycles on the Great Lakes), during the periods in which bearings are being obtained, and it is expected that such antennas will be adopted in the future.

It is directed that you bring the foregoing to the attention of the masters of the vessels on which you are licensee of the radio station, and also bring to their attention that section of the Ship Act which places the responsibility directly upon the master of seeing that the proper watches are maintained, and Section 502 of the Communications Act of 1934 which specifically provides a penalty for willful violation of any rule or regulation of the Commission or of any provision of treaty.

(Signed) HERBERT L. PETTEY,
Secretary.

Broadcast Station News

(Continued from Page 16)

Cumberland Broadcasting Co., Inc., Portland, Me. 100 watts, on 1210 kc.

Hartford Broadcasting Co., Hartford, Conn. 100 watts, on 1200 kc.

Pope Foster, Mobile, Ala. 100 watts, on 1500 kc.

Neth L. Leachman, Dallas, Tex. 100 watts, on 1200 kc.

Educational Radio, Inc., Spartanburg, S. C. 100 watts, on 1420 kc.

The Ardmoreite Publishing Co., Inc., Ardmore, Okla. 100 watts, on 1210 kc.

Duluth Broadcasting Co., Duluth, Minn. 100 watts, on 1200 kc.

KGBX, Inc., St. Joseph, Mo. 100 watts, on 1500 kc.

Alexandria Broadcasting Co., Alexandria, La. 100 watts, on 1200 kc.

Evangeline Broadcasting Co., Lafayette, La. 100 watts, on 1310 kc.

Radio Service, Las Vegas, Nev. 100 watts, on 1200 kc.

APPLICATIONS GRANTED

W. Wright Esch, Daytona Beach, Fla. Granted CP 100 watts, on 1420 kc.

Community Broadcasting Co., Toledo, Ohio. Granted commissions permission 100 watts on 1200 kc.

SET FOR HEARING

Samuel L. Finn, Dayton, Ohio. 250 watts, on 1250 kc.

Robert H. Fette, Nr. Meriden, Minn. 100 watts, on 1310 kc.

Arthur Westland & Jules Cohn, Santa Rosa, Cal. 100 watts, on 1500 kc.

Wm. A. Schall, Carter Lake, Iowa. 100 watts, on 1420 kc.

F. L. Whitesell, Forty Fort, Pa. 500 watts, on 930 kc.

Radio Service, Inc., Redlands, Cal., 100 watts on 820 kc.

TELEGRAPH SERVICE APPLIED FOR

American Radio Telegraphists Association, Inc., New York, N. Y. New Mobile Press Station for 4750, 6450, 8360, 11355, 16720, 22250 kc, using 1 kw power.

Charles Topmiller is handling his new job as chief engineer at WKCY, Covington, Ky., nicely.

We would like to hear from V. K. Hatfield as to how the Certified Radio Technicians Association of Los Angeles is going.

Polk Purdue signed up some time ago with WLAC, Nashville, Tenn.

William E. Symons, formerly with WMBD, Peoria, Ill., is now with the WLW Crosley Radio, Cincinnati, staff.

E. H. Gager has been appointed plant manager of KYW, Philadelphia. He was for four years chief engineer of WEMR in Chicago. Control operators at KYW are: M. Sloan, formerly KDKA, Pittsburgh; I. N. Eney and C. E. Donaldson, formerly WBZ.

J. J. Michaels is chief operator of KYW, Philadelphia. He was formerly chief operator at KYW, Chicago. The KYW operating staff are Bryan Cole, Bernand Clark and W. C. Ellsworth.

Charles J. Leipert, formerly with WOR, and who wrote that fine article in our September issue, "The Calculation of 'H' and 'T' Attenuation Pads Simplified," is now in Los Angeles.

H. R. Miller, former WBZA operator, has taken new duties with the Anacostia Station of the Naval Research Laboratories.

J. G. Beard has been appointed manager of all Westinghouse police radio activities.

J. C. Matheny, WGN operator, also operates Amateur W9DLH in his spare moments.

Wm. G. McGlumphy, of WWVA, Wheeling, can also be aroused at Amateur W8DAS.

Paul E. Miller, formerly with WIBO, is now with WEDC, Berwyn, Ill.

Glenn G. Boundy, chief engineer of WWVA, is an amateur at heart and operates W8ZW.

You can get Dwight E. Williams some of the time on W8FLU, but in his busy moments he is at work with WWJ, Detroit.

F. Lee Dechant is another amateur at W9QC, even though he is Chief Engineer at WRJN, Racine, Wis., when on the job.

Edward A. Carroll, who is with that fine WCAU, operates Amateur W3CXR.

J. C. Eddy, former United Fruit ship to shoreman, has gained a land berth for himself at WBZA, the Westinghouse Springfield station. He was with WEAF in 1926 and 1927.

When some of you broadcast station men get the itch to write some good technical material we would like to publish this for you.

You will find
Robert Eubank at WRVA
Winifed H. Wood at WMBG
Walter R. Selden at WPHR
F. E. Maddox at WDBJ
R. J. Miller at WRBX
J. T. Orth at WLVA
W. R. Rosenkrans at WBT
Earle Glouck at WSOC
R. S. Meisenheimer at WDNC
Avery Wayne at WEED
Douglass Lee at WSJS.

Resistors of Full Cross-Section Conduction

(Continued from Page 17)

throughout, with a protective coating. Terminal caps cannot work loose. Uniform diameter and length for usual range of standard resistance values and wattages. Color-coded if desired. The wattage ratings are exceptionally conservative. Temperature coefficient is practically negligible. A 1000-hour steam-box test for moisture variations indicates change of less than 2 per cent where 15 per cent variation in resistance is not unusual. Life tests indicate exceptional span with very gradual and practically negligible change in resistance.

SHIP LICENSES TO TERMINATE

Approximately 430 outstanding licenses expiring Feb. 1, 1935, will be renewed, on ship stations, so as to have them expire at different dates according to service, frequency assignment, and companies holding large numbers of licenses.

One hundred and fifty-seven Radiomarine licenses get renewals of from fifteen to sixteen months, and 131 Radiomarine and Mackay licenses get renewals of one year. The remaining number get renewals for different periods according to service.

Loudness and Pitch

(Continued from Page 19)

there is no doubt but that the results will show that timbre is dependent not only upon the overtone structure but also upon the intensity and the pitch of the tone. It is thus a safe conclusion that each of the three psychological characteristics of a tone is dependent on all three of the physical characteristics, although the influence of one is predominant in each case.

The Six-String Oscillograph

(Continued from Page 16)

quite active, but it fell off as soon as all the oscillographs were supplied. The new wire, being two or three times as strong as the old, was much less likely to be broken.

Setting out to design equalizers, we had to learn wire-drawing, but now with a supply of uniform wire we could go ahead. The natural frequency of the first oscillograph galvanometers was 3200 cycles, all the old wire would permit. Experiments showed that it was not wise to attempt to equalize the string much beyond two and one-half times its natural frequency, since some peculiar effects occur in the neighborhood of the third multiple of the string's fundamental frequency, where the sensitivity varies with amplitude. The new wire would permit a natural frequency of 4500 cycles with a good margin of safety, and Messrs. Norton and Wood designed a new equalizer which gave a flat characteristic up to 10,000 cycles, to be used with the standard three-string galvanometer and optical system. The light, the developer and the maximum paper speed of the oscillograph are inadequate for the higher frequencies.

The new equalizers relieved us of one source of complaints, the voice-frequency engineers. The power required for an oscillogram—about sixty milliamperes in eight ohms, or about thirty milliwatts—could be obtained from a reasonably simple amplifier. But it was another story with those who wanted to go all the way down to direct currents, in studying the contact chatter of some relays, for example. The best low impedance vacuum tube then available, the Western Electric 275A, could not give more than ten milliamperes direct-current output without troublesome distortion. An amplifier with six 275A tubes in the output stage, even if one were available, would be rather awkward, since a quarter ampere of plate current must be supplied at about 200 volts from a battery which must be insulated from ground and thus cannot be a plant B-battery. Some alternative had to be found.

The equalizers work by taking a strong, complicated input current and attenuating the lower frequencies to make the deflection of the equalized oscillograph linear with frequency. An amplifier supplying the signal has to pass the currents of the lower frequencies which are later on discarded. A possible alternative to the use of the equalizer and linear amplifier is the use of two amplifiers in parallel: a linear one supplying the direct and low-frequency currents, and one for the higher frequencies whose output increases with frequency. Such an amplifier was built and worked as expected.

A simpler method of producing the same result was then developed by Ira E. Wood and Ira E. Cole, who designed an amplifier output circuit in which the oscillograph galvanometer was equalized by the usual resonant shunt up to its natural frequency, the amplifier being linear with frequency so far, but was equalized beyond this by the circuit which coupled the plates of the amplifier output stage to the string. That circuit is like an autotransformer in several sections: for low frequencies it is a simple direct connection, but as the frequency increases, its effectiveness increases. It allowed us to reduce our hypothetical six-tube output stage to a real two-tube stage, and the design of a direct-coupled first stage of voltage amplification was comparatively simple. Our troubles will start when someone needs such a sensitivity for direct currents that two direct-coupled stages must be put ahead of the output stage.

Considerable work was done before the equalizing amplifier was considered safe for general use in the laboratory. A pair of thermal delay-relays prevents the oscillograph string from being connected to the amplifier while the filaments are heating, and a cage with a door switch prevents curiously inclined people from adjusting the interstage coupling circuits or tapping the grid connection of the first-stage tube while the string is in circuit. The probability of breaking the string is reduced by the proportioning of the output circuit.

A pair of these amplifiers with all their batteries mounts on a six-foot portable relay-rack and extends the range of the oscillograph to 10,000 cycles with voltage inputs into impedances of several values from 100,000 ohms to three megohms. The signal voltage required is from three-tenths volt to a hundred volts, depending on the dial settings; the amplifier is not intended for use as a voltmeter on circuits of very high impedance. The transformer input gives negligible phase and frequency distortion from 50 to 10,000 cycles and requires only two-tenths milliampere into twenty ohms for the usual oscillogram.

Neither the rapid record oscillograph nor the amplifier may safely be connected in circuits on the high side of an inductance through which current from a grounded battery is to be made and broken. The voltage to ground in such a case will often reach 1500 volts, causing a spark to pass from the string to the pole face, only four-thousandths inch away, and burning off the string. Most of the mysterious cases of string breakage are due to this simple trouble. For example, in studying the wave shape of the current in a relay attached to a plant battery, the string must be connected between relay and battery, not between relay and circuit. It is also unsafe to connect one string on the high side of a positive-grounded —130-volt telegraph battery, and another on the high side of a negative-grounded +130-volt B-battery. If the strings are deflected by the signal so that they touch or pass, they are quite likely to pull together and burn off. The safest practice is to arrange the circuit so as to keep all strings as close to ground potential as possible.

Making an oscillogram from a distance was readily made possible by replacing the hand lever which starts and stops the paper by a simple solenoid actuated through a relay and a push button. The latter may be replaced by an ordinary relay controlled from any distance. For about a year, for instance, things occurring in experimental apparatus in the transatlantic radio control room at 32 Sixth Avenue have been recorded on an oscillograph at the West Street building of the laboratories, controlled from Sixth Avenue.

The new feature of the visual attachment designed for the rapid record oscillograph is that it uses only that part of the light beam which is wasted anyway. This permits an oscillogram to be recorded while it is being watched on the screen of the revolving mirror, and a change in a wave which occurs only occasionally may be watched for and caught on the paper when it does happen, if

CLASSIFIED ADS

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Remittance in full must accompany copy, closing date for classified advertisements is the 15th of the month preceding publication date.

its duration is not less than a few tenths of a second.

We still had to take care of the telegraph engineers who complained that the sensitivity of the oscillograph was too low for studies of things such as the "Morse metallic" circuit unless an amplifier was used. As they were content with a record of the signal frequencies from zero to 1000 cycles, it was a simple matter to lengthen the string and reduce the tension.

A model with six strings would satisfy the demands of those interested in records of many things at once. It could be used in the "sound ranging" of artillery shells. It would also be helpful in locating oil pools underground by the method which uses the fact that oil and a "dome" of rock salt occur together. A charge of dynamite is set off in the ground at one side of the suspected area, and the arrival of the explosion wave through the ground is picked up by six microphones buried at various locations. A difference in the rate of travel of the wave along the six radii gives a clue to the location of the rock salt. In the laboratories the six strings have proved very useful. In the study of a telegraph repeater, for instance, it is possible to record almost everything which happens at both terminals and the intermediate station.

Galvanometry in Vacuo

(Continued from Page 14)

dust core of a loading coil, shown in Figure 5, is an example of its utility. The flux densities measured range from seven-thousandths gauss down to the extraordinarily small value of two ten-thousandths gauss. Accurate measurements at these extremely low flux densities are only made possible by the fact that the sensitivity of the new galvanometer is some 135 times that of the galvanometers previously used in these laboratories.

The Fall of Samuel Jones

(Continued from Page 12)

his fair Evelyn. From photographs that the chief wireless operator had seen in a sporting paper, he instantly recognized the fellow as Battling Bob Campbell, a Western heavyweight slugger, with a record for one-round knockouts. Was he Evelyn's brother—?

"Oh, Bob, meet Mr. Jones," exclaimed Evelyn, smiling graciously upon Samuel, who had halted, uncertainly. "He is the chief radio man of the 'Wapama,' and he has been awfully nice to me—"

"Glad to meet yer," growled the husky prizefighter, extending a wicked looking paw.

Gingerly, Samuel Jones put out his hand, and it was crushed in an iron grip that made the chief operator bite half through his tongue.

Evelyn Campbell put one dainty little gloved hand up on the boxer's broad shoulder, in an unmistakably affectionate manner, and smiled sweetly upon poor Samuel.

"This is my hubby," she said, naively.

History repeats itself, we are told, and this often seems to be true. Another cloudy autumn afternoon saw the "Wapama" pull away from that same pier in San Francisco, and, shortly afterward, another sweet young damsel came tripping along to the wireless-room door.

"O-o-o-o-h! Here's the wireless!" she cried, enthusiastically. "Please, may I come in, mister man?"

Samuel Jones slammed down the book that he was reading and twisted around in his chair.

"No, you can't come in!" he snapped, shortly and sourly. "It's against orders an' it's against the law, an' it's a ten thousand dollar fine an' fourteen years in the penitentiary; so get away from here an' stay away from here!" He glared, savagely.

With a gasp of terror, the fair one fled.

Disdaining to notice a clearly audible snicker from the top bunk, Samuel Jones turned back to Sir Sigismund Mugfoot's adventures in Bonga Tonga, and read how that intrepid adventurer slew three hundred blood-thirsty cannibals single-handed, by throwing red pepper at them until they sneezed themselves to death; after which he bound their hideous wives in rattan and drowned them all in a lake. (The End)