



42ND STREET AND THE THEATRICAL DISTRICT, FROM THE TRANSMITTER HOUSE

This photo happened to be taken when the station was broadcasting music from the Hotel Astor Roof, which is seen brightly illuminated at the right of the picture. The horizontal dots in the background are lights on the Jersey shore

Behind the Scenes at a Broadcasting Station

By CARL DREHER

There are times when quick decisions and rapid work are demanded of the operating personnel at a broadcasting station. The average listener-in knows little of the complications, and of the incidents both amusing and trying that make up the operator's daily life. Mr. Dreher, who is in charge of the Radio Corporation's New York station, says: "Looking at the apparatus in all its complexity, and revolving in one's mind the number of things that can go wrong, one is surprised that it ever works at all." People, too, cannot always be relied upon to do the things expected of them. How the artists, as well as the apparatus, are handled so as to maintain a smooth and satisfactory program for the broadcast fan, is told in this article.—THE EDITOR.

ACERTAIN broadcast listener was disturbed one day by the testing of a couple of amateur phone transmitters in his vicinity. For about half an hour two zealous experimenters recited each other's call letters, the story of Mary and her lamb, and a list of the defects in their modulation, which were many and various. Although the amateurs were on their legal wavelength, this conversation mingled inextricably with the music from a commer-

cial broadcasting station whose program interested the listener. Like the situation in Kipling's ballad when two strong men meet face to face, in radio, when one is close enough, there is neither East nor West, wavelength or frequency or tuning—just QRM. The broadcast listener, vastly and understandably annoyed, did not pause to analyze the facts of the situation. He sat down and wrote to the broadcasting station:

"How do these private talks get into your

amplifying room to be broadcasted, instead of the advertised programs?"

To this inquiry our friend appended many bitter complaints. The notion that the trouble lay in the location or electrical characteristics of his receiving set apparently never occurred to him.

Another gentleman suffered with a receiving system which was capable of picking up signals, but without prejudice as to wavelength; its tolerance was such that it did not differentiate very well between 405 and 455 meters, and consequently there was considerable interference, in this listener's set, between WJY and WJZ. The listener knew that these two stations are located at Æolian Hall in New York, as the halves of a duplex station, but he did not know that the two programs are radiated from separate sets, separate aerials, and separate studios, with inappreciable cross-talk between the two wavelengths. He sought and found a simple physical reason for the interference which he experienced, informed the broadcasting station of his observations, and berated the technical staff soundly with this rhetorical question:

"Why . . . don't you close the doors between the studios?"

Having been a radio man for many years, I have little respect for myself or other members of the fraternity. Still, they have more sense than that; they really have.

Complaints also come in by telephone. The conversation usually begins as follows:

"Something's wrong with your modulation. Are you listening in?"

Informant is assured that three men are listening in, and that it sounds all right at the transmitting end. After a few minutes of conversation it develops that the receiver is howling. The trouble is not usually at the broadcasting station; if it is, the operators are aware of it. When there is something rotten in Denmark, the Danes are apt to know it.

THE JOB OF KEEPING A STATION GOING

NOT that the broadcaster is never at fault. Looking at the apparatus in all its complexity, and revolving in one's mind the number of things that can go wrong, one feels surprised that it ever works at all! Yet it works



NOT TOO MUCH HERE TO OBSTRUCT THE WESTBOUND WAVES

View taken from the base of the Æolian Hall towers, looking toward Hoboken and San Francisco. At the left is the Wurlitzer Building, with Bush Tower behind it, then the Candler Building, Times Building, and the unfinished Times Annex. Beyond flows the beautiful blue Hudson

successfully almost all of the time; after less than two years of commercial existence, metropolitan broadcasting is substantially on the level of operating efficiency of other public utilities. This in spite of the fact that radiotelephony presents problems of unique and inherent difficulty to the engineer. The slight energy of the voice and of musical instruments, in all its complexity of pitch, quality, articulation, inflection, and shading, must be amplified to power level, and this final half-kilowatt of radio power which is flung out from the aerial of the transmitting station must be a faithful reproduction of the original feeble acoustic vibration. To accomplish this, not only in the laboratory, but for a reliable grade of public service, is probably a more difficult job than running an electric railroad, say, for here we start and end on the power level; or manufacturing wrist watches, for in this instance we work with small energy and no great demands in the way of power will ever be made on the system. The object of this article is to give readers some idea of how carefully the various energy transformations are checked in a well regulated broadcasting station, what precautions are taken against interruption of service, and what, in general, goes on during the day's work.

The work may be divided roughly into three parts. First, the picking up with a microphone or other acoustic-electric device of the sounds to be broadcasted. Secondly, amplifying this energy and putting it out on the air. Thirdly, listening to and observing the output, and finding fault with it if possible—for if any faults exist, and the station critics don't find them, outside critics will. Broadcasting is in one way a division of the show business, and the luxury of nursing their weaknesses in private is denied to professional broadcasters, as to politicians, actors, and multi-millionaires. They always have the comforting thought that their mistakes will be heard and noted by the general manager and a squad of directors of their own corporation, besides a few chief engineers and such, besides some score of professional musicians with an ear for what drops out and what is over-emphasized, besides the emissaries and representatives of rival broadcasting stations, besides a few hundred thousands of the general public. Consequently the work of checking the output of the transmitters is not the least important part of the job. The place where this is done—the control room—is

in fact the heart of the station, and while the station is in operation the control operators have supreme direction of what is to be done, and how, and when. G. H. Q. is in the control room.

THE ARRANGEMENT OF STUDIO AND APPARATUS AT ÆOLIAN HALL

IN THE description which follows, station WJZ of the Radio Corporation of America, at Æolian Hall in New York City, will be used, that being the station which the writer happens

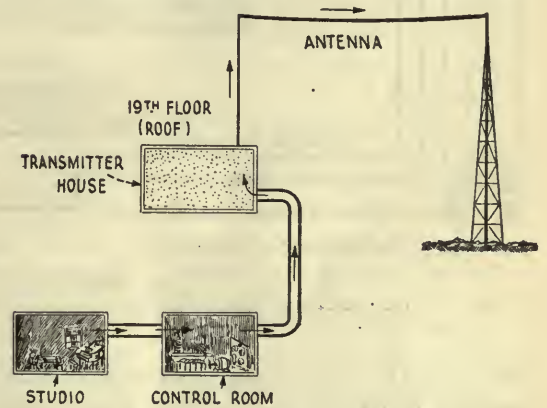


FIG. 1

to know more or less intimately. The layout of this installation is rather unusual. It is shown schematically in Fig. 1. The studios, reception rooms, and control room are located on the sixth floor of an eighteen-story building. The actual sets and all the power equipment—motor-generators, storage batteries, etc., together with the aerials, are on the roof. The necessary connections are made through a mass of pipes or conduits carrying insulated wires, installed according to the best electrical practice. Of course all wireless stations are prolific in the matter of wires, but as one stands in the sixth-floor corridor, near Forty-Second Street, and gazes at the row of black pipes stretching out to Forty-Third Street, thence rising majestically up the freight elevator shaft a few hundred feet, before going half way back to Forty-Second Street to the transmitter house on the roof, and reflects on the number of wires each pipe contains, the name "Conduit Central" springs to one's mind as a fit alternative for the station's official cognomen of "Broadcast Central."

In Fig. 2, a schematic view is given of the control operator's equipment. There are six single-step amplifier units, of which not more

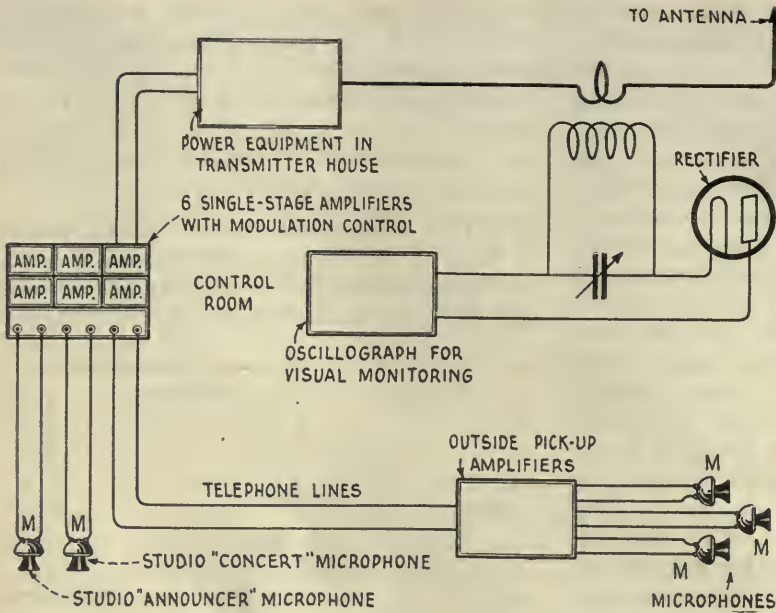


FIG. 2

A schematic diagram of the control operator's equipment

than two are used at any given time, the remainder being spares. Four of these amplifiers are intended for use in connection with the studio; two are for outside work. By means of plugs and jacks similar to those on a telephone switchboard, and a set of knife switches, the control operator can connect either studio microphones or outside lines to his amplifiers and send the output upstairs to be progressively amplified to power level and put out on the air. The plates of all these single-stage units in the control room are connected and all that is necessary is to give the unit input energy and to light the tube. In the transmitter room, coupled to a single turn in the antenna lead, there is an edgewise-wound copper ribbon inductance, which draws a small amount of energy from the aerial to actuate an instrument in the control room, called an oscillograph. This apparatus gives a faithful picture, in the form of a light ray thrown on a revolving mirror, of the sound wave impressed on the radio oscillations sent out from the station. By means of it the control operator can ascertain at a glance what the state of his modulation is, and make any indicated changes. "How much is she modulating?" or, less elegantly, "How much is she kicking?" is one of the most frequent questions asked in any broadcasting station. At many stations the answer is a matter of guesswork, but at WJZ the control

operator can answer: "Forty per cent. average; seventy per cent. peak," or whatever the figures are, just as if he were reading temperatures on a thermometer, or miles on a speedometer.

This matter of per cent. modulation is important enough to warrant an extended description, of which only a brief outline will be given here. It amounts to this: You have a certain amount of radio frequency—say 500 watts—to put out on the air. This energy is not itself audible. All that people can hear is the variations produced in the radio-frequency output by the sound waves impressed on the latter. Modulation is the business of varying

the radio frequency in accordance with these sound waves. If you undermodulate, no one on the outside hears you. The available energy of the station is not being used. It is like investing one's \$500,000 in a project yielding interest at the rate of $\frac{1}{4}$ per cent. The investment would probably be perfectly safe, but one could not entertain many Follies girls on the income. If you overmodulate, everyone on the outside will hear you, but it would be better if they did not, for what they will hear is like a combination of bricks sliding down a chute, the songs of amorous cats, and the war cry of the noble red-man. This is equivalent to investing one's 500 talents in a bootlegging enterprise, getting caught by the revenue officers, and losing both one's patrimony and one's freedom. There is a happy mean which is at the same time audible and safe. The control operator must find this mean and stick to it, or to-morrow he gets fired. (However, even if the per cent. modulation is well gauged, the control operator has a number of other means of getting fired.)

Fig. 3, in its several divisions, shows what may be seen in the revolving mirror of the oscillograph. There are three straight vertical lines, the left-hand one being the zero line, the right-hand one marking 100 per cent., with a median line indicating 50 per cent. A wavy line formed by the reflection of a beam of light

on the revolving mirror, by the extent to which it fills the space between the two extreme marks, indicates the measure of modulation. In Fig. 3a, the modulation is low—about 10 per cent. corresponding to a pianissimo passage in music. In Fig. 3b, the modulation is 60 per cent.—a good, audible value, with adequate margin for most exigencies. Fig. 3c, illustrates a bad case of over-modulation.

But now, instead of continuing our description in the regulation way, let us proceed from this bare outline of the equipment, and fill in the details by telling the story of a composite day in a control operator's life.

AN AVERAGE DAY IN THE LIFE OF THE CONTROL OPERATOR

WE WILL call him Jim. Jim wakes up at about ten o'clock in the morning, for he worked the evening before till after eleven, and probably took out his girl, or a

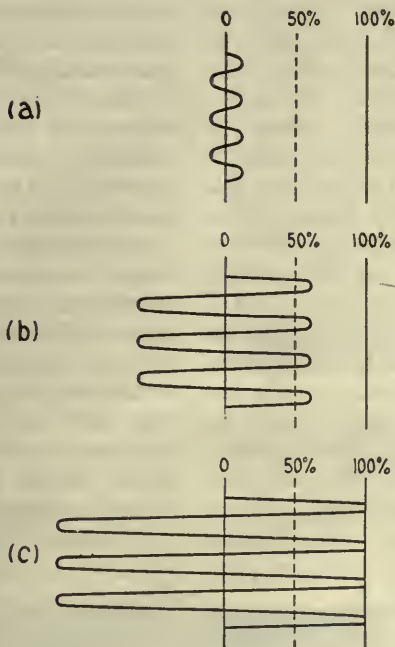


FIG. 3
Low, good, and too great modulation, as indicated by the oscillograph

plurality of girls, after that. He breakfasts in bed while glancing at the radio programs in the morning papers. However, we are not concerned with Jim's activities until, after two o'clock, his limousine rolls up to the Æolian Building. Ascending in the elevator, he observes a number of musical celebrities, for this building is one of the chief musical centers of New York, and makes a mental note of the latest fashions in flowing scarfs before getting off at the sixth floor and entering the control room. Here some of his own colleagues are already seated, earnestly discussing the rotten modulation at all the other stations in the country, the faults of the announcers, means of making broadcasting pay, and the grave error of the executives of the company in not immediately doubling the salaries of the whole staff.

At 3.00 P. M. the program is scheduled to



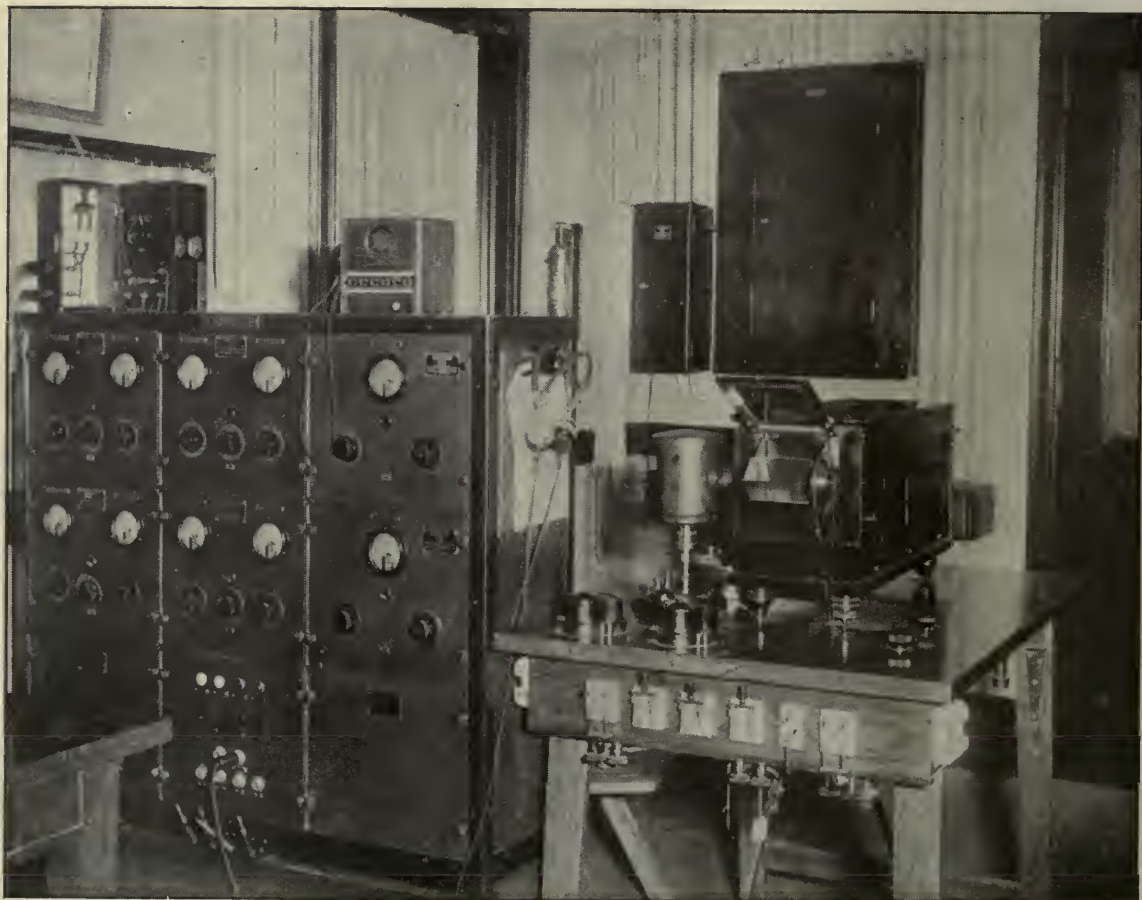
T.M.

"HIS OWN COLLEAGUES . . . DISCUSSING THE ROTTEN MODULATION AT ALL OTHER STATIONS, The faults of the announcers, means of making broadcasting pay, and the grave error of the executives of the company in not immediately doubling the salaries of the whole staff"

start. Shortly before this time the control operator throws a number of switches, putting current on the microphones and tubes, and, drawing aside a curtain, he glances through a horizontal window into the studio, where the announcer is conferring with the first artist, a red-haired soprano, regarding the numbers she is to sing. At fifteen seconds before three o'clock the control operator lifts the receiver of a small intercommunicating telephone before him, rings the roof, and gives the order, "WJZ on the air." Or he may use the local designation of "Channel B." An instant later a green signal light glows on the amplifier rack in the control room and also in the studio, notifying the announcer and the control-room operator that the transmitter is on the air and ready for the program. As yet, however, nothing but inaudible C. W. is going out. Several other signal lights are put on at this time, but

these have no material part in the working of the station, communication between the several rooms being by interphone.

Observing the green light on his table, the announcer sits down and throws on his microphone by setting a small cam switch at "Announce." This lights a red bulb in the control room and also in the transmitter house, warning all hands that speech is about to go out. The announcer then gives his preliminary speech, introduces the artists, and throws his cam switch to "Concert." The music begins. The control operator, who has paid only casual attention to the announcement, for he is familiar with the announcer's speech and has his apparatus properly set beforehand, is now very much on the alert; he turns a knob rapidly, puts out the room lights in order to observe the oscillograph better, and peers through the window at the scene in the studio. Appar-



THIS IS WHERE JIM PUTS IN HIS EIGHT HOURS A DAY

A section of the control room at "Broadcast Central," Aeolian Hall. The amplifier rack, with the interphone unit on top of it (for talking with "the roof" and the studio), is seen at the left. At the right is the oscillograph with its four-sided mirror in which the voice pictures appear

ently he is not satisfied, for he holds the telephones tightly to his ears, and even mumbles inarticulate comments to himself while listening. Finally he calls the studio on his interphone and says, "Too much piano; but let it go till the end of the number." This is a matter of judgment. If the microphone is moved during the number a jarring sound goes out on the air, and the artist may be somewhat disturbed in her singing. As the accompaniment is only slightly too loud in proportion to the voice, Jim has decided to defer the change to the end of the first selection. Perhaps he was influenced by the singer's red hair. At the end of the number the announcer gives the usual formula: "The number you have just heard is—" and throws the cam switch to the "Off" position. The red light goes out and the station is momentarily inactive, although the oscillators are still on the air and the green light glows as before. Before continuing with the next number the announcer moves the microphone pedestal so that it will pick up less energy from the strings of the piano and more from the singer's vocal cords. He may do this by asking the singer to stand nearer to the microphone, or by shifting the microphone to a position farther from the piano. A frequent setting for vocal solos is shown in Fig. 4. The change being made, the concert continues.

KEEPING IN TOUCH WITH THE ROOF

A WORD about the interphone system of calling. The telephones on the roof, in the control room, and in the studios, are equipped with the usual buzzer system of ringing, but in the studios, where silence is imperative, a white light on the telephone unit glows for calling. The announcer answers by lifting the receiver off the hook and listening. The control operator hears the receiver being lifted and makes his request. The announcer acknowledges receipt by tapping his transmitter twice, forming the code letter "I", which passes in radio and wire circles for "Received"; this procedure is inaudible in the studio, but perfectly clear to the control man. In the absence of this signal, the control operator repeats his instructions till they are understood. This system has worked out well in practice. In case of a matter requiring a consultation of any length, the control operator may call the announcer into the adjoining control room.

During the second number of the red-haired soprano's repertoire Jim confines himself to

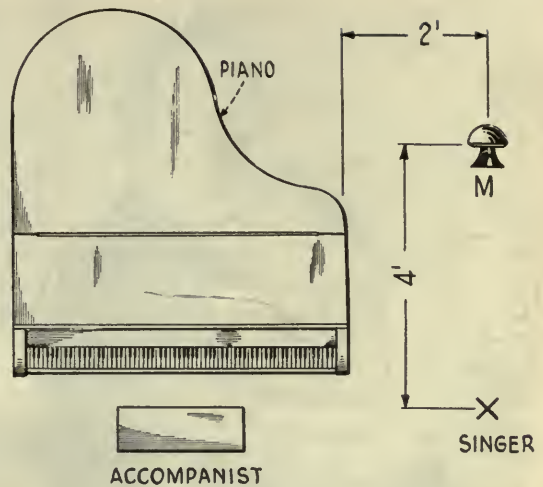
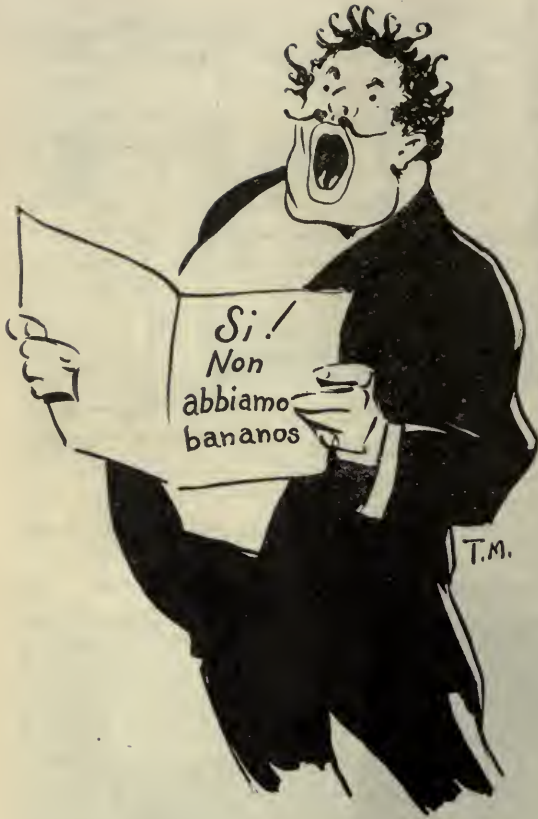


FIG. 4
This arrangement has been found suitable for vocal solos

adjusting modulation, bringing up his "gain control," as it is called, on very pianissimo passages, and "holding her down" to prevent over-modulation on the forte notes. However, he does not attempt to level out the music or to edit it in any way; on the contrary, his business is to put out on the air, as faithfully as possible, the material given him in the studio, making only such adjustments as are required by the nature of the media, physical and electrical, intervening between the artist and the audience. This is easier for some artists than for others. In general, performers with experience in phonograph recording are the best to handle. They realize that they are singing in a room and not in an opera house, and graduate their volume accordingly. The apparatus and the operators are grateful to them and they go out well. Others sing with enormous volume in the hope of reaching New Zealand, but of course they do not get out any louder and there is a tendency to overload the microphone, with the production of a scratching sound, more or less prominent, which detracts from the quality of the voice on the air. However, within considerable limits the operators can compensate for inequalities, and the usual answer to the question, "Shall I play or sing in any special way?" is, "No; perform in your natural manner, and it will get out best."

HELPING THE PERFORMER "GET OUT" WELL

THE control operator is aided in his work if he knows most of the songs that are apt to be rendered, and has enough knowledge of musical composition to know a few seconds



"IN THE HOPE OF REACHING NEW ZEALAND"

ahead when a fortissimo passage is coming. This is in fact one of Jim's qualifications, and it preserves him from ever being caught flat-footed when the artist pulls out the stops and takes it on high—to mix three metaphors—and under these conditions it would take an earthquake to over-modulate when Jim is holding down the channel. To a certain extent, also, he may rely on his judgment of the artist's vocal capacity; but this is apt to be treacherous. The writer remembers one occasion when a very small coloratura, with whom he did not have the honor of any previous acquaintance, started on her first number in the studio. She had a beautiful radio voice, but did not look dangerous in the matter of volume, after some fairly bulky girls who had preceded her. The writer made his settings accordingly. In a few seconds she hit 85 per cent. on a peak. The writer was familiar with the aria and knew there were some fortissimo breakers ahead, but he did not think that the artist could get up any higher. This thought, unfortunately, had no basis in fact, the lady swept up to her high note with astonishing force, modulating

about 150 per cent., and before anything could be done the plate relay on the transmitter tripped and the set shut down with a squawk. The spare set was on the air in five seconds, but the writer felt like a tennis player who gets a soft lob at the net, sets himself to bury it, and slams it into the backstop. Well, accidents will happen when one is dealing with strange coloraturas and judges them by weight.

After Mademoiselle has got through with her program, there is a talk on fashions. This item gives Jim little concern, and when one of the announcers brings in the soprano to look over the control apparatus, Jim is able to tilt one of the phones off his ear and to monitor with the other side while explaining the functions of all the lights and knobs. Of course she wants to know how she went out, and here Jim applies his code. If she was fair, he tells her that she was good. Good he calls wonderful. If she was really wonderful, words fail him. If she was bad, he says he wasn't listening. But even that is not necessarily a discredit to the artist, for occasionally one hears a voice which is good concert material and makes a fine impression in the studio, but does not transmit well, owing to some obscure acoustic factor which does not affect the human ear as much as it does the microphone.

WHEN TUBES GO BAD DURING A PROGRAM

TOWARDS the end of the fashion talk, however, Jim notices a slight muffling in the voice, which leads him to call up the transmitter room with the question: "Are your modulator tubes gassing?" The transmitter men have already noticed as much, and they proceed to push a few buttons and start the spare set. A slight click on the air marks the change-over, and the signals clear up at the same instant. While the second set is carrying the load, the defective tubes may be replaced in the first set. If there were not two sets available the trouble could not be rectified without interrupting the program. In a first-class broadcasting station everything is provided in duplicate or better, and kept ready for service at a few seconds' notice.

The next feature on the program is a five-piece jazz band. Jim already knows the characteristics to expect from this ensemble, and he places the violin close to the microphone, the saxophones somewhat farther back, and the traps and banjo to the rear. After the

first number a few minor adjustments in placing may be necessary.

Jim's real troubles begin when he has an outside event to broadcast. All that the public knows about it is the announcer's request to stand by while the program is switched from the studio to such-and-such a place umpty-ump miles away, a 15-second pause, and the voice of the announcer at the new scene of action. But there is a great deal of action behind the scenes.

In the studio there is a well-known pianist. Owing to slight but cumulative delays in the program, the studio is running five minutes behind its schedule. At 8:30 a symphony orchestra of one hundred pieces is to be broadcast. The wires have been in for several days, they have been tested a few hours before the beginning of the concert, and since 7:30 Jim has been on the line at intervals, talking to the pick-up men, listening for extraneous noise on the wires, and so on. It is 8:29. The pianist is in the middle of his last selection.

"Say, Jim," comes the voice of the chief pick-up man, "I've got to have the air. They're going to start."

"It's only eight twenty nine and a half," replies Jim, stalling for time. "He's on his last number. Just a second and I'll give it to you."

"I can't wait a second," declares Bill, on the outside. "We've got 8,000 people here. The conductor's glaring at us. For heaven's sake give us the air."

Jim begins to sweat. He looks through the window at the pianist. He looks at the announcer, who lifts his index finger—one minute more. Will the number never end? Of course Jim could take the piano off the air without the performer knowing it, but the audience would know it, and the pianist's relatives who are listening on the outside would tell him before very long. So the plug remains in. The outside men, in the meantime, are making appealing gestures at the conductor. If he should



THE TRANSMITTER HOUSE ON TOP OF AEOLIAN HALL

It is here that the voice currents from the studio and control room, thirteen floors below, are amplified and delivered to the antenna, part of which can be seen in the upper left-hand corner of the picture. The announcer in the studio, the operator in the control room, and the transmitter house personnel keep in constant touch with one another by means of a special telephone system

start, the first number of the symphony program, which will take 15 minutes, will be lost. By running over two minutes at the studio, the station stands to lose thirteen minutes on the air, with nothing to fill in, and the certainty of losing the audience to other stations with attractive programs. At 8:32 the pianist finishes. As the local announcer finishes his say Jim pulls the plug, leaps to his telephone, calls, "You're on the air," and closes the switch which connects the distant microphones to the set on the roof. The voice of the concert announcer is heard, and an instant later the symphony begins. Jim monitors this locally, with the pick-up men making adjustments at their end, and the transmitter men on the job upstairs. There may be as many as five men checking on one channel.

In the intervals the wire is used for conversation regarding the wire line transfer between the control room and the pick-up point. If Jim neglects to pull the switch, this stage business goes out on the air. Occasionally this happens, and the radio audience hears directions like: "Change to 440 loop; this wire's getting noisy," or, "Hey, haven't they got any string instruments in that orchestra?" But this is a rare occurrence.

So the program runs its course—vocal

numbers, instrumental numbers, jazz, opera, talks, recitations, symphonies, time signals, bedtime stories, plays—anything that the program manager has reason to believe will please some considerable fraction of the audience. As closing time approaches Jim has listened to a hundred thousand words about the income tax, international relations, the boll weevil, love and marriage, the preparation of prunes, how to keep one's good looks if one never had any, why the army should be enlarged, and measures to stop the next war. He has heard arias from every opera from

Orpheus to The Girl of the Golden West. He has had six fights with announcers bigger than he is, been challenged to duels by four outside pick-up men, received twelve very insulting telephone calls from listeners who were wrong and three moderately insulting ones from listeners who were right, and ogled twenty pretty girls, all escorted and inaccessible. Promptly at 11:30, with the last syllable of the sign-off, Jim collapses and is dumped into his limousine to be carried home. Let the invisible audience drop a tear for him next time they slip on the "cans."

THE MASS OF STEEL AND MASONRY EAST OF AEOLIAN HALL

The aerial towers rise 115 feet above the roof from which this picture was taken, thus clearing all these buildings. The Biltmore Hotel (with flag flying) is seen at the left, the Commodore pushes up against the sky-line in the centre, and the banks and business buildings which cluster around Madison Avenue and 42nd Street form the walls of a "Grand Canyon." The dark patch at the bottom of the "canyon" is the motor-traffic bridge leading around Grand Central Terminal joining the up and down-town sides of Park Avenue. A bit of the East River and some power houses on the Brooklyn shore may be seen in the background. This is the kind of territory over which the radio waves must travel and into which they must penetrate

