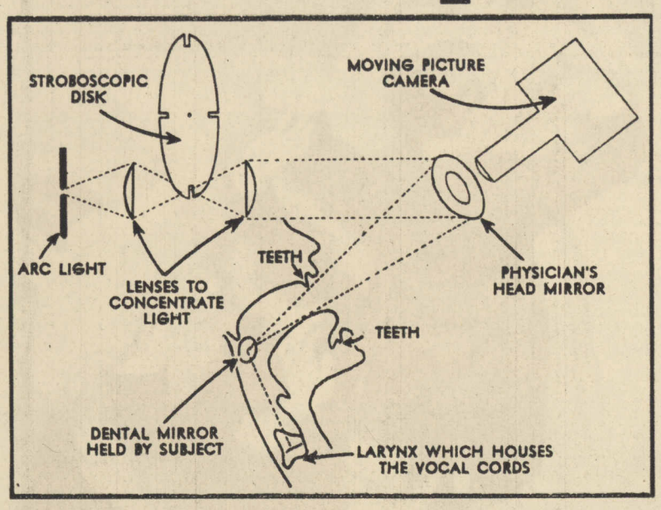
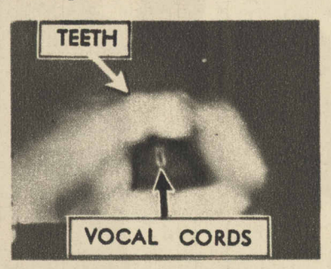
The Graphic Laboratory of Popular Science



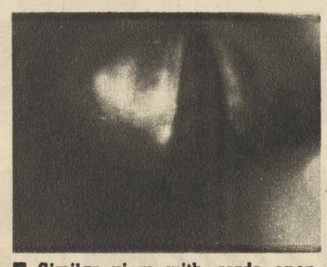
1 The method used by Drs. Steer and Tiffin in photographing vocal cords in action. The stroboscope disk breaks up the light beam to produce the effect of slow motion pictures.

2 Cameraman's view of subject holding dental mirror in mouth.



3 Longer lens gives this closeup of oral cavity.

4 Still closer view, showing vocal cords closed during speech.



5 Similar view with cords open while patient breathes.

Purdue Scientists Dissect the Human Voice

By JOHN A. MENAUGH

MODERN science has perfected a means by which the human voice can be taken apart and analyzed.

By the employment of an ingenious apparatus called a vibrograph, devised by two scientists of Purdue university, Drs. Mack D. Steer and Joseph Tiffin, the voice—in the form of a sound wave converted into a beam of light—actually is photographed. From the photograph, or oscillogram, a chart analysis or pitch graph is made that discloses at a glance the true characteristics of the voice.

The Graphic Laboratory of Popular Science, with the consent of Drs. Steer and Tiffin, herewith makes the first public announcement of their unique achievement and describes what they have done in this particular field.

As a result of their experiments it now is possible to explain with a great degree of accuracy why, for example, Adolf Hitler's excitable tirades against democracies are unpleasant to the ear, even though one does not understand the words, and why in contrast Prime Minister Chamberlain's speeches seem so soothing, at least in an auditory way.

The two Purdue scientists made an intensive study of the radio voices of Hitler, Chamberlain, Mussolini, and Daladier during the Munich crisis of last autumn, preparing pitch graphs of each to show its characteristics. They also have analyzed other voices in a similar manner, including those of President Roosevelt and well known stage and radio speakers.

The median pitch of Hitler's voice, they have ascertained from his Munich crisis speech, is 232 vibrations a second, whereas that of the average conversational speech of a male voice is only 130 vibrations. By median pitch is meant the typical number of vibrations a second of the vocal cords.

A study by Dr. Fairbanks of the effects of emotion on the voice has disclosed that the median pitch of anger is 229 vibrations a second and of fear 254 vibrations. Hitler's voice, therefore, falls between fear and anger, but closer to anger. Chamberlain's speech has a pitch level of approximately 130 vibrations a second, which is normal for conversational speech. Mussolini's median pitch is 190 vibrations, Daladier's about 140, and Roosevelt's 160.

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Hitler's voice range is small—only about two-thirds of an octave—because he is so near the top of his vocal register that much variation of pitch is impossible. Chamberlain's range is slightly more than octave, Mussolini's an octave and a half, and Daladier's and Roosevelt's each about an octave. The range of a professional actor or radio speaker frequently is much greater than that of any of these statesmen.

At Purdue university Dr. Steer is director of the speech clinic and voice science laboratory, and Dr. Tiffin is professor of applied psychology. Together they have worked out their present method for the scientific study of speech.

There are two essential approaches to complete analysis of speech. These belong together, and they deal with (1) the vocal cords themselves and their observation and study, and (2) the sounds that the vocal cords produce. In both approaches photography is employed for accurate results. The vibrograph perfected by Drs. Steer and Tiffin, as previously mentioned, photographs the sound wave of the voice. A motion picture camera is employed in photographing the vocal cords.

If one places a finger on the tip of his "Adam's apple" and says "ah" he feels a buzz or vibration. This buzz is the vibration of the vocal cords, two pearly white bands of tissue located in the top of the trachea or windpipe. The vocal cords are the source of the sounds of speech. They determine the pitch and quality of one's voice. Air forced through the opening between the cords causes them to vibrate, and it is this vibration that produces sound. The tighter the cords are stretched the faster they vibrate and the higher is the pitch of the sound produced.

The vocal cords are about twice as large in a man as in a woman, hence the deeper pitch of the masculine voice. Men's voices, however, and women's, too, vary with the individual, depending upon the characteristics of each set of vocal cords. If a man's average speaking voice is highly pitched it is an indication that his vocal cords are relatively short or possibly under abnormal tension from one or another cause. Hitler's is a notable example of a highly pitched voice.

When a person has a cold or a case of laryngitis the vocal cords become inflamed or covered with mucus. This "loading" makes them heavier than normal and they vibrate more slowly. The result is a lowering or huskiness of the voice. Many cases of voice defect can be traced directly to the vocal cords. Singers and public speakers sometimes develop nodes. These are slight protuberances or calluses that prevent the cords from coming tightly together, as they must do to vibrate properly. In severe cases nodes must be removed surgically, but frequently they will disappear with proper training and use of the voice.

Less than a hundred years ago medical men believed that it was impossible to see the vocal cords of a living human being. Today it not only is possible to see the vocal cords in the throat of a living person but it also is possible to take moving pictures of them—pictures which are employed in analyzing the movements of the cords to explain quality differences such as harshness, huskiness, and throatiness. The motion picture camera, since its invention not so long ago, has been put to numerous uses other than in connection with entertainment, but perhaps as novel a use as any has been its employment for making pictorial records of the vocal cords for scientific study.

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Only a few persons in this country, however, have been able to take movies of the physical source of speech. Among these are Drs. Steer and Tiffin of Purdue. Others are Dr. John Steinberg of the Bell Telephone laboratories, Dr. G. Oscar Russell of Ohio State university, Dr. Paul Moore of Northwestern university, and Dr. Joel Pressman, a California physician and the husband of Claudette Colbert, the movie actress. Dr. Pressman has obtained what are said to be excellent views of pathological larynges.

The method employed by Drs. Steer and Tiffin in making movies of the vocal cords is diagrammed in an accompanying sketch. Briefly, it is this: An arc light projects illumination into a lens which condenses the light source. This condensed light flashes through an aperture in a stroboscopic disk to stop the motion, or, in other words, produce slow motion. The light at this point is picked up by a second lens that brings the rays from the source into parallel rays. This light is reflected by a physician's head mirror to a mirror in the subject's throat, which in turn reflects it down to the larynx. Through an opening in the physician's head mirror the motion picture camera's lens receives the image that is reflected back from the larynx—it takes pictures of the vocal cords. In addition there is a small mirror set at a proper angle to permit the subject of the experiment to see his own vocal cords. By means of the stroboscopic illumination the vibrations of the vocal cords are slowed down for detailed observation and study.

Movies of the vocal cords taken by Drs. Steer and Tiffin have been shown before speech organizations from Oregon to New York and from Arkansas to Chicago.

Making motion pictures of the vocal cords represents only half of the purely mechanical process necessary in the complete study of the voice. The other half involves the sound itself. It is here that the vibrograph comes into use. This permits the scientific study of the sound waves.

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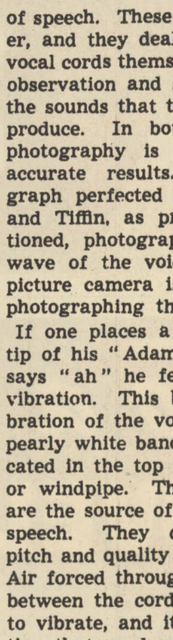
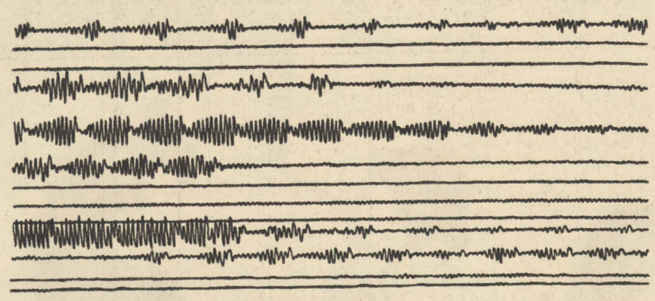
After the sound waves leave the vocal cords they travel through the air to the ear of the listener. Everything conveyed to a listener through speech is carried on a sound wave. The emotions of anger, love, jealousy, hate, rage, and fear usually can be detected from the sound wave. But to do this with a degree of accuracy the sound wave must be photographed. This is done by means of the vibrograph. Pulsations of the air pressure first are transferred into pulsations of electrical energy. These in turn are transferred by means of an oscillograph into oscillations of a beam of light. When the movements of the beam of light are photographed you have the oscillogram—a picture of the sound wave.

An oscillogram readily may be

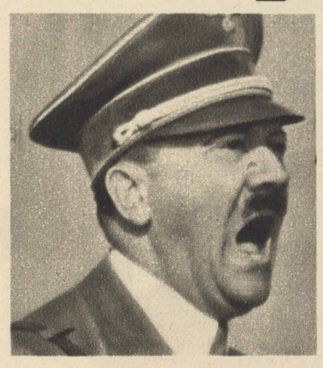
(Continued on page nine.)

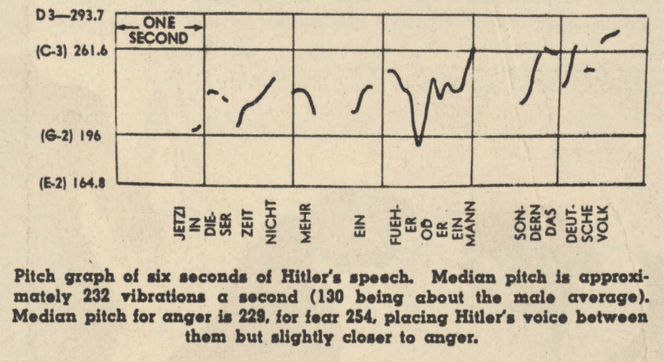


Professor Tiffin, right, photographs voice of Professor Steer, using the vibrograph which produced oscillogram pictured on this page.

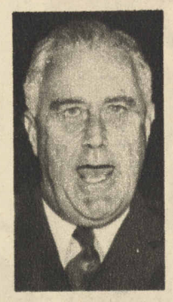


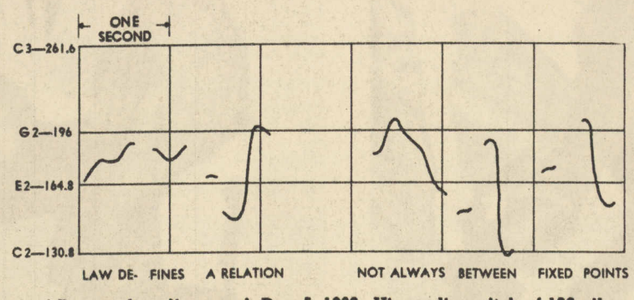
Vibrograph oscillogram of part of Hitler's radio speech Sept. 26, 1938. Interpreted, this curve yields graph to right of Hitler's picture.



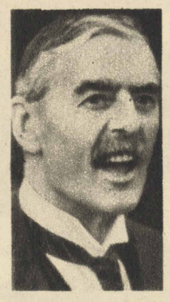


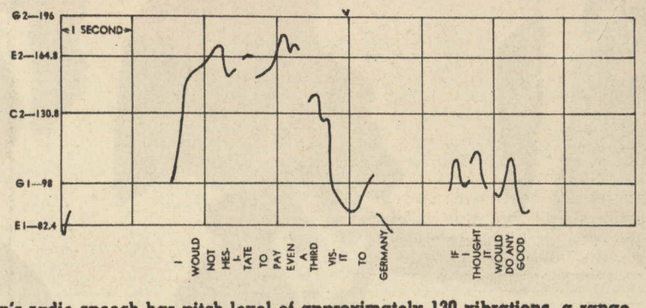
Pitch graph of six seconds of Hitler's speech. Median pitch is approximately 232 vibrations a second (130 being about the male average). Median pitch for anger is 229, for fear 254, placing Hitler's voice between them but slightly closer to anger.



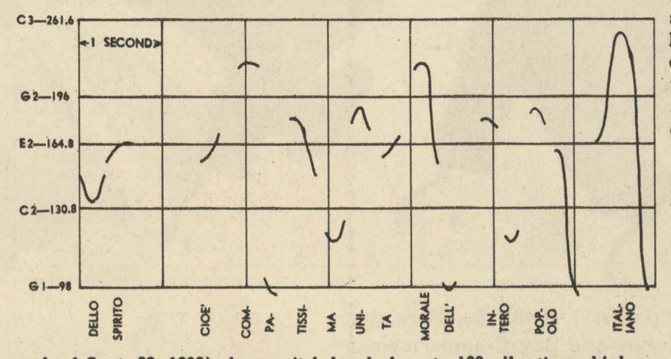


Six-second pitch graph of Roosevelt radio speech Dec. 5, 1938. His median pitch of 160 vibrations is far below emotional extreme of Hitler, but indicates emphasis greater than many public speakers. Range of one octave also is greater than that of most public speakers.





Neville Chamberlain's radio speech has pitch level of approximately 130 vibrations, a range slightly more than an octave, according to this graph from Sept. 27, 1938, speech. There is no indication of appeal based to any extent upon emotional persuasion.



Mussolini's pitch graph (from radio speech of Sept. 20, 1938) shows pitch level close to 190 vibrations, higher than either Roosevelt's or Chamberlain's but under that of Hitler. Range is about an octave and one-half, with marked degree of emotional frenzy on words "compatissima" and "popolo Italiano."

Refueling on Ocean Flights

By WAYNE THOMIS

LAST SUMMER Imperial Airways and the British air ministry tried one experiment in launching a long-range airplane with the pick-a-back team, Mercury and Maia. In that instance a small plane, loaded with more weight of fuel than its own motors could pull off the water, was helped into the air on the back of a large plane that was carrying no other burden.

The idea was based on the fact that an airplane that is flying can with relative ease carry a much greater load than it is able to pull off the ground. This is true because the plane, once it reaches flying speed, develops much more lift than can possibly be attained during the period between the start of its run on the ground and the moment the ship becomes air-borne.

This summer the British intend to conduct a second experiment based upon this same fact. Again the experiment will involve trans-Atlantic flights, probably of ships carrying mail and express. This time the method used for getting the plane and its load into the air, however, will be much different.

During the winter Short Bros., manufacturers of the Imperial flying boats, have completed four new machines for these flights. They resemble the original Imperial class boats and have the same external dimensions—116-foot wing span, 78-foot length—and each has four motors. They are, however, much more heavily and, consequently, more strongly built.

Where the Imperial boats can be loaded to a gross weight of 40,000 pounds, the newest machines can carry up to 48,000 pounds. The Imperial boats had four 730-horsepower Bristol Pegasus motors. The new C class boats have four 905-horsepower Bristol Persus engines with sleeve valves. And the C class boats are equipped with new British paraphernalia for taking aboard fuel while in flight.

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It is by refueling in flight that these boats are to be given their full gross load. They will take off loaded to about 39,000 pounds. Once in the air, they will make contact with a refueling ship. A hose will be drawn between the two planes and another 1,500 gallons of gasoline, weighing about 9,000 pounds, will be pumped aboard. According to reports from England, this can be done in about twenty-five minutes.

The four boats prepared for this purpose are the Cabot, Caribou, Connemara, and Clyde. Sir Alan Cobham, an aviation authority and an early pilot, developed the entire refueling system during the last three years. He was aided by Imperial Airways and the air ministry, which expects to use the same method for getting fuel aboard long-range bombers in war time. The method is said to be foolproof and accidentproof.

Tanker airplanes—obsolete bombers from the Royal Air Force—already have been stationed at Foynes, Ireland, and at Botwood, Newfoundland. Botwood is the jump-off point for the transoceanic crossing of 1,940 miles between Canada and Ireland. And as soon as the ice breaks up in Botwood harbor the first crossings will be made.

The tanker planes will take off from the new airport at Hattie's Camp, forty miles inland from Botwood.

Means used for getting a line from tanker planes to the trans-Atlantic flying boats in flight are deep official secrets, although aerial refueling is far from new. The endurance flying that was all the rage in the United States between 1927 and 1933 was made possible by exactly this kind of refueling. The endurance flights, however, were made with small, slow airplanes.

The big trans-Atlantic boats are much faster and must be flown at about 120 miles an hour even during the refueling contact. Furthermore, the refueling done by the endurance flyers involved a transfer of less than 100 gallons of gasoline at any one contact. The British propose to pump 1,500 gallons into their machines at each contact.

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If the summer's flights are successful, passengers may be carried aboard the machines that are refueled in flight. Those who have been connected with the aerial refueling experiments carried out to date say there is no danger of an explosion from static electricity or from any other source. This, however, is yet to be proved in actual service tests. The summer's flying will provide the experience needed to determine whether this refueling is practical.

The Imperial flying boat Cabot receiving 1,000 gallons of fuel in midair from tanker.