

[72] Inventors William W. McCrory, Jr.;
Earl Kent Hunter, Panama City, Fla.
[21] Appl. No. 799,031
[22] Filed Feb. 13, 1969
[45] Patented Jan. 26, 1971
[73] Assignee the United States of America as represented
by the Secretary of the Navy

[56] References Cited
UNITED STATES PATENTS
2,394,613 2/1946 Houlgate et al. 179/175.1
Primary Examiner—Kathleen H. Claffy
Assistant Examiner—Douglas W. Olms
Attorneys—Louis A. Miller, Don D. Doty and William T.
Skeer

[54] UNDERWATER MICROPHONE TESTING DEVICE
10 Claims, 4 Drawing Figs.

[52] U.S. Cl. 179/175.1
[51] Int. Cl. H04r 29/00
[50] Field of Search. 179/175.1A,
183, 187

ABSTRACT: This invention pertains to an apparatus and method of objectively testing microphones mounted in diving masks as an integral part thereof. The apparatus comprises an especially made manikin, a pressurized chamber, a source of recorded audio test signals, and an indicator device.

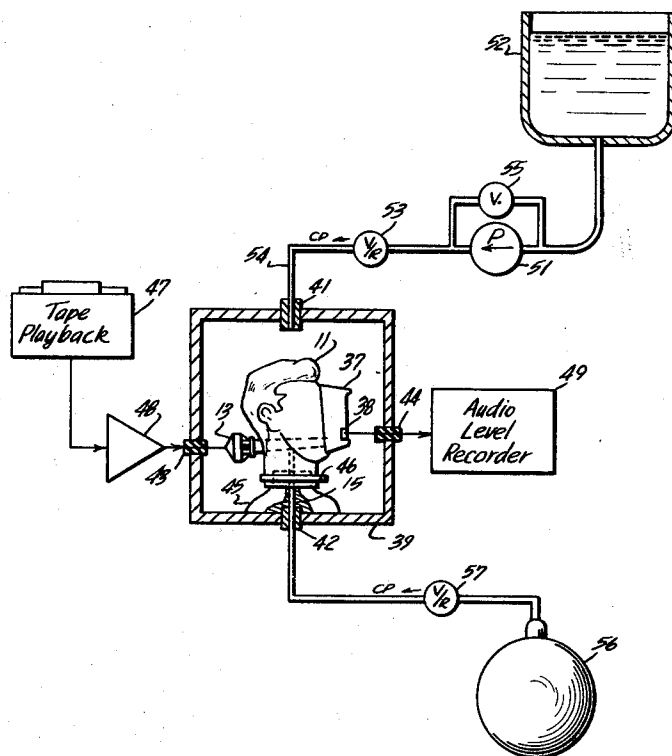


Fig. 1

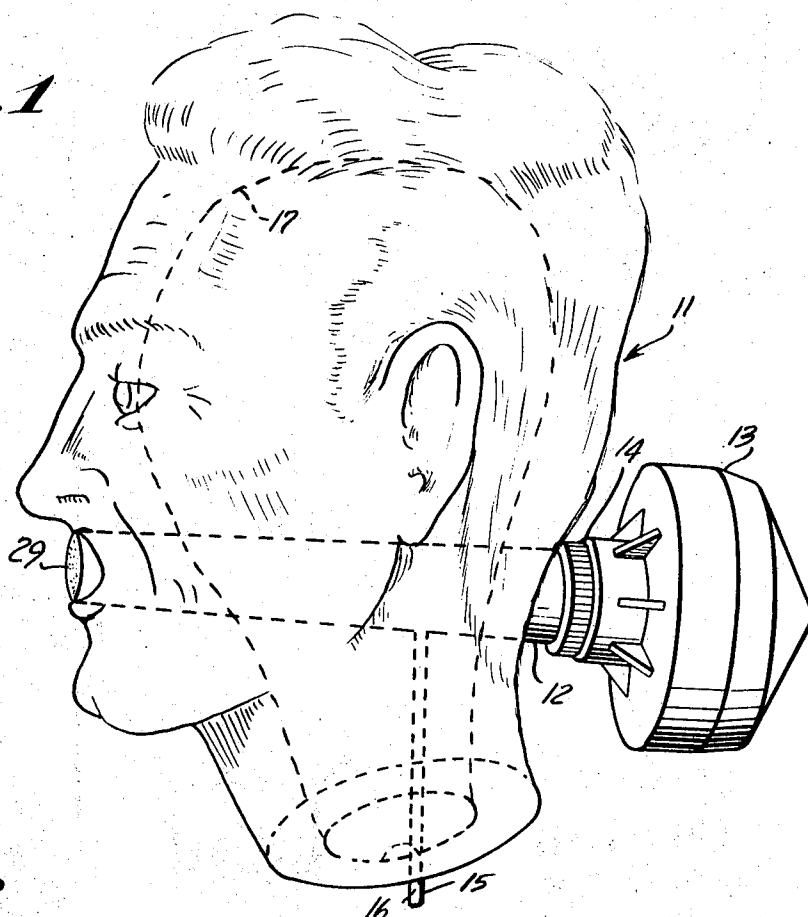
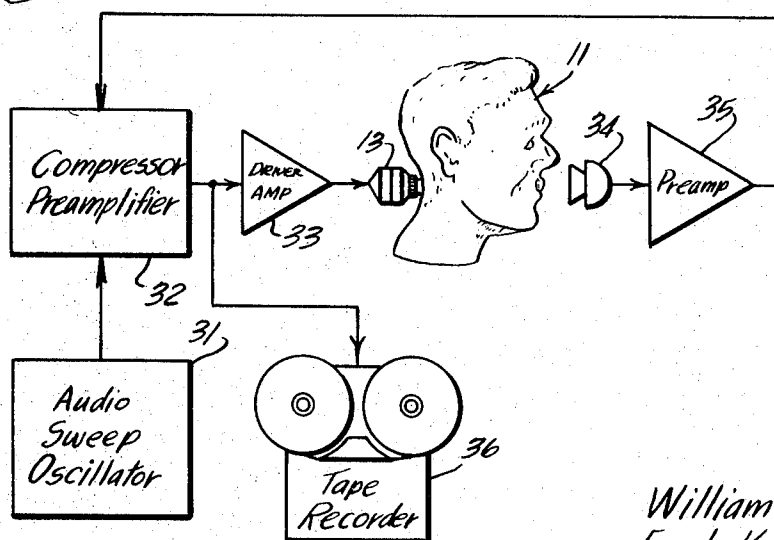
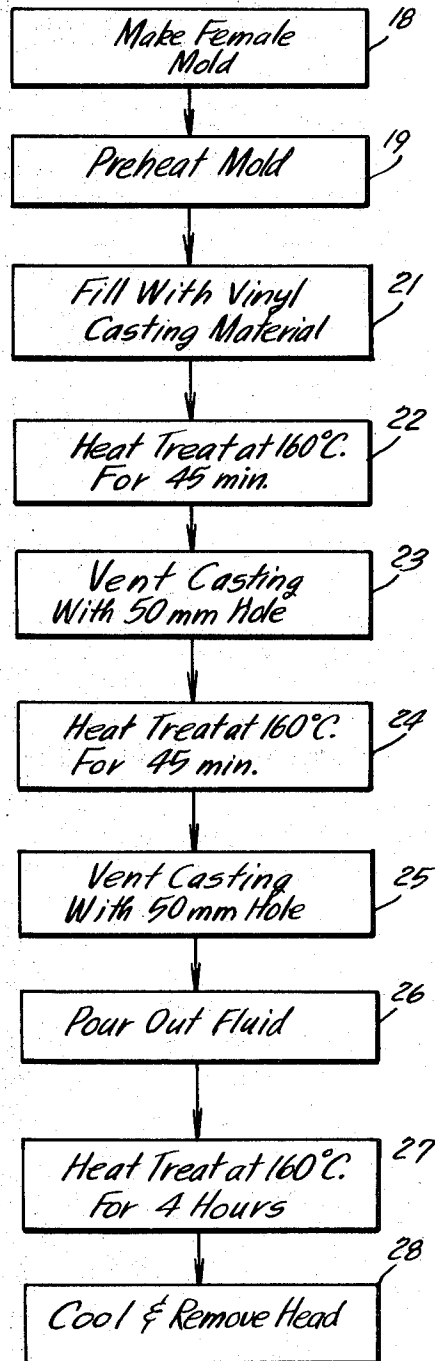


Fig. 3



William W. McCrory, Jr.
Earl K. Hunter
INVENTORS

BY William T. Skeer
Agent
Dox S. Duff
Attorney

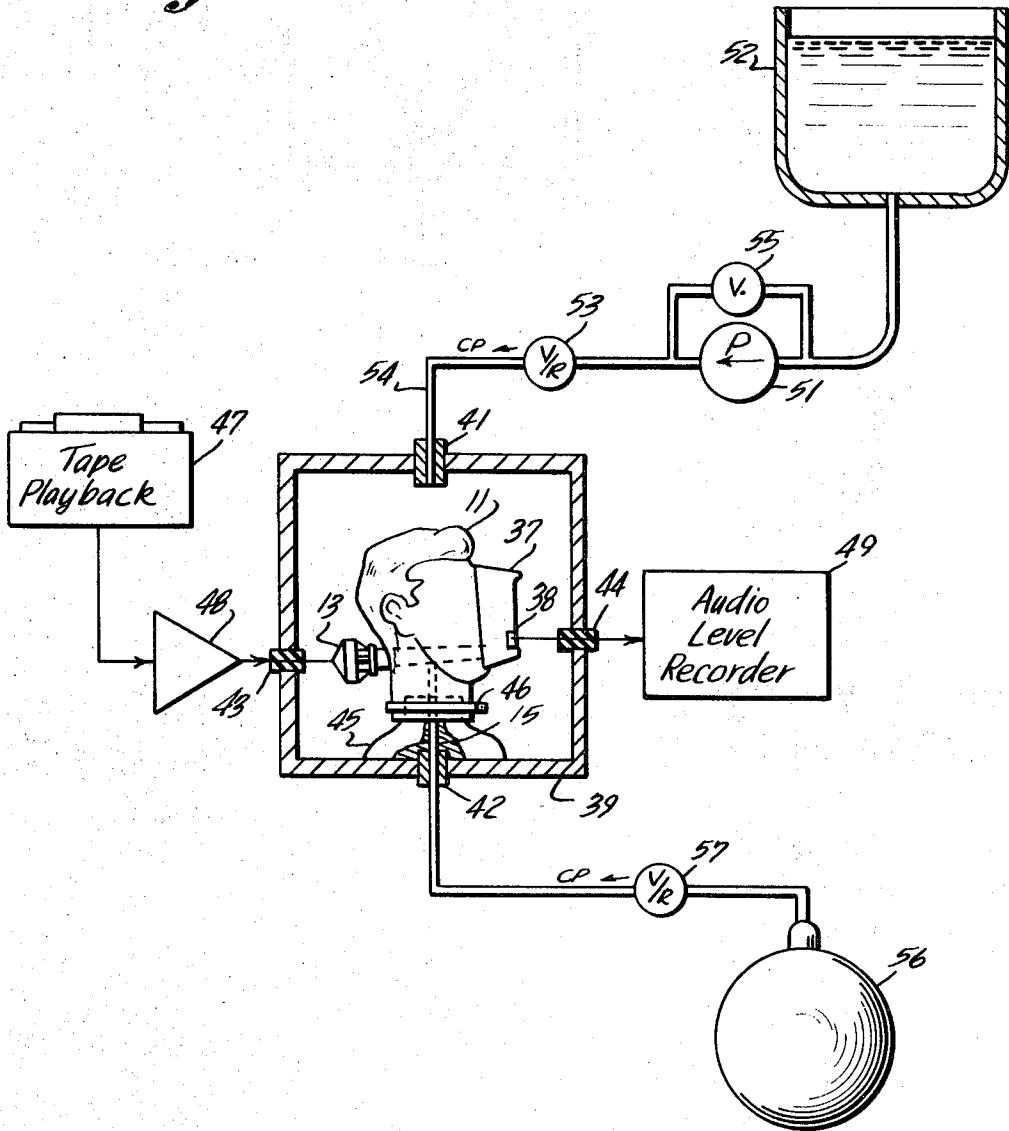
Fig. 2

William W. McCrory, Jr.
Earl K. Hunter

INVENTORS

BY William T. Sheer
Agent
Don D. Doherty
Attorney

Fig. 4



William W. McCrory, Jr.

Earl K. Hunter

INVENTORS

BY William T. Sker
Agent

Don O. Sker
Attorney

UNDERWATER MICROPHONE TESTING DEVICE

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Modern marine and oceanographic operations frequently employ teams of underwater swimmers and divers whose activities require close cooperation between individual members of said teams. The personnel comprising the teams communicate between themselves by means of electronic voice intercommunication equipment, and their successful operation as a team depends, to a large extent, upon said equipment's satisfactory operation.

Experience has shown that one of the most common causes of failure of underwater communication equipment is malfunction of the speech transducers, particularly the microphones. These troublesome failures cause interruption of the activities of the underwater team while the defective unit is replaced. Replacement requires the wearer to surface in order to exchange the faulty equipment for equipment that is operating correctly. The work of the team is therefore shortened by the time this replacement requires. Since the microphone is an integral part of the face mask, the replacement time is considerable.

Testing of microphones prior to use, at the present state of the art, is difficult and uncertain. Microphones which work under surface conditions do not always perform in operational situations. Also, since the special gas mixture used by the underwater personnel for breathing differs in density from surface air, the voice of the underwater user differs from the surface voice of the same individual. Microphones designed for underwater applications are made to accommodate the frequency range of the user breathing the special gas mixture, and, as a result, do not respond well to the surface voice frequencies. Because of these factors, present state-of-the-art testing techniques rely heavily on "in use" tests which are rather subjective.

What is needed is a testing apparatus which will test the microphones prior to their being placed in use. Such an apparatus would assure that personnel were equipped with operationally satisfactory units prior to being sent beneath the surface. This single advance in the art would save both time and money, and would be a significant achievement in the oceanographic sciences and other fields employing personnel engaged in underwater activities.

An additional utility for the testing apparatus is in the design and construction of the microphone units themselves as well as associated communication equipment. When using diving personnel to test a large number of units, it is difficult to maintain uniform test procedures. The personnel engaged in testing fatigue after repeated emergence, fitting different equipment, and submergence. Too, the time spent in so doing, particularly when the depth of submergence is great, limits the number of tests which may be made in a given test period. To a person engaged in the development of communications gear, the advantages of a test apparatus to synthesize the voice of a person using speech equipment beneath the surface of the water are apparent.

The invention described herein meets the aforescribed needs of an operational field-testing device, as well as of a developmental instrument. The improvement over prior testing, when using the device of the invention, is marked by dependability, accuracy, and speed.

Accordingly, it is an object of this invention to provide an apparatus for the testing of underwater voice communication equipment.

A further object of the invention is the provision of a testing apparatus to evaluate the performance of microphones when installed in an underwater diving mask.

A still further object of the invention is the provision of a testing apparatus which comprises an artificial voice source.

It is a further object of the invention to provide a testing apparatus for a microphone mounted in a face mask which simulates the acoustic influence of the face of a wearer of the face mask.

It is another object of the invention to provide a testing procedure to effectively evaluate the acoustic transducing performance of a face mask mounted microphone arrangement.

Other objects and many of the attendant advantages will be readily appreciated as the subject invention becomes better understood by reference to the following detailed description, when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is an illustration of the artificial voice and mask support according to the invention;

FIG. 2 is a flow diagram of the process for casting the manikin employed;

FIG. 3 is an illustration of the arrangement employed in making a reference signal source, i.e., a magnetic tape, used in the device of the invention; and

FIG. 4 is an illustration of the test apparatus according to the invention as employed to test face mask mounted microphones.

Referring to FIG. 1, there is seen a manikin head 11. As will be explained, the manikin head 11 is made of a vinyl casting material. A hollow cylindrical tube 12 extends from an aperture in the region of the mouth of manikin head 11 to protrude through the rear thereof. An electroacoustic driver 13 is mounted on the protruding end of tube 12 for generating compressional waves therein.

Electroacoustic driver 13 has a watertight casing and is mounted on tube 12 by means of a watertight threaded coupling 14. Any suitable type having a construction to withstand the underwater pressure and having a uniform response over the audio frequency range may be employed. In particular, successful results have been obtained with a B & K Artificial Mouth 04216 made by the Bruel & Kjaer Instrument Company of Cleveland, O., and a model "ID 40" made by University Speaker Co., although others may be employed, if desired.

A small diameter conduit 15 is joined to tube 12 to permit filling said tube with gas, as will be explained herein. Conduit 15 exits manikin head 11 through an opening 16 in the truncated neck thereof. A suitable mounting pedestal may be concentric with conduit 15 and extend through opening 16 into manikin head 11 for the mounting thereof, and head 11 may be secured to said mounting means by contracting metallic band clamp encircling the neck of the manikin head 11, as will be discussed in greater detail in conjunction with FIG. 4.

The exact acoustic properties of the human head, as they apply to the wearer of a microphone equipped face mask working under water, have previously escaped accurate synthesis. The skin texture, facial contours, and the pressure effects of the water on the skin and mask all contribute acoustical-loading factors not easily obtained on the surface. It has been discovered by experiment that a manikin head made of a vinyl material of a hardness of Durometer 30 produces the most satisfactory results. The acoustic properties of a real human head are more closely approached if the manikin head has a wall thickness of approximately 4 cm. To this end, a void 17 is purposely left in the interior of manikin head 11. Because of the molding procedure employed in producing manikin head 11, void 17 communicates with opening 16, as will be understood.

Referring now to FIG. 2, there is shown a flow diagram representing the steps in making manikin head 11. Each of the blocks 18, 19, and 21 through 28 represent a step in the manufacture of manikin head 11 and will be discussed in the order in which they are executed.

A solid sculpture of a human head is made using the anthropometric measurements of the average adult male user of the equipment. This sculpture is coated, one-half at a time, with a separation compound and a layer of epoxy matrix material containing a suspension of fine aluminum particles. Any suitable material may be used for this purpose such as that made by the Devcon Corp. of Danvers, Mass. and sold under the trade name "Devcon F2," or that made by the Emerson and Cuming Co. of Canton, Mass. and sold under the

trade name of "Econobond Aluminum." The sculpture is half embedded in a suitable layer of material, such as plaster of paris, and the exposed half and a portion of the embedding material is coated with the epoxy material. The embedding and coating operation is repeated for the other half of the sculptured head. The resulting female impressions of sculpture halves have flanges where the epoxy material extended out a distance on the embedding material. The two halves are joined by clamping their respective flanges together to form a female mold of the sculptured head, as indicated by block 18 in FIG. 2.

As shown at block 19, the next step in the production of manikin head 11 is preheating the mold. This may be accomplished in a conventional small oven. The temperature to which the mold is preheated is 160° Celsius. Since this is the heat of curing, the same oven or heating apparatus may be used throughout the manufacturing process.

As indicated at block 21, after preheating, the mold is taken from the oven and filled through the open neck with a thermal setting vinyl plastic liquid. The filled mold is returned to an oven, as indicated at block 22, to heat cure for 45 minutes.

As the heat-curing process proceeds, the vinyl in contact with the surface of the mold and exposed to the air across the open neck begins to solidify. Because the unhardened plastic vinyl in the center of the mold continues to expand after the outer portions harden, a vent must be provided. As indicated at block 23, the venting is accomplished by cutting a 50 mm hole in the hardened crust formed over the open neck of the mold and removing the cut plug.

The filled mold is then returned to the oven for an additional 45 minutes for further curing and hardening. During this additional curing step, illustrated in FIG. 2 as block 24, the vinyl continues to harden. The thickness of the solidified material gradually increases until a layer about 4 cm thick has formed, and the vent hole previously cut has filled and solidified.

As shown at block 25, the mold is removed and the vent hole reopened. The remaining liquid material is poured from the vent hole 16, as indicated at block 26, thereby creating void 17. Following this step, the mold returned to the oven, block 27, where it remains undergoing final heat treatment for 4 hours.

The mold is then removed from the oven and cooled sufficiently to permit handling and the molded manikin head 11 is removed therefrom, as indicated at block 28. This completes the casting steps required to make the manikin head 11.

The completion of assembly is best explained by reference to FIG. 1. After manikin head 11 has cooled sufficiently to permit handling, coaxial apertures are cut in the mouth region thereof and in the back thereof to receive tube 12 with conduit 15 attached. The unthreaded end of tube 12 is inserted through the opening 16 and the hole in the mouth region of manikin head 11. Tube 12 is pushed through the mouth hole until the threaded end thereof clears the backside of opening 16 so as to permit its insertion through the hole in the back of manikin head 11. Tube 12 may be lubricated to facilitate the aforescribed insertion, if desired. Likewise, tube 12 may be cemented in place after it is installed if additional position retention beyond that provided by the resiliency of manikin head 11's material is desired. Tube 12 is loosely filled with acoustic damping material 29 to make it more closely approximate the acoustic properties of the human vocal passage.

When tube 12 is installed in manikin head 11, audio driver 13 is mounted thereon. Threaded coupling 14 is tightly secured to complete the mounting. Should the water integrity of the joint between tube 12 and audio driver 13, or that of the housing of audio driver 13 be in doubt, additional water tightness may be provided by suitable coatings and potting materials which are known in the electronic fabrication arts.

With reference to FIG. 3, the production of a source of test signals to drive the artificial voice will be described. An audio sweep oscillator 31, for example a B-and K-type 1022, is periodically swept through the normal audio frequency range,

20 Hz to 20 KHz. The output of oscillator is fed to audio driver 13 via a compressor/preamplifier 32 and a power amplifier 33. A reference microphone 34, positioned in front of manikin head 11 in a position closely approximating the position to be occupied by a test microphone in the testing arrangement, converts the acoustic output emanating from manikin head 11 to an electrical analogue signal. The microphone signal is amplified by suitable preamplifier 35, which may be incorporated within microphone 34, if desired. The amplified microphone signal is fed to the compressor/preamplifier 32 which, in turn, is set so as to vary the output thereof to produce a constant audio level at the reference microphone 34. The signal necessary to obtain the uniform audio level is recorded upon magnetic tape by recorder 36.

The precise types of the various pieces of equipment used, and the manner in which they are connected in circuit is a matter of choice to a person versed in the electroacoustic arts. A variety of units made by different manufacturers are adaptable for this purpose and may be connected to form the illustrated and above-described circuit. For purpose of completeness, however, it may be noted that satisfactory results have been obtained by using a B-and K-Model 1022 Beat Frequency Oscillator for oscillator 31. This unit includes compressor/amplifier circuitry making separate units for compressor/amplifier 32 and amplifier 33 unnecessary. A-B-and K-Model 4133/4 cartridge microphone together with a B-and K-Model 2615 cathode follower were used as reference microphone 34. The function of preamplifier 35 was performed by a B-and K-Model 2604 preamplifier. All of the above named units are made by the Bruel and Kjaer Instrument Co. of Cleveland, O. The tape recorder may be of any type proven suitable for audio use. In combination with the above equipment, the Ampex Model 440, made by the Ampex Co. of Redwood City, Calif., will provide satisfactory service.

The test tape may contain other recorded test signals than the swept audio signal, if desired. For example, tone bursts may be recorded on the test tape and replayed for test purposes. Such tone burst audio tests, like others which may be used, are of common knowledge to persons versed in the audio equipment arts, and their incorporation into the testing procedure of the invention is considered discretionary to such skilled personnel.

Referring to FIG. 4, the use of the apparatus for testing microphone mask combinations is illustrated. A mask 37 with a microphone 38 mounted therein is mounted on manikin head 11. The manikin head 11 together with mask 37 and microphone 38 are then placed within a pressure chamber 39. Steel or other pressure resistant material may be used in the construction of pressure chamber 39.

Pressure chamber 39 is a fluid tight chamber having two fittings 41 and 42 for conduits to pass therethrough and two electrical feed through insulators 43 and 44. A suitable closure means, not shown, permits chamber 39 to be opened for the insertion and removal of equipment. A mounting means 45 together with a clamp 46 for supporting manikin head 11, as described above, may, if desired, be included as a part of test chamber 39.

A tape playback deck 47 replays the tape made by recorder 36 and drives an amplifier 48 with the signals therefrom. Amplifier 48 may be of any suitable type having good linearity over the audio frequency range. If tape playback deck 47 has an integral preamplifier, amplifier 48 may be the same unit as used for amplifier 33 in recording the test tape. The output of amplifier 48 is fed, via feedthrough insulator 43, to electroacoustic driver 13 to recreate the acoustic test response.

The electrical output generated by microphone 38 in response to the acoustic test signals is fed, via electrical feedthrough insulator 44, to an audio level recorder 49. Variations in recorded level indicate variations in microphone 38 from the standard of performance defined by reference microphone 34. Audio level recorder 49 may also provide instantaneous level readings and other parameters may be monitored and indicated to operating personnel, if desired, and the

term as used herein should be considered inclusive of these other functions.

Chamber 39 is pressurized to simulate the predetermined operating depth desired by means of a fluid pump 51 delivering the contents of a fluid reservoir 52 through a regulating valve 53 and a conduit 54 which passes through fitting 41 to the interior of chamber 39. A safety valve 55 bypasses pump 51 as a protection therefor when regulating valve 53 is closed. This system permits manikin head 11, together with mask 37 and microphone 38, to be subjected to the same pressures as a diver would experience at the predetermined operating depth. By suitable adjustments of valve 53 this depth may be selected to a desired valve.

To accurately synthesize the acoustic conditions of a diver operating at the predetermined test depth, it is necessary to fill tube 12 and the space between manikin head 11 and mask 37 with the gas mixture used by diver personnel. This gas mixture, commonly termed breathing gas, is a mixture of oxygen and inert gases such as helium. Although the masks undergoing evaluation or testing have separate provision for introduction of this gas when in use by divers, a lack of standardization of fittings has made it more expedient to seal the mask's fitting and introduce the breathing gas via conduit 15. To this end, a quantity of gas from a storage tank 56 is supplied to conduit 15, via fitting 42. A regulating valve 57 in the gas delivery line permits the regulation of the delivery pressure to a valve corresponding to that used by a diver operating at the predetermined test depth determined by the setting of regulating valve 53. Tank 56 may be of any standard type including the type worn by divers.

Because the amount of fluid used in filling pressure chamber 39 and the amount of breathing gas required to pressurize tube 12 and mask 37 are quite small, the entire test apparatus of FIG. 4 may be reduced to quite compact dimensions. This compact packaging permits portability, thereby enhancing the device's applicability to on site testing of equipment prior to deployment of operating personnel.

Like the apparatus used in making the test signal tapes, the individual components of the testing arrangement are of standard manufacture. For example, tape playback deck may be the same unit as was used to record the test tape. A-B-and K-type 2305 level recorder, made by the Bruel and Kjaers Instrument Co. of Cleveland, O., provides satisfactory service as audio level recorder 49.

From the foregoing it may be seen that the invention provides a method and means for the testing of microphones mounted in underwater face masks. It may be readily appreciated that the invention meets the objects of invention as outlined above. Taken together with the appended claims, the above material comprises disclosure enabling a person to make and use the device of the invention.

We claim:

1. An apparatus for testing audio communication microphones combined with underwater diving masks comprising:

- a manikin head made of a material which closely approximates the acoustic properties of the adult human head for supporting a microphone and mask combination;
- an opening in the base of the neck of said manikin head communicating with the interior thereof for mounting said manikin head and for insertion of parts therein;
- a void within said manikin head communicating with said opening for acoustic loading of said manikin head;
- a first aperture in the front of said manikin head in the region of the mouth thereof and extending through the wall thereof so as to communicate with said void therein for serving as in acoustic radiation point;
- a second aperture in the opposite wall of said manikin head extending therethrough so as to communicate with said void and in axial alignment with said first aperture;
- tube means mounted in said manikin head extending from said first aperture through said second aperture to extend beyond the rear of said manikin head for transmitting compressional waves therethrough; and

electroacoustic driver means mounted on the end of said tube extending beyond said manikin head for conversion of electrical signals supplied thereto into compressional wave signals.

2. A testing apparatus according to claim 1 wherein said manikin head is made of vinyl material that is heat treated to a hardness of durometer thirty.

3. A testing apparatus according to claim 1 further including a signal source which supplies predetermined electrical signals to said electroacoustic driver means for the conversion thereof into corresponding compressional acoustic waves.

4. A testing apparatus according to claim 1 further including conduit means joined to said tube means and communicating with the interior passage thereof for supplying a gas mixture thereto.

5. A testing apparatus according to claim 1 further including:

- a source of pressurized gas; and
- a pressure regulator means connected between said source of pressurized gas and the aforesaid tube means.

6. A testing apparatus according to claim 5 wherein said pressurized gas is a mixture of oxygen and predetermined inert gases in a ratio permitting said mixture to be used for breathing by divers.

7. A testing apparatus according to claim 1 further comprising:

- pressure chamber means for containing said manikin with said face mask and microphone combination mounted thereon;

- a source of fluid communicating with said pressure chamber means for filling the portion thereof not occupied by said manikin head and attached mask and microphone combination; and

- regulation means connected between said fluid source and said pressure chamber means for maintaining the fluid pressure within said pressure chamber means at a predetermined value.

8. A testing apparatus according to claim 7 in which said pressure chamber means further includes:

- mounting means positioned within the interior of said pressure chamber means and cooperating with said opening in the base of the neck of said manikin head for supporting said manikin head and the mask and microphone mounted thereon; and

- insulated electrical feedthrough conductor means mounted in the walls of said pressure chamber for making electrical connections therethrough, so as to electrically connect said electroacoustic driver means and a microphone supported by said manikin head to predetermined electrical apparatus located outside said pressure chamber means.

9. A testing apparatus according to claim 8 further including an audio level recorder means connected to predetermined ones of said insulated electrical feedthrough conductor means for making a record of the output signals of the microphone undergoing test.

10. A testing apparatus for evaluating microphone means mounted within underwater diving masks comprising:

- a manikin head made of a vinyl material heat treated to a hardness of durometer thirty;

- an underwater diving mask mounted on said manikin head; microphone means mounted within said underwater mask in a cooperating relationship to the mouth region of said manikin head;

- an opening in the base of the neck of said manikin head for facilitating the mounting thereof;

- a void within the interior of said manikin head communicating with said opening for acoustic loading of said manikin head;

- mounting means extending into said opening for support of said manikin head;

- tube means extending through said manikin head from the mouth region thereof to a point beyond the rear thereof for effecting an artificial vocal column therefor;

electroacoustic driver means mounted on the terminus of
said tube means located beyond the rear of said manikin
head for producing acoustic energy in response to electrical
signals supplied thereto;
pressure chamber means surrounding said manikin head 5
and supporting said mounting means on an inner surface
thereof for providing an artificial environment for said
manikin head and said underwater mask and microphone
combination mounted thereon;
insulated electrical feed-through means located in the walls 10
of said pressure chamber means and extending
therethrough for transmission of electrical signals
between electrical apparatus and the interior of said pressure
chamber means;
electrical signal source means located outside said pressure 15
chamber means and electrically joined to said electroacoustic
driver means via said electrical feed-through means for
generating an acoustic test signal within said pressure
chamber;
audio level recorder means located outside said pressure 20
chamber and electrically connected to said microphone
means via said electrical feed-through means for providing
a recorded indication of the electrical output of said
microphone means;

25

30

35

40

45

50

55

60

65

70

75

a source of fluid for filling the portion of said pressure
chamber not occupied by said manikin head, underwater
mask mounted thereon, and associated mounting structure;
fluid pressure regulating means for predetermined regulation
of the pressure of fluid delivered therefrom;
first conduit means joining said pressure chamber means
and said source of fluid via said fluid pressure regulating
means for supplying fluid at a predetermined pressure to
said test chamber;
a source of breathing gas mixture for filling said tube means
and the space between said manikin head so as to
duplicate the acoustic conditions of a diver using said
breathing gas mixture;
gas pressure regulating means for predetermined regulation
of the pressure of gas delivered therefrom; and
second conduit means attached to said tube means, extending
through said opening and mounting means and connecting
to said source of breathing gas mixture via said
gas pressure regulating means for supplying said tube
means and the space between said manikin head and said
mask with breathing gas mixture at a predetermined pressure.