Norfolk Record Office

What changes happen to the body in flight?

This resource was created on behalf of the Norfolk Record Office, using material held in the archive. References for each of the documents included in the pack can be found on the thumbnails. The majority of material is found within the archive collections of the 2nd Air Division Memorial Library held at the Norfolk Record Office (prefixed NRO).

We are extremely grateful to the family of Charles Bosshardt for permission to use an extract from an oral history about his experiences during the Second World War.

Documents can be consulted free of charge at the Norfolk Record Office at:
The Archive Centre,
Martineau Lane,
Norwich, NR1 2DQ

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(01603) 222599
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LOTTERY FUNDED

What changes happen to the body in flight?

Introduction:

The following activities are designed to accompany the study of the Your Body In Flight booklet (NRO, MC 371/576/4). The activities focus on human biology. The booklet was issued to new United States Army Air Force (USAAF) pilots when entering training during the Second World War to explain to them what would happen during flight and how best to keep healthy and safe. It is part of a set of documents issued to new pilots. One activity also looks at Elementary Physics for Trainee Pilots (NRO, MC 371/576/1).

The following resource is designed for the KS2 topic for Year 6: Animals including Humans. Through this resource pupils will be able to look at parts of the human circulatory system and their functions and look at the effects of different environments and pressures on the way the body functions.

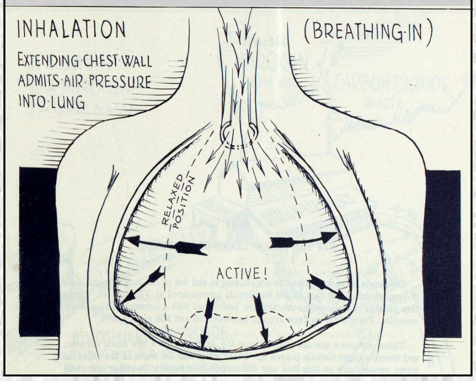
The pack contains four sections:

- How do our lungs work?
- What do we use oxygen for?
- How does the heart work?
- How do our eardrums work?

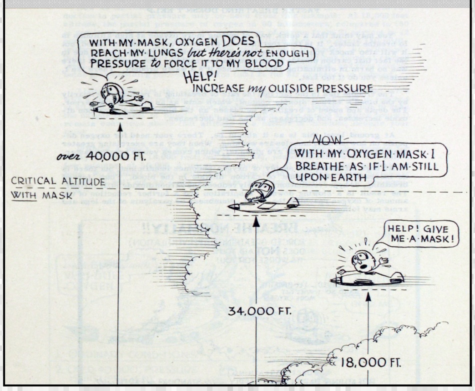
Each section is designed to form one lesson. Pupils can work through the sections online under the guidance of the teacher. Additional notes are available and videos of some of the experiments included.

Click on a thumbnail to view

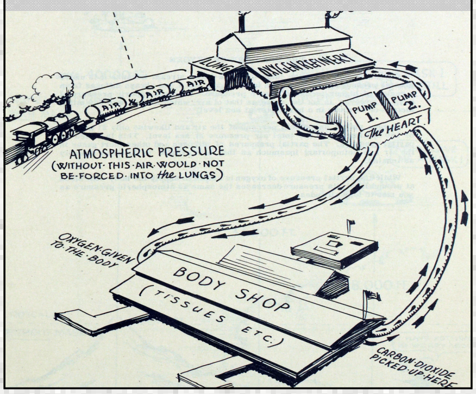
How do our lungs work?



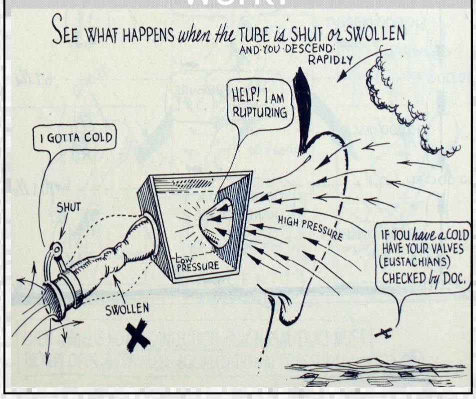
What do we use oxygen for?



How does the heart work?



How do our eardrums work?



How do our lungs work?

Introduction:

Everyone breathes in order to live: when we breathe in we are taking in vital oxygen and when we breathe out carbon dioxide is released. When we take in oxygen we use it in 'respiration'. During respiration, the body uses oxygen to create energy for all the body's living processes. The reactions which occur in the body also create carbon dioxide as a waste product: the body needs to get rid of by breathing out.

The chemical equation for respiration is; $6O_2 + C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$ (+ energy)
The body gets the oxygen we need by breathing in air and extracting the oxygen.

Click on an activity to start

Starter
What is the composition of gases in the air?

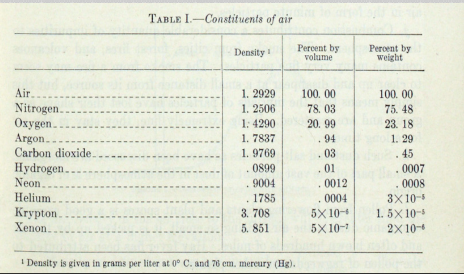
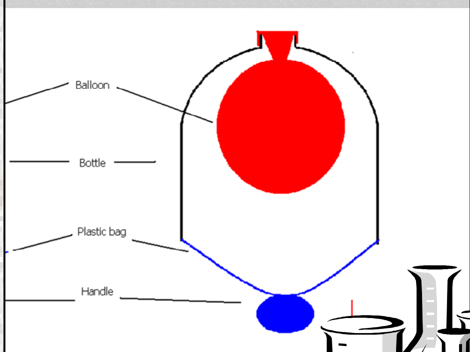


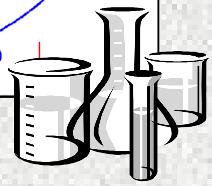
TABLE I.—*Constituents of air*

	Density [1]	Percent by volume	Percent by weight
Air	1. 2929	100. 00	100. 00
Nitrogen	1. 2506	78. 03	75. 48
Oxygen	1. 4290	20. 99	23. 18
Argon	1. 7837	. 94	1. 29
Carbon dioxide	1. 9769	. 03	. 45
Hydrogen	. 0899	. 01	. 0007
Neon	. 9004	. 0012	. 0008
Helium	. 1785	. 0004	3×10^{-5}
Krypton	3. 708	5×10^{-6}	1.5×10^{-5}
Xenon	5. 851	5×10^{-7}	2×10^{-6}

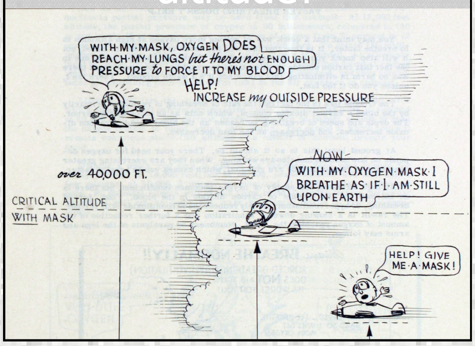
[1] Density is given in grams per liter at 0° C. and 76 cm. mercury (Hg).

Main
Create a model lung





Plenary
What happens at high altitude?



Teacher's notes

Go to Home

Starter activity

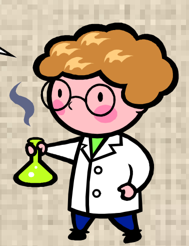
What is the composition of gases in the air?

What gases make up the air? In pairs have a go at listing them and then see if you can order the list so that the gas we find most of is at the top, then the second most common gas is next and so on, until you have the gas that there is least of at the bottom.

Check page 5 of Elementary Physics for Trainee Pilots (NRO, MC 371/576/1) to see if you are right.

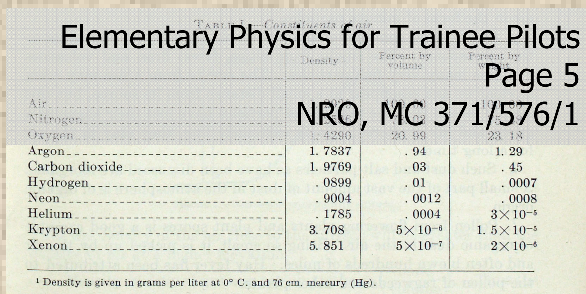
Think about what parts are included in your lungs. Can you have a go at drawing your own lungs– think about the fact you need somewhere for the air to go in and out.

Look at page 15 of the Your Body In Flight booklet (NRO, MC 371/576/4). This shows a simplified picture of lungs. Can you name anything missing from the image?



Documents you will need

Click on an image to see full size version



Elementary Physics for Trainee Pilots
Page 5
NRO, MC 371/576/1

TABLE 1.—*Constituents of air*

	Density [1]	Percent by volume	Percent by weight
Air	[illegible]	[illegible]	[illegible]
Nitrogen	[illegible]	[illegible]	[illegible]
Oxygen	1. 4290	20. 99	23. 18
Argon	1. 7837	. 94	1. 29
Carbon dioxide	1. 9769	. 03	. 45
Hydrogen	. 0899	. 01	. 0007
Neon	. 9004	. 0012	. 0008
Helium	. 1785	. 0004	3×10^{-5}
Krypton	3. 708	5×10^{-6}	1.5×10^{-5}
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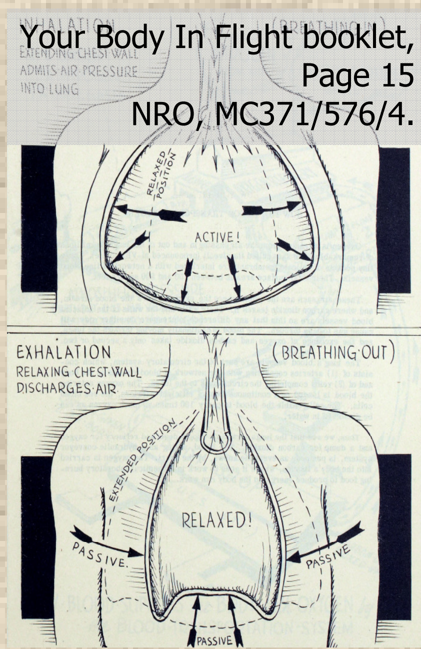
[1] Density is given in grams per liter at 0° C. and 76 cm. mercury (Hg).



Your Body In Flight booklet,
Page 15
NRO, MC371/576/4.

Main activity

Create a model lung

The oxygen we breathe in is taken into the lungs and the following model demonstrates how this happens.

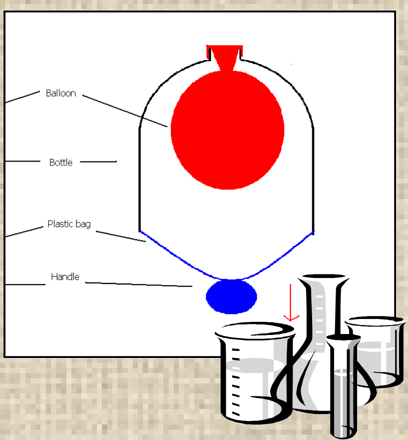
What you need:

- A clean empty 2-litre bottle (with the bottom section cut off)
- A balloon
- A circle of 40cm diameter cut from an old plastic bag
- An elastic band
- Scissors
- Tape

Procedure:

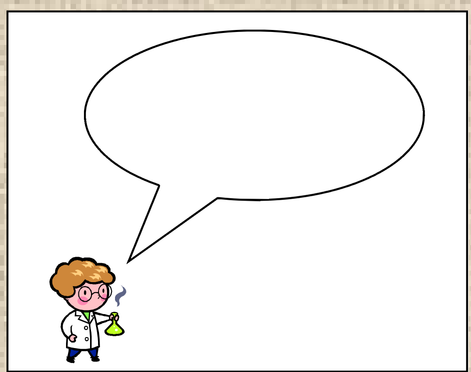
1. Push the bulb of the balloon inside the bottle.
2. Stretch the mouth of the balloon over the spout of the bottle.
3. Fold the circle in half, half again and half again and twist 2.5cm of the folded corner. Tape around this so that you now have a handle.
4. Open the circle out again, without loosing the handle and secure the piece of plastic to the bottom of the bottle using the elastic band. The handle needs to be on the outside and in the centre of the opening.
5. Pull the handle and watch what happens.

Click on the links below to find out more



Diagram

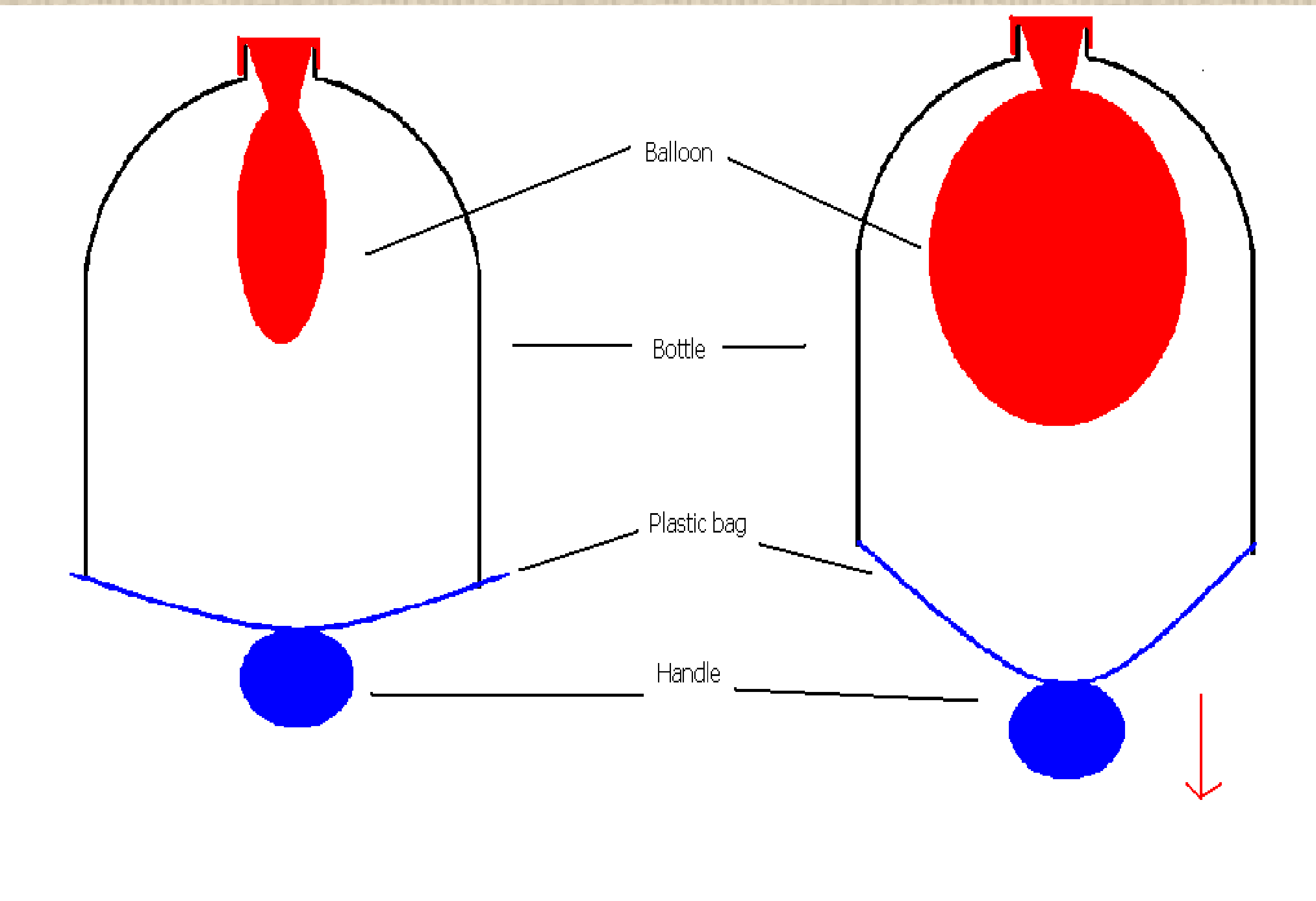
Video



Explanation

Main activity

Create a model lung



Your model lung should look something like this!

Explanation

The balloon should inflate with air from outside the bottle. The plastic on the bottom of the bottle acts as the diaphragm. When this is pulled down it creates a lower pressure in the bottle (chest cavity). This pulls higher pressure air from the outside into the balloon (lung) and the balloon expands. When the plastic is released the pressure increases again and the gases inside the balloon are now expelled.

The lungs themselves can’t expand on their own. They need the diaphragm to contract and drop, and the ribs to move out (this is due to the actions of the intercostal muscles between the ribs). Then the lungs can expand when the air is drawn in due to the pressure difference.

Plenary activity

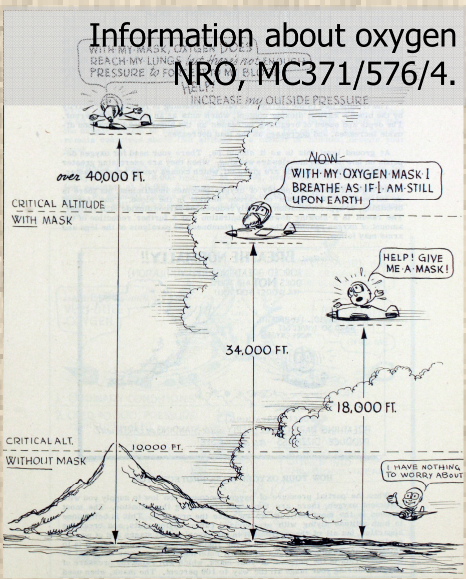
What happens at high altitude?

At high altitude the air pressure changes.

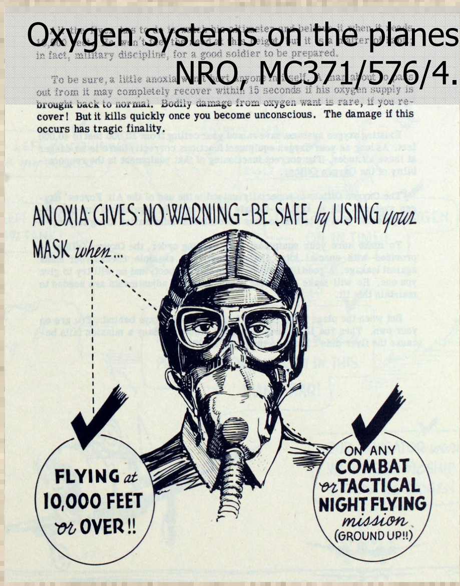
Have a look at the images and instructions for the oxygen systems used on the planes and discuss why do you think they were needed.

The outside air pressure is what creates the pressure difference in our lungs when we breathe in. At high altitude the air pressure is too low for the difference to be great enough to force enough air into our lungs therefore the oxygen mask is needed to ensure the airman gets enough oxygen.

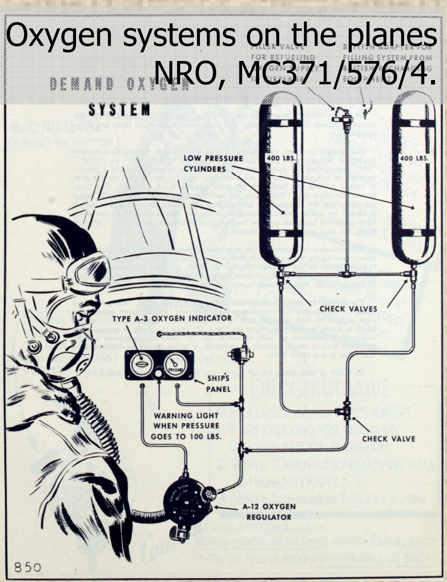
Documents you will need



Information about oxygen NRO, MC371/576/4.



Oxygen systems on the planes NRO, MC371/576/4.



Oxygen systems on the planes NRO, MC371/576/4.

How do our lungs work?

Glossary

High altitude: flying at high altitude (altitude is the word for height commonly used in aviation) means flying at a very high height relative to a planetary constant e.g. above sea level.

Air pressure: the force exerted on objects by the surrounding atmosphere.

Diaphragm: This is a muscle below the ribs which moves as we breathe to change the air pressure in our chest cavity so that air is drawn into our bodies.

Lungs: The lungs allow us to exchange gases. We breathe air into our lungs, where it is passed into the blood stream and carbon dioxide is removed and breathed out.

Intercostal muscles: These are muscles between the ribs which contract to make the ribs move. Without these, the ribs would not move and we would not be able to breathe.

What do we use oxygen for?

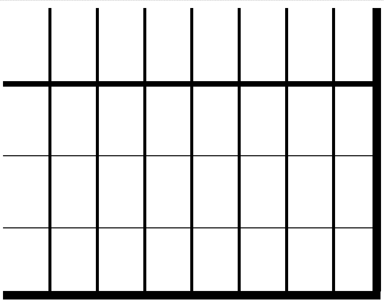
Introduction:

Oxygen is one of the vital substances that the body needs but cannot store. Some is stored in the blood but it is continually being used therefore needs to be continually replaced; this is why we breathe constantly. The brain actually measures the amount of carbon dioxide in the blood not the amount of oxygen and this measurement dictates the respiration rate.
During exercise we burn more energy therefore we need more oxygen. Therefore the respiration rate goes up to get this increase of oxygen.

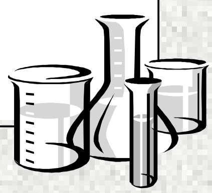
Respiration rate can be measured by seeing how many breaths (1 breath is both in and out) are taken in a particular space of time.

Click on an activity to start

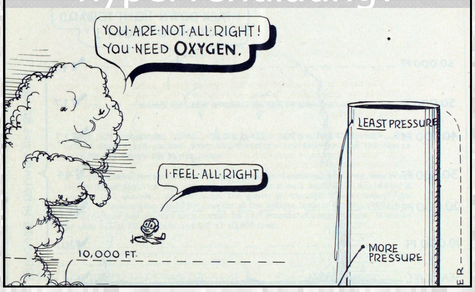
Starter
How do we measure respiration rates?



Main
The effects of exercise on respiration rates



Plenary
What are the causes and effects of hyperventilating?



Teacher's notes

Go to Home

Starter activity

How do we measure respiration rates?

Use a stopwatch to count how many breaths you take in two minutes and write this down in the table.

Once everyone has completed this experiment go around the class and fill in your table with your classmates' results.

Click on the links below for help

Blank table for the experiment

Measuring Respiration rate:

Name	Respiration rate at rest

Main activity

The effects of exercise on respiration rates

Draw a bar graph of the different respiration rates. On the side record the respiration rate and on the bottom the number of students.

Repeat the experiment to see if exercise has any effect on respiration rate. Do two minutes of physical activity e.g. star jumps and immediately measure the number of breaths. After two minutes' activity, measure the number of breaths again and write down the figure in the table.

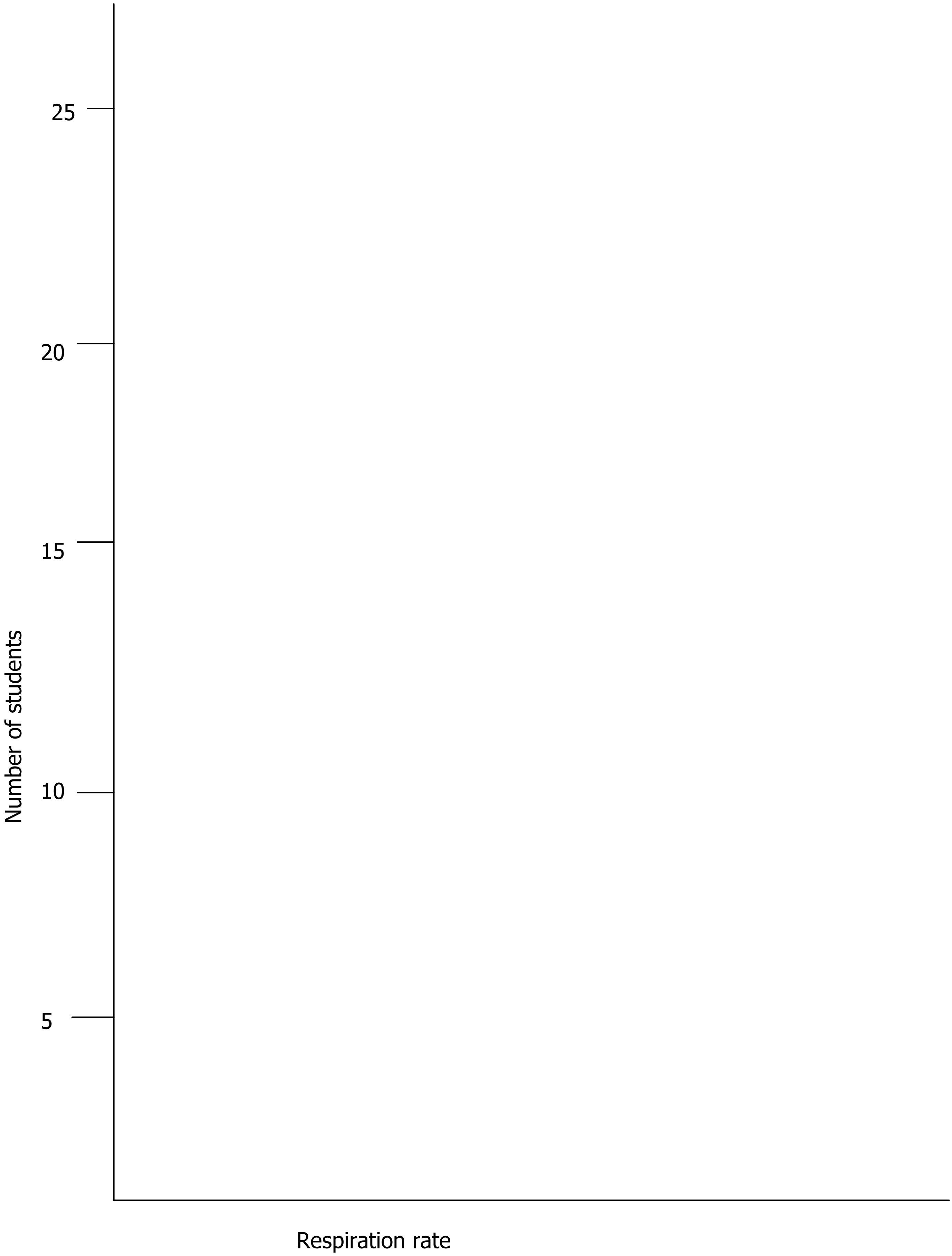
Did the rate go up or down? Why do you think this happened?

Share the results with the rest of your class.

Click on the links below for help

Blank table for the experiment

Blank bar graph for the experiment


Number of students
25
20
15
10
5
Respiration rate

Measuring Respiration rate:

Name	Respiration rate at rest	Respiration rate after exercise

Plenary activity

What are the causes and effects of hyperventilating?

Using the internet carry out research to find out what hyperventilating is.

Check whether you are correct by looking at pages 9 and 20 of Your Body in Flight (NRO, MC 371/576/4).

- Why would hyperventilating be different in an aeroplane at high altitude?
- Why do the pilots need oxygen masks at high altitude?

Listen to the audio clip of Charles J Bosshardt's recorded memoirs (NRO, SCOP 1/26, MC 371/396/2).

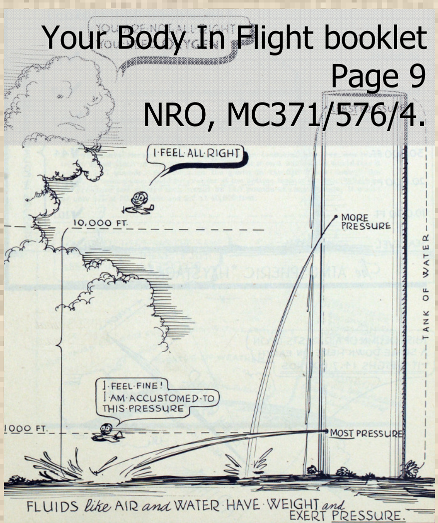
- How has this changed your opinion about hyperventilating at high altitude?

Documents you will need

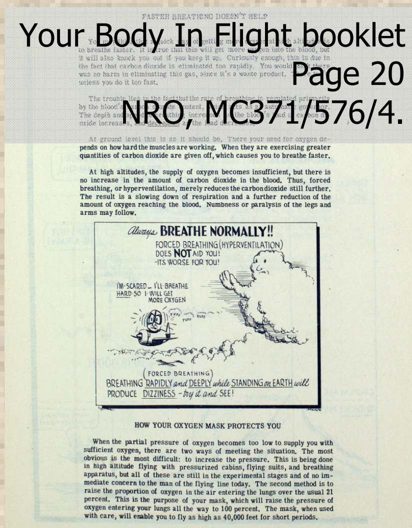
Charles J Bosshardt's recorded memoirs
NRO, SCOP 1/26, MC 371/396/2.

Transcript of Charles J Bosshardt's memoirs

Your Body In Flight booklet
Page 9
NRO, MC371/576/4.



Your Body In Flight booklet
Page 20
NRO, MC371/576/4.



FASTER BREATHING DOESN'T HELP

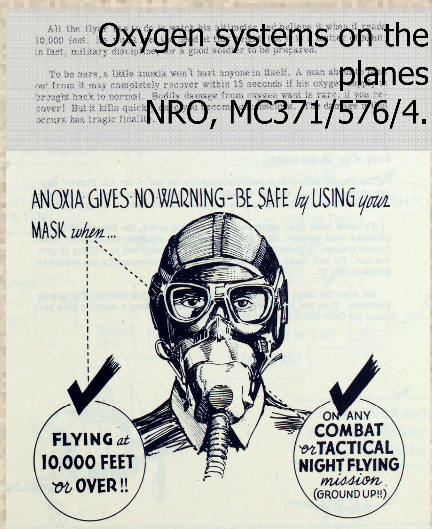
pends on how hard the muscles are working. When they are exercising greater quantities of carbon dioxide are given off, which causes you to breathe faster.

At high altitudes, the supply of oxygen becomes insufficient, but there is no increase in the amount of carbon dioxide in the blood. Thus, forced breathing, or hyperventilation, merely reduces the carbon dioxide still further. The result is a slowing down of respiration and a further reduction of the amount of oxygen reaching the blood. Numbness or paralysis of the legs and arms may follow.

HOW YOUR OXYGEN MASK PROTECTS YOU

When the partial pressure of oxygen becomes too low to supply you with sufficient oxygen, there are two ways of meeting the situation. The most obvious is the most difficult: to increase the pressure. This is being done in high altitude flying with pressurized cabins, flying suits, and breathing apparatus, but all of these are still in the experimental stages and of no immediate concern to the man of the flying line today. The second method is to raise the proportion of oxygen in the air entering the lungs over the usual 21 percent. This is the purpose of your mask, which will raise the pressure of oxygen entering your lungs all the way to 100 percent. The mask, when used with care, will enable you to fly as high as 40,000 feet for short periods.

Oxygen systems on the planes
NRO, MC371/576/4.



What do we use oxygen for?

Glossary

Anoxia: Anoxia is a condition where there is insufficient oxygen in the blood. At high altitude it is harder to get enough oxygen therefore pilots could become dizzy and pass out. Pilots could die if their oxygen supply were not increased quickly.

Respiration (or respiratory) rate: the number of breaths per minute.

Hyperventilation: This is when someone is exhaling carbon dioxide more quickly than their body is producing it. You actually need some carbon dioxide to keep your blood pH steady. If your levels of carbon dioxide drop too much your blood pH will change and this can lead to dizziness, fainting and other symptoms.

How does the heart work?

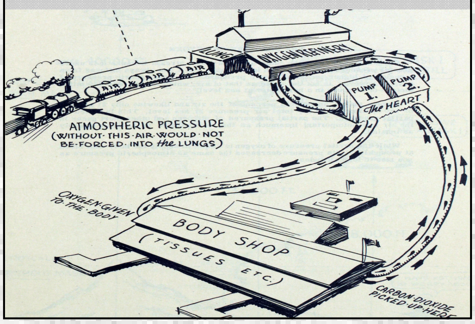
Introduction:

Your heart needs to pump to push blood around your body. If you gently press your fingers to your wrist you will feel your pulse. This is caused by the heart pumping the blood around. The number of heart beats per minute is called the heart rate.
The heart rate increases during exercise due to the increased need for oxygen. It is the same principle as the increase in respiration rate. You increase the number of breaths to increase how much oxygen you are getting and therefore the heart needs to pump faster to get the oxygen to the tissue faster.

Blood pressure is usually expressed as two numbers. These are measured by blood pressure monitors that a doctor may use. The systolic pressure is the higher number as the pressure is measured as the heart contracts and forces the blood around the system. The diastolic pressure is the smaller number as the heart is filling with blood.

Click on an activity to start

Starter
How does blood circulate?



Main
Measuring blood pressure

Plenary
How fast is a heart rate?

Teacher's notes

Go to Home

Starter activity

How does blood circulate?

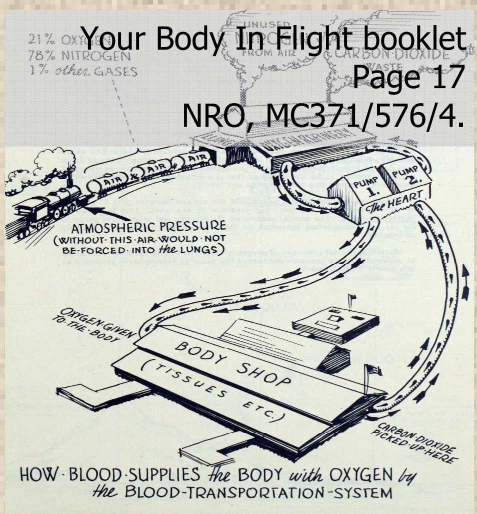
Now that the oxygen has been passed to the lungs, it needs to get to the tissues where it is needed. It gets there *via* the circulation system.

In pairs write a list of words you know relating to the circulation system. Include any specific parts of it, such as the heart.

Look at the cartoon drawing of the circulation system on page 17 of Body in Flight. Draw your own cartoon version of the circulation system to help you remember.

Documents you will need

Click on an image to see full size version



Your Body In Flight booklet
Page 17
NRO, MC371/576/4.

Main activity

Measuring blood pressure

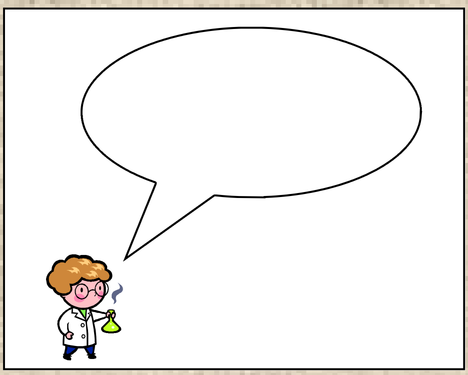
What you need:

- A blood pressure monitor
- Watch

Procedure:

1. If you have access to a blood pressure monitor measure your blood pressure and think about what the numbers mean.
2. When measuring blood pressure you will get two numbers; a larger one which should be written above a smaller one. The systolic number correlates to the pressure in the circulatory system when the heart beats and the diastolic number correlates to when the heart is at rest. Which number do you think is which?
3. Now measure your pulse by counting how many beats you feel per minute. It is easiest to find the pulse in the wrist or side of the neck. The easiest way of counting is to count the number of beats in 10 seconds and multiply by six.
4. Repeat this after exercise to see if there is any change in rate. The recovery rate of the pulse can also be measured by measuring the pulse every two minutes after exercise to see how long it takes for the pulse to return to the resting rate. The fitter the individual the faster the recovery rate.
5. Why do you think the pulse rate increases after exercise?

Click on the links below to find out more



Explanation

Plenary activity

How fast is a heart rate?

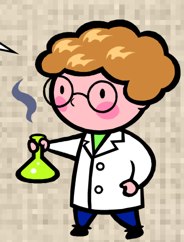
The average human adult's heart rate is between 55-90 beats per minute (bpm). All animals have heart rates too.

Look at the list of animals. Starting with the highest put them in order of their heart rates.

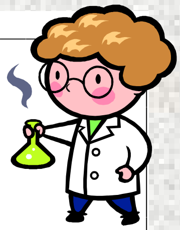
- Elephant
- Mouse
- Hamster
- Cat

See what the rest of the class thinks and then find out the answer from your teacher.

- What do you notice about the size of the animals and their heart rates?



How do our eardrums work?



Introduction:

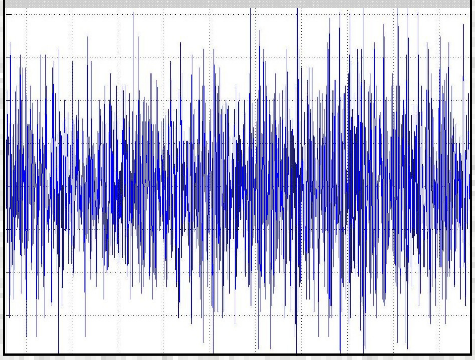
Sounds are all around us. We can hear using our ears which are specially adapted. Our ears are a specific shape in order to collect sound and channel it into our ear canal towards our ear drum. In this section you will create a model ear drum.

The ear also aids us with balance and body position. If you shut your eyes you rely on the sense in your ears to figure out how to balance. You are no longer able to rely on visual clues. Some people who have sight problems can use sound as a way of figuring out positions of objects by listening to the sounds and echoes coming off them.

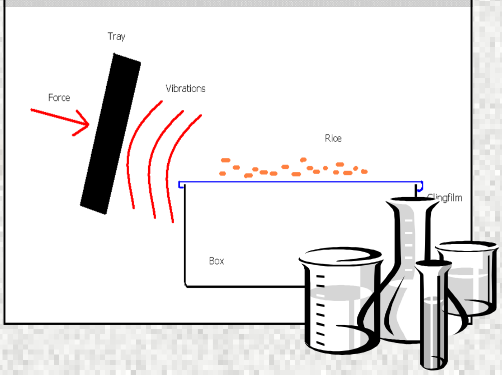
Some people have hearing problems and cannot hear at all or not completely. These people may need to use hearing aids. Humans' ability to hear also gets worse with age so older people may also have to use hearing aids.

Click on an activity

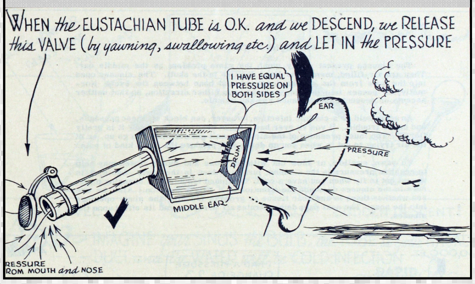
Starter
What causes sound?



Main
Create a model eardrum



Plenary
What causes changes in your eardrum?



Teacher's notes

Go to Home

Starter activity

What causes sound?

Close your eyes and listen quietly for a short amount of time, listening carefully for any small noises you might not normally notice. Tell the class what you heard, for example traffic on a nearby road, a clock ticking.

- In groups can you come up with some different things which can create sound?
- What kind of different sounds are there?
- Does anyone play a musical instrument in the group?

If some instruments are available, have a go with some different ones and think about the sounds they create and see if you can come up with some possible reasons as to why this happens?

Carry out some research on the computer to see what causes sound.

Main activity

Create a model eardrum

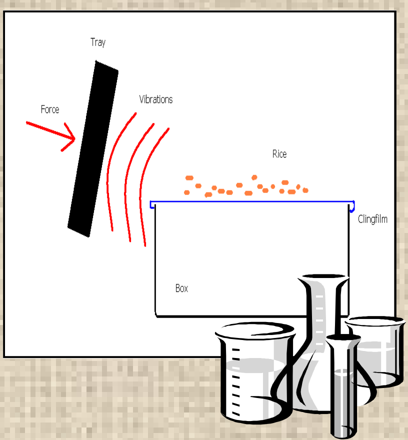
What you need:

- A large bowl or a plastic box, such as an old ice-cream box
- Clingfilm
- Uncooked rice
- Metal tray

Procedure:

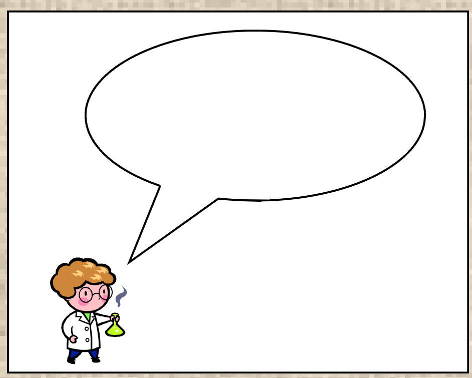
1. Cover the box or bowl with the clingfilm. This acts as the ear drum.
2. Put some of the rice on top of the clingfilm.
3. Hold the tray near to the top of the bowl but do not touch.
4. Hit the metal tray hard and watch the rice closely at the same time.

Click on the links below to find out more



Diagram

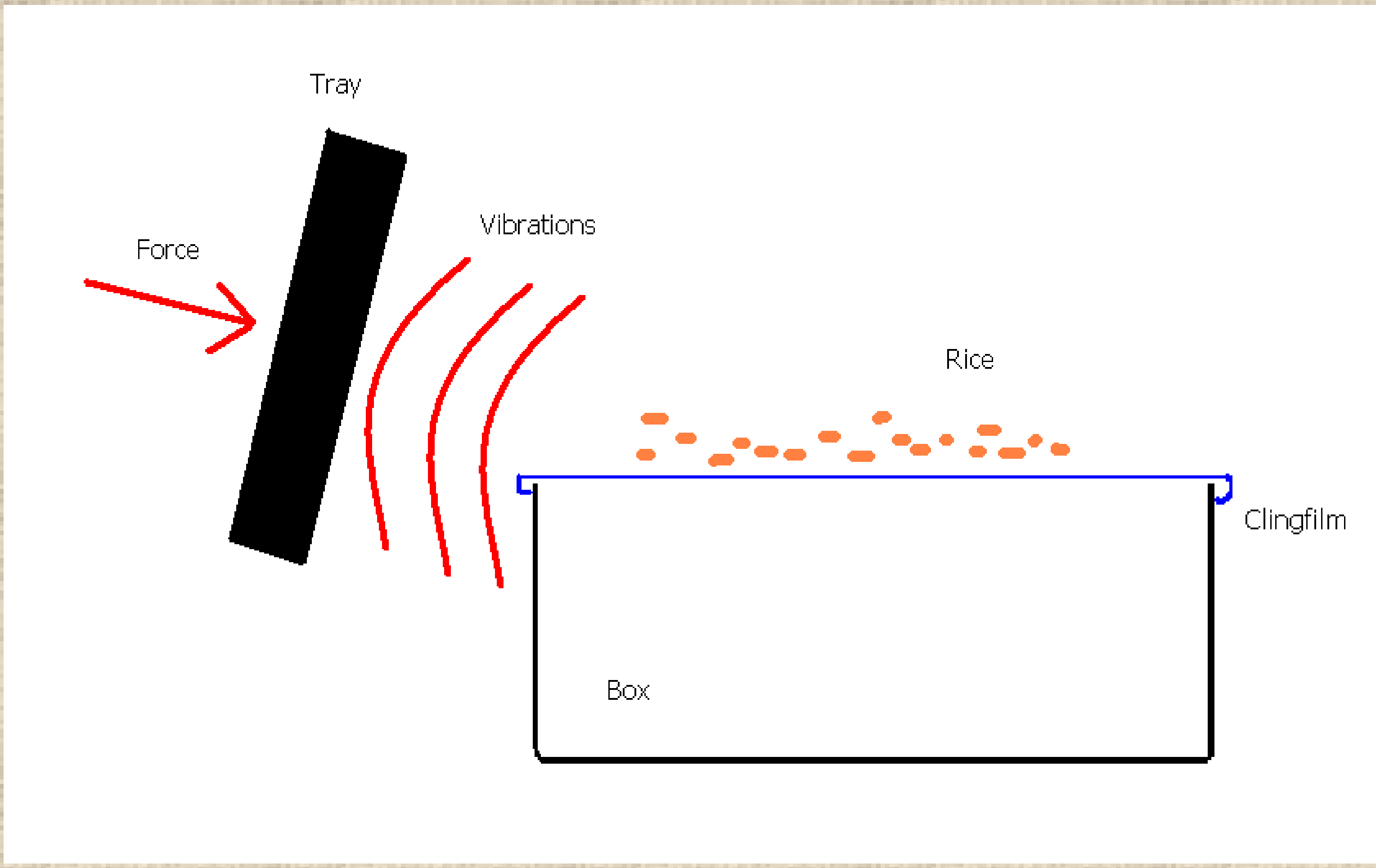
Video

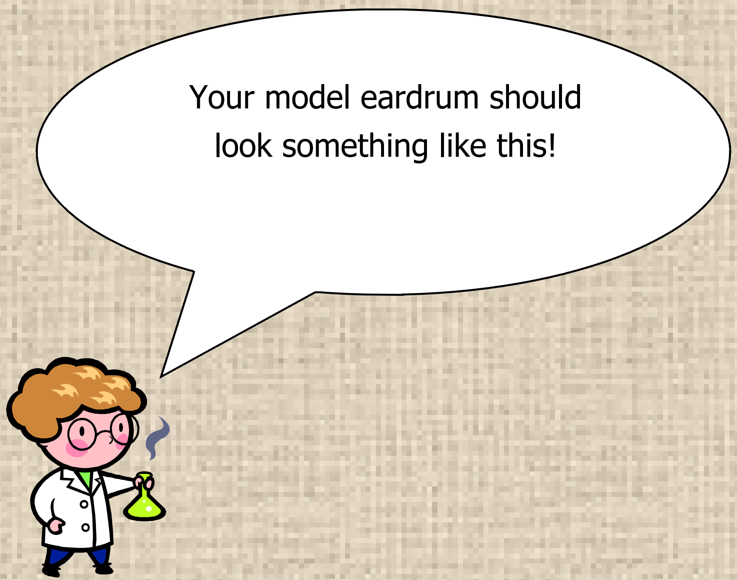


Explanation

Main activity

Create a model eardrum





Explanation

Sounds are caused by sound waves which are vibrations in air. The tray vibrates when it is hit which in turn vibrates the air around it and this vibration is passed through the air to the eardrum. The eardrum vibrates and this in turn causes a knock-on effect which ends in an electrical signal being sent to the brain.

Musical instruments all create vibrations too. With drums this is easy to see as you are actually hitting the drum. However all other instruments do the same thing. With woodwind instruments, the flute or the clarinet for example, you are blowing through the instrument. This column of air is vibrating and the keys which are pressed change how the column of air moves and escapes the instrument therefore changing the note.

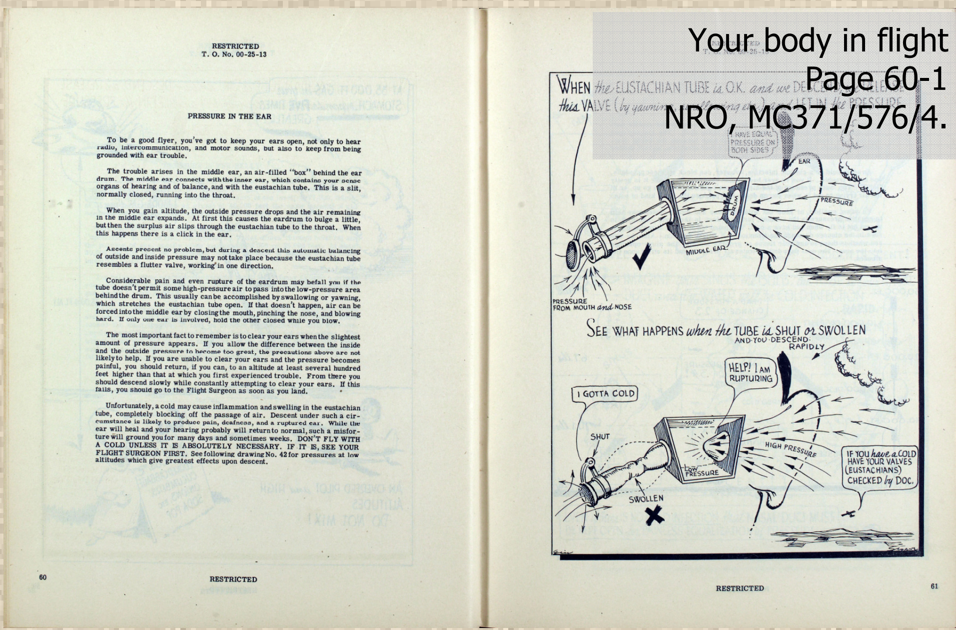
Plenary activity

What causes changes in your eardrums?

As a class discuss whether you have ever noticed anything strange about your ears. For Example, at height such as in an aeroplane or going up and down hills in a car, and what about when you have a cold? If so discuss what this might be and what causes it.

Look at page 60-61 of Your Body in Flight for a diagram of the ear drum and pressure in the ear.

Documents you will need



RESTRICTED
T. O. No. 00-25-13

PRESSURE IN THE EAR

To be a good flyer, you've got to keep your ears open, not only to hear radio, intercommunication, and motor sounds, but also to keep from being grounded with ear trouble.

The trouble arises in the middle ear, an air-filled "box" behind the ear drum. The middle ear connects with the inner ear, which contains your sense organs of hearing and of balance, and with the eustachian tube. This is a slit, normally closed, running into the throat.

When you gain altitude, the outside pressure drops and the air remaining in the middle ear expands. At first this causes the eardrum to bulge a little, but then the surplus air slips through the eustachian tube to the throat. When this happens there is a click in the ear.

Ascents present no problem, but during a descent this automatic balancing of outside and inside pressure may not take place because the eustachian tube resembles a flutter valve, working in one direction.

Considerable pain and even rupture of the eardrum may befall you if the tube doesn't permit some high-pressure air to pass into the low-pressure area behind the drum. This usually can be accomplished by swallowing or yawning, which stretches the eustachian tube open. If that doesn't happen, air can be forced into the middle ear by closing the mouth, pinching the nose, and blowing hard. If only one ear is involved, hold the other closed while you blow.

The most important fact to remember is to clear your ears when the slightest amount of pressure appears. If you allow the difference between the inside and the outside pressure to become too great, the precautions above are not likely to help. If you are unable to clear your ears and the pressure becomes painful, you should return, if you can, to an altitude at least several hundred feet higher than that at which you first experienced trouble. From there you should descend slowly while constantly attempting to clear your ears. If this fails, you should go to the Flight Surgeon as soon as you land.

Unfortunately, a cold may cause inflammation and swelling in the eustachian tube, completely blocking off the passage of air. Descent under such a circumstance is likely to produce pain, deafness, and a ruptured ear. While the ear will heal and your hearing probably will return to normal, such a misfortune will ground you for many days and sometimes weeks. DON'T FLY WITH A COLD UNLESS IT IS ABSOLUTELY NECESSARY. IF IT IS, SEE YOUR FLIGHT SURGEON FIRST. See following drawing No. 42 for pressures at low altitudes which give greatest effects upon descent.

60 RESTRICTED

RESTRICTED 61

Your body in flight
Page 60-1
NRO, MC371/576/4.

Teacher's notes

How do our lungs work?

Starter activity - what is missing from the lungs?

The following could be included in a the diagram of the lungs:

- Diaphragm
- Ribs
- Two lungs
- Intercostal muscles
- Heart
- Alveoli
- Bronchioles
- Bronchi
- Trachea

How does the heart work?

Starter activity - How does blood circulate?

Words for the circulation system can include:

- Blood
- Blood vessels
- Veins
- Arteries
- Heart
- Pumping
- Oxygen
- Carbon dioxide
- Valves
- Atria
- Ventricles
- Tissues

Plenary activity - How fast is heart rate?

Example heart rates are:

1. Hamster 450bpm
2. Cat 150 bpm
3. Small dog 100bpm
4. Large dog 75bpm
5. Elephant 30bpm

Small animals have a larger surface-to-volume ratio of in blood vessels. More of their blood is in contact with the walls. This blood in contact does not move as fast which means small animals have to work harder to pump enough blood around their system. The only way they can do this is by increasing the heart rate.

Teacher's notes

How do our eardrums work?

Plenary activity – What causes changes in your eardrums?

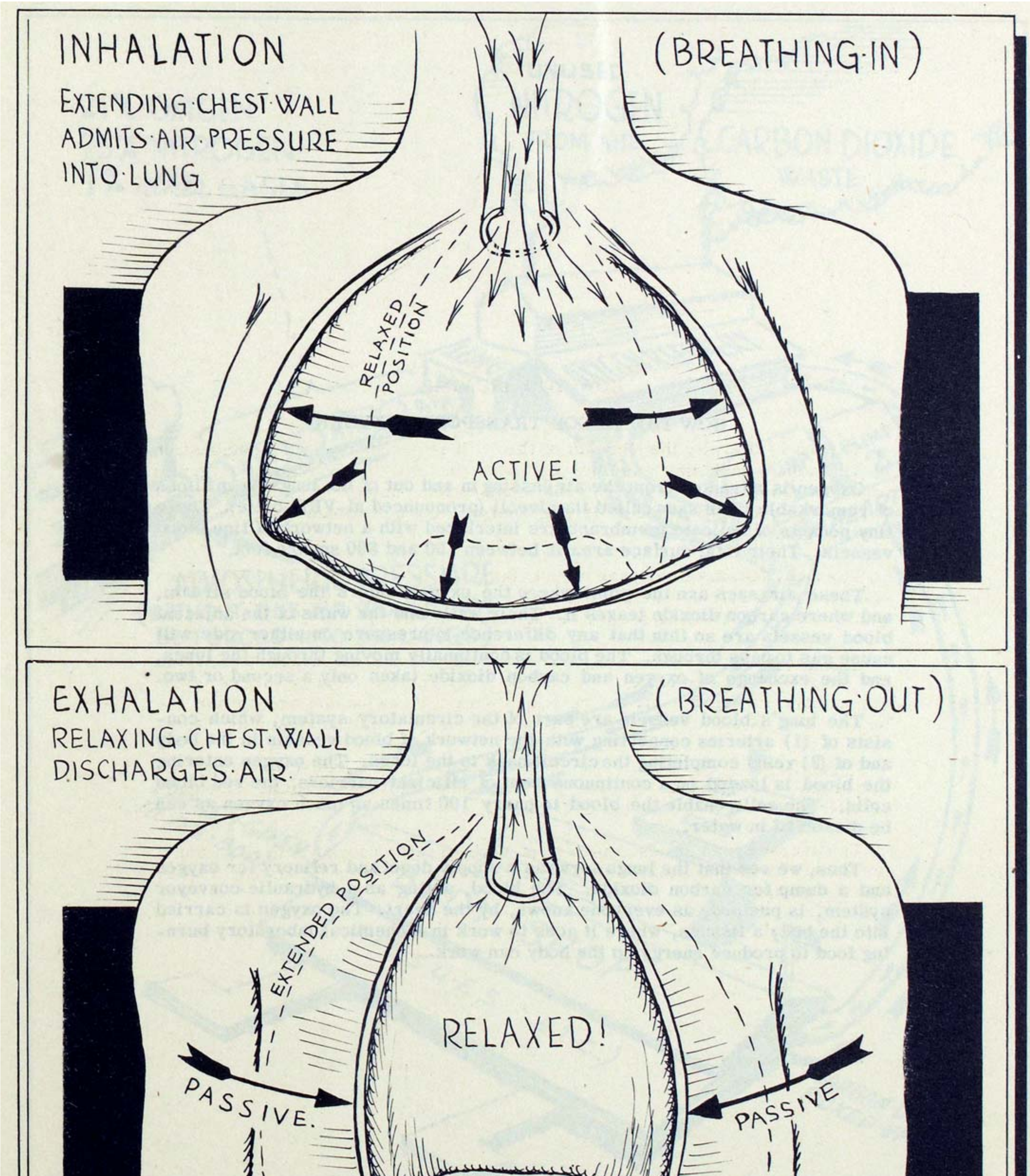
Children should think about times when their ears have 'popped'. Going up and down in altitude at speed will cause this to happen as the pressure change is rapid in the ear. Swallowing or sucking sweets can pop the ear to get rid of any muted feeling and balance the pressure again. When people get colds they may actually have liquid in the ear canal which puts pressure on the ear drum and mutes the vibrations. Sometimes water can get in the ear after swimming, this also causes the ear to mute until the water drains away.

TABLE I.—*Constituents of air*

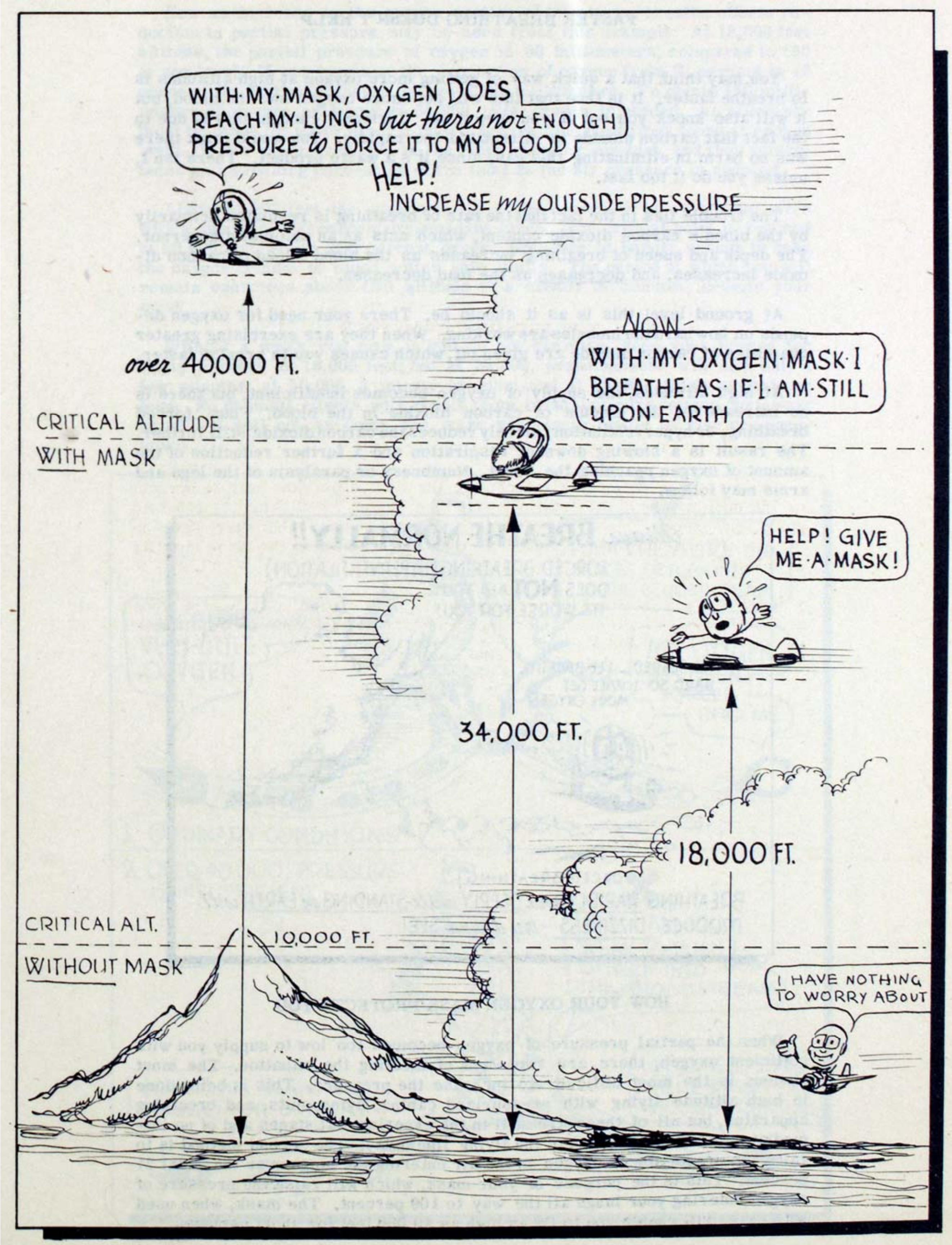
	Density [1]	Percent by volume	Percent by weight
Air	1. 2929	100. 00	100. 00
Nitrogen	1. 2506	78. 03	75. 48
Oxygen	1. 4290	20. 99	23. 18
Argon	1. 7837	. 94	1. 29
Carbon dioxide	1. 9769	. 03	. 45
Hydrogen	. 0899	. 01	. 0007
Neon	. 9004	. 0012	. 0008
Helium	. 1785	. 0004	3×10^{-5}
Krypton	3. 708	5×10^{-6}	1.5×10^{-5}
Xenon	5. 851	5×10^{-7}	2×10^{-6}

[1] Density is given in grams per liter at 0° C. and 76 cm. mercury (Hg).

Back to *How do our lungs work?*



Back to *How do our lungs work?*



Back to *How do our lungs work?*

All the flyer has to do is watch his altimeter and believe it when it reads 10,000 feet. He won't feel the need at this height, but it is a matter of habit; in fact, military discipline, for a good soldier to be prepared.

To be sure, a little anoxia won't hurt anyone in itself. A man about to pass out from it may completely recover within 15 seconds if his oxygen supply is brought back to normal. Bodily damage from oxygen want is rare, if you recover! But it kills quickly once you become unconscious. The damage if this occurs has tragic finality.

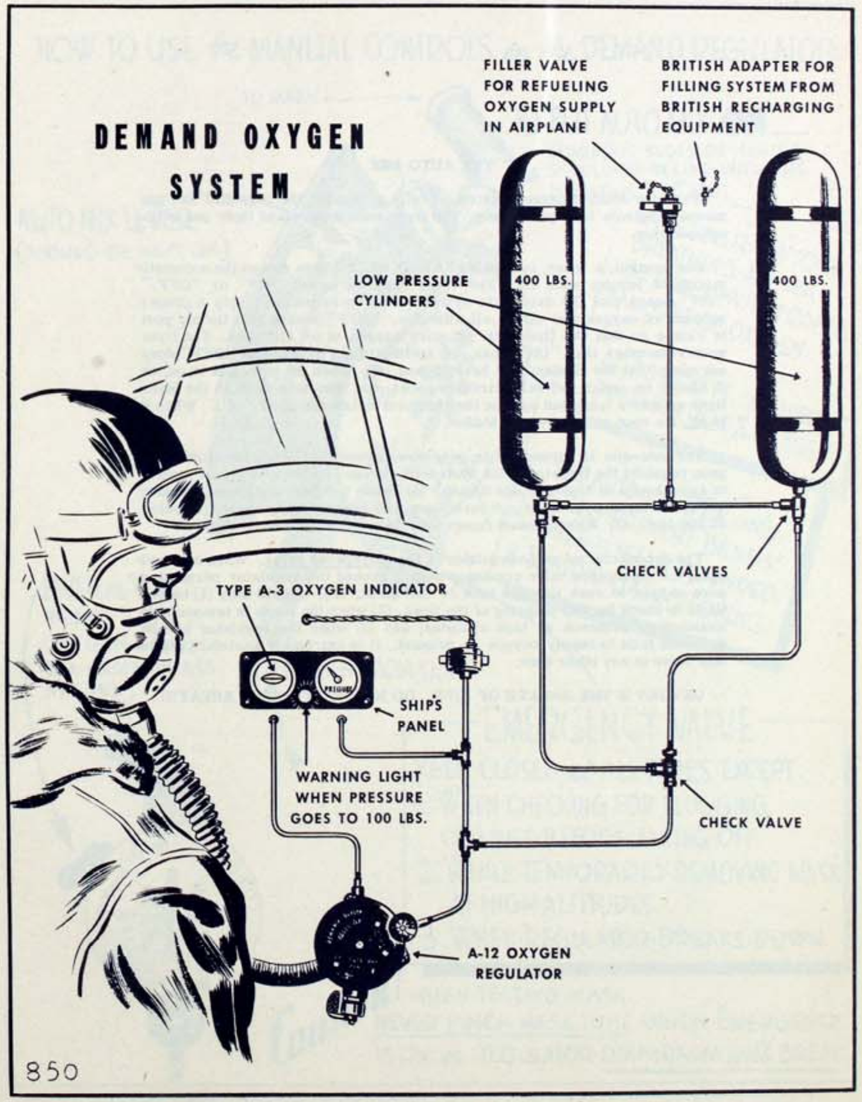
Back to *How do our lungs work?*

THE DEMAND OXYGEN SYSTEM

Our planes are equipped with either of two types of oxygen "plumbing:" (1) The demand system, and (2) The continuous flow system.

The demand system is fully automatic, and supplies oxygen according to the demand for it. Its flow regulator contains a valve which opens and lets oxygen pass through a tube to the mask when the flyer inhales; when suction ceases, the valve closes. The regulator has a tiny bellows which responds to atmospheric pressure. It is attached to a valve which permits ordinary air to flow into the mask at sea level, where no additional oxygen is needed. As altitude increases, the bellows closes the air valve and opens an oxygen valve, thus changing the proportions of air and oxygen to meet the need. Finally, at 30,000 feet, all air from the outside is shut off and the regulator supplies the flyer with 100 percent oxygen. The demand system has two great virtues: It gives a man all the oxygen he needs, whether he is breathing fast or slow; yet it doesn't waste oxygen, which becomes precious when operations are dependent upon how long it will last.

The station of each flyer in a bomber is equipped with a regulator and a series of oxygen cylinders piped together. In this respect, the system resembles that in a one-place pursuit plane. In a bomber, however, the cylinders at each station are connected with those at all other stations for two purposes: (1) So that the entire system can be refilled through one intake. (2) So that an interchange of pressure may take place between stations should one individual, such as a hard-working gunner, consume more than the others. Each cylinder is independent of all others to the extent that if it is shattered by gunfire, the sudden release of pressure causes a check valve to cut it off from the rest of the circuit, thus conserving the remainder of the oxygen supply. If all cylinders at one station are shot up, the man there must rely on a portable oxygen unit. The cylinders are shatterproof and under low pressure (425 pounds per square inch) so that a bullet's impact will not cause an explosion.



Back to *How do our lungs work?*

THE AUTO-MIX

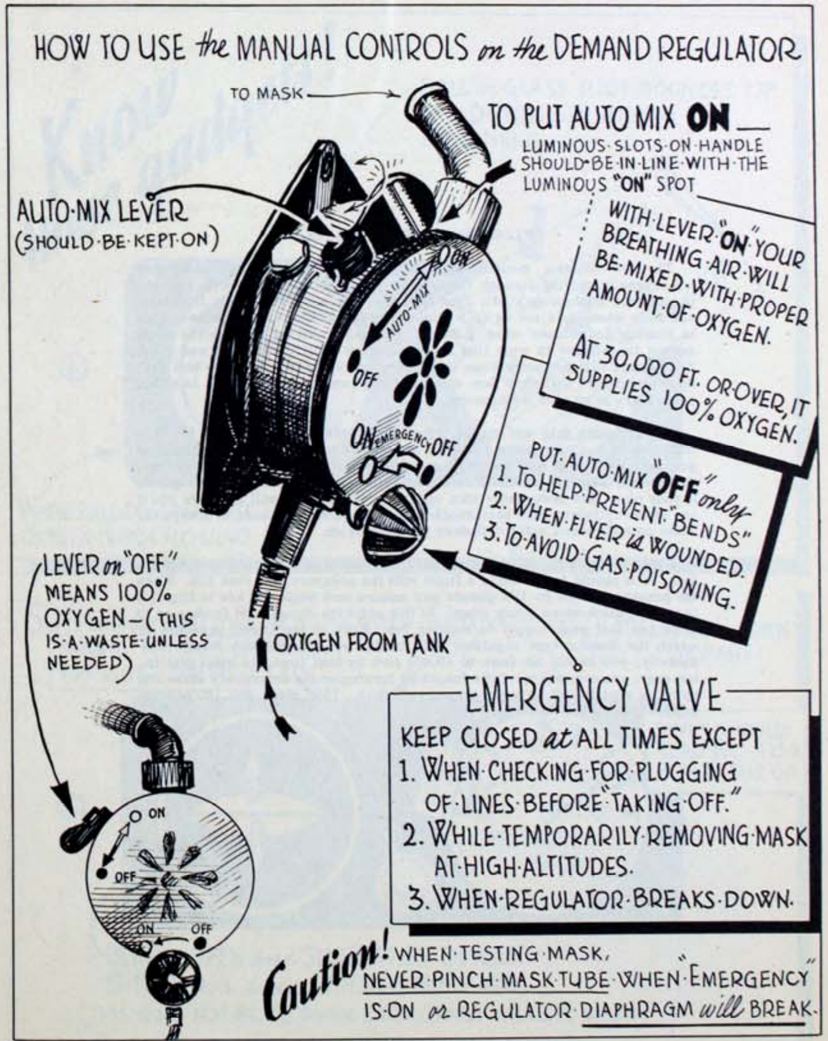
While the demand oxygen system is fully automatic, the regulator has two manual controls for special use. The flyer must understand their use without question.

One control, a lever, is labeled "AUTO-MIX." This means the automatic mixing of oxygen with air. The lever may be turned "ON" or "OFF." "ON" means that the automatic system is in operation to supply a proper mixture of oxygen and air at all altitudes. "OFF" means that the air port is closed so that the flyer will get pure oxygen at all altitudes. The flyer must remember that "ON" does not mean straight oxygen and "OFF" does not mean that the system has been turned off. When the auto-mix is on, as it should be under ordinary circumstances, the luminous spot on the lever lines up with a luminous spot on the regulator below the word "ON." When it is off, the spot on the lever is hidden.

The auto-mix is turned off in only three cases: (1) When the flight surgeon requests the flyer to rid his system of nitrogen by breathing pure oxygen to avoid bends on high-altitude flights. (2) When a flyer is sick or wounded and the demand system is not furnishing 100 percent oxygen; that is, below 30,000 feet. (3) When exhaust fumes or poison gas endanger the flyer.

The second control on the regulator is the emergency valve. When screwed open, the emergency valve creates a bypass around the regulator permitting pure oxygen to rush into the tube to the mask. It is opened only (1) before flight to check for any plugging of the lines, (2) when the mask is temporarily loosened or removed at high altitudes, and (3) when the regulator breaks down and fails to supply oxygen on demand. It is extremely wasteful to open this valve at any other time.

OXYGEN IS THE BREATH OF LIFE. DO NOT WASTE YOUR BREATH!



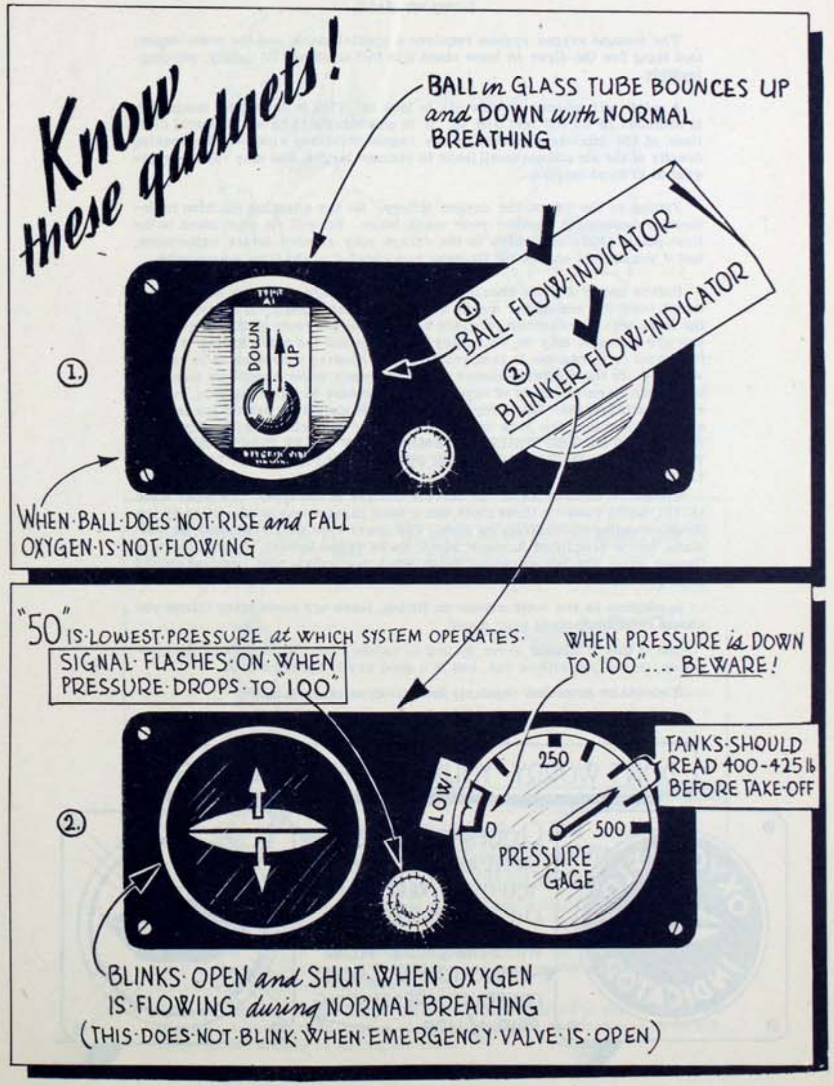
Back to *How do our lungs work?*

FLOW AND PRESSURE SIGNALS

The flow indicator, mounted near the regulator, tells the flyer whether or not oxygen is moving through the system. The indicator may be (1) a transparent tube containing a ball (type A-1) which rises when oxygen is flowing and falls when it is not or (2) a blinker (type A-3) which opens when oxygen is flowing and closes when it stops. Normal breathing through the mask causes the blinker to wink like an eye and the ball to bounce up and down. The blinker will not work when the emergency valve is on, but the ball will. Some regulators will show flow at ground level and others will not. In either case, there is no need for concern.

The pressure gage and signal lamp are mounted on a panel with the flow indicator in a single-place plane or separately in a multi-place ship. The pressure gage tells you the oxygen supply you have. From it, you can estimate how long you can last at critical altitudes. There is one exception: If your plane has been badly shot up, the pressure gage will not show you if any of the cylinders have been knocked out. The total pressure is always the same no matter how many cylinders you draw from.

Filled to capacity, the cylinders have a pressure of 425 pounds per square inch. You should never begin a flight with the pressure less than 400. When the pressure drops to 100 pounds per square inch while you are in flight, it is time to think about going down. At this point the signal light flashes on to warn you that your supply is running low. Fifty is the lowest pressure at which the demand type regulator will furnish you oxygen with safety. Ordinarily, you should be down to 10,000 feet by that time. In emergencies, however, you can stay up a little longer by turning on the emergency valve and using up what is left in your oxygen cylinders. This gives you 100 percent oxygen but it won't last long.



Back to How do our lungs work?

DEMAND MASK

The demand oxygen system requires a special mask, and the most important thing for the flyer to know about it is that it should fit tightly, yet comfortably.

A misfit will permit outside air to leak in. This is extremely dangerous at altitudes of 30,000 feet and up. It is undesirable to have accidental dilutions of the mixture provided by the regulator at any altitude. Decreasing density of the air causes small leaks to become larger, and may cause oxygen want at critical heights.

Fitting is the job of the oxygen officer. He has a testing machine to determine accurately whether your mask leaks. He will fit your mask in the first place. Natural stretch in the straps may require future adjustment, and if you have to change the fit, have him check it at the first opportunity.

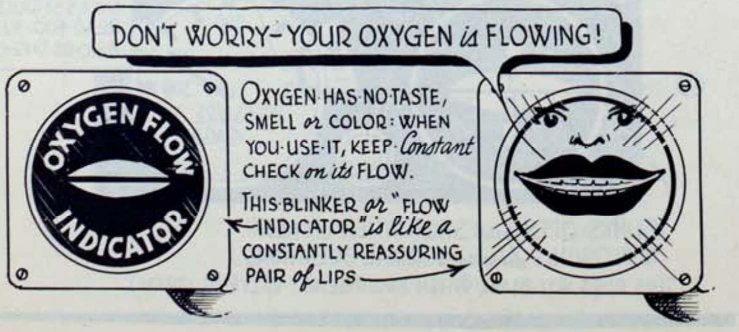
Before taking off, you should make a quick test for leaks by holding your thumb over the end of the supply hose and inhaling gently. If in good order, the mask will press against your face and prevent you from getting air. While you are flying it may be necessary to manipulate the mask to free it of ice formation or to remove it temporarily when blowing your nose or in case of vomiting. In these circumstances, the emergency valve should be turned on to provide an extra supply of oxygen under pressure to offset the thin, outside air you will breathe. When replaced the mask should be tested for leakage as just described, the hose in this case being held closed with your hand. BUT NEVER DO THIS WHILE THE EMERGENCY VALVE IS OPEN BECAUSE THE BACK PRESSURE WILL BLOW OUT THE DIAPHRAGM IN THE REGULATOR.

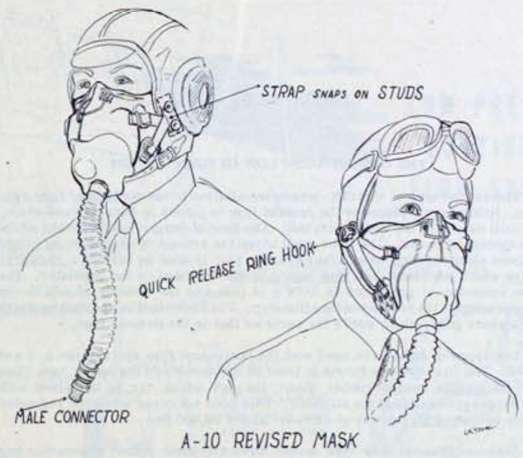
Almost all demand masks in current use are of two types. An older style (A-10), which comes in three sizes, has a head harness easily identified by the strap extending upward from the nose. The newer type (A-10 revised), in four sizes, has a simplified harness which hooks to the helmet. In both types, a flapper valve discharges waste gases when you exhale and remains closed when you inhale.

In addition to the instructions on fitting, there are some other things you should remember about your mask:

One is that it should never be lent to anyone else. It may not fit the borrower, leaves you without one, and is a good way to spread a cold.

It should be inspected regularly for cracks or other damage.





It should be wiped dry when you return from a flight, and occasionally washed with soap and water. Be careful, however, not to wet the microphone.

When you "plug in" your mask, make certain that the rubber gasket is in place in the end of the male connector. And be sure that a snug connection is made with the outlet from the regulator.

The spring clip on the supply hose should be fastened to your clothing or parachute harness close enough to the face so that the head may be turned freely without kinking or pulling the hose.

Back to *How do our lungs work?*

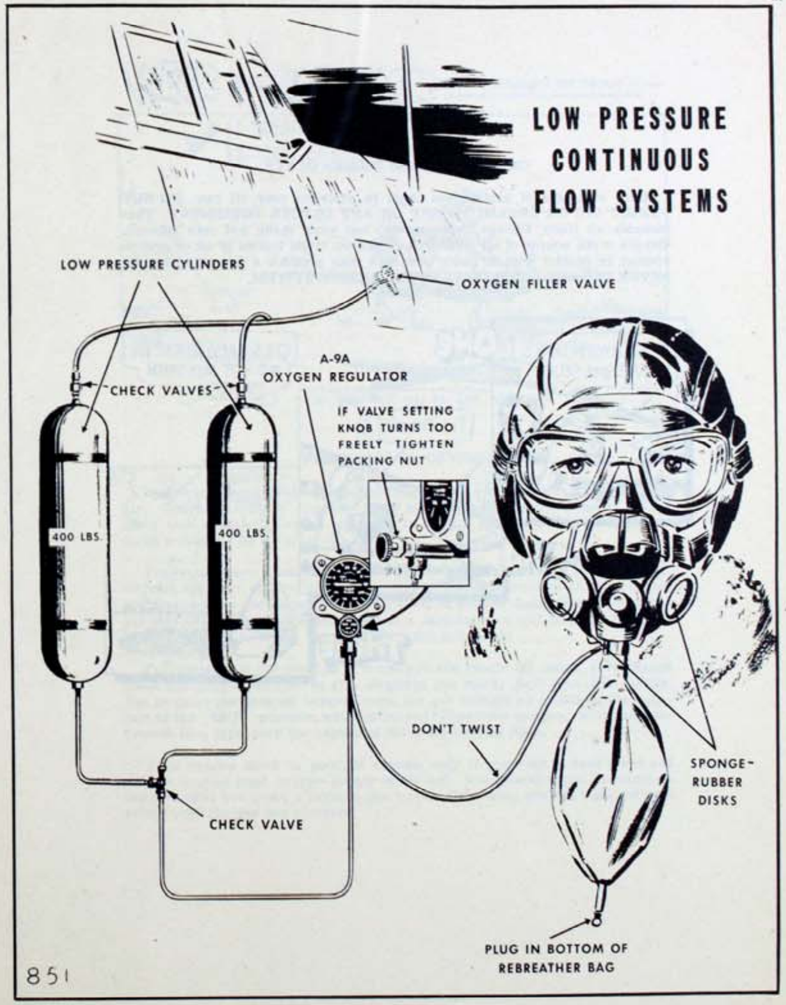
THE CONTINUOUS FLOW OXYGEN SYSTEM

The second type of aircraft oxygen installation is the continuous flow system. It has been replaced by the demand type in planes in current production, but still exists in the older aircraft. The flow of oxygen is continuous while the system is in use. The flyer must adjust the amount of oxygen being mixed with the air to correspond with the altitude. This is done by turning a regulator valve which registers on a flow indicator dial mounted on the regulator. The flow indicator is graduated in 1000's of feet and the reading should be set to approximate the reading on the altimeter. The lower half of the dial contains a pressure gage, which works the same as that in the demand type.

Two types of masks are used with the continuous flow system; the A-8 and A-8B. The first has one turret in front of the mouth and the latter, two. The turrets contain sponge rubber disks, through which air to be mixed with the oxygen is admitted at low altitudes. This does not occur when the regulator valve is opened all the way at altitudes above 30,000 feet.

These continuous flow type masks have a flexible rubber rebreather bag hanging below the mask and connecting at the top with the oxygen intake. At each inspiration, the flyer breathes the contents of the bag. Furthermore, he exhales part of his breath into the bag. This does not mean that he is breathing stale air inasmuch as the oxygen content of the last part of each breath remains unchanged. It comes out first and fills the bag. This saves oxygen which otherwise would be wasted in exhaling. The waste portion of the breath goes out through the turrets.

It is important that the rebreather bag should never completely collapse at altitudes above 30,000 feet, since this will cause air to be taken in through the turrets. If it should collapse, turn open the regulator valve until it ceases to do so. The valve knob should not be allowed to loosen to a point where the brush of a sleeve will change the setting. Tightening of the packing nut will correct this. Ice should be kept out of the mask turrets. As a safeguard against a freeze-up an extra mask should be carried, especially by flyers in the waist and tail of a bomber. Otherwise, the care of the mask and equipment is much the same as that for the demand type described on pages 36, 37.



Back to *How do our lungs work?*

THE WALK-AROUND BOTTLE

In large bombing planes it is often necessary for men to move about during flight to perform their duties or to go to the assistance of another member of the crew. Portable oxygen units called walk-around bottles, supply them with oxygen during periods away from their stations.

The walk-around bottle consists of a small oxygen cylinder which fastens to the clothing and attaches to the flyer's own oxygen mask. It comes in both demand and continuous flow types.

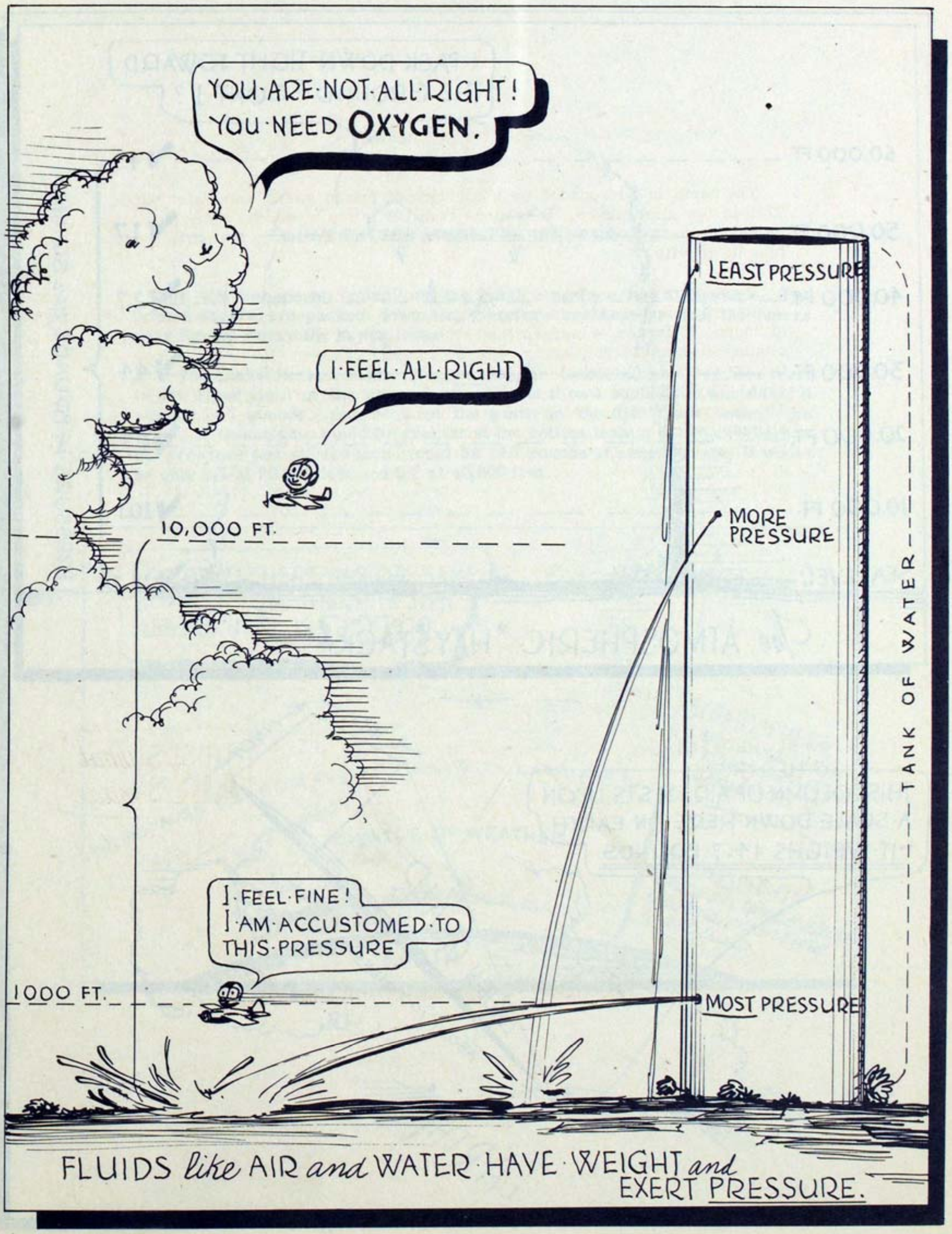
The demand type furnishes pure oxygen only, and has a 4- to 8-minute supply, depending on the altitude and activity of the user. However the bottle can be filled from the airplane's oxygen system by means of a portable filling hose. A regulator on the bottle shows the amount of pressure. The cylinder should be kept fully charged at all times for emergency use.

The continuous flow, walk-around bottle is sufficient to provide oxygen for about 1 hour at an altitude of 30,000 feet. It cannot be recharged in the plane.

To use either type of walk-around bottle, the flyer holds his breath while disconnecting his mask from the plane's oxygen system and then connects the mask directly to the portable unit's regulator.

WALK AROUND BOTTLE

Back to *How do our lungs work?*



Back to *What do we use oxygen for?*

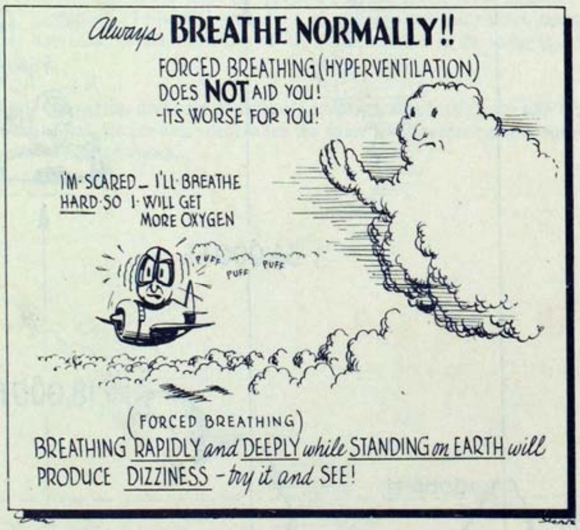
FASTER BREATHING DOESN'T HELP

You may think that a quick way of getting more oxygen at high altitudes is to breathe the faster. It is true that this will get more oxygen into the blood, but it will also knock you out if you keep it up. Curiously enough, this is due to the fact that carbon dioxide is eliminated too rapidly. You would think there was no harm in eliminating this gas, since it's a waste product. There isn't, unless you do it too fast.

The trouble lies in the fact that the rate of breathing is regulated primarily by the blood's carbon dioxide content, which acts as an automatic governor. The depth and speed of breathing increases as the blood's load of carbon dioxide increases, and decreases as the load decreases.

At ground level this is as it should be. There your need for oxygen depends on how hard the muscles are working. When they are exercising greater quantities of carbon dioxide are given off, which causes you to breathe faster.

At high altitudes, the supply of oxygen becomes insufficient, but there is no increase in the amount of carbon dioxide in the blood. Thus, forced breathing, or hyperventilation, merely reduces the carbon dioxide still further. The result is a slowing down of respiration and a further reduction of the amount of oxygen reaching the blood. Numbness or paralysis of the legs and arms may follow.



HOW YOUR OXYGEN MASK PROTECTS YOU

When the partial pressure of oxygen becomes too low to supply you with sufficient oxygen, there are two ways of meeting the situation. The most obvious is the most difficult: to increase the pressure. This is being done in high altitude flying with pressurized cabins, flying suits, and breathing apparatus, but all of these are still in the experimental stages and of no immediate concern to the man of the flying line today. The second method is to raise the proportion of oxygen in the air entering the lungs over the usual 21 percent. This is the purpose of your mask, which will raise the pressure of oxygen entering your lungs all the way to 100 percent. The mask, when used with care, will enable you to fly as high as 40,000 feet for short periods.

Back to *What do we use oxygen for?*

All the flyer has to do is watch his altimeter and believe it when it reads 10,000 feet. He won't feel the need at this height, but it is a matter of habit; in fact, military discipline, for a good soldier to be prepared.

To be sure, a little anoxia won't hurt anyone in itself. A man about to pass out from it may completely recover within 15 seconds if his oxygen supply is brought back to normal. Bodily damage from oxygen want is rare, if you recover! But it kills quickly once you become unconscious. The damage if this occurs has tragic finality.

Back to *What do we use oxygen for?*

The tape contains a discussion between Lt. Charles Bosshardt, navigator and Lt. Cecil Johnson, pilot about their missions as part of a crew flying a B-24. Both men served in the 753rd Squadron of the 458th Bomber Group.

Charles Bosshardt- **'**Cecil was real fanatical about checking to make sure that we were all alright when we were on oxygen. Once we went above, what, 10,000 ft we had to put on our masks and if there was a lot of condensation then it could freeze in the hose and cut off the flow of oxygen. So he would periodically call 'oxygen check' and you would have to respond 'navigator ok', 'nose gunner ok', and so on through all the positions on the plane'.

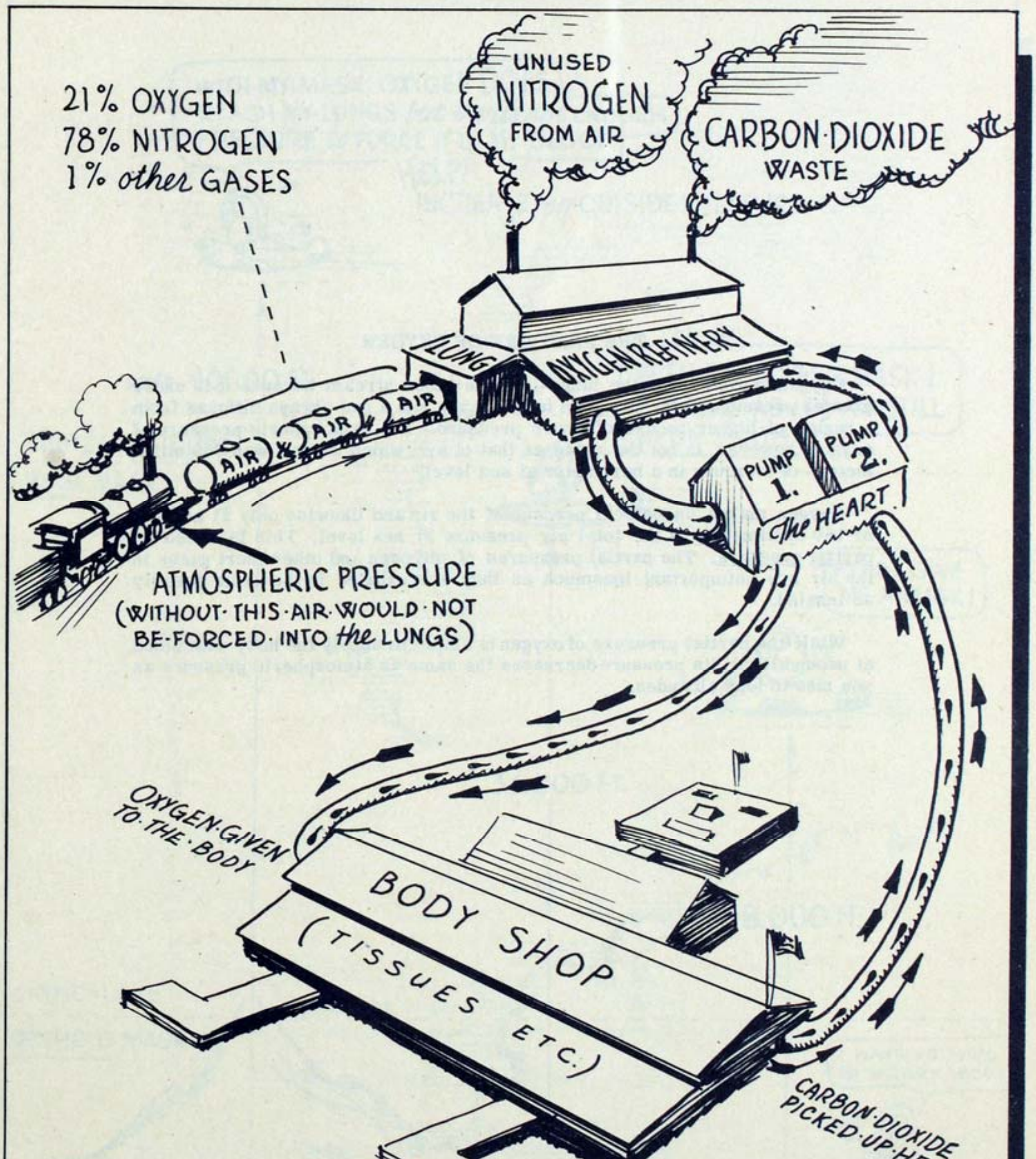
'I don't recall which mission it was, we'll probably run across it in my notes here later, but, we were coming back after the mission and I was working on my maps as usual. I didn't think anything was wrong, but [Whitey]? DeVries was out of his nose gun in the compartment there with me. He said all of a sudden I slumped over my table there. He got hold of my hose and worked it and broke it up, broke up the frozen moisture and the oxygen started coming back to me. He said I perked up right away and grabbed my pencil and started writing again like it just never did happened. I was thankful that Cecil was so rigorous about the oxygen check because it was possible for a person to suffer from lack of oxygen and not even be aware of it'.

Cecil Johnson- 'Suffer you mean die'

'What happens to anoxia is, anoxia is something you don't know it is happening to you and suddenly you are gone and you don't last very long without it. The reason we did it, and I'm sure you did it, in your training is that they take you in the tank and get some volunteer to take off his mask and watch how many minutes, have him sit there and write, and watch how many minutes it happen before he'd slumped over and never did know what happened….'

'The symptoms of yours was typical. You don't even know what was happening and when they bring you back to, 'what happened to you?', you were out of it. It looks like a very painless death'.

Back to *What do we use oxygen for?*



HOW BLOOD SUPPLIES the BODY with OXYGEN by the BLOOD-TRANSPORTATION-SYSTEM

Back to *How does the heart work?*

PRESSURE IN THE EAR

To be a good flyer, you've got to keep your ears open, not only to hear radio, intercommunication, and motor sounds, but also to keep from being grounded with ear trouble.

The trouble arises in the middle ear, an air-filled "box" behind the ear drum. The middle ear connects with the inner ear, which contains your sense organs of hearing and of balance, and with the eustachian tube. This is a slit, normally closed, running into the throat.

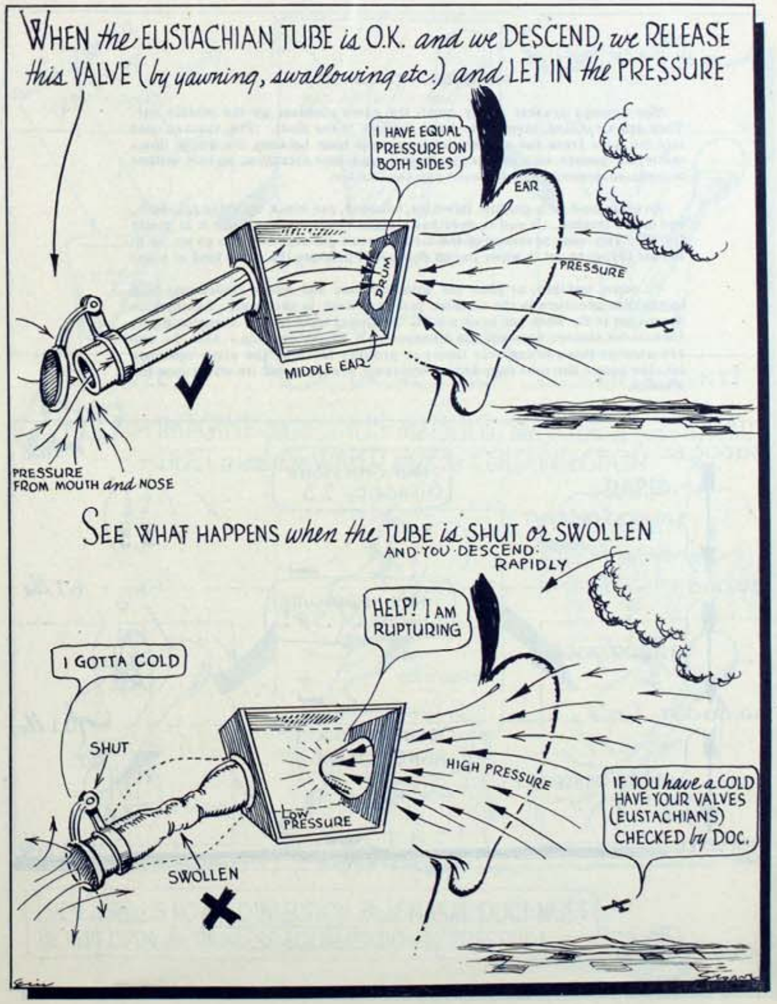
When you gain altitude, the outside pressure drops and the air remaining in the middle ear expands. At first this causes the eardrum to bulge a little, but then the surplus air slips through the eustachian tube to the throat. When this happens there is a click in the ear.

Ascents present no problem, but during a descent this automatic balancing of outside and inside pressure may not take place because the eustachian tube resembles a flutter valve, working in one direction.

Considerable pain and even rupture of the eardrum may befall you if the tube doesn't permit some high-pressure air to pass into the low-pressure area behind the drum. This usually can be accomplished by swallowing or yawning, which stretches the eustachian tube open. If that doesn't happen, air can be forced into the middle ear by closing the mouth, pinching the nose, and blowing hard. If only one ear is involved, hold the other closed while you blow.

The most important fact to remember is to clear your ears when the slightest amount of pressure appears. If you allow the difference between the inside and the outside pressure to become too great, the precautions above are not likely to help. If you are unable to clear your ears and the pressure becomes painful, you should return, if you can, to an altitude at least several hundred feet higher than that at which you first experienced trouble. From there you should descend slowly while constantly attempting to clear your ears. If this fails, you should go to the Flight Surgeon as soon as you land.

Unfortunately, a cold may cause inflammation and swelling in the eustachian tube, completely blocking off the passage of air. Descent under such a circumstance is likely to produce pain, deafness, and a ruptured ear. While the ear will heal and your hearing probably will return to normal, such a misfortune will ground you for many days and sometimes weeks. DON'T FLY WITH A COLD UNLESS IT IS ABSOLUTELY NECESSARY. IF IT IS, SEE YOUR FLIGHT SURGEON FIRST. See following drawing No. 42 for pressures at low altitudes which give greatest effects upon descent.



Back to *How do our eardrums work?*