pick.

In any event, total air mobility should be examined. A company that thinks it will only haul executives around should consider if it could employ the 'copter for other than executive use. It may have nonexecutive requirements for its machine. A construction company which first anticipates its 'copter will be used only for hauling the boss around may find, if supervisors and foremen are consulted, that it could well use the whirlybird for other purposes. *Use* defines the kind of 'copter to buy.

Who is to pilot is also paramount when considering a 'copter as a company plane. Instead of hiring a good commercial pilot, some companies assign 'copter flying to a salesman, or member of the firm. This is especially tempting in the Brantly and Hughes, where the company wants two of its men to go on a job and there would not be room for a regular pilot. Because the firm member-pilot may be inexperienced as a pilot, the 'copter gets cracked up and then sold.

A company may save some money on initial outlay by purchasing a smaller craft and using a company man as pilot, but it may be wiser to purchase a larger machine and hire a good pilot—one who knows that type of craft. The Army helicopter program is turning out many qualified pilots who may well flood the market as they graduate and leave the service.

Buying a 'copter must make economic sense. If it isn't going to be used as a company plane for 300 or 400 hours a year, it would be economically unwise to purchase it unless it saved a tremendous amount of money. If the 'copter is going to be used less than that number of hours annually, the company might best consider chartering or leasing.

The future of 'copters as company planes is already being written at places like Brantly and Hughes, upcoming with three-to-five-place ships; and Hiller and Bell, capitalizing on military experiences and latest turbine and jet power. Then, too, Doman Helicopters, with its D-10B, and the R. J. Enstrom Corporation, with its F-28 should soon be making initial deliveries of aircraft incorporating the latest advances in helicopter technology. ●

Don Lawson (left), president and pilot of Western Feed Supplements, and Jerry Van Horn, vice president, find the company's Brantly B-2 invaluable in sales work and in aiding customers to round up cattle

Ted Robinson, public relations director and helicopter pilot for Ervin D. Varwig Contractors, puts parts for a "downed" piece of earth moving equipment aboard the company's Bell 47G3B1 for a quick flight to the San Francisco bay area

At any hangar flying session worth its salt, the topics discussed are very likely to include women, flying techniques, weather, one's latest hairy escape, and the newest model *Airbird* just released by the proud manufacturer.

They may not be mentioned in the order named, nor are all equally interesting to all participants. If we omit women (probably the most interesting to all present but a subject on which I am no more qualified to write than any other red-blooded American male pilot), flying techniques (generally controversial since in any group of pilots there are always two who have opposing views as to how to perform any given maneuver), weather (probably lousy at the moment else there would be no hangar flying session since all would be out flying), one's latest hairy escape (and in the best interests of the ulcer my insurance underwriter is cultivating, I'll omit mine), we are left with the *Airbird*.

Shortly after any new model aircraft is placed on the market, most of the aviation journals and magazines report on a check flight given this new ship by editors or staff of the particular publication. Any major change in existing models produces the same result. While describing the performance characteristics, one usually finds a short remark about the comfort in the cabin. It generally is something to the effect that the cabin is well-upholstered and quiet, or that conversation may be carried on with ease. Remarks of a similar nature occasionally sail past at hangar flying sessions when one pilot will be heard to announce that his new Beechcraft is the quietest ship he has ever flown. This remark may be challenged by a Cessna or Piper owner who will make the same statement about his plane. These are generally subjective opinions, that is, they represent what the pilot believes. However, there is an objective factual method by which the noise level in any given airplane can be accurately and scientifically measured.

In order to understand something of this method, some background is necessary. Sound is a particular form of energy just as is heat, electricity, or light. Most sound energy is related to very small quantities of the other forms of energy for it has been estimated that 100,000 men shouting as loudly as possible would generate enough sound energy to cook one egg. Just as the eye is a specialized sensory receptor for light energy, the ear is an extremely sensitive receptor for sound energy. The range over which the ear works is stupendous. It can recognize extremely minute amounts of energy and translate these into impulses which are interpreted by the brain as sound or noise. At the same time, it can handle amounts of sound energy which are a million million times as large as that just mentioned. In other words the range of distoration-free operation of the ear is from 1 to 1,000,000,000,000 in terms of the energy involved.

TABLE 1—Dr. Wick's Classification of Lightplanes by Sound Level

Aircraft	Over-all sound level in decibels	Octave band sound level in decibels (bands in cycles per second)						
		75-150	150-300	300-600	600-1,200	1,200-2,400	2,400-4,800	4,800-9,600
Piper J-3 (65 h.p.)	107	103	95	92	87	87	84	78
Aeronca Champ (65 h.p.)	109	105	101	96	92	83	81	75
Cessna 140 (85 h.p.)	103	97	96	90	86	84	82	77
Cessna 150	109	106	97	89	84	79	75	71
Piper Colt	106	102	99	88	86	87	77	77
Cessna 172	108	104	94	92	89	80	79	76
Piper Tri-Pacer (150 h.p.)	105	102	93	90	85	79	76	75
Piper Cherokee (160 h.p.)	108	104	93	86	86	82	79	72
Cessna 182	104	101	93	90	83	77	73	68
Mooney Mk 21	109	106	97	89	83	76	71	66
Bonanza "H" Model	102	100	88	81	75	69	65	63
Piper Comanche 250	100	96	94	90	86	79	76	73
Helio Courier (260 h.p.)	106	100	96	90	85	86	83	79
Piper Apache (160 h.p.)	103	99	95	88	80	77	72	68
Cessna 310G	104	102	94	84	80	74	71	67
Beechcraft E18S	106	101	93	85	80	77	72	72
Ford Tri-Motor	108	106	100	96	88	85	81	78
Douglas DC 3	110	105	98	92	83	80	75	65
Boeing Stearman (230 h.p.)	116	110	107	102	100	98	96	98

Noise In The Cabin

Most of the decibels in lightplanes are generated in front of the firewall. Author's investigation shows that the loudest noise may not always be the most disturbing

Because of the large numbers with which we would have to work, we use some mathematical maneuvering to give us smaller and more easily manipulated figures when dealing with sound energy. This maneuvering involves ratios, and logarithms, but it is not necessary to understand these fully to have a working knowledge of sound. One of the original units of measurement in this field was a "bel" named after Alexander Graham Bell, the "father" of the telephone. This unit, too, was somewhat awkward to use, so a unit one-tenth as large called a decibel, or db for short, has come into common use. A sound level of about one db in the present standard reference is about the least amount of sound or noise which the average person can hear. At the other end of the scale a sound level of over 125-130 db will become painful to most individuals, and still higher levels will result in actual immediate physical damage, not only to the ear, but to other structures of the body. An increase in the sound pressure level of about three db indicates that the sound energy present has been doubled, adding three more db to the sound energy present quadruples the original energy and it therefore follows that mathematically, a 10 db increase in the sound level means that there is now 10 times as much sound energy present as previously.

A few comparisons may help to clarify the situation. Leaves rustling gently in a breeze produce a sound level of about 10 db. A whisper at five feet will result in a 20 db level; a quiet street, 30 db; the average living room, 40 db; a normal conversation at 12 feet, 50 db; normal office noise with typewriters, 60 db; a busy street, 70 db; very heavy traffic with streetcars or an elevated train, 80 db; a subway or Niagara Falls, 90 db; a passing train at six feet, 100 db; a riveter working at two feet, about 110 db; and a shotgun blast, about 120 db.

While discussing sound, a brief comment on the difference between sound and noise is in order. Noise has been defined by some as unwanted or undesirable sound energy. It is a subjective definition though, and depends on the individual. To a Scot, bagpipes produce music, but to many others, they produce only noise. On the other hand, to a pilot of a single-engine aircraft, the noise of his engine is preferable to the silence if it should stop over the Rockies or one of the Great Lakes.

One other measurement of sound or noise should be understood and that is "pitch." Sound is measured in terms of pitch as well as pressure. We define pressure in terms of db, and we define pitch in terms of cycles per second. This refers to the fact that sound is visualized as a series of waves spreading out from the sound source just as waves spread out on the surface of a pond when a rock is dropped into the still water. If we stand on the shore and count the number of waves arriving in any one second, we have arrived at a cycle-per-second count. The human ear is capable of hearing sounds which vary from about 15-20 cycles per second to around 15,000 or 16,000 cycles per second. A more familiar example of the quantity of pitch may be found in the fact that a woman's voice is higher pitched than is a man's. However, normal speech does not require the entire range of hearing, for most conversation occurs between about 100 and 1,500 cycles per second. Trained singers are capable of frequencies between 70 cycles per second for a bass to about 2,000 cycles per second for a soprano.

When speaking of sounds, mention is frequently made of "octaves." This actually refers to the pitch of two sounds and means that the frequency of one sound is twice that of the other. A sound with a frequency of 200 cycles per second is one octave lower than a sound with a frequency of 400 cycles per second, but it is one octave higher than a sound with a frequency of 100 cycles per second. The name came from the fact that keyboard musical instruments like the clavier and piano are usually built with each group of eight white keys representing a one octave range between the lowest and highest pitched sounds.

Noise is usually measured then in terms of db for the over-all noise level,

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but it is also quite feasible to specify any given octave band, and measure just the amount of sound energy occuring within that range. This becomes important when we are talking about aircraft noise, because different types of aircraft produce different types of noise.

Most turbojet aircraft produce what is called "white" noise since the frequency distribution tends to be uniform. If the noise level in the 400-800-cycle octave band is measured to be 110 db, the probability is that the noise level in the 4,000-8,000-cycle will also be about 110 db. This is in sharp distinction to propeller-driven piston engine aircraft however, for if the noise level in the 400-800 cycle band is 95 db, the noise level in the 4,000-8,000 cycle band may well be only 65 db. In other words, in conventional-engined aircraft there is far less noise energy present in the higher frequencies than in the low frequencies. This noise is largely generated beyond the fire wall and is caused by the engine and propeller. The noise at the higher frequencies is usually "aerodynamic" noise and is caused by the flow of air past the aircraft structure. A glider produces only aerodynamic noise while most general aviation aircraft produce both aerodynamic noise and engine and propeller noise unless one is fortunate enough to be driving a new executive jet.

Recently, I became curious as to just how noisy certain aircraft were. Armed with a fancy electronic black box which measures both over-all sound pressure levels and sound levels occurring within various octave ranges, I ventured forth to the local airport and borrowed or begged rides on some of the general aviation aircraft available. Manipulating the airplane with one hand, the black box with another, and writing down data with my third hand, I found a number of interesting things. Since most time in the air is spent in cruising, the data obtained with the airplane set up in normal cruising conditions are shown as Table I. The readings during the takeoff and climb configurations were not much higher, for you will remember that the sound energy present must be doubled to raise the indicated level by three db.

Several interesting conclusions can be reached by inspection of this table. Several aircraft which are supposedly noisy really have over-all noise levels which compare favorably with some of the "quiet" airplanes. Furthermore, the sound levels in the Ford tri-motor and "Dizzy three" are not far in excess of those in some of the smallest trainers. Why then do some airplanes have a reputation of being very quiet? The answer can be obtained by looking at the noise levels in the various octave bands. Some aircraft are noisy in the ranges where human speech take place and therefore conversation is very difficult even though the over-all noise level is not much higher than in the quiet airplane. Compare the early Comanche with the Model H Bonanza. Conversation can be held much more easily in the *Bonanza* although it has a slightly higher over-all noise level. What a pilot usually reports then, is really how easy it is to talk with another occupant rather than actually how much noise is present in the aircraft.

Sound energy has another peculiar property which is not generally known. Enough noise for a long enough period of time can actually cause a hearing loss. It is not possible to say in the case of any individual how much noise must be used for how long a period of time, for each of us varies in his susceptibility. However, a general rule of thumb has been adopted and it is now believed that over the span of one's working years, exposure to over 95 db for more than eight hours a day based on a five-day work week will ultimately result in a hearing loss. A conservative safety factor is contained, so that exposure to this level appears to be safe for most persons. Furthermore, the guideline has been expanded to include exposure for the same time periods to any one octave band which has over 85 db of sound energy in it. These figures are estimates only and should be considered as such. Unfortunately, medical science so far has been unable to produce more than these estimates, and even these can not be applied in any given case for they seem to be valid only for a majority but not all.

Strangely enough, this is not a new problem. A noise induced hearing loss was first noted over 130 years ago in England when an astute observer found that blacksmiths as a group were hard of hearing. Some short time after that, the editor of a question and answer section of a medical journal was asked what to do about hearing losses caused by gunfire, and his answer was, "Use cotton in the ears." Unfortunately, although medical science has made wonderful progress in other fields since that time, there has been relatively less progress made in this particular field. One of the better solutions today is still not far removed from the use of cotton in the ears as we shall see.

The next logical question is, "What happens to an individual exposed to high sound pressure levels for a shorter period of time than eight hours per day or five days each week?" The answer is that we simply do not know. A number of theories and guides have been proposed, but no good experimental evidence has yet been found to confirm them. This presents a problem for the pilot. Although it is clear that most are subjected to more noise than is desirable, pilots just do not fly eight hours a day for five days each week. A pilot flying 1,000 hours a year will average only about three-four hours a day when vacation time and weekends off are considered. Most general aviation pilots fly far less than that.

Pilots can and do develop hearing losses, however. A number of years ago, a curious fact was discovered among airline pilots. The copilots tended to be hard of hearing in their left ears, while the captains were partly deaf in both. The explanation was somewhat in doubt until it was realized that the copilots wore their earphones with the left one pushed back of the ear so they could hear the pilot's commands. The left ear was exposed to all the racket in the cockpit while the right one was partially protected by the earphone. When a copilot was promoted to the left seat, he reversed the position of his earphones so that he could hear the new copilot's answers. He then exposed his right ear, previously shielded, to the cockpit noise, and, after a few years, became partly deaf in both!

Several years ago, I met an agricultural pilot who had in excess of 15,000 hours of flying time in dusting and spraying operations. Almost all of this flying had been done in Stearmans. He was quite obviously hard of hearing, and it had been his habit over the years to wear an old leather flying helmet. This does not provide much sound proofing against the noise of that old biplane. He was persuaded to wear the more modern Air Force type crash helmet which deadens the sound far more efficiently than the leather helmet. (This incidentally may have saved his life in a subsequent crash so that it had a two-fold benefit in his case.) It is extremely unlikely that his hearing will improve, but at least he has some additional protection to prevent it from becoming worse.

Most of us do not fly Stearmans, nor do we fly Fords or Gooney Birds. What seems advisable then in the latest *Airbird*? Over the past few years, it has become something of a status symbol to have a cabin speaker in one's aircraft. However, the protection afforded by a well-fitting set of earphones is lost. Ideally, the crash helmet with the built-in earphones is even better than ordinary earphones since it provides more sound insulation as well as being useful in the event of an accident. However, they are heavy, expensive, awkward, and uncomfortable, particularly in hot weather. I once tried to wear one in my Globe *Swift* only to find that I was unable to close the canopy since the helmet, added to my height, exceeded the distance from the seat to the top of the hatch. A high-quality properly-fitted set of earphones provides a more practical solution to the problem of cutting down the noise which reaches the pilot's ears.

The manufacturers are acutely aware of the problems involved. They each are attemping to produce an airplane with more power but less noise audible to the occupants. Until they are successful, the old-fashioned earphones may not be so old-fashioned after all! ●