Problems Associated with Small Helicopter Developement*

By COMMANDADANT H BORIS, M B E

A Meeting of the Association was held at The Royal Aeronautical Society, 4 Hamilton Place, London, W 1 , on Friday, 11th September, 1953

In the Chair

E MENSFORTH, ESQ , C B E , M A
(President of the Association)

Introducing the Author, the Chairman said We have a very important lecture tonight before our annual dinner, this being one of the principle evenings of the year Commandant BORIS has been good enough to come to give us a Paper which I think will stimulate a good deal of discussion We can listen to him with much respect, for he is a man with enormous flying experience—some 6,000 hours total, with 400 hours in helicopters He is managing director of Helicop-Air, which is Hiller's representative in Europe He had a considerable number of racing successes in light aeroplanes in his early flying days, and during the last war he had a very distinguished aviation career, which is shown by the fact that he has the honour of being a Member of the Most Excellent Order of the British Empire a well as being an Officer of the Legion d'Honneur with the Croix de Guerre, the Resistance Medal and many other distinctions

COMMANDANT H BORIS

When a few months ago the Helicopter Association of Great Britain invited me to give the opening lecture of the 1953-1954 season, I must say I was very surprised I fully appreciated the great honour which was offered to me, but, giving a lecture in a foreign language is always difficult, specially in front of such a select authority I still hope that the following half hour will be of some interest to you and that you will understand my broken English

To make myself clear, I will first give you the general outline of this lecture First I will briefly relate what has been my experiences in the helicopter field, as it is on these experiences I am basing my arguments , then I will explain the three main problems I have found interfering the most with developments of small helicopters , and finally, I would like to explain what would, in my mind, be the most efficient small commercial helicopters

For the past four years I have been concerned with the sales and

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maintenance problems of light helicopters, also the operating side has been a large part of my activity From the time my company started in the helicopter game, its activities can be summed up by the following figures

8,700 flying hours have been accomplished on our own ships or ships of some of our customers but with our staff and our maintenance, out of which 2,200 hours have been school work

We graduated and trained 35 civilian and 10 military pilots Today we also have a contract for training 20 more military pilots, 13 of which are now following our course

1,500 hours have been flown for publicity and, during this time, over 60,000 people have ridden in our ships

2,300 hours have been flown for passenger transportation in the South of France on short distances between Nice, Cannes, and several cities of the coast This has been performed by Helicop-Azur, a company closely connected with us

1,500 hours have been on agricultural work in France, mainly on rape-seeding and in cockchaffer destruction , for this last work we have mainly been using aerosols A few other less important jobs have been accomplished on potatoes, beets, and destruction of caterpillars Other experiments have been carried out on rice seeding In Northern Africa 300 hours have been flown spraying and fogging for mosquito control , in Morocco demonstrations for over 200 hours have been used on several pest controls , in Tunisia 200 hours have been flown on weed control , in Guinea demonstrations on different pest controls have been also carried out

1,200 hours have been accomplished on miscellaneous work in France high tension survey , transportation of material in mountainous areas , pipe-line lay-outs, and so on

The above examples just show you the versatility of our operations Many of them have been successful as far as results are concerned and this means quite a large number of satisfied customers therefore the following question comes naturally into my mind today why are small helicopters developing so slowly and what problems associated with them, could, if solved, help in their development ?

The first answer which naturally comes to everybody's mind is the high cost of the helicopter , but this is, I consider, a lazy answer which is, I believe, only partially, very partially true

If today we examine each of the operations I have outlined to you just now and analyse the reasons which have prevented satisfied customers from buying or to go on using the helicopter facilities, we find out that always three main points are coming back

(1) Ability of the ship used to perform the intended job in the most efficient way we could call this efficiency
(2) Operating costs (in this chapter initial cost naturally intrudes)
(3) Maintenance

There are also quite a few other problems such as easiness to fly, safety, and so on, but these objections do not come up so repeatedly as those I mentioned above and it is those problems I would like to discuss

Efficiency

Let us first examine how small helicopters have been used up to now

the same types have been trying to fulfil all the different jobs agricultural, school, survey, publicity, executive transportation, and even short distance passenger transportation

The same helicopter has been considered a general purpose vehicle I fully realize that, when the small helicopter started its commercial expansion, only one or two models of helicopters could be procured, but time must soon come when, if we want to see a large development, this must change

First of all, it seems to me that the general idea of associating helicopter manufacturing with aircraft manufacturing could now be more or less revised and that, thinking more or less in the automotive line would certainly help to solve many problems

What would you think of a ground vehicle operator using the same vehicle as a tractor in his field, as a touring car to take his family out on Sundays, and also as a truck for freight transportation ? If this specific vehicle was definitely good for one of these jobs, it would certainly and definitely be inefficient for all the others this is in fact what has happened with the small helicopters An old French saying comes into my mind and fits perfectly the small helicopter we are using today for all jobs " Apte a tout, bon à rien " which means able to perform any work, specifically good for none

Do you believe that for agricultural work you need a three seater when we all know the pilot is always alone for this work ? Must we increase the empty weight, therefore decreasing the useful load, with all sorts of refinements, panel instrumentation, dual control, elaborated electrical equipments and so on Do you believe also that for school work a three seater helicopter is absolutely essential ? Do you believe that for executive transportation you need a helicopter which is fitted with agricultural attachments ? Do you not consider that for mountain flying everything should be sacrificed to altitude performances , for some other specific survey jobs it is the electrical equipment which should be the essential point

I fully realise that manufacturing a specific type of ship for each specific work is an impossibility , the quantity for each type would be so small that the price would be very much increased compared to what it is now , but if it was possible to use the same basic frame, I would say more or less, as a helicopter chassis (thinking automotive) and to have this chassis equipped with different fittings and body configurations, configurations that would be adapted for each specific jobs, the problem of efficiency could be greatly advanced and many jobs that operators have had to refuse up to now because the equipments of their ship would not allow a sufficiently high efficiency could, in the future, be accepted Coming back to automobiles when you buy a car, you can have on the same chassis a station wagon, a convertible, a six-seater sedan, or eventually a light truck Why not use the same principle for the helicopters ? The aim to reach is to make the helicopter a profitable tool for its owner, by profitable I do not only mean money making, but also capable of fulfilling a job that can be achieved better than by any other means

Before going any further, I would like to illustrate by a true example the above sayings A little over a year ago an important group of farmers in the Northern part of France decided to try to use the helicopter for dusting on rape-seed , most of their fields were small, one to two acres and quite scattered one from each other Generally when dusting or spraying in our climate and on reasonably large fields we load the helicopter with about

360 to 400 lbs of dust For the job I am speaking of, after several tests, due to the small size of fields, and to the fact that the helicopter had to be very manoeuvrable on account of many obstructions, we were only able to load to a maximum of 300 lbs I will not give you all the details, but finally, with this load, we could treat an average of 36 acres per flying hour As we were paid 15 shillings per acre, we were flying for £27 per hour If you figure the necessary ground crew and truck equipment, this means that the average operator should be logging 500 to 600 hours a year (as we will see later) to to make this job a profitable one

For an agricultural operator this is very difficult to obtain in continental Europe For instance, if you can send your ships out to Africa during a few months of the year, you can reach and even exceed the 600 hours per year but then many other items have to come into consideration transportation cost, living expenses for the crew, spares to be stocked where the job is to be performed, and so on, and anyhow this means a quite elaborate organization all the way through

Therefore for the average helicopter operator the job I am speaking of was a non-profitable one, as it was on account of this, we tried another experiment during the second part of the same job We stripped the ship down to a maximum , the standard battery was replaced by a very small one (the helicopter had to be started by an outside field battery), we removed the generator, the canopy, some of the instruments which were not absolutely essential and we managed to reduce the empty weight of about 100 lbs , we then could load the ship with 400 lbs of dust and could average, instead of the 36 acres per hour mentioned previously, 55 acres , this meant that we were flying for just over £41 per hour I therefore say that the helicopter was efficient and made this job a profitable one for an average operator

Let us take another example the big French automobile firm Renault was considering the use of a helicopter for its executive transportation between their main plant in Paris, Flins, which is in the west of Paris, and Le Mans, which is in the south-west Paris—Flins is 30 miles no problem there Paris—Le Mans is about 130 miles and Flins—Le Mans is about the same With possible head winds and with safety reserve fuel margin, it appeared to be necessary to have a helicopter with about 3 hours endurance To obtain this result, it was necessary to add an auxiliary fuel tank with all its fittings, and it came out then that, with its 3 hours endurance, the ship was no longer a three-seater but could only carry two people and a small extra load

As it was, the helicopter was insufficient , had a more powerful helicopter been available, it would have been easy to reach the requested performances , it would have been an efficient ship , and it would have meant one more customer

From these two examples, we can easily conclude that the ships that are actually for sale on the market are, in many cases, not efficient enough and, if the manufacturers want to develop the sales of their small helicopters for commercial uses, some thoughts should be given to this problem

Coming back to efficiency, we have examined two cases where the actual types of three-seater helicopters were either too heavy, underpowered, or too small Let us now take an example where, on the contrary, the actual types are too big, too powerful, too expensive School work a basic trainer does not require more than two seats and certainly does not need to

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be overpowered, I would even say that training with a low-powered helicopter gives to the student a very good instruction This helicopter must still have comfortable accommodations for the instructor and the student, a clear instrument panel with, for advanced training, night flting and blind flying instrumentation , the noise level or the intercommunication facilities should enable the instructor to speak to his pupil without getting a sore throat at the end of the day But, for the moment, everyone is still using the general purpose three-seater, and training expenses are extremely high

I believe we can easily conclude this first part by saying that

(*a*) The present types of small helicopters are in many cases inefficient , but that it would not mean a complete change to considerably improve their efficiency ,

(*b*) To cover the largest possible commercial range of operations 2 basic types of small helicopters would be useful

Operating Cost

Fig 1 will show you what amounts were taken into consideration to calculate the operating costs versus the annual flying hours, these figures apply to Hiller helicopters and are average results of our own operations, or operations performed by some of our continental customers

Pilot salaries approximate £1,200 a year plus a bonus of £1 per flying hour , mechanic salaries approximate £600 a year , insurance premiums are culculated on the price of the helicopter f a f Factory which is $36,000 plus cost of the transportation and packing , the insurance rate is 22 per cent , which is very high I know, but it includes all jobs school, agricultural, rescue, and so on , third-party covers the owner's liability up to £100,000 and each passenger is insured for £5,000

Miscellaneous expenses cover hangar and landing taxes, C A A inspection fees, phone calls, and so on

	FLYING HOURS PER YEAR							
	300	400	500	600	700	800	900	1 000
FIXED EXPENSES								
Pilot salaries	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200
Mechanic salaries	600	600	600	600	600	600	600	600
Insurances Hull / 3rd party liability	2 400	2 400	2 400	2 400	2 400	2 400	2 400	2 400
Amortization (5 years)	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500
Miscellaneous	240	240	240	240	240	240	240	240
TOTAL (fixed expenses)	6.940	6.940	6.940	6 940	6.940	6.940	6 940	6.940
VARIABLE EXPENSES								
Fuel	930	1 220	1 540	1 845	2 100	2 460	2 770	3.080
Spare parts	600	800	1 000	1 200	1 400	1 600	1.800	2.000
Ea'or overhaul engine	300	400	500	600	700	800	900	1 000
Flying bonus	300	400	500	600	700	800	900	1 000
TOTAL (variable expenses)	2 130	2 820	3 540	4 245	4 900	5 660	6.370	7 080
GENERAL TOTAL	9 070	9 760	10 480	11 185	11 840	12 600	13 310	14 020
COST PER FLYING HOUR (£ s)	£30 5	£24.8	£21 00	£18 13	£17 00	£15.15	£14 15	£14 00

FIGURE (1)

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Fuel and oil have been calculated at the French prices and this is about 6 shillings for a gallon of fuel

Spare parts, including those for major inspections, amount to £2 per flying hour, and £1 per flying hour is allowed for the maintenance and overhaul of the engine

You will notice, however, that no provision has been made for overhead expenses as they are so variable from one company to another, nor has any allowance been made for taxes and profits Therefore the given figures are really a minimum or at least a net cost price for the operator

Fig 2 shows you the different curves of the variable, the fixed, and the total expenses per flying hour, according to the total number of hours flown per year You will immediately realize that, under a total of 500 flying hours per year, the fixed expenses boost the operating cost to a very high level

Some of these expenses cannot be altered—such as pilot or mechanic salaries , but amortization and insurance, which are in direct relation with initial cost, should be lowered

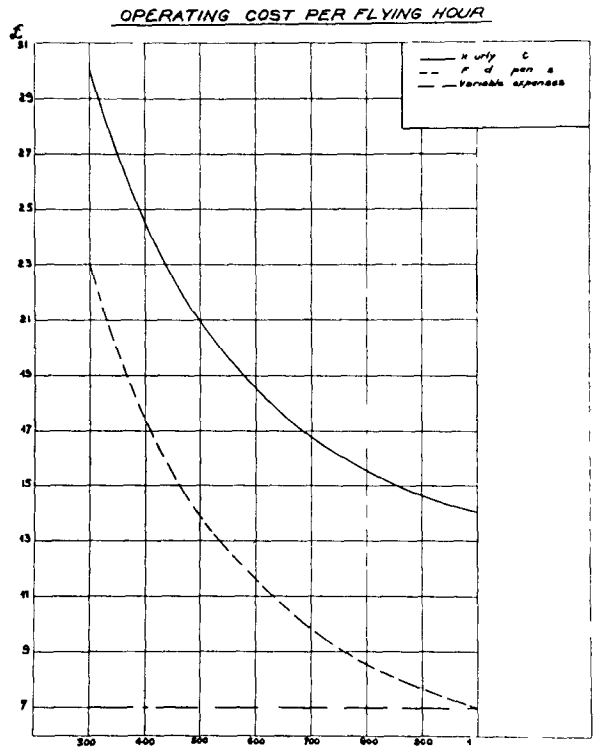

FIG 2

I do not have the pretention to advise the manufacturers how initial costs could be cut down, but one thing is certain, high production will mean lower prices , and higher production needs more customers, but customers want efficient and profitable helicopters

As far as insurance goes, there is a different problem The actual requested 22 per cent premium is much too high, and Mr COLIN COOPER

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some time ago thought of a scheme which should cut down this percentage

In fact, we ourselves are working more or less according to his idea we have agreed with our insurance company that parts necessary for replacemenat after an accident would be invoiced at cost price and so would the labour, this brings our own insurance down to 17 or 18 per cent , but if manufacturers agreed also that those parts required for replacement after an accident would be invoiced at their cost price the insurance premium could certainly be brought down to 10 or 12 per cent , and, after all, it seems natural that nobody should make a profit out of an accident

	FLYING HOURS PER YEAR							
	300	400	500	600	700	800	900	I 000
FIXED EXPENSES								
Pilot salaries	I 200	I 200	I 200	I 200	I 200	I 200	I 200	I 200
Mechanic salaries	600	600	600	600	600	600	600	600
Insurances Hull / 3rd party liability	800	800	800	800	800	800	800	800
Amortisation (5years)	700	700	700	700	700	700	700	700
Miscellaneous	I02	I20	I20	I20	I20	I20	I20	I20
TOTAL (fixed expenses)	3 420	3.420	3 420	3 420	3 420	3.420	3 420	3 420
VARIABLE EXPENSES								
Fuel	I 440	I 920	2 400	2 880	3 360	3 840	4 320	4 800
Spare parts	3I5	420	525	630	735	840	945	I 050
Jet engine overhaul	35	47	58	70	82	93	I05	II7
Flying bonus	300	400	500	600	700	800	900	I 000
TOTAL (variable expenses)	2 090	2 787	3 483	4 180	4 877	5 573	6 270	6 967
GENERAL TOTAL	5 5I0	6 207	6 903	7 600	8.297	8 993	9 690	I0 387
COST PER FLYING HOUR (£.S)	I8.7	I5 I0	I3 I6	I2 I5	II I7	II 5	I0 I5	I0 8

FIGURE (5)

As far as variable expenses are concerned for this type of ship, the only figures that could be slightly revised are the cost of spare parts per flying hour , however, I will come back to that subject when dealing with maintenance , but I can say right now that there is not much to be changed on the present expenses as they seem very reasonable for the present type of helicopters

I would like to examine now the same diagrams if the operator could use a helicopter that was very close to the Hiller Hornet , I agree that, up to now, this type of ship does not yet exist but experiments seem to prove that the Hornet is getting pretty close to it

We have previously seen that the small ship could very well achieve many jobs such as certain agricultural work, school work, publicity, and so on Let us therefore examine a ram-jet driven helicopter (I have chosen ram-jet on account of its simplicity) that could fly 50 to 60 minutes with two people on board or carry a useful load of 300 lbs plus a pilot and half-an-hour fuel , the fuel consumption should not exceed 40 to 50 gallons per hour, which, if not achieved today, seems to be within the reach of the future The operating costs of such a ship are shown on Fig 3 Pilot and mechanic

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salaries are the same as for the larger ship, *i e*, £1,200 and £600 a year Insurance has still been based on the actual high 20 per cent premium Fuel is based on an hourly consumption of 40 gallons Spare parts figure for £1 per hour , on a very simple ship of the Hornet type this should be a maximum , jet engines are replaced every 300 hours, their cost being actually $50 each The initial cost of the helicopter has been figured at £3,500 or around $10 000

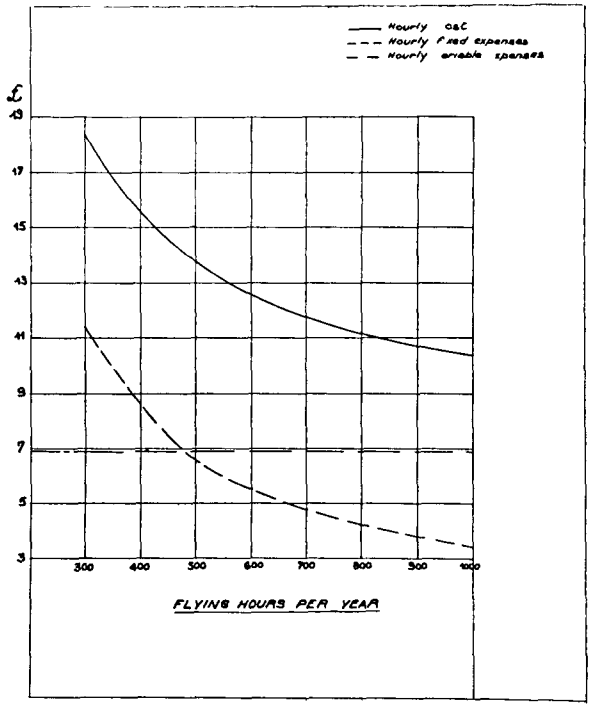

FIGURE 4

The diagram of Fig 4 shows that, at around 500 flying hours per year, the fixed expenses become smaller than the variable expenses and that, with a use of 300 hours a year, the total hourly costs would be under £18 making this helicopter, for its adequate jobs, a profitable one

Such a helicopter flying only 3 or 4 months a year would be profitable to its owner , and he would, on account of the reduced cost per flying hour, be able to accept many jobs that with a larger ship he could not undertake

To sum up this operating cost chapter, we can see that

(*a*) For the larger ship, insurance premium should be cut down and the initial cost, if larger quantities could be sold, could be reduced as well this would mean that such a ship could already be operated at a reasonable price and profit provided it was flying 300 to 400 hours a year, and, if this ship was of, let us say, the " efficient type " as described in the first chapter, this number of hours could very easily be reached This

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type of ship would also certainly open new markets, specially in Africa , this means new customers and therefore larger production

(*b*) The smaller type of helicopter, provided its price, performances, and operating cost were close to those mentioned on Fig 4 would certainly have very large development possibilities Out company has received many requests for such a ship

Maintenance

Maintenance is the nightmare of most operators , it certainly is the factor which influences the most (for a given ship) on the operating cost and this in two ways

(*a*) Directly by the general expenses involved, spare parts and man hours

(*b*) Indirectly by having ships in the air or grounded during working periods A grounded ship at that time does ont only mean a dissatisfied customer, but it also contributes to decrease the yearly flying hours and therefore, as Figs 1 and 3 show, increase considerably the operating expenses

As far as (*a*) is concerned, all operators naturally aim to decrease the amount of money spent on spares and on man hours We all have noticed that man hours come down as time goes, essentially because the mechanics get to know their ships better and to know also how to do the same work in less time , but besides these two human factors, the life of the several parts of the helicopter increases generally with the experience acquired on that model , I hope and believe that this improvement will steadily progress and therefore it may very possibly no longer be necessary to have, as is now the case, one licensed mechanic per helicopter , a fleet of four ships could, for instance, be maintained by two licensed mechanics and one helper The life increase of parts can very often be obtained by a close collaboration between the operator and the manufacturer I want to demonstrate this by one example initially the main rotor head of the Hiller required dismantling, inspection, and often changes of the bearings about each 150 hours Today, the same head requires no attention except for greasing between major overhauls—this means during 600 hours How was this achieved ? With the Factory's help we made on one of our ships a certain number of modifications that experience on the field revealed useful , we ran a certain number of tests and, without going into the mechanical details, little by little the endurance of the head has been improved to its present stage and this has recently been approved by Bureau Veritas I must here state that the collaboration between Hiller and ourselves has always been most efficient All technical advices, data, engineering drawings, etc , which we requested have been given to us with the most valuable advice and, thanks to that collaboration, we have obtained very good results

But manufacturers can still considerably help the operators and the man on the drawing board should be obliged to join in an operator's operation for some time , he would realize how very small modifications could often spare many hours

As regards (*b*), the only answer we have found is to have in stock a large number of complete components and spares This may mean to start with a large money investment, but it certainly pays in time

Naturally overhauls should be done progressively, but this procedure

is now in general use with those for regularity is the main point

Once more here is a precise example we are now training 13 military pilots, each one is to receive 50 to 60 hours of instruction and, for this, we only have 3 ships , the maximum time allowed to us by our contract is 3 months (except for weather conditions) Each ship is therefore flying from 5 to 6 hours a day and must be ready the next morning to start again We stop flying at 6 p m One foreman and three mechanics at our station start to work in the afternoon at 4 p m and go on until midnight , this leaves them 4 hours to work on the helicopter after they have stopped flying , nearly always, I really cannot say always, the ships are serviceable the following morning This procedure may seem expensive on account of the night shift pay but, in fact, it is the only way to have the ships flying from 100 to 120 hours a month, and anyhow the ratio of flying hour per man hour has been actually established to the very reasonable amount of 1 hour and 40 minutes

I think I can conclude that, as far as maintenance goes, both manufacturers and operators have an important part to play , manufacturers by producing easy interchangeable and long life components , operators by proper organization

Conclusion

Now that I have mentioned the main problems our experience has been able to outline (and this surely does not mean all the problems) I would like to examine what would be, in our mind, the most efficient type of helicopters to be used by operators and what should perhaps be tried to bring the operating cost down

We have seen that operators want, I think, two types of ships

(*a*) An efficient ship that could, according to the jobs, be a heavy, load carrying helicopter (let us say around 1,950 lbs) or a long range or a helicopter having good altitude performances

(*b*) A small cheap, easy to maintain helicopter

For case (*a*) I think that the helicopter should first of all have approximately a 350 h p engine , if such a ship was built with the chassis idea I expressed at the beginning, it could really be a very efficient helicopter , it should be delivered in this case from a single seater to a 4 seater version , I know naturally that this means a lot of problems with the C G but I think they can be solved What about the price, you are thinking this is really a question to be answered more by the manufacturers than by the operators but it seems very possible that such a ship could be sold at a price very close to of that actual helicopters For those manufacturers who have been building 2/3 seaters, I do not think the problem is so difficult, I would like to point out the following the first Hiller 360 was delivered with a 178 h p engine , the actual 12-B is equipped with a 200 h p engine, and, with one exception, all components are pretty near the same The Factory is testing today the use of more powerful engines, and I hear that the C A A will accept, with only very minor alterations, the installation of engines up to 260 h p From 178 h p to the 260 h p blades are exactly the same and transmissions have only very small differences It a ship of this class was to be redesigned today calculations show that, with only a few pounds more empty weight, it could be fitted with an engine up to 350 h p This shows

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clearly that the actual 3-seaters helicopters can be boosted up with only a very small increase in price If such a ship be now redesigned with a chassis idea, it could then be delivered to customers with the exact type of fittings or body required , and separate kits could be sold independently to equip the ship for different uses Preliminary calculations show that such a ship could have about the following performances

Weight empty		1,750 lbs
Pilot		170 lbs
Fuel and oil (4 hours)	540 lbs	
Payload	1,260 lbs	
Disposable load	1,800 lbs	1,800 lbs
Gross weight		3,720 lbs

Assuming that the disk loading (lbs /sq ft) and the tip speed are the same as those of the Hiller 12-B, it is possible to estimate the performances of the new ship, specially in vertical flight, as the power required in those conditions is proportional to the weight Such a ship would have a hovering ceiling of over 4,000 ft out of ground effect and about 7,500 ft with ground effect Its vertical rate of climb would be about 900 ft per minute at a gross weight of 3,720 lbs

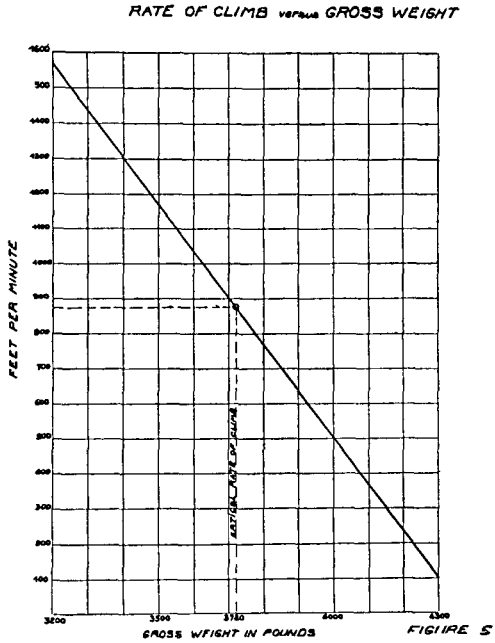

FIGURE 5

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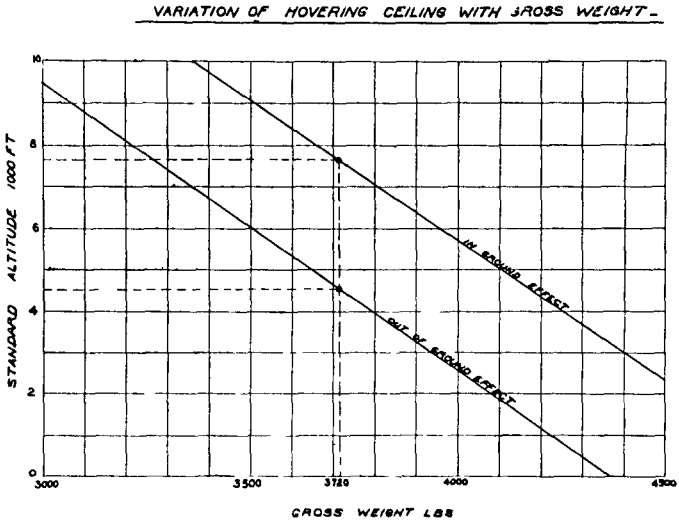

FIGURE 6

Used as an agricultural tool this helicopter, with one hour endurance, would have a payload of about 1,300 lbs if you estimate that the agricultural equipment weighs about 100 lbs

With two passengers plus pilot, the disposal load would still be over 900 lbs which could be used either for an auxiliary tank or for electrical equipments, eventually a hoist

Figs 5 and 6 will give you a better idea of the estimated performances of such a helicopter Its operating costs would be very close to those shown on Fig 2 as, in fact, only fuel and initial cost would be a little higher

Furthermore, such a helicopter would have larger possibilities to be used overloaded if necessary or, anyhow, would still have good performances in tropical climates

For case (*b*) a Hornet type helicopter seems to be the answer, not that I absolutely insist on ram-jet , pulse jet, if noise level can be brought down, could perhaps be used, or even compressed air as in the little Djinn, provided then that the price can be kept down Such a helicopter should not cost more than £3,500 to £4,000 It should have an endurance of around an hour and have a payload of 300 lbs

With this scale of possible small helicopters all operators would not only be happy, but have the advantage of achieving a great many jobs for which the helicopter is fit, but which have proven unsuccessful up to now, on account of the inefficiency of the actual types

May I express the wish that manufacturers, on what everside of the ocean they may be, will give some thoughts to the problems of the small helicopters I feel confident that, if they do so, they will find the most suitable answer , and you may be sure that, with suitable small efficient helicopters on the market, their uses will increase considerably in the coming years

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