A G Holland.

Journal and Proceedings of the Institution of Agricultural Engineers

WINTER
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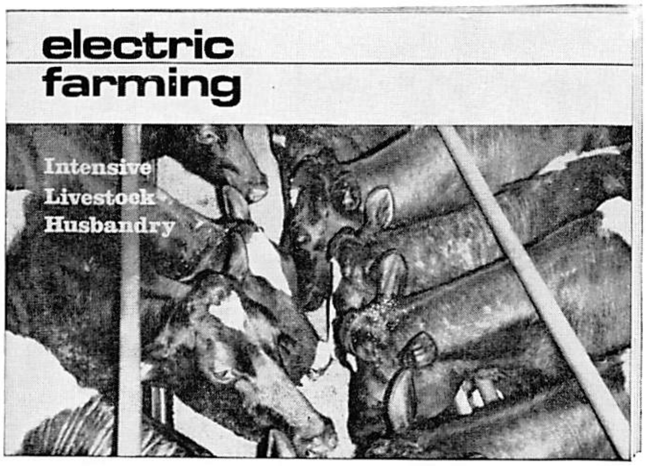

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JOURNAL AND PROCEEDINGS OF THE INSTITUTION OF AGRICULTURAL ENGINEERS

IN THIS ISSUE

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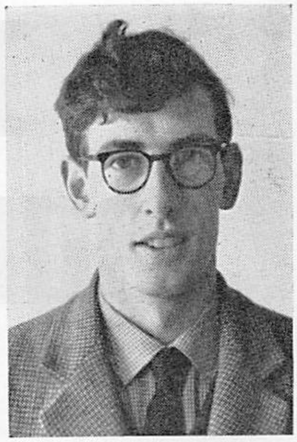
VOLUME 22 **NUMBER 4** **WINTER 1966**

INSTITUTION NOTES

Johnson Medal Winner

Council is pleased to announce the award of the Johnson Medal to David Ian Bartlett as the most outstanding candidate in the 1966 Examinations for the National Diploma in Agricultural Engineering. The Medal commemorates the foundation of the Institution in 1938 by the late Lt.-Col. Philip Johnson.

Mr Bartlett, who is 23, obtained the College Diploma of Agriculture and the National Diploma in Agriculture from Seal-Hayne Agricultural College and then proceeded to the course at the Essex Institute of Agriculture leading to the award of the ND AGR E, in which he gained Distinctions in four subjects. A good deal of Mr Bartlett's practical training took place on farms in Somerset and he is now an Assistant Farm Mechanization Adviser in the National Agricultural Advisory Service. He was recently elected a Graduate Member of the Institution.



Mr D. I. Bartlett
Johnson Medallist 1966

A New Branch

Council has been pleased to approve the formation of a major new Branch of the Institution in the South East Midlands area. Its title is 'The South East Midlands Branch' and it comprises members resident in the counties of Beds, Bucks, Herts, Cambs and Isle of Ely, Hunts and Peterborough (excluding the Soke of Peterborough). Branch status is thereby conferred upon well over 200 members of the Institution, making this new Branch the largest in the Institution network in this country. The total of Institution Branches is now nine.

This important development is of special interest to everybody connected with the National Institute of Agricultural Engineering and the National College of Agricultural Engineering at Silsoe. This new formation has necessitated some re-organization, so that members in Cambridgeshire and Huntingdonshire, who hitherto had been attached to the East Anglian Branch, now find themselves members of the new South East Midlands Branch. The new Chairman of the Branch, Mr R. F. Norman, MI AGR E, Managing Director of Fisons Farmwork Limited, is himself a Cambridgeshire member. The Hon. Secretary is Mr G. Spoor, GR I AGR E, and his address can be found on page 168 of this *Journal*

Agricultural Engineering Symposium

It is with great pleasure that the Council was recently able to release detailed information about the long-awaited Agricultural Engineering Symposium (AES). It will take place between Monday evening and Thursday mid-day, 11-14 September 1967, at the National College of Agricultural Engineering, Silsoe, Bedford and nearly 50 speakers will take part, drawn from Great Britain, Europe and the United States of America.

Full details of this, the largest single event ever organized by the Institution since its foundation, are available on application to the AES Honorary Secretary whose name and address are given on page 152 of this *Journal*.

Other Institutional Activities

As the current Winter Sessions closes, plans are already well advanced for the 1967-68 Institutional programme of open meetings, conferences, technical visits and social occasions throughout the United Kingdom. Regional activities will be organized by the Committees of the nine Branches of the Institution and the Annual Conference will take place in London in May 1968. It has been decided not to hold the customary Autumn National Open Meeting in 1967 as the Agricultural Engineering Symposium will be taking place at about that time. There will however be the Spring National Open Meeting in 1968 at which the subject-theme will be 'Fertilizer Handling and Distribution'; exact details will be announced later.

Annual Subscriptions

Members are cordially reminded that annual subscriptions to the Institution became due on 1 January and it is most important that these be remitted promptly. Any member who has not yet done so is respectfully asked to give this his very early attention.

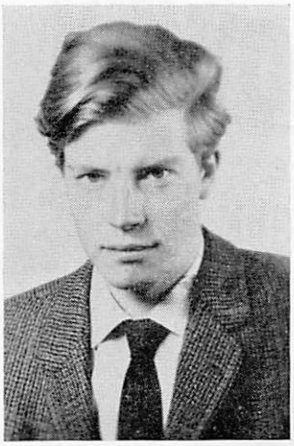
The Institution is approved by the Inland Revenue authorities as qualifying its members to claim tax relief in respect of the annual subscription. Members who have not yet claimed this benefit are strongly advised to get in touch with their local Tax Office (*not* the Institution) who will advise them fully.

Publications

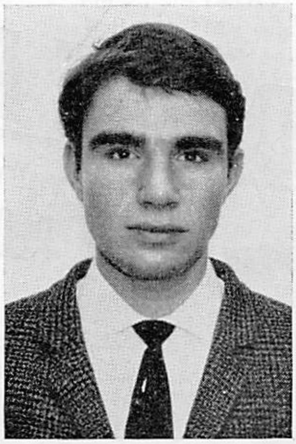
By now, every member should have received his Yearbook 1966-67. It is regretted that some delay is still being experienced in publishing the *Journal;* this issue is several weeks late and the Spring 1967 issue will probably appear in June. The delays have resulted from the need to review publication costs; however, the situation should be back to normal by the middle of 1967.

Scholarship Awards in Agricultural Engineering

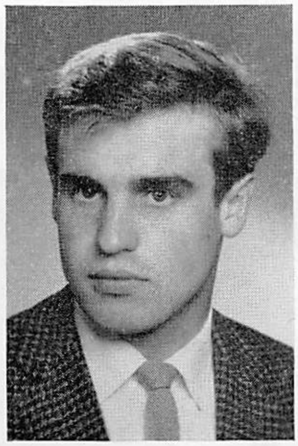
The Institution announces the the following Scholarships to full-time students of Agricultural Engineering during 1966-67



R. C. Osborne



R. Alcock



P. Crisford

W. F. Maunder

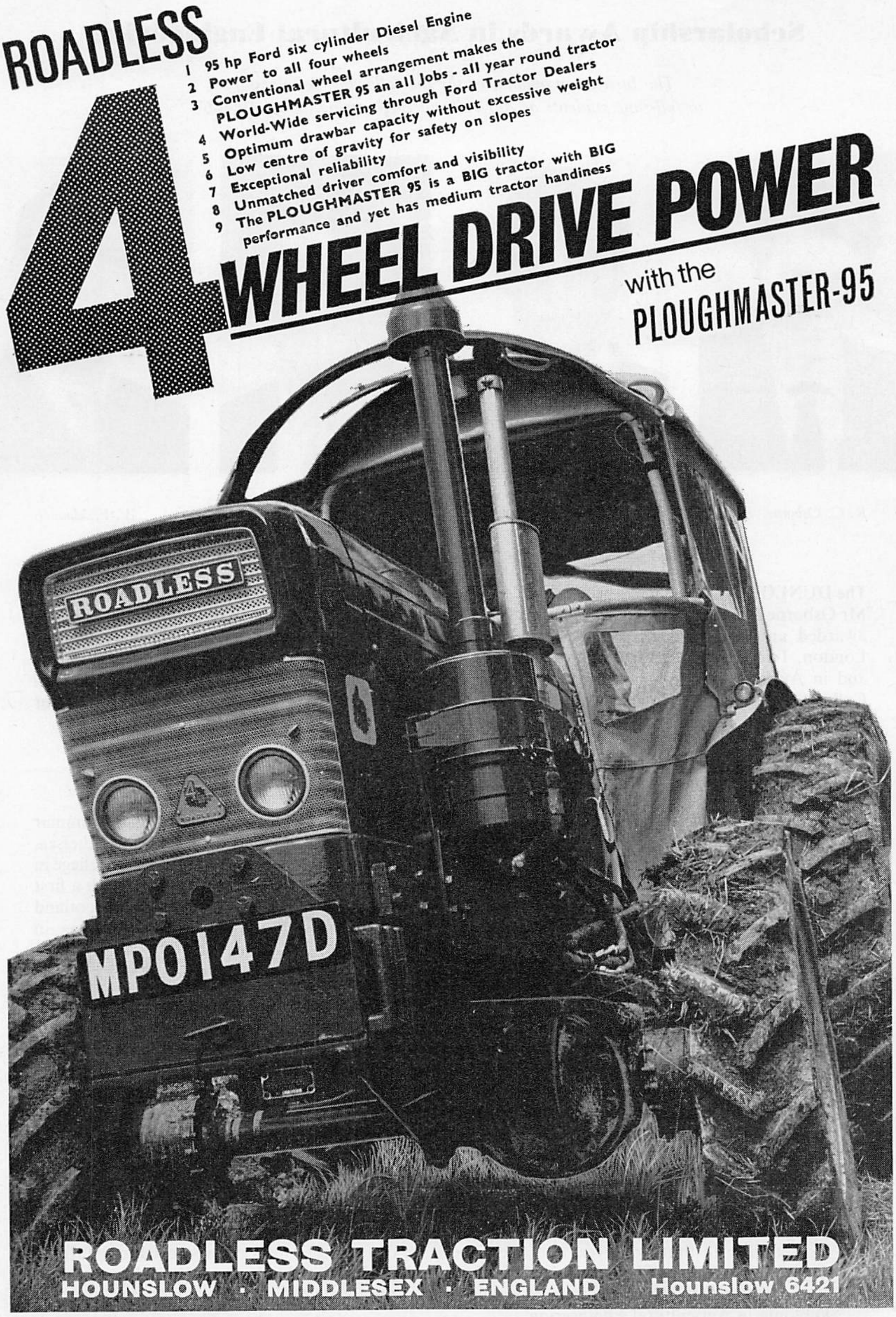
The DUNLOP Scholarship has been awarded to MR RICHARD C. OSBORNE, age 21, of Mill Hill London. Mr Osborne attended University College School, Hampstead, London from 1952-1962 and in 1966 was awarded an honours degree in mechanical engineering following a course at University College London. Two of his long vacations were spent gaining practical experience in agricultural engineering and in Autumn 1966 he commenced a one-year post-graduate course of study at the National College of Agricultural Engineering, Silsoe, Bedford, to make a special study of machine design for agricultural engineering.

SHELL-MEX & B.P. Bursaries have been awarded to:—

(1) MR RALPH ALCOCK, age 19 of Lancaster. Mr Alcock attended Doncaster Technical Grammar School from 1958-1963 and the College of Aeronautical and Automobile Engineering, Chelsea, London from 1963-1966. He followed a combined practical and theoretical course at the College in agricultural engineering and attained the College Diploma in Agricultural Engineering with a first class grading. In Autumn 1966 he commenced a one-year course of study at the West of Scotland Agricultural College, Blythswood Square, Glasgow C2, leading to the National Diploma in Agricultural Engineering.

(2) MR PAUL CRISFORD, age 21 of London. Mr Crisford attended Northampton Grammar School from 1956-1962. On leaving school he gained various agricultural experience in preparation for a course at Kesteven Farm Institute. After deciding to specialize in agricultural machinery he gained further experience through working with a firm of agricultural engineers and in 1965 he returned to Kesteven Farm Institute where he gained his City and Guilds 261 Certificate in Agricultural Engineering Technicians Work in 1966. In Autumn 1966 he commenced a one-year course leading to the National Diploma in Agricultural Engineering, at the Essex Institute of Agriculture Writtle, Chelmsford.

(3) MR WILLIAM F. MAUNDER, age 22 of Dorchester. Mr Maunder was educated at Prior Park College. Bath and Bournemouth Municipal College. On completion of his secondary education he attended Dorset Farm Institute for a year and after experience of general farm work proceeded to the Royal Agricultural College, Cirencester, at which he gained the National Diploma in Agriculture in 1966. He now attends the Essex Institute of Agriculture for the 1966-1967 course leading to the National Diploma in Agricultural Engineering.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THE PHILIP JOHNSON MEMORIAL LECTURE

A TRIBUTE TO A PIONEER AND NATURAL GENTLEMAN

by

JAMES A. CUTHBERTSON, OBE, MI AGR E*

Presented at a meeting of the Institution of Agricultural Engineers held at the Institution of Mechanical Engineers, London on 16 *November* 1966

I have the honour to present to you today a synopsis of the lifetime of service given to his country, his fellow agricultural engineers and to agriculture, transport and engineering in general by one whom a number of us knew very well in life and whom we now honour as one of our founder members and much respected friends, the late Lt.-Col. Philip Johnson, CBE, DSO, MI MECH E, HON MI AGR E.

May I be permitted at the outset of this talk to inform my listeners that I had not the good fortune of being closely associated with Col. Johnson until quite late in his life, so that much of what I will tell you I have had to glean from others. Although there may be slight discrepancies, some of you, I have no doubt, will have very much greater knowledge than I have of the work and life of this gentleman. Please do not condemn me for my lack of knowledge, which I hope may be compensated for by the very great respect which I had for Col. Johnson both in his work and as a man. Also at this juncture I would like to say that it is a wonderful thing in anyone's life to be able to give freely of one's experience and knowledge for the benefit of humanity at large and it has a two-fold advantage; it brings great benefits to the giver as well as the receiver. To men like Col. Johnson, the very fact that he was able to help others was in itself a benefit to him and was probably a basis of his philosophy of life.

I will tell you why I make this remark at this early stage. It was my pleasure some 8-10 years ago to have a visit from the Colonel to see some of the work I was doing in Scotland. It would be only fair to admit that our ideas did not always run exactly parallel. This I think was mainly due to the fact that often, when speaking to each other, we put forward our separate views but in discussion each of us appreciated the other's view and thoroughly thrashed out our differences. I always gave deep thought to the views of a man whom I realized had so much more experience in life and in the work which we were doing than I had myself. As a great respecter of experience, I always found the Colonel well worth listening to and well worth following to the last degree.

We had met, at the time I mention, to have a look at a track and tyre problem which was at that time interesting us both. I had the temerity to tell Colonel Johnson that I thought that tracks were the answer. The Colonel of course was almost the father of track development while I, at that time, was a mere child to this type of work. He had been saying to me that he thought there was great scope for four-wheel drive by large wheels, clad with rubber tyres instead of tracking, since the developments which were then taking place in the manufacture of very much larger wheels were opening up completely new fields. Our conversation took us along many paths and in fact we covered quite a bit of territory, seeing work I was doing and visiting various sites where work was in progress. We had accompanying us a friend of mine who at that time was working with the Shell organization in the mangrove swamps of Nigeria on exploration for oil and who had encountered many problems of land travel in swampy conditions, and this interested the Colonel. He had, in the field of transport on many different types of soil, a vast and well thought out knowledge to pass to others and we discussed for many hours the various things which could be done to develop oil in a country which, at that time, so badly needed the quick wealth which oil could bring —although no doubt, in our hearts, we would rather have seen something growing. As he left he was saying goodbye to my friend and he said to him 'I have no doubt you will be passing through London on your way back to Nigeria'; my friend agreed that he would be and Colonel Johnson, with his usual inimitable kindness, said 'What train are you travelling with? I will have a car at the station to meet you to get you to the airport to take you wherever you want to go.' Now, you may think this is a simple story to recount in this mad rush of life, when probably we do not always take note of very simple kindly actions, but greatness, at least to me, holds in itself not only great actions but great simplicity and I have always remembered Col. Johnson for his simple act on that occasion where there was absolutely no question of selfishness or business gain. It was just the action of a gentleman.

Now I would like to mention his early life, information of which I gleaned in the main from others.

Col. Johnson was the grandson of a former Chairman of the Gloucester Railway Carriage & Wagon Company, a Mr Henry Wright of Birmingham who retired at the ripe old age of 90 at the beginning of the century. Col. Johnson was apprenticed to a firm of ship repairers in South Wales, with whom he stayed for a relatively short time after his apprenticeship. In the 90's he spent two or three years with Maudslay, Sons & Field, the leading firm of marine engine builders at that time, at their works in Westminster Bridge Road, London.

At the outbreak of the South African War, he attempted

* Director, James A. Cuthbertson Ltd., Biggar, Scotland.

to join the army but was rejected on the grounds of defective eyesight. He then worked his passage to Cape Town on a cattle boat and succeeded in getting into a very primitive mechanical transport unit being organized by the military authorities. Motive power was provided by steam traction engines of various kinds.

He remained in South Africa for three or four years after the end of the war and then returned to England where he spent a year or so with Fowlers of Leeds prior to being appointed their representative in India. He was extremely successful in developing Fowler sales of steam rollers and tractors in India. I believe that for most of the time, the only European member of his staff was his wife, who acted as his secretary and general assistant, and his personal activities ranged from supervising the unloading of his cargoes at the port of entry to delivering complete machines under their own steam to the remotest parts of the country. In those days, immense topographical difficulties were associated with such unusual operations and wayside repairs were the order of the day. He also undertook, with his wife, sales tours extending from Bombay to Madras and Eastern Assam during which he acquired an intimate and varied knowledge of agricultural conditions throughout that country.

At this juncture, may I break in a little on the information which was supplied to me and give you again a few words on some of our early conversations and some of the things which drew Col. Johnson and myself together. As some of you know, we were always interested in our Institution of Agricultural Engineers in developing machinery which would make the growing and harvesting of rice very much easier. The Colonel was one of the people who was selected to put forward his views on this development. I had many long conversations with him on this subject and we exchanged ideas of various mechanical methods, complicated and simple, which might be adapted and might be of great use to the population of India and other rice growing countries. I have no doubt that his early stay in India gave him much of the knowledge at which I marvelled and which came out in our conversations. It was refreshing and of inestimable value to one like myself to get this first hand knowledge from an expert. We also, at that time, discussed at length the merits of a wire rope haulage system for working in paddy fields and again I marvelled at his knowledge of the various complications of this wire rope system which was really an early Fowler development. Now that I have learned of his earlier associations with Fowler, I can easily see the connection.

At the outbreak of war in 1914 he returned to England and obtained an honorary commission attached to the Ministry of Munitions. In 1915 his work brought him into contact with the very first stages of the development of the original tanks which quickly absorbed his whole time and energy. He went to France at the earliest opportunity and took part, as a Tank Commander, in the first operations in which tanks were ever used. He became involved in every aspect of tank warfare as it was then practised and, as regards its tactical and strategic implications, he shared the outlook of Fuller and Martel as opposed to that of the 'top brass' of the time.

Again I shall break in here to tell you another simple story of a surprise conversation which we had one day. We were again discussing the merits of tracks as against wheel and in my exuberance I said to him, 'Colonel, I have come across in the north of Scotland a most unusual vehicle built about the start of this century. As a matter of fact, I think it dates from around 1914 or 1915. It is known as a Citroen Kegresse'. I saw a smile come over his face as he asked me to explain it. I told him that this was a rubber belt type of half-track vehicle which was more or less a private car of that early vintage with a tracked rear axle assembly, the performance of which on peat bogs, to my great amazement, was absolutely outstanding. I had been invited by a friend to come to see the machine operating over Highland peat bogs. Hoping that I would get the demonstration over and start for home reasonably soon, I chose to test the machine on an extremely difficult bog; I was astonished to find that the machine performed perfectly over all of the area I had picked. It was an outstanding vehicle to have been designed at that time. The Colonel then said to me 'I knew the designer very well. Kegresse was a great friend of mine' and he then went on to tell me about the early development of the Citroen Kegresse which was in fact the first half-track vehicle made for military use and which not only operated as a military vehicle but had quite extensive use in desert work. It was eventually, I think, the main machine which undertook the early crossings of the Sahara and other deserts. I think that this machine was followed up eventually by some of the German adaptations of track vehicles.

After the war Col. Johnson became Chief Inspector of Tank Design and was responsible to the War Office for all tank development work until this essential activity was suppressed on the grounds of economy in 1923.

In 1919 he founded a company, Roadless Traction Ltd, with a view to the future exploitation of several patents he had taken out in connection with tracked vehicles. In 1923, therefore, he activated the Company and established it in its premises at Hounslow.

I understand that the early work of his Company was largely associated with the development of half-track conversions for commercial vehicles. Its early involvement in agriculture resulted in the production of tracked versions for standard steam agricultural tractors. The development of tracked and half-tracked versions of standard internal combustion engined tractors followed as a matter of course, together with the development of submersible tractors for the beach launching of lifeboats, and of the rubber jointed track which was extensively used in the sphere of horticulture.

It was in this latter field of half-track development and all of the wheel track development that I came closest to Col. Johnson. Again I will give you a simple little story to let you see how much the development of accumulated thought meant to a man like Col. Johnson. I had watched with great interest the development of Col. Johnson's half-track for agriculture and by this time I was in a position to make my own half-tracks. I felt, as a young designer that to cut out wear and give the maximum hp available from the engine to the ground were the essential points. I therefore set out to make half tracks which would give those features and found that although probably the theory was sound enough it was not so easily carried out. Probably, much of the ground might have been travelled by Col. Johnson, whom I had not yet met. I was therefore a complete stranger to him although, unknown to him, I had been watching some of his work, since I was particularly interested. I was exhibiting at both the Royal and Royal Highland Shows at that time and most of the new developments that I was making in agricultural engineering were being shown. Having brought forward the rubber and wire rope track and having tested it reasonably well, I thought it was time to take it down to the Royal Show to see what customer reaction would be. I received a pleasant surprise. There was a tremendous amount of interest. However I was not carried away because I had already learned some of the pitfalls. I went over to the Roadless Traction stand to have a look at their developments; Col. Johnson was sitting at the front of the stand. I can see the picture yet, as clearly as if it were yesterday. I hesitated for a little, because I thought he might misunderstand and think I wanted to copy rather than learn—two entirely different things. But I mustered up courage and went forward to introduce myself. He immediately said 'Sit down and let me hear your various experiences with your new development of half-tracks'. I think some of you will understand when I tell you that maybe I gilded the lily a little. The exuberance of youth is a good thing. Indeed sometimes I could wish to see it exhibited a little more in others. Anyhow, on this certain occasion, the Colonel listened with interest and pulled me up once or twice on statements which may have been a little rash. After a fairly lengthy conversation, he said 'I will come over and have a good look at this development during the evening when the rush of the day is past' and he was as good as his word. He came and we went over every detail and every point which I had tried to build into those half-tracks. He told me some of the faults and congratulated me on the points he considered sound. He then gave me his view on my own thories.

I can tell you now that he was right and I was wrong. After persevering with the half-tracks for some six or seven years (after this meeting with Col. Johnson) and remembering the conversation we had had, I decided that the correct method of development was to build from the ground floor up and not make an adaptation. I think, like the Colonel, that I found there were no wheeled tractors being built which could take the full engine hp through their rear axles and gearboxes, when one was able to give them tractive means to apply the hp to the ground. This, unquestionably, was what the half-tracks being developed by the Colonel and myself set out to do. The sum total of our work was that it eventually broke up the rear axles and gearboxes of the tractors, although very much good work was done in the interval, especially by the Roadless Traction half-tracks, which led the way to other developments.

Col. Johnson made a very large contribution—as is known by many—to the lifeboat service by making it possible to launch lifeboats on varied and difficult conditions along beaches, both by his tracked tractors and tracked trailers which carried the boats. He understood probably as well as any man in the early days, the simple facts of ground pressure and how to apply tractive effort under certain ground pressure conditions and shear strengths of very poor soil conditions. His open mind and search for truth never left him and this is one of the greatest aspects of someone who is privileged to leave to others a valuable asset.

Towards the latter part of his life, the Colonel switched his attention to large driven rubber tyres with certain types of tread. I am sure that many of you know of the more recent development and of the available four-wheel drive versions, large and small, which speak for themselves and which have the early stamp of the Colonel on them. I am sure if it were our privilege to have him with us today he would be the first to tell you that, in this work, he had a team and that the work of the team was in fact one of the foremost factors of his success. This of course is often the case, but in most teams there is a Captain and Col. Johnson was indeed the good Captain.

We again met each other and compared various designs in the field of very large driven tyres and again I will say, quite openly, that being a little biased towards tracks, I received a real surprise as to what tyres could do, from seeing the large-wheeled version of the Roadless Traction conversion of the Land Rover. Performance of the wheeled vehicle was quite outstanding. Although I do not know the details, I understand that one of his most recent loves was the development of a small amphibian exploration vehicle.

It is apparent that the brain behind the Colonel's work was a versatile one, capable of large contributions towards the development of various schemes of inestimable value to others. Although there must be many incidents and facets of this man s life of which I know nothing, I have tried, in a somewhat faltering manner, to pay tribute to Col. Johnson whom I greatly admired and whose example both in engineering and in his work with this Institution, is well worthy of being recorded in the memories of us all.

One feels that his varied experiences and accumulated knowledge resulted from his seeing and understanding eye and this may well be the outstanding secret of the human success which a man like the Colonel has among his fellow men. However, not only did those eyes appreciate the need in the field of engineering and development in agriculture, but also the need to pass on this information and ability to others. For a gifted man—such as the Colonel was—to see his life's work grow and develop and prove to be an advantage to many, must provide some measure of satisfaction. I feel that the Colonel must have felt this in the latter part of his life and I hope that he enjoyed some of the fruits of a very well-run race.

Immediately following the conclusions of the above lecture Mr R. Booth, AMICE, Managing Director, Roadless Traction Ltd, spoke as follows:

The Directors, staff and many employees of Roadless Traction, who knew Colonel Johnson particularly, asked me to join their thanks with mine to you tonight for inviting me to represent the Company which Colonel Johnson founded and which he directed for so very many years.

Most of you know him as being primarily a mechanical engineer interested in agricultural and allied developments. However, he was more versatile than that. Faced with any problem, he welcomed the opportunity to attack it. I was brought up as a civil engineer and as a result of his experience in India, he came to the firm of Consulting Engineers for whom I was working and said 'We want bridges of a kind which you can take up mountains on mules, with a few men to put them up with virtually nothing'. We got down to it and designed these things and I was personally involved in the design of a number of these bridges which materially contributed to the development of mountain transport in Burma and Eastern Assam shortly after the first World War.

Other developments of his I think you know about pretty well, but I would like to refer to an application of the girder track units which he was instrumental in developing. Perhaps you may remember at the beginning of the last war Sir Winston Churchill's naval land equipment, which was the code name for an immense burrowing machine. This was supposed to cut its way underneath or through the Siegfreid Line but, fortunately, it was not needed. However, it became necessary to transport large portions of this apparatus from Manchester, where it was being made, down to its operational base in Derbyshire and the only possible way of moving it was to put it on a specially-built trolley fitted to 20-ton track units and transportation was successfully effected. Unfortunately, with those locking girder tracks every time it passed over a traffic pad in a town, it would tear it up and fling it across the road. Stones would be cracked like nuts in the locking faces and break windows. From the point of view of the spectators and people who lived by the wayside, it was a rather terrifying experience.

If you will permit me, I will refer to a rather trivial and less serious incident which occurred in the really remote past. I first met Colonel Johnson when I was nine years old. By coincidence, my father also made his aquaintance when he was nine years old; Philip Johnson was then four. They met at a garden party at my grandmother's house in Gloucester and after eyeing each other for some time with distaste, were informed that they were only there on sufferance and on condition that they became friends and playmates. You can imagine that to two small boys this suggestion was perfectly horrifying and they both tried to escape in opposite directions but they were quickly seized and pushed into each other's arms where they were forcibly made to embrace and kiss each other. That very inauspicious introduction did in fact develop into a friendship lasting until my father's death 75 years later; I refer to that as a special instance of Colonel Johnson's particular gift for making and keeping firm and lifelong friendships. I am quite certain that this evening's meeting is itself the best possible proof anyone can have of that truth and I can assure you that nothing could be more acceptable to Colonel Johnson than the manner in which you have chosen to commemorate him and I must say that I found Mr Cutherbertson's address quite absorbing and greatly enjoyed it, as it gave a really true picture of many sides of the Colonel's life.

Dr J. S. Clarke, OBE, PHD, C ENG, MI MECH E, **of Joseph Lucas Ltd. then spoke as follows:**

It is a great honour to be here tonight to attend this Memorial Lecture to a very distinguished engineer. I am here in two or three different roles—to represent the President of the Institution of Mechanical Engineers, Lord Hinton, bringing you his greetings and those of the Institution as a whole; on my own part as a former Chairman of the Automobile Division of the Institution, and also as a farmer!

TABLE 1

PRODUCTION

Agricultural Industry
(in millions of £'s)

	1960	1961	1962	1963	1964	1965	% Increase 1965/1960
Engineering							
Machinery	54.2	67.4	57.5	62.1	73.8	88.4	63%
Tractors	112.1	108.9	124.5	141.9	128.4	122.7	9%
Total	166.3	176.3	182.0	204.0	202.2	211.1	27%
EXPORT	101.7	104.0	114.0	129.6	126.6	133.1	31%
Produce							
Sales at the Farms	1,504.5	1,609.7	1,667.1	1,660.1	1,791.0	1,849.1	23%
Food Imports	1,394.6	1,336.9	1,443.3	1,525.1	1,622.3	1,573.4	13%

I have enjoyed listening to Mr Cuthbertson; clearly his lecture is a hall-mark of a brilliant engineer, and he has, I am sure, interested the whole audience in the personality of the late Colonel Johnson. His choice of words and the composition of his matter has given us a beautiful pen-picture of the man, and although I am not proposing the vote of thanks I would like to say to Mr Cuthbertson how much I have appreciated his lecture.

Colonel Johnson, with several colleagues, founded this Institution which was a brotherhood of a number of kindred spirits—engineers who wished to apply themselves to engineering amongst the farming and earth-moving operations (a subject which had been somewhat neglected by the profession of mechanical engineering). There is no doubt that Colonel Johnson and his immediate colleagues have made a remarkable impact on the study of agricultural machinery and by the formation of this Institution given increased status to engineers working in the agricultural industry.

Agricultural engineering now figures to an ever increasing degree in our own personal domestic lives as well as the life of the country. It is of interest to review the contribution that agricultural engineering makes to the National Economy.

From Table I it will be seen that the export content of agricultural equipment is strong, but by no stretch of the imagination has it reached the maximum.

The sequence of the above endeavours must be considered in relation to the labour on the farms, which is given in Table II.

TABLE II

U.K. FARM LABOUR

	1960	1966	*Decrease*	%
Total full-time male workers	410,000	268,000	142,000	35%
Add total full-time female and seasonal workers	570,000	410,000	160,000	28%
(There has been a general decline in the number of workers in agriculture since 1960 except in the year 1963 when there was a flattening out of the trend)				

The tremendous output of the agricultural industry will be noticed while at the same time, we are importing about 50 per cent by volume of our food, at a cost of £1,530 million to our foreign exchange. British farms can undoubtedly produce more, and reduce loss of currency, given the requisite machinery and Government policy.

TABLE III

MOTOR INDUSTRY PRODUCTION (1965) (millions of £'s)	*Total*	*Export*
Passenger Cars	735.1	249.0
Commercial Vehicles	353.8	140.4
Motor Cycles	17.8	9.2

It is interesting to compare the above data relating to agriculture with the output of the motor industry.

It can be seen from Table III that the output of the motor industry is inferior to that of the agricultural industry. The exports of the motor industry are smaller than our imports of food. To increase our home-grown food production we need more effective machinery in order to increase profitability per man and also to increase the return on capital investment. At the same time, and with all the pressures we can command in engineering design, productivity and overall efficiency, we must increase the exports of our automobile and engineering industries.

There is one aspect of the work of agricultural engineering that I would like to emphasize. Product quality and reliability (QRY). You are all aware that this is a special year of endeavour, but speaking as a farmer I would like to say that in many instances one can quarrel with the quality of the engineering products from your industry insofar as the surfaces have not been properly prepared from the point of view of having received appropriate pre-treatment and final painting. In so many cases new machinery is delivered to the farms that is already showing signs of considerable corrosion which, in the long run, will result in decreased durability and ultimate loss in farm production. I would suggest to you, Mr President, this is a matter of serious concern to the work of your Institution, and that the appropriate British Standards of the S.M.M. & T. should be examined and introduced.

I have enjoyed this lecture very much indeed. I think it has been beautifully given.

The following Vote of Thanks was given by Mr D. R. Bomford, HON MI AGR E, **Past-President of the Institution:**

It is my privilege to speak for the members of the Institution and for the many friends of Colonel Johnson who are here tonight and to thank you, Mr Cuthbertson for the Memorial lecture that you have given us. You have almost apologized for the short period of years during which you knew Colonel Johnson. Everybody here will be feeling that that apology was totally unnecessary. Knowledge of a man is not necessarily acquired by long years of contact; real knowledge comes by shared experience particularly when it is shared in circumstances of adversity, of which men like you and Johnson inevitably have had more than your share. You have known the bright glow of success alternating with the cold douch of failure. The common creed to which you both adhere is that if a thing has been done by somebody else it is not really worth doing.

Of course, none of us is old enough to tap the Colonel's stream back to its source, although I think Mr Booth can take us back further than anybody else. I cannot help thinking tonight of that distinguished Past-President, Wilfred Nolan, who was with him in the first pioneering days of the early tanks and I believe shared with him the experience of their initial use in the first of all tank attacks. Looking back, it seems that the closing of the Tank Research Department, of which he was Director, must have been a terrible blow. He, perhaps, more than anyone else, would know the folly of that action and he lived to see another generation of soldiers paying a terrible price for that act of folly.

I think it is possible to mark down some of his best achievements after retirement from his Directorship; I would regard the rubber-jointed track as something so completely original and so logically designed, as an escape from the pin and bush, that it was typical of Johnson. In exactly the same way the driven girder track, a thing which never moved under load, a thing which required no idlers to support it and a thing that worked in compression instead of in tension was again a brilliant conception. It was extraordinary that a man who had worked all his life on tracks could in his old age break away and say 'This is not on the right lines, I am going on to something different'.

Sir, you have given us a portrait of a man who arrested our admiration and our affection, a portrait which has highlighted for us his characteristics of wit and wisdom, courage and kindness and for this you have our sincere gratitude.

OPERATING CONDITIONS FOR MAXIMUM EFFICIENCY IN THE USE OF CLEANING AND GRADING MACHINES FOR GRAIN

by

D. W. Garvie, B SC(ENG), MI AGR E*

The cleaning and grading of grain is important to the use of all kinds of grain for milling, brewing and other industrial purposes. Cleaning and grading of seed is especially important for seed which is to be sown. To obtain high quality seed that will increase farm production and provide uniform raw material for industry, efficient seed-cleaning practices are necessary. Even though many types of machine are used it is estimated that at least 50% of good seed is lost in cleaning and handling because it is damaged or not sufficiently cleaned to meet quality standards.

One machine basic to all seed-cleaning plants, from the small farm to the largest commercial plant, is the air-screen cleaner. Virtually all other separators are finishing machines and follow the air-screen unit in the processing line. The air-screen cleaner makes seed separations mainly on the basis of three physical properties, namely, size, shape and density.

The purpose of this paper is to throw some light on the process of passing grain through a reciprocating screen and in this way to show how greater efficiency of separation can be obtained.

Separation can only occur when the separable constituents are over the middle mesh and are directed through it by means of a force. As long as the material lies in a very thin layer on the middle surface without any friction or positive connection between the grains, movement of the material in the middle plane is as a rule sufficient for the separable elements to fall through the middle mesh as a result of gravity. However, as soon as the material is held together by cohesive forces, these static forces must be offset by dynamic ones during separation. Dynamic forces in the material can be produced only by acceleration of the material by the riddle. When layer depth does not greatly exceed the size of the elements that are being separated, small accelerations are enough to ensure separation. However, with greater depths of layer, the material must be so rapidly accelerated that the separable elements overcome the resistance to penetration of the surrounding material and the cohesive forces and so reach the middle apertures.

In view of the practical importance of this separation the determination of the best oscillating conditions of the sieve has been regarded as one of the fundamental tasks. As a result of these investigations it has, in particular, been established that the efficiency of the sieve depends to a large extent on the magnitude of the maximum acceleration of the sieve, $\omega^2 r$, and that there is only one definite value of this factor at which the highest quality of work is obtained.

It is known that the breaking up of the grain mixture on the sieve is effected only by the relative displacement of the grain and sieve for which purpose an oscillating motion is imparted to the sieve. The arrangement shown in Fig. 1 has been used almost exclusively in grain cleaning machinery.

The arrangement is a pivoted four link system in which the link AB is the dressing riddle, AC and BD are the supporting straps, link CD is the frame of the machine. The supporting straps are of equal size and parallel to each other and are vertical when in the central position.

The four links system is caused to reciprocate by the crank OE=r through the connecting rod EA, which is in the same horizontal plane as the axis of the crankshaft As compared with the length of the supporting links the radius of the crank is sufficiently small so that the arc described by point A may be assumed to be a chord. For this reason the following relation may be accepted without great error: $\frac{r}{AE}=O$.

The equation of the speed of relative motion—the sliding of the grain down the sieve can be shown to be as follows:—

$$\frac{ds^d}{dt} = K_1\left[\omega r\left\{\sin\omega t - \sin\omega t^d\right\} - g\left\{t - t^d\right\}\tan\left\{\alpha - \phi\right\}\right] \qquad (1)$$

Equation (1)

and up the sieve:

$$\frac{ds^u}{dt} = K_2\left[\omega r\left\{\sin\omega t - \sin\omega t^u\right\} - g\left\{t - t^u\right\}\tan\left\{\alpha + \phi\right\}\right]$$

Equation (2)

when s^d = relative motion of the grain down the sieve.
s^u = relative motion of the grain up the sieve.
ω = angular velocity of the crankshaft.
r = radius of the crankshaft.
α = inclination angle of the sieve.
φ = dynamic angle of friction between the grain and the sieve.
g = acceleration due to gravity.
$K_1 = \cos\alpha + \sin\alpha \tan\varphi$
$K_2 = \cos\alpha - \sin\alpha \tan\varphi$
t^d and t^u = moments of time, denoting the beginning of sliding down or up respectively.

* Proprietor, R. G. Garvie & Sons.

Depending on the magnitude of the acceleration $\omega^2 r$ the grain may either slide down the sieve only or up and down or finally it may break away from the surface of the sieve.

To obtain the maximum efficiency of separation, the sliding of the grain up and down without breaks is the most favourable type of motion, since any movement of the grain off the sieve, i.e. making the grain jump on the riddle, is useless—i.e. the optimum magnitude of the acceleration factor is bound to lie within certain limits.

It can be calculated from the formulae that for average conditions in which $\alpha=8$ deg. and $\varphi=17$ deg, the best acceleration must lie between 7.5 to 70 m/sec^2.

Firstly let us examine theoretically the condition under which a single grain in the form of a rotating ellipsoid passes through a perforation (Fig. 2). Suppose that the grain (a rotating ellipsoid with small diameter d and a large diameter l and which moves at a relative velocity v along an inclined plane set at an angle α) moves towards a sieve perforation of $D (D > l)$ diameter. The relative velocity at which the grain can still pass through sieve perforations D under the action of the force of gravity, and above which it will jump over will be expressed in the equation:

$$V_{max} = \frac{\left(D - \frac{L}{2}\cos\alpha\right)}{\sqrt{\dfrac{2\left[\left(D - \frac{L}{2}\right)\sin\alpha + \frac{d}{2}\cos\alpha\right]}{g}}}$$

Equation (3)

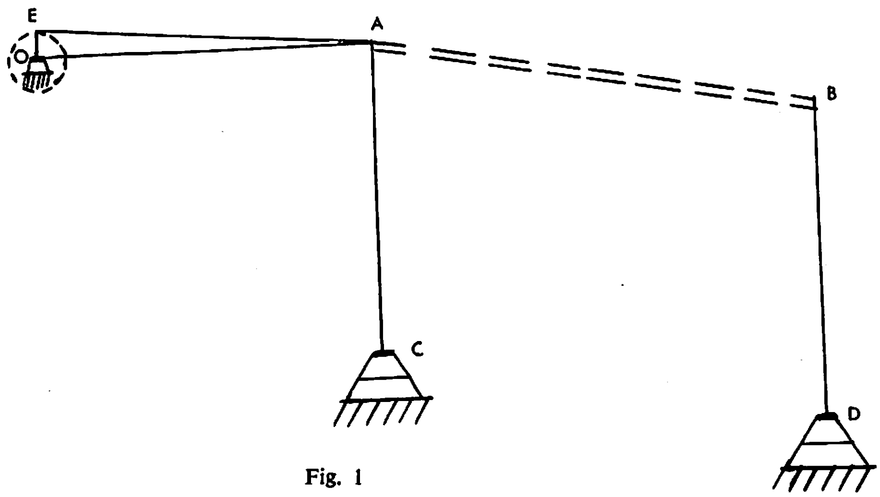

Fig. 1

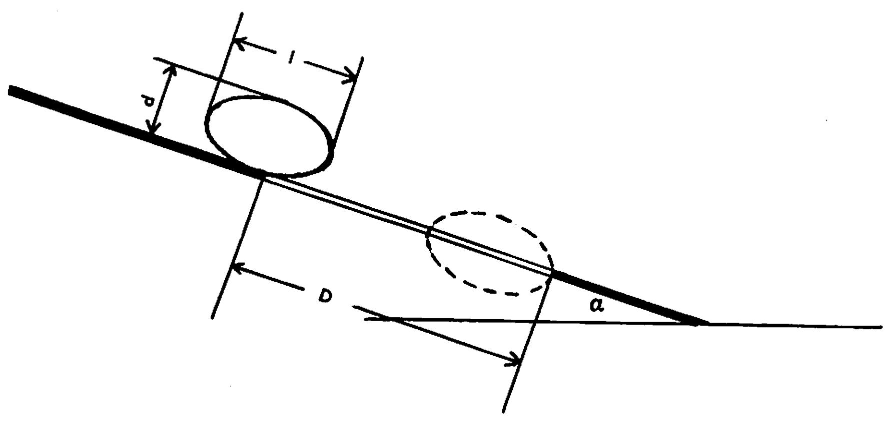

Fig. 2

When $\alpha=0$, equation (3) becomes:—

$$V_{max} = \frac{D - \frac{L}{2}}{\sqrt{\frac{d}{g}}}$$

Equation (4)

The formulae given above has been derived for individual grains and for this reason they do not take account of the influence of a whole series of factors, appearing in the movement of a layer of grain. However, they are useful to shed some light on the fundamentals of the question under examination. It follows from (3) and (4) that the magnitude of the limit speed V increases with the length D of the perforations. The limit speed of grain motion imposes certain limitations on magnitude of the acceleration factor $\omega^2 r$.

Fig. 3, $\alpha=8$ deg; $\varphi=17$ deg.; $r=0.007$m and $\omega^2 r=30$ m/sec^2; the grain will slide up and down the sieve without jumping.

In the established movement the points A, A_1 and B, B_1, denoting the beginning and end of sliding up and down, will lie in the same horizontal plane. The relative speed of the grain varies from nil to a maximum and once more to nil. If the length of the perforations of the sieve and the dimensions of the grain are known it is possible to calculate the limit relative speed of the grain. If its value is plotted from point A downwards and through point C, a straight line CD will be drawn parallel to AB.

If this straight line intersects the wave of the sine curve (points 1 and 2) the relative speed of the grain will obviously exceed the limit speed and consequently no sifting of the grain will take place.

For the most favourable conditions of separating the grain it is essential that the straight line CD does not intersect the sine curve or that at the most it is its tangent i.e. the following conditions must be met.

$$\left(\frac{ds^u}{dt}\right)_{max} \leq V_{max}$$

Equation (5)

The moments of time at which the speed of relative motion of the grain reaches a maximum t^d_m (at a movement of the grain down the sieve) and t^u_m (at a movement of the grain up the sieve) are determined from the formulae:

$$t^d_{max} = \frac{\pi}{\omega} + \frac{\cos^{-1}\left\{\frac{g\tan(\alpha-\phi)}{\omega^2 r}\right\}}{\omega}$$

Equation (6)

$$t^u_{max} = \frac{2\pi}{\omega} + \frac{\cos^{-1}\left\{\frac{g\tan(\alpha-\phi)}{\omega^2 r}\right\}}{\omega}$$

Equation (7)

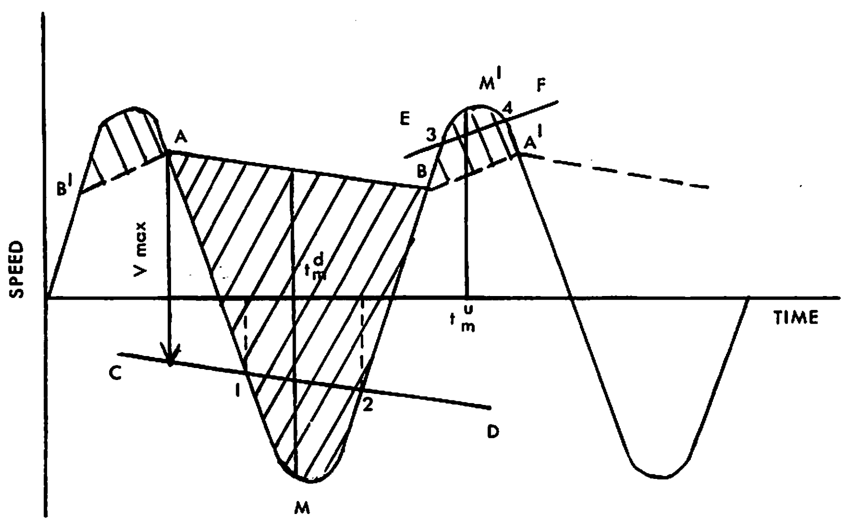

Fig. 3

The maximum value of the relative speed of the grain is found from equation (1) by introducing into it the time t^d_m from the expression (6) instead of t and the time t_A from the expression:

$$t_A = \frac{1}{\omega}\left[\cos^{-1}\frac{K}{\omega^2 r} + B\right] \quad \text{where} \quad B = \frac{\pi \tan(\alpha-\phi)}{\tan(\alpha-\phi)+\tan(\alpha+\phi)}$$

& $K = \tan(\alpha-\phi)\frac{B}{\sin B}$, where t_A represents the moment of time when the grain starts to slide down the riddle. (FIG. 3)

Equation (8)

Then the formula (5) can be written thus.

$$K_1\left[\omega r\left\{\sin\omega t^d_{max} - \sin\omega t_A\right\} - g\left\{t^d_{max} - t_A\right\}\tan\left\{\alpha-\phi\right\}\right] \leq V_{max}$$

Equation (9)

The only unknown factors in this equation are the angular velocity ω and the radius of the crankshaft (r). If the value r is given, the angular velocity can be determined and consequently also the magnitude of the oscillating factor $\omega^2 r$.

The expression (5) is correct only for sieves with oblong mesh, since for this mesh the limit speed of relative motion of the grain has a value which always satisfies the condition

$$V_{MAX} > \left\{\frac{ds^u}{dt}\right\}_{MAX}$$

In the case of sieves with circular mesh, V_{max} is so small that it may be written:

$$V_{MAX} < \left\{\frac{ds^d}{dt}\right\}_{MAX}$$

For this reason the relative motion of the grain will exceed the limit both when the grain moves down and when the grain moves up the sieve.

On the speed diagram (Fig. 3) this is expressed graphically by the straight line CD cutting the sieve curve at points 1 and 2 and the straight line EF, cutting the sieve curve at 3 and 4.

The angular velocity and consequently also the limit value of the acceleration may be approximately determined by setting up the function:

$$\left\{\frac{ds^u}{dt}\right\}_{MAX} \leqq V_{MAX}$$

Equation (10)

which permits one to find the angular velocity. Equation (5) and the similar equation for circular mesh riddles also are transcendental and it is easier to solve them by graphic means. For this purpose the graphs (Figs. 4a and b) are plotted for different values of $\omega^2 r$; $V^d_{max}=f(\omega^2 r)$ and $V^u_{max}=f_1(\omega^2 r)$.

At a certain limit speed the upper limit of the acceleration for sieves with oblong and circular mesh can be determined from these graphs.

In experiments[1] conducted on a laboratory riddle (Fig. 1) the efficiency of the work of the sieve was assessed by the efficiency of separation which was calculated from the formula:

$$\varepsilon = \frac{p}{p_1} \times 100$$

where ε = efficiency of separation in %

p = weight of grain passing through the mesh of the sieve in the test.

p_1 = maximum possible separation (weight of grain capable of passing through a sieve with a mesh of given size).

Fig. 5 shows the curves of variation of efficiency of separation in relation to the number of rev/min of the crankshaft. Curve (b) is for sieves with circular mesh of 1.8 mm and curve (a) for sieves with oblong perforations of 1.5×20 mm with their long side in the direction of motion of the sieve.

Both curves were obtained with the same material at the same angles of inclination, amplitude of acceleration and capacity. The effective dimensions of the sieve mesh were selected in such a way that both sieves separated the grain mixture at the same ratio; consequently the thickness of the layer of grain on the sieve was the same in both cases. In this way it was possible to observe the influence of the shape of the mesh in its pure form having excluded the influence of all other factors. As will be seen from Fig. 5 the shape of the curves is quite different.

Curve b is steeper than curve a. The maximum values of efficiency of separation for curve (b) are reached at n=400 rev/min or at an acceleration oı $\omega^2 r=12.3$ m/sec² whereas curve (a) reaches the maximum at n=500 rev/min or at an acceleration of $\omega^2 r=19.3$ m/sec². It can be deduced from formula (3) for a rectangular mesh of 1.5 mm×20mm and a circular grain diameter of mustard seed d of 1.9 mm at an angle of inclination of the sieve of 8 deg; that $V_{max}=0.68$ m/sec.

Similarly for a round-hole mesh of 1.8 mm and assuming a grain diameter of 1.9 mm at an angle of inclination of the sieve = 8 deg,

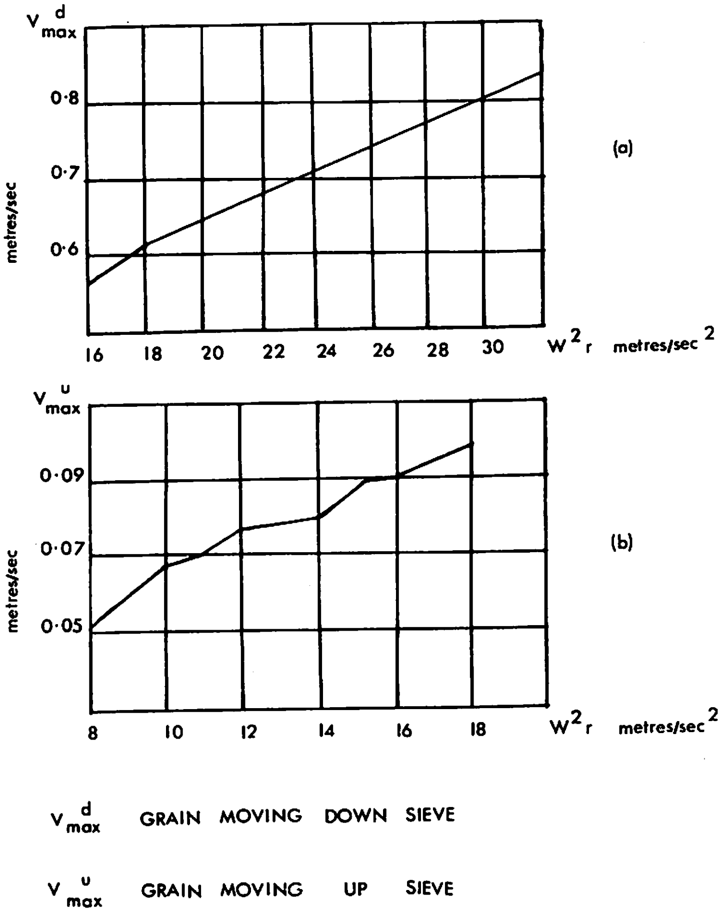

Fig. 4a and 4b

V_{max}=0.0765 m/sec.

Using curves 4(a) and 4(b) a limit value of:

$\omega^2r=22$ m/sec^2 will be found for sieves with a mesh of 1.5×20 mm at $V_{max}=0.68$ m/sec.

From graph 4(b) a limit value of $\omega^2r=12$ m/sec will be found for sieves with a mesh of 1.8 mm at $V_{max}=$ 0.077 m/sec.

Taking into account that the formula of the limit speed and graphs fig. 4 (a and b) have been derived for individual grains, it must be admitted that the theoretical results coincide with the experimental ones.

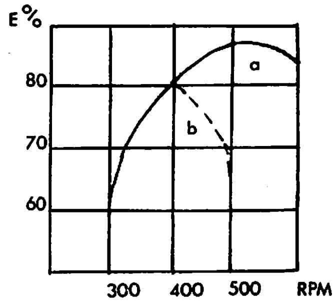

Fig. 5

It will be seen from the character of the curves that sieves with a circular mesh are more sensitive to variations in the acceleration and its optimum value is approximately 50% lower than in the case of sieves with oblong mesh.

When the relative motion of the grain exceeds the limit speed a condition is created causing the grain to jump over the mesh openings, but since grain is less likely to drop through a circular hole than through an oblong one, grain has in the second case a greater chance of passing through the following mesh opening after jumping over one. This explains the slow reduction, on sieves with an oblong mesh, in the completeness of sifting after reaching its maximum.

Thus in establishing the rotational speed of the crankshaft of grain cleaning machinery whose separating arrangement consists of sieves with oblong or circular mesh one must start from the optimum value of acceleration for sieves with circular mesh. With such an approach a sieve with circular mesh working under the most favourable accelerating conditions gives the best separating efficiency and the efficiency of the sieves with oblong mesh is reduced only to a very small extent.

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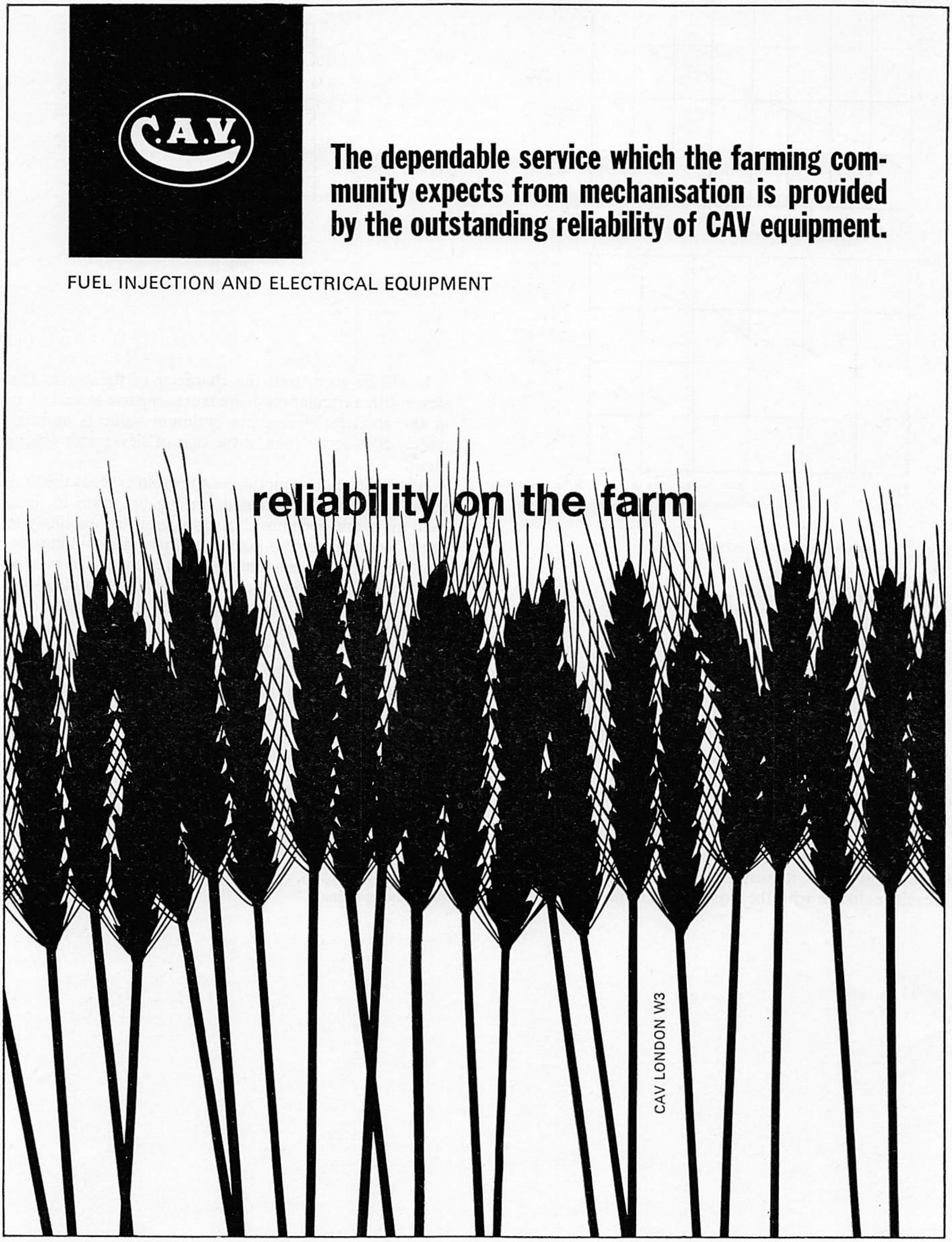
1. Ksifilinov *The Dynamic Working Conditions of a Flat Sieve* (Sel. Khozmashina)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GENERAL ENVIRONMENTAL REQUIREMENTS FOR LIVESTOCK

by

D. W. B. SAINSBURY, MA, PHD, BSC (VET SCI), MRCVS*

Presented at the Annual Conference of the Scottish Branch of the Institution, at Dunblane, Perthshire on 2 March 1966

HOUSING FOR INTENSIVE BEEF PRODUCTION

Many problems with the environment are occurring in the modern densely stocked intensive cattle yard. These are generally connected with respiratory disease and pneumonia, condensation and dampness of the litter, and poor growth in the colder weather. It is hardly surprising perhaps that this has occurred since the cattle are being housed as densely as in a piggery or a broiler chicken house, yet attention to environmental control is rudimentary or even absent. We accept that animals on slats or on litter from three months onwards are reasonably well endowed with protective hair and are quite hardy, but it is wrong to suppose that they can be kept in grossly fluctuating and humid conditions. Nor are they able to accept with equanimity undue exposure to the elements, particularly to draughts, to which they may have no resistance by virtue of their previously sheltered existence. In practice, we find the following major faults are commonly made in the construction of yards.

1. There is either none, or insufficient, ridge outlet for stale air.
2. Eaves openings are absent, or where they are present are uncontrollable and at the mercy of the weather, causing chilling draughts in cold weather.
3. The extreme width of many yards (120 ft upwards) prevents natural ventilation functioning properly. This problem is often combined with multi-span construction and low eaves and roofs so that the flow of air is generally impeded.
4. The gable ends of the yards are closed.
5. The roof contains no thermal insulation layer.
6. Poor drainage around the yard leads to excessive straw usage.

The practical approach that may be taken to deal with problem of environment in these yards is suggested on the following lines.

Extraction Ventilation

Firstly, ridge ventilation must be adequate and unobstructed. Natural ventilation works on exposed sites, but it is useful to have it controllable. An open ridge 1 ft wide and with a flat continuous top at least 6 in. above is a simple answer, but a more satisfactory arrangement is to have a series of chimney-type ventilators along the ridge, allowing 50-60 in^2 per beast. A useful size of chimney is one 30 in. square, sufficient for fifteen animals. With natural ventilation, the opening can be controlled by a butterfly valve.

Secondly, mechanical ventilation is achieving greater popularity, as it has done with other forms of intensively housed stock. With a system of chimney trunks mechanical ventilation can be added as a complementary arrangement, since an extractor fan may be fitted at the base. If a 24 in. fan running at maximum revolutions of 900 per minute is fitted, 6,000 ft^3/min will be removed. An approximate maximum allowance of 200 ft^3/min per beast or approximately $\frac{1}{4}$ ft^3/min per lb body weight is found satisfactory, so that one fan will serve up to thirty beasts.

Thirdly, control of the fans can be achieved automatically or semi-automatically, using a proportion (one half to two-thirds) of the fans on thermostatic control, with a thermostat which is easily seen and adjusted. Fans which are thermostatically operated should have automatic anti-back-draught flaps fitted to prevent down-draughts when they are switched off. All fans should be speed controlled.

With fan ventilation the number of roof outlets that need be installed is reduced by one half. The total cost of a fan operated system will hardly be in excess of £2 per animal-place, which is an economical cost for semi-automatic environmental control.

Intake Ventilation

The inlet of fresh air is no less important, and it has been found satisfactory to provide inward opening hopper flaps along both side walls, bottom hung and 2 ft 6 in. to 3 ft deep, with gussets and variable control with either casement stays or remote control from the central passage when present. Alternatively, the hoppers may be controlled from the ends with greenhouse-type fittings. The top of the inlets should not be closer than 2 ft below the eaves. The flaps should be made so they can be removed or hinged down flat in the summer and should extend along at least half the wall length, and preferably two-thirds.

With wide yards of over 70 ft span it is recommended that slatted boarding (4 in. boards, $\frac{1}{2}$ in gaps, or 6 in. boards and 1 in. gaps) is fitted at the gable ends, part of which area is made as hinged doors that can be opened in the summer. This is normally not necessary however, in narrow span yards.

It is not suggested here that this is the only recommended method of ventilating intensive cattle yards. Other mechanical means have been used, often with success. Some of the more sophisticated methods do, however, need more careful designing and management to prevent draughts and to give adequate control. The

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system suggested is logical and generally understood and easily controlled by the stockman. Mechanical assistance is complementary to natural flow and indeed may be used as an additional and complementary stage in development and improvement. Draughts are least likely as there is the fullest control of the system. Ventilation continues to function at a reduced rate in the event of power failure since natural 'stack-effect' ventilation takes over from the fans to tide the stock over this period.

If the trend of high stocking continues, it is inevitable that the farmer will turn increasingly to thermal insulation of the surfaces, just as has been found necessary in piggeries. Farmers who have used insulation of the roof have recorded considerable benefits in terms of live weight gain and food conservation. It also helps to solve the environmental problems. The optimum temperature for intensively kept beasts may be as high as a range of from 50-60°F., so that in cold winter weather, insulation must be used to maintain the right conditions. A very popular way of arranging the insulation is by using two skins of asbestos sheeting for the roof separated by a vapour sealed layer of mineral or glass wool. For the latter, 2 in. thick is desirable, 1 in. a minimum.

For those with existing buildings, a false ceiling or wire mesh supporting vapour sealed insulation is very economical.

It must be emphasized that individual attention does need to be given to each yard according to the site and locality. It is one of the advantages of fan ventilation that with mechanical assistance, this statement is much less true. The use of fans partially rules out the dependence on site and weather. It is generally better to have yards in exposed positions because it is easier to restrict the open area if too much air comes in than to open up the ventilating space in a sheltered spot. Sometimes the proximity of other buildings makes it impossible to increase the air flow at all.

Yards are often made very wide, in the order of 100-150 ft. These are the most difficult units to ventilate. From the point of view of ventilation, it is desirable to limit the span to 70 ft approximately. Indeed if the trend towards the use of thermal insulation continues, a different conception may develop on the desirability of having adequate cubic area. In an uninsulated yard, a large cubic area helps to buffer the outside weather extremes. But, in insulated constructions, the roofing area must be reduced to a minimum to cut costs and more economical dimensions would be a height of 12 ft to eaves with a maximum yard span of 70-80 ft.

CALF HOUSING

The provision of correct housing conditions for calves has always been important, but with more intensive methods, the risks and dangers from bad housing become proportionately greater. Calves can usually thrive well when kept in ones and twos in loose boxes, but when specialised buildings are used, much more care is needed in detailed design. Ventilation, insulation, drainage, pen sites, fittings and materials must all be carefully chosen to avoid cold, dampness, bad hygiene and other housing conditions that lead to poor growth and disease.

The Environment

The calf is not a delicate animal, but when it is very young, great care must be taken to avoid any 'stress' produced *chiefly* by fluctuations in conditions, but in general by cold, damp and draught. The housed calf will develop its natural hardiness relatively slowly and the aim in the beginning is to keep the calfhouse temperature above 50°F, and as near as possible between 50 and 60°F. In the veal house, temperatures are needed higher than this and between 60 and 70°F is more usually the aim. The relative humidity of the air is also a guide to the conditions needed, and we try and keep it below 80% and nearer a maximum of 70%. These conditions are easily obtained if correct design is used with perhaps a little supplementary heat for the youngest calf. Farmers find cheap answers are electric infra-red lamps or fan heaters or gas space heaters of the flameless or radiant heat types. Nothing elaborate or expensive is necessary.

Ventilation can be on simple lines, in some respects similar to beef yards. Inlet ventilation is normally provided by using inward opening bottom hinged hopper windows along both sides of the building. It is essential that there is variable control on these windows and this can be done by having several holes in the top of the gussets and small bolts in the windows to pass through them. This gives a completely rigid fixing. Double glass is strongly recommended, not so much for the reduction in heat loss, but because it will prevent condensation. In the most exposed areas of the country, it is often preferred to have some small baffled ventilators between the windows to enable the latter to be completely closed in cold and windy weather. Outlet ventilation is easily effected using box type outlet chimneys with flat tops as illustrated. Fan capacity should be on the basis of a maximum of approximately 25 ft^3/min of air per 100 lb of calf liveweight in the house.

Lighting, incidentally, is easily provided if hopper windows are used. No great areas of glass are needed in the calf house, but wherever roof lights are preferred or used of necessity, double thickness is essential. With artificial lighting, it is satisfactory to bank on the basis of a light point (incandescent bulb) every 10 ft along the house. The veal calfhouse normally has artificial lighting only.

Thermal Insulation

To keep the building at the correct temperature and the surfaces free from condensation requires the use of insulated construction. Insulation of the walls can be in a traditional manner—that is using a cavity brick wall or two skins of concrete blocks, or by the use of now well tried prefabricated methods which are tending to push the laborious traditional ways out. Roof insulation should be of a very high standard. A good construction would be an interior lining of flat asbestos sheets, with a vapour seal on top of this of polythene or kraft paper. Over this would rest 2 in. of glass fibre with an air space and finally the outer cladding on top. This construction is economic, hygienic and requires no maintenance.

When calves are to lie on a concrete floor with the usual amount of bedding, it should be damp proofed and insulated. From below, the floor would be built up as follows: site concrete, damp-proof course, insulation layer, e.g. wood wool slab or lightweight concrete layer, and finally 1-1½ in. cement and sand screed. The floor should have a good fall—recommended is 1½ in. in a yard.

Finally, to assist in correct environmental control, the size of the building should be kept within modest proportions. The very large building is to be avoided and the roof should be kept low. Where a larger building is to be adapted to house calves, it is strongly recommended that it is divided into smaller sections by complete cross-partitions. In planning calf accommodation, it is most important that the building can be closed at times completely, disinfected and rested. It is desirable to have separation of housing for calves in two units—one for the very young, another for the older calf, as not only are different environments needed, but the disease risk is reduced in this way. If a building is to take all ages of calves, it is often very difficult for it to be completely vacated and rested—but this is quite essential if disease build-up is to be avoided.

Pens and Layout

Generally the best layout is to have the pens of a calf house on each side of a centre passage not less than 4ft wide. Drainage can then be to shallow channels on either side of this passage discharging to a gully at one end.

For the first few weeks, individual pens are preferred for calves, but they are not essential and pens containing 3 or 4 can certainly be used. Satisfactory space allowances are as follows: allow for single pens a maximum of 24 ft^2 per calf up to three months, but rather less is possible and pens as small as 4 ft 6 in. × 3 ft or 2 ft 6 in. are sometimes used, giving areas therefore as small as 13½ and 11¼ ft^2 per calf. The smaller sizes are not usually liked so much, and good dimensions are 5 ft × 4 ft for the young calf up to six weeks. Space allowances should be increased up to 40 ft^2 by six months and 50 ft^2 by twelve months—when traditional straw bedded pens are used—though rather less is often given satisfactorily. For example, one has seen excellent pens taking six calves to four months of age, allowing only 25 ft^2 per calf. A reduction up to 50% in the dimensions given would appear to be permissible. This flexibility is important as so many calf houses are adapted buildings where an exact following of recommended figures can be difficult.

A development of considerable importance in recent years has been the use of slatted floors for young calves. Also, portable pens that can be easily assembled, to take young calves up to 2-3 months of age, have been tried and found satisfactory. They can be dismantled for cleaning and disinfection, and placed in any suitable box or building, and thus allow the utmost adaptability and avoid expensive specialization. Slatted floors are often made of 2 in. × 2 in. or 2 in. × 1¼ in. slats spaced 1½ in. apart. On top of the slats can be placed ½ in. wire mesh to stop the bedding (long straw) falling through. Such slats can be used in portable pens or as a top floor over an existing concrete one.

Pen divisions are always a debatable point, and an endless argument goes on as to whether solid permanent wall, demountable solid wood or metal divisions, or tubular rails should be used. Probably it matters little which are used if the conditions in the building are right, but it should be pointed out that solid permanent walls should be smooth cement rendered, and are still difficult to clean and disinfect adequately. It is a great advantage if divisions can be taken down and cleaned, and of course, when divisions can be dismantled, pens can be run together as necessary. All in all, there is much to be said for solid sheeted divisions that are taken right out as the solid partitions are cosier for the calf and prevent sucking between calves in different pens. Useful sections are, in fact, made up economically in exterior grade plywood. The front of the pens can be made in timber or galvanized metal with access by the calf through openings to food and water containers outside. The whole front should be easily unfixed. Where several calves are kept together, the front should have yokes so the stock can be secured for feeding, and usually some time afterwards hayracks should be provided, with 2 in. spaces between the slats. They may be fixed on the inter-pen partitions near the front. Automatic water bowls should also be fitted as near the front of the pen as possible, so that spillage passes straight outside.

CONTROLLED ENVIRONMENT PIG HOUSES

Our increasing knowledge of the nutritional and environmental requirements of the pig, together with the need to reduce housing and labour costs have led to the 'Controlled Environment' Pig House as a logical step forward in pig management. For most stages of the pig's life it is felt we can generally provide the best conditions by keeping them indoors. The precise feeding requirements are well established so that there is no necessity to keep stock on pasture to derive nutrients and by concentrating the stock into a few buildings, labour can be reduced to a minimum. Farmers also appreciate more and more that the pigman is a man of infinite value and his time should be used to manage and tend the pig, not to hump food or shovel dung! If however, mechanical means are to be used to move food into the piggery, and dung out of it, costs must be carefully watched, yet the pig must not suffer, as so often is the case. The machinery must serve both the pig and the pigman, and not the reverse.

A correct order of priorities in designing a controlled environment pig house would be strictly to put the pig and the pigman first, with labour and constructional requirements, important as they are, quite definitely second. Problems that have occurred in the controlled environment house have been connected far more with the stock than with the machinery or construction.

The Environment

The starting point must be to define the term 'Controlled Environment' and decide what is needed and how it can be achieved. The aim is to control temperature, ventilation and light, and keep them within the range required by the pigs. This will be achieved in practice by good design of the building, limiting the cubic air space, good insulation of floor, walls and roof, mechanical ventilation and artificial heating wherever necessary. We shall require a temperature of 70-75°F for the weaner, 60-75°F for the fattener, and not less than 50°F for the adult. Heating is needed only for the piglet and probably as a temporary measure at some times of the year for the weaner. The standard of insulation should be equivalent to at least 2 in. of glass fibre or mineral wool in a cavity between two impervious linings. A 3 in. thickness adds little to the cost and is a further substantial help. Artificial lighting is satisfactorily provided by one row of lights (Tungsten bulbs) at 10 ft centres over the food passage or the pen, and another row of low intensity over the dung passage. Light intensity control is an important feature of the controlled environment pig house and this is quite easily achieved by installing a voltage regulator or altering the bulbs.

Design Essentials

First essential—above all else—is to make sure that any unit for young pigs is so divided that it can be regularly emptied, cleaned and disinfected. Intensive housing invariably demands this or 'build-up' disease agents generally occur. It is well known that pigs or any form of livestock 'do' well in a new building: these benefits may be retained indefinitely by running the pigs through the building on a 'batch' basis. Design must also provide surfaces that can be cleansed and disinfected readily. Clean rendered walls, or hard impervious inner claddings such as asbestos or exterior grade plywood provide this. This is not to say that ordinary wooden fittings should never be used, but if they are, they should be easily removable for resting and disinfection.

Keep the Building Small

The greatest enemy of one pig is another! Ideally, one pig in a unit by itself would give the best results. We cannot do this economically, but we may approach it by various means. To achieve periodic depopulation without leaving a building empty for more than three weeks, and then achieving full stocking, it is essential to keep the overall size of the building down. The actual size must depend on the size of the herd, but in any event, a fattening house for 200 pigs is big enough, whilst a farrowing house of 16 stalls is also a good maximum.

Economics can always divide a unit into two. For example, two eight-pen farrowing houses may lie on each side of a central food store, effectively making it into two separate units.

The more partitions there are within a unit the more this may help towards good hygiene and good environmental control. A fattening house with 200 pigs will benefit from three or more cross partitions: 50 pigs in a common air space is quite a good criterion though much depends on the health status of the herd. The need for divisions within a unit are far less in a self-contained herd than on a farm where pigs are being bought in. The excellent results that such successful farmers as Mr Jordan of Northern Ireland who buys in over 23,000 pigs per annum yet achieves extremely low mortalities and disease incidence is undoubtedly partly due to the benefits of keeping the pigs in small groups quite separate from their fellows. It is also most vital not to have too many pigs per pen nor to be too enthusiastic in their stocking density. One of the major problems that has occurred in 'Controlled Environment' housing and particularly where no bedding is used, is cannibalism, shown in its various forms of tail and ear biting and savagery. It is apparently much more common in the large pen (e.g. 20-30 fatteners) where the bully has every opportunity of satisfying his perversions. A large pen may also lead to more unevenness in the pigs because the large pig expands its appetite and its size at the expense of the small one!

Cannibalism, an enormous problem in the modern litterless piggery, may be related to other factors of course. If it is boredom, a chain should be hung for the pigs to bite on or give the pigs some hardwood legs to play with. If it is environment, the building may be too hot and stuffy—apparently a very common reason. Reduced light intensity or a change to red lights may help. Cannibalism presumably arises because of discomfort for one reason or another, and the root source, needless to say, may be nutritional. Though nutrition is outside the scope of this article, it must be considered and particular thought given to the content of the food (enough vitamins and minerals?) and the texture of the food (does the pig need a coarser diet to aid its digestion?)

Slats and Floor Feeding

Increasingly, pigs are being reared on solid floors, without troughs and with slatted dunging passages. Little or no litter can be used. Pen size and design and number are all vital considerations. If the pen is long and narrow, with the dung passage along the narrow width of the pen, and if the pen contains a large number of pigs, it is difficult for the pig at the end remote from the passage to get to the dung passage at all. Hence, he will muck on the floor and floor feeding on top of muck is not good practice! Also, it may be questioned as to whether he will get enough water from the automatic bowl over the slats. There is therefore much to be said for a square design of pen, allowing access to the dung passage not from one corner but both corners adjoining the passage.

Single-Stage Housing

The way in which pigs, kept together as an entire litter unit, progress excellently from birth to finishing has long been observed. Also well known are the ill-effects that may result from moving and mixing pigs. Each move may check growth for several days, and depress appetite. Mixing of pigs nearly always leads to some fighting. A move or a mixing seems to upset the 'bacterial equilibrium' of pigs and it is often after one or the other that certain diseases so often occur—for example Bowel Oedema. It may therefore be asked why a building should not be used that involves no move from birth to finishing. This in fact is being done with considerable success by several breeders. It requires ideally a controlled environment house: pens can be of normal farrowing pen size with all fittings demountable and floor feeding after the piglets have been weaned. This might be the pattern for the future in the controlled environment house and such a design should certainly give the farmer every chance of rearing the healthiest pigs in the quickest possible time.

PROBLEMS WITH INTENSIVE POULTRY HOUSES

Because the size of poultry units are generally greater than any other livestock units, disease problems are probably at their greatest. The environment is all-important in trying to *alleviate* symptoms because drugs offer no cure. It may therefore be helpful to look at the subject in this case from a different angle, viz. how should an adviser approach the problem 'in the field' when he is asked to investigate a problem. Bascially, however, the question asked and the solution to be applied are similar in other forms of animal housing.

Procedure for Investigation of Poultry Housing Problem

(*a*) First impression on entering house: a stuffy, high temperature in summer indicates insufficient ventilation, a damp fetid atmosphere with perceptible ammonia smell is indicative of low ventilation rate in cold weather. Draughts and uneven temperatures may be noted in a careful walk down the length of the house.

(*b*) Stock distribution. The position of the birds when kept on the floor should be observed immediately the house is entered and before they are disturbed. Bad distribution indicates uneven temperature, ventilation or lighting. The density of stocking should be noted and may be checked against accepted standards (from 0.5 ft^2 per bird for broilers, up to 3 ft^2 per bird for deep litter layers). In sickness, birds tend to huddle in groups and this can sometimes be noted as the first sign of an impending outbreak of disease.

(*c*) Temperature. It should be noted whether the temperature in the building is within the accepted range for the type of birds being examined. For intensive poultry houses air temperatures should range from 70°F for the brooder or broiler house at day-old to 50° to 55°F for the adult. The use of space heating should be noted; carefully used, this greatly assists in the maintenance of correct conditions.

(*d*) Ventilation. With mechanical ventilation, the fan capacity should be checked to see if it is sufficient for the birds housed (up to 1 ft^3/min per lb bodyweight for broilers and 2 ft^3/min per lb for layers.) Errors are common in this respect as also are the absence of suitable controls on the fans. Check that fans are all speed controlled: note position and setting of thermostats remote from air inlets. Thermostats should, for preference, be used in association with not more than two-thirds of the fans. The use of one thermostat connected with all fans and without speed controls is a typical and glaring mistake. The thermostat itself should not be a box type which is too slow to respond. Thermostat temperatures are commonly set too high, giving the correct temperatures at the expense of ventilation. Examine fans to see that they are correctly mounted in ducts that are clean and give unrestricted air flow. They should always be of slightly larger dimension than the fans themselves. When 'natural' ventilation is used, check that the outlet area is sufficient (up to 6 in^2 per bird for layers).

(*e*) Air inlets. Many errors are common in inlet design, the most serious being (1) poor distribution of inlets, (2) absence of sufficient controls, (3) bad design giving direct down-draughts, (4) insufficient inlet area, (5) siting of inlets too close to the ceiling, and with exposed purlins giving indirect down-draught.

(*f*) Construction. Condensation on surfaces is a common fault that indicates either bad insulation, bad ventilation or both. Another frequent fault is poor fittings of doors, windows and ventilators, giving rise to draughts and uncontrollable ventilation.

(*g*) Floor and Litter. Caked and wet litter usually indicates poor ventilation but may also be associated with damp underfloor conditions, (water-logged soil etc.) and absence of guttering.

(*h*) Light. Observe that the distribution of light in the house, natural or artificial is of even intensity. Incandescent lighting points should not be more than about 12-15 ft apart and are usually better at 10 ft intervals.

(*i*) Space Heating. A good brooder or broiler house should have means of space heating and/or brooding giving a maximum capacity of about 10,000 Btu/h per 1,000 ft^2 of floor area.

(*j*) Siting. Finally, some attention should be given to the siting of the house. Houses in particularly exposed positions often suffer from the effects of high winds and special measures may be needed to control its effects by placing wind baffles over inlets and giving finer controls to inlets and outlets. In abnormally sheltered positions, fan ventilation will not normally be affected, but natural ventilation may be more restricted or even unworkable.

It will be appreciated that there are few of these points that do not lend themselves to consideration in examining housing problems in any livestock building and form a general basis for *locating* the underlying cause of the trouble and its subsequent *correction*.

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The Institution announces its Agricultural Engineering Symposium to be held in September 1967. At this first event of its kind to be held in Britain nearly 50 papers will be given, ranging over the broad spectrum of agricultural engineering technology in the world of today. All Divisional Sessions and meals will be held in the National College of Agricultural Engineering. Limited residential facilities will be available.

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CONSERVATION OF HEAT WITHIN FARM BUILDINGS

by

MICHAEL F. TILLEY, ARIBA, AMTPI, ASSOC IHVE*

Presented at the Scottish Branch Conference of the Institution on 2 March 1966 at Dunblane, Perthshire.

Building for warmth begins at the planning stage. Each animal in a building produces so much heat. In that building there are so many square feet of floor, wall and roof space. If this total quantity is divided between the number of animals housed then there will be an area through which each animal's heat will escape. This heat loss can be halved either by doubling the resistance to the heat loss, i.e. by doubling the insulation, or else by halving the area. In practice, neither is usually possible on such a scale as this and it is a matter of a bit of both, reduced area and increased insulation, but the mathematical heat equation remains the same. In terms of money it is, of course, cheaper to reduce the area than increase the insulation.

Fig. 1 shows a section through a piggery with a fairly narrow feeding passage, no trough, and pigs housed at the minum Brambell recommended area—six square feet of sleeping area and two square feet of dunging passage each. The eaves are kept as low as will allow a man to walk in comfort along the dunging passage. It has a total area from which heat can escape of 57 ft^2 per pig.

Fig. 2 shows the same accommodation planned on more generous lines. The feeding passage is a foot wider. The pigs have a 7.5 ft^2 per pig for sleeping and feeding area and 3.5 ft^2 per pig of dunging passage. The side walls have been raised to eight feet to eaves with a view to possible future adaptation. More generous than Fig. 1 but by no means a 'pig palace', or a wastefully extravagant use of space, these quite modest increases have increased the total area through which heat can escape to a 77 ft^2 per pig—same number of pigs housed, same heat input, but 25.6% greater area through which the heat can escape. This leads to a 25.6% reduction in heat rise between inside and outside the house. If Fig. 1 gave say a 20°F temperature rise over outside ambient, then Fig. 2 would give a 20°F minus 25.6% or only a 15°F temperature rise.

In this case we have considered two buildings doing much the same sort of job, with materially the same type of management. Even more dramatic changes can be obtained when slightly different types of housing and different types of management are considered.

Fig. 3 shows a cross section through a fairly conventional beef cattle yard. The beasts are housed in a strawed yard on either side of a roadway so that they can be fed from a tractor and trailer or a forage box. They are allowed 50 ft^2 of yard space per animal. The area of floor, walls and roof through which heat can escape is 379 ft^2 per beast.

Fig. 4 shows the same accommodation, only the beasts are housed on slats, with a central auger feed into double sided manger. Each beast has 25 ft^2 of yard space (again minimum Brambell recommendations). The heat escape area is reduced here to 126 ft^2 per beast, a 200% improvement.

Nor is planning in relation to animal accommodation the only thing to consider. Fig. 5 shows a fairly reasonable piggery. From the labour saving point of view it may be handy to start mucking out at one end and go out at the other, also to be able to feed right through and go on from the end into the next house. But from the heat conservation point of view, these six doors, three at each end, spell draughts—particularly if pairs at opposite ends get opened at the same time once or twice a day. Fig. 6 shows a far happier arrangement with at least the one most used access through a food room which will do much to buffer the effects of a strong cold wind. If the dunging passages could be slatted and the outside doors to the dunging passages cut out altogether so much the better.

Here of course, heat conservation conflicts not only with labour saving, but also with the control of disease spread. I think most people will agree that one of the most effective ways of controlling the spread of disease is to build a series of small housing units rather than one large one. From the labour saving point of view it is desirable to have plenty of doors, so that men can get quickly and easily from one unit to another. Here there is a conflict of planning requirements, and it is necessary to consider them all and strike the most satisfactory balance in the circumstances. It is, however, important to bear *all* considerations in mind; unless you do it is unlikely that you will strike a very satisfactory balance.

Now having got the shape and layout of the building right, what do we build it of to conserve as much heat as is economical to conserve?

It has been shown above that there is no simple answer to this question. If you have the minimum area through which heat will escape, you will achieve satisfactory results with a lower level of insulation. If you have a larger heat escape area, you may well need a higher degree of insulation to achieve the same result. The answer is, however, a mathematical one, and a heating engineer, in designing any building, performs certain calculations to reach a satisfactory answer. These are designed to equate the quantity of heat available to warm the room with the 'U' values of the building materials, the areas involved, the anticipated temperature outside the building, and the temperature it is designed to maintain inside the building. I do not propose to go in detail into these calculations. If you want to learn how to do them, there are a number of text books and reference books available. In particular, may I draw your attention to a recently

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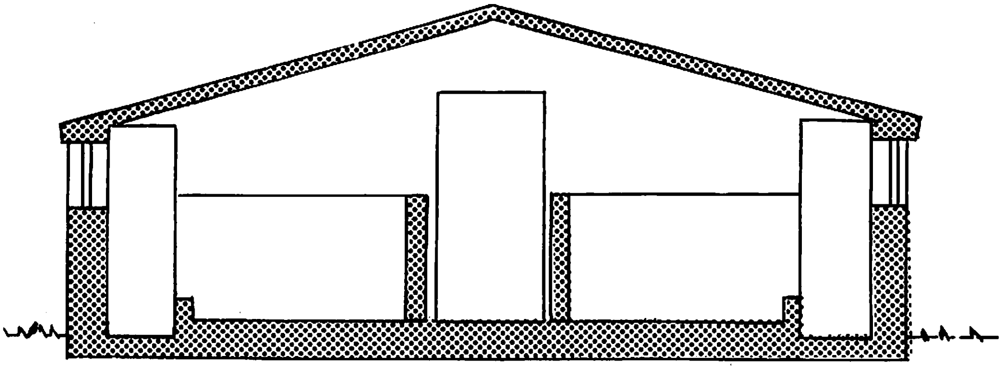
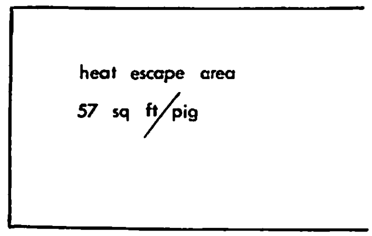
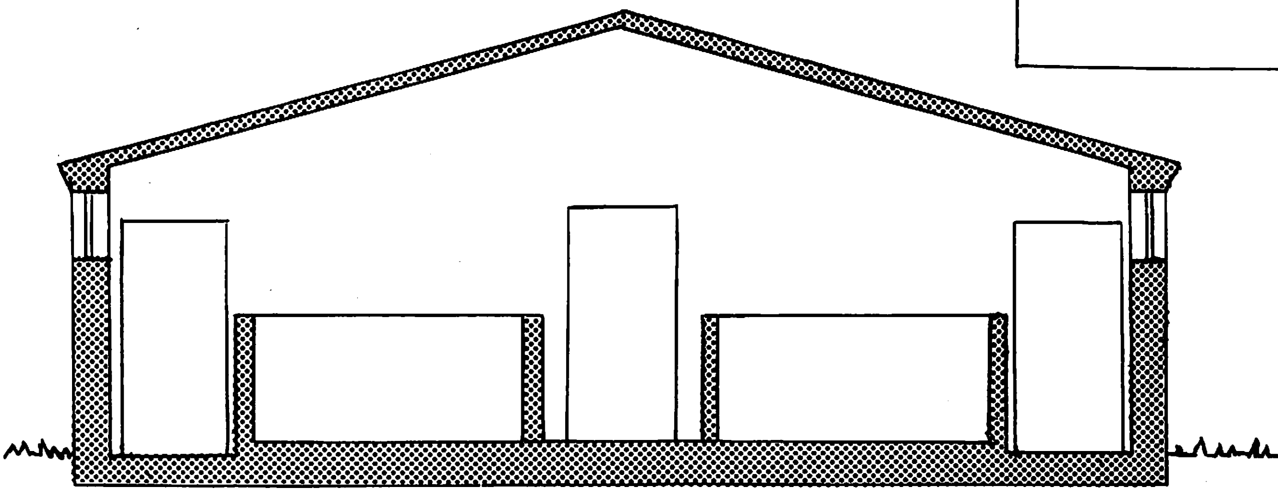


Section through Piggery

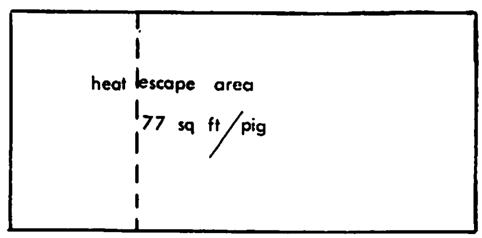
FIG.1

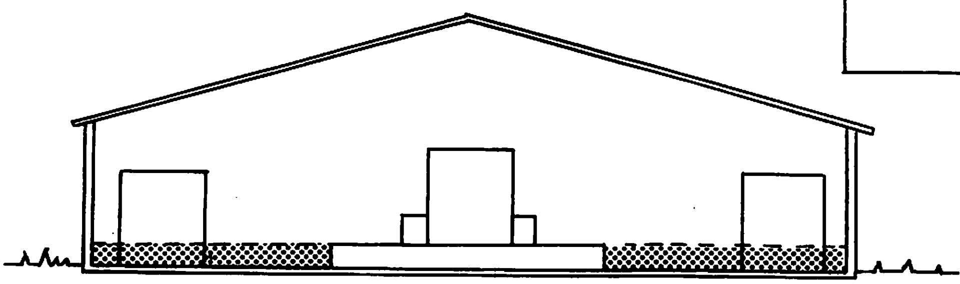




Section through Piggery

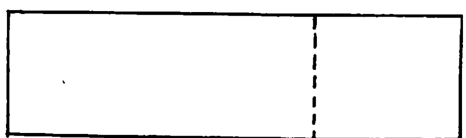
FIG. 2



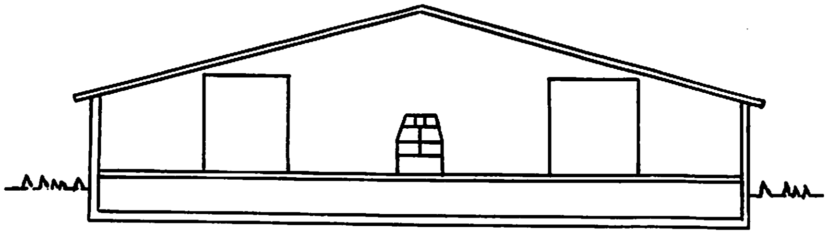


Section through beef yard

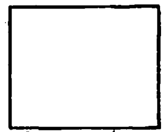
FIG. 3



heat escape area 379 sq ft/beast



Section through slatted beef yard



heat escape area 126 sq ft/beast

FIG. 4

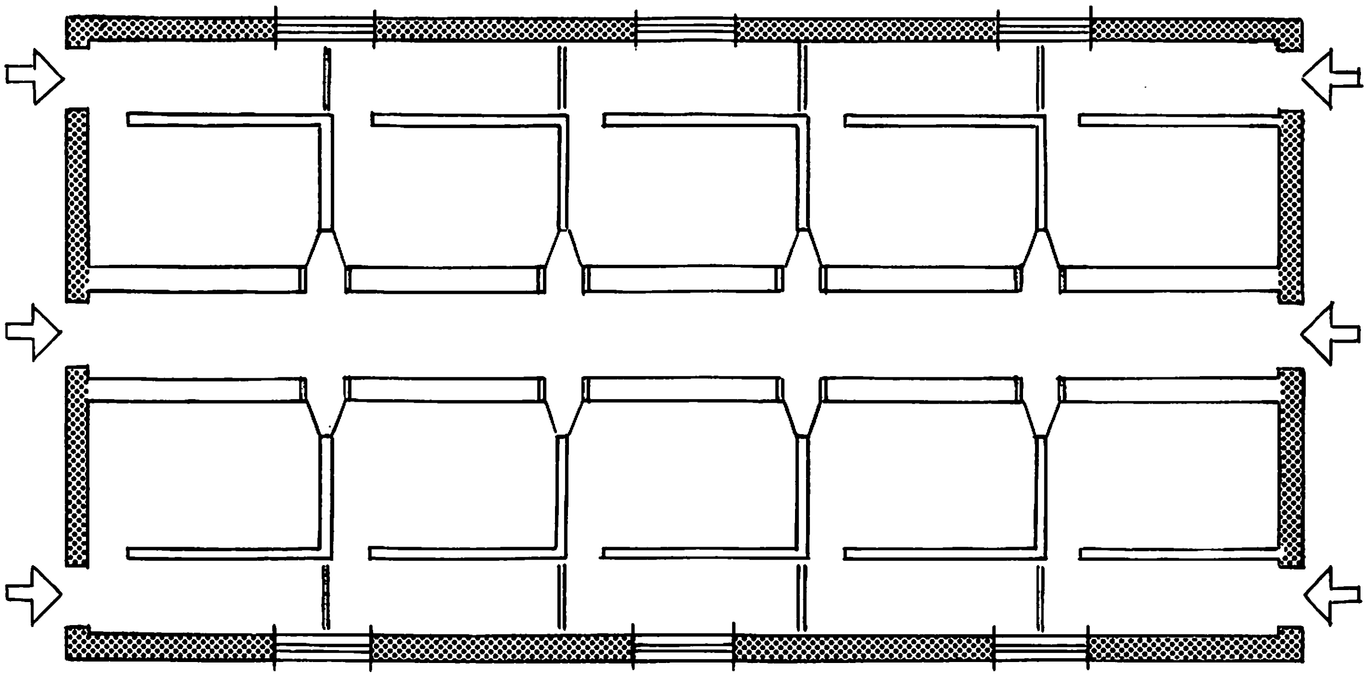


FIG. 5

Plan of Piggery

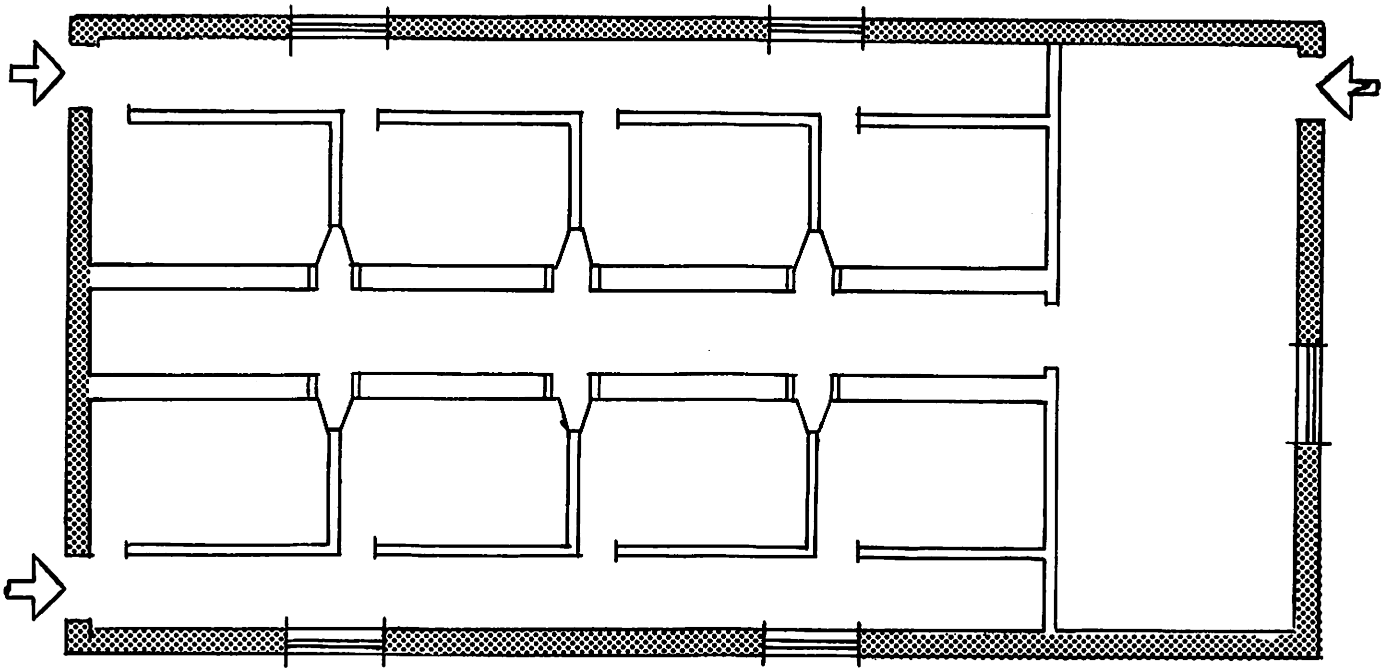


FIG. 6

Plan of Piggery with foodroom

published EDA Handbook No. 10 'Control of Environment'.[1] But for those who do not wish to bother themselves with very lengthy calculations, there are a number of fairly simple, but none-the-less reasonably accurate methods of deciding the level of insulation required in any particular set of circumstances. To be able to compare various materials, it is important to know something about 'U' values and 'K' values. I hope I am not insulting your intelligence by describing these things in detail. If I am, I apologise, but I have heard so many farmers and consultants flicking these figures about without a clear understanding of their meaning, that I think it worth spending a little time on them. In any system of buildings, heat flows, like water, downhill until it finds its own level, that is from high temperature to low temperature until the two temperatures are equal. The steeper the hill, i.e. the greater the temperature difference, the quicker the heat flows. However, in flowing through any form of construction heat encounters certain resistances as I have depicted in Fig. 7. Here you will see that the heat encounters a certain resistance on meeting the inside surface of the wall. This is, in very many cases, constant no matter what the material. Heat then encounters the resistance of the first building material, in this case an insulant, so the resistance is high and is represented by a steep line. The heat then meets further resistance when it leaves that material and crosses an air gap. It meets further resistance on entering the second building material and also in crossing it. In this case the second material is not so good an insulator, so the resistance is represented by a shallower line. Finally, on leaving the wall the heat meets a further surface resistance before it is finally blown away by the wind. Now the total resistance encountered by the heat can be represented by the line AB and it is the reciprocal of this which is the 'U' value which is of interest to the heating engineers. This is a measure of the number of Btu per hour which will escape through a square foot of the construction when there is a 1°F difference between internal and external temperature. This sort of figure is specific to a particular type of construction, to the thickness of the various material used, and the sorts of air space in between the various materials. It is useful to compare one type of construction with another. To be able to say for example that corrugated asbestos roof underlined with 1 in. expanded polystyrene has a 'U' value of 0.17 whereas a claytile roof on felt with ½ in. fibreboard nailed to the under side of the rafters has a 'U' value of 0.35. The first 'U' value is about half of the second. That is to say, the first sort of construction will let through half the amount of heat that the second will. It is therefore twice as good as an insulator as the second.

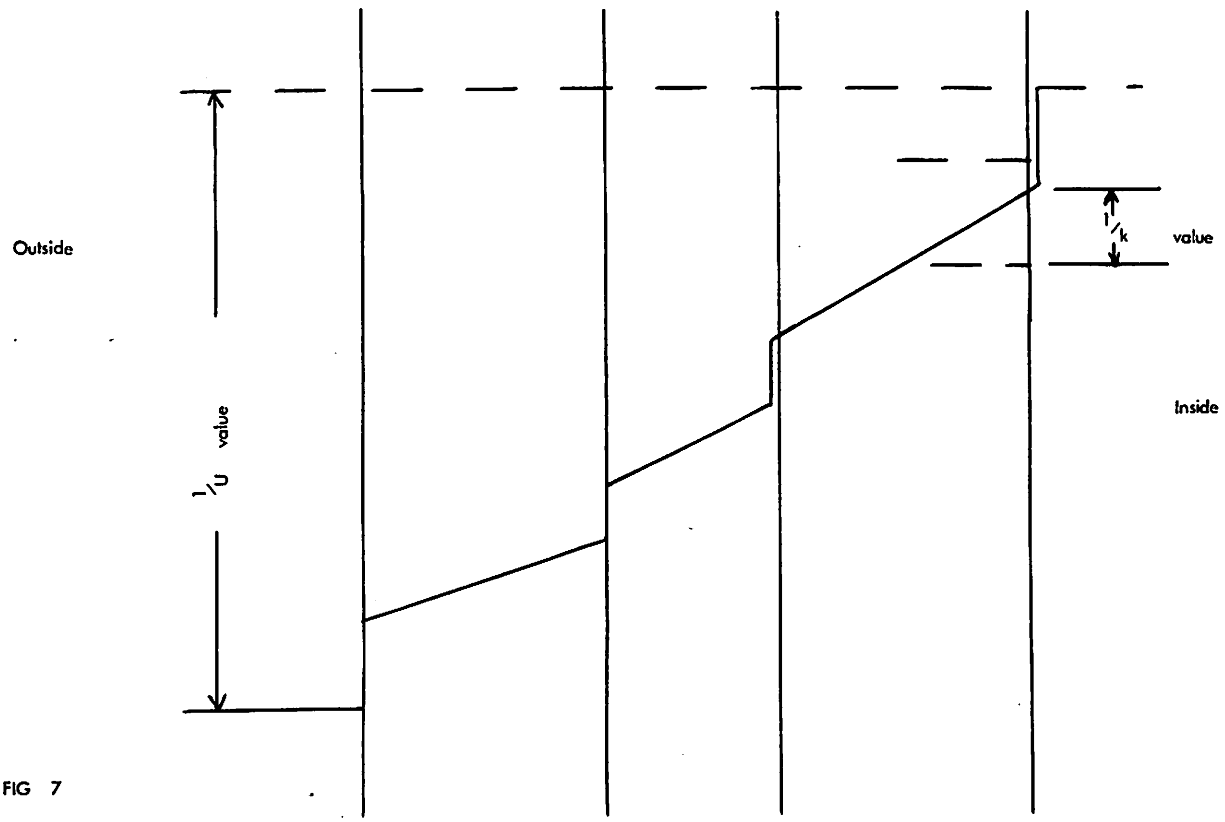


FIG 7

'K' values (also shown in the figure) on the other hand relate essentially to a 1 in. thickness of a specific material and take no account of the surface resistances mentioned above. It is a measure of the amount of heat (in Btu) which will travel through a square foot of material 1 in. thick when there is a 1°F temperature difference between the two faces of the material. It is therefore useful in comparing one *material* with another. But it is meaningless to talk about the 'K' value of a certain kind of roof, just as it is meaningless to quote the 'U' value of say fibreglass. Fibreglass, though a very good insulator, cannot be used by itself, so it cannot have a 'U' value. It can only form a part of a more complicated construction from which a 'U' value can be worked out, based on the 'K' value and the thicknesses of the various members.

It is also well to remember, and please bear it in mind for the next few pages, that the 'U' value for any particular type of construction is not constant. Although many of us, myself included, talk as though it was constant, the 'U' value varies quite appreciably from one site to another. On an exposed site, say the top of a hill, it is raised; that is, more heat will escape. On a sheltered site, say in the middle of a homestead surrounded by other buildings, it falls because less heat escapes. Put that way of course, it is common sense and common knowledge, but when working with mathematical terms one tends to lose sight of the common sense approach. In making the recommendations which follow, I am bound to adopt a rather shorthand approach, and talk in terms of average sites. If you are thinking of a particularly exposed site, you may have to think in terms of a lower 'U' value to achieve the same result. If the site you have in mind is particularly sheltered, you may be quite adequately served by a form of construction with a slightly higher 'U' value than I recommend. I would again emphasize that the figures given here are only intended as a guide to what I believe to be good economical practice. They must be used with care and common sense. The best result will undoubtedly be obtained by working out the answers mathematically, but this is a skilled and somewhat lengthy process and is really the job of a heating engineer.

Farm buildings can be broadly divided into three categories:

1. Highly Intensive Buildings.
   e.g. Battery hen houses
   Broiler houses
   Quality veal houses
   Some intensive pig fattening houses
   Nursery pens for young calves
2. Semi-intensive Houses.
   e.g. Some deep litter laying houses
   Pens for older calves
   Some pig fattening houses
   Farrowing pens
   Some intensive beef yards
3. Less Intensive Houses.
   e.g. Traditional beef yards
   Most cow sheds
   Most calf pens
   Dry sow yards

In the first type of house, the farmer, for good or bad reasons, wants to maintain a high degree of control over temperature and humidity. It may be argued that farrowing pens should come into this group, and for the nests at least this is so, but I have put them in group two, mainly because it is so easy and cheap to provide artificial heat by means of infra-red lamps that really the level of insulation of the house as a whole is less important. In highly intensive buildings in this part of the country, I think it worth aiming for a 'U' value for the roof of at least 0.1. This degree of insulation will be provided by a corrugated asbestos roof underlined with at least a 2 in. layer of glass wool and a 2 in. air gap. If you can afford 4 in. of glass wool, so much the better. This would need to be supported on a suspended ceiling of painted hardboard or compressed asbestos board. For the walls you should aim at the 'U' value of slightly better than 0.2. This will be achieved with an 11 in. cavity wall with the cavity lined on the inside with 1 in. thick slabs of resin bonded glass fibre or by a timber stud wall faced on the outside with good weather boarding and lined with ½ in. expanded polystyrene.

For semi-intensive houses where less control of temperature and humidity is required a roof 'U' value of 0.15 will probably be adequate. This will be provided by say roofing felt on 2 in. thick compressed straw slabs with ½ in. fibreboard fixed to the under side of the rafters and purlins to provide an air gap. For the walls a 'U' value of about 0.3 should be sufficient, such as would be provided by a simple 11 in. cavity wall.

For the less intensive houses, where little attempt is made to control temperature, many people now use corrugated iron (or corrugated asbestos) roofs ('U' value 1.4 to 1.5), and often run into condensation problems and also, perhaps less noticeably, problems of ill health and unthriftiness associated with high humidities. For these reasons, I suggest they would be wise to aim for a 'U' value of at least 0.3 to 0.5 such as is provided by a double-skinned asbestos roof, with or without a 1 in. fibreglass sandwich.

Walls are usually less important here, but I think stock would do better for a wall with a 'U' value of at least equivalent to a 9 in. brick wall (0.47) rather than one which does no better than corrugated sheeting.

There is another building characteristic which should be mentioned, though it has little to do with actually keeping heat in. It is more to do with smoothing out the temperature changes. Let me put it to you this way. If you only put half a pint of boiling water in your hot water bottle, when you go to bed at night the hot water bottle will become cold. If you fill the same bottle with say two pints of boiling water, it will probably still be slightly warm next morning. In both cases, the temperature of the water is the same. In both cases the insulating properties of your bed clothes are identical, but the sheer mass of heat in the fuller bottle will keep it warm longer. The same is true of buildings. All buildings are subject to diurnal temperature fluctuations for most of the year. The temperature rises to a maximum at about mid-day and drops to a minimum usually in the small hours of the following morning. This temperature fluctuation is shown in solid line in Fig. 8. Now modern farm buildings are frequently of frame construction covered with sheet materials. These have very little mass, and so they have little capacity for storing heat. Their temperature therefore quickly follows the normal diurnal fluctuations (the broken line in Fig. 8), but if the building has a greater mass, if it has solid brick walls instead of corrugated iron,

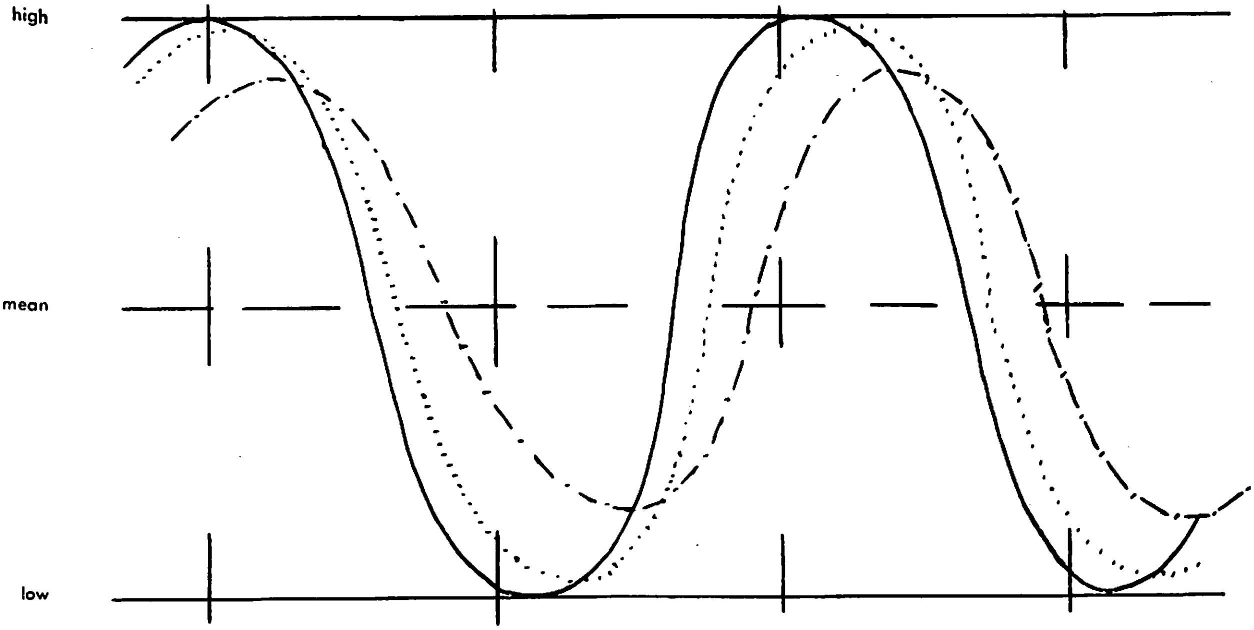


FIG 8 Diurnal Temperature Fluctuation

and if the pen divisions are of brickwork instead of tubular steel, it is able to absorb some of the heat during the daytime and store it up to release when the external temperature is falling. This smooths out considerably the diurnal temperature fluctuation and can lead to the sort of conditions represented by the chain line in Fig. 8. Here you will see the minimum night temperature is considerably higher than the external night temperature and the temperature fluctuation between maximum and minimum is considerably smoothed out.

Now a brief word about insulating materials and their uses. On the whole, I think the farming community are far too conservative in their choice of construction. This is not to suggest that you dive in at the deep end with new, fancy types of construction which have not been properly tested. There are, however, many types of construction which have a long and honourable history in the construction of other types of building, domestic architecture, hospitals, factories and the like. It is high time they were also used in farm buildings. Their use will usually cost more, but not much more, and will lead to dramatic improvements in thermal insulation. For example a 9 in. brick wall will cost you about 42/6 per yd^2 to build, and have a 'U' value of about 0.47. Turn that wall into an 11 in. cavity wall and you will use just the same number of bricks. You will need some extra wall ties, but the bricklayers can usually get on with the job a lot quicker. For this reason, the cost of an 11 in. cavity wall is usually much about the same as a 9 in. solid wall, or perhaps a shilling or two more, say 43/6 to 44/- per yd^2. The 'U' value is dropped to 0.3, an improvement of over one-third. If you want to make a substantial improvement to the insulation of this wall, you will have to put an insulator in the cavity, say resin bonded glass wall slabs. Now in my experience, builders are not yet used to this type of construction, and so tend to fight a little shy of it, but once they have got the hang of the thing, they will realise that really, they do not need to add more than another 2/6 to 3/- per yd^2 to the basic price of the cavity walling, and for that small extra cost, you have a wall of a 'U' value of 0.14 or very nearly only a quarter of the 'U' value of the original 9 in. wall.

Much the same applies to roofs. A straight corrugated asbestos roof, including roof trusses, purlins, ridge pieces, gutters etc. will almost certainly cost you at least 50/- for each square yard it covers, and will have a 'U' value of 1.4 to 1.5. The same type of construction, but with a double-skinned asbestos roof and a 1 in. glass fibre sandwich lining will only add about 11/- per yd^2 to the cost and will have a 'U' value of 0.3.

In most cases you will notice the glass wool is mentioned as an insulator. This is not because I have a vested interest in any of the firms producing the stuff, but because I sincerely think it is one of the best insulators used in farm buildings. Slag wool is a similar kind of material, but is frequently made under less exactly controlled conditions and so is less constant. Either can be supplied in matt form, that is in a roll which can be simply unrolled and cut to width, which makes it easy to lay. Slag wool can also be more cheaply supplied loose in bags, but it has to be picked out of the bags and placed in position. This is a more laborious process and is also difficult to get a consistent thickness, particularly when you are working in artificial light in a restricted roof space. Glass wool also comes in rigid slabs and tubes for use in wall construction and for fitting around pipes. Both these materials have the enormous advantage that they are entirely inert and are intensely disliked by all types of vermin.

Exfoliated vermiculite is also a good insulator, though with not quite so high a 'K' value as glass wool, (0.45 compared with 0.25 to 0.3) so you will need a slightly greater thickness to achieve the same result. Expanded polystyrene sheeting is another very good insulator with a very good 'K' value (0.22). The trouble with both these last materials is that their insulating properties are also recognised by rats, mice and birds who are very inclined to use them in the construction of their own houses. They can therefore only be used in places where vermin will not get at them. In most farm buildings, these places are hard to find. Expanded polystyrene is also liable to attack from poultry and should not be used in exposed conditions where the birds have access to it.

Insulating fibreboard is also a good insulator (K=0.35 to 0.45) but gets expensive if used in the thickness to give results comparable with say glass fibre.

All these materials are not structural, though both expanded polystyrene and fibreboard can be used for ceilings, and all (except expanded polystyrene) are highly hygroscopic. That is to say, they will absorb moisture and moisture vapour. When used in stock buildings, they must therefore be protected on the inside against the penetration of moisture given off by the stock. This vapour barrier can take the form of painted hardboard, fully compressed asbestos sheeting or one of the waterproof sheeting materials such as polythene or building paper. Glass fibre can also be bought already completely encased in a long 'sausage skin' of polythene rube. This protects it from moisture penetration on all sides and also makes it easier and more pleasant to lay in large areas though, of course, it is not possible to cut it to fit round obstructions without at the same time cutting and so destroying the vapour seal.

Strutural roofing insulators come in the form of compressed straw slabs (Stramet K=0.60) or cement wood wool slabs (Gypklith K=0.57) Both are usually used in 2 in. thicknesses and can be used with roofing felt to give a reasonably cheap insulated roof which can be laid to a far lower pitch than ordinary corrugated asbestos sheeting. Both need to be protected on the underside by a vapour seal. Both can also be used in conjunction with timber studs for new walls and as insulating lining to existing walls.

With existing buildings, you will probably need to use much the same materials as have been mentioned above, though it may be necessary to exercise a little more ingenuity in their application. Most of the materials mentioned can fairly readily be used on the underside of existing roofs to give insulation, either fixed to the underside of the rafters or else in the form of a suspended ceiling at eaves level. For this last many farmers make a 'ceiling' from chicken wire fixed over light timbers or stretched wires. Above this they lay a polythene sheet or building paper vapour barrier, and then two to three inches of fibreglass or twelve to fifteen inches of straw. This is indoubtedly cheap but looks pretty dreary, is almost impossible to clean and disinfect and one wonders for how long it will remain vapour proof. I would much prefer to make a job of it with a suspended ceiling of painted hardboard, though I am very conscious of the fact that in making this recommendation I shall not be faced with the bill for the cost.

For existing walls, all that it required is some form of air space to form an insulant. The walls can be lined with Gypklith or Stramet boards which are then rendered to give strength. These form their own insulation. Dove-tailed bituminous lath (Newtonite) can also be tacked to the walls, or stood away from them for ¾ in. to 1 in. by nailing it to a batten fixed to the walls. The lathing is then rendered. This forms quite a satisfactory insulating cavity with a strong impervious inner face. It take up very little room and is fairly cheap.

One could go on with these sort of examples for a very long time, but I do not think there is much point in it. I hope I have said sufficient to indicate the sort of possibilities open to farmers both with new buildings and with alterations to their present buildings. I hope I have also indicated that adequate insulation is not the expensive luxury that some of us tend to imagine it is.

This is, however, only one side of the coin, and I think it is within my terms of reference to deal, however briefly, with the other side. Heat escapes not only through the fabric of the building, but also through the air which is essential to ventilate the building. For health reasons this air change must take place, and we must accept a certain level of heat loss. But it should be cut to the minimum consistent with maintaining a sweet, healthy atmosphere in the building. It is a sheer waste of effort to go to considerable lengths to insulate a building if you allow the heat to be blown away through excessive ventilation. The figures I am going to give you are, of course, only of very general application, but I have found them cropping up with remarkable regularity in a number of cases in farm buildings with which I have been associated. If you get the ventilation right in an uninsulated building, for every unit of heat which is blown away by the ventilation, between three and four units will escape through the fabric of the building. If you get the ventilation right in a well insulated building, the two frequently about balance out. One unit of heat goes through the ventilation system and one unit through the fabric. But of course, in an uninsulated building, you need a higher ventilation rate to maintain the same relative humidity of the atmosphere, so it is not possible to do a simple addition and compare 1 plus 4 with the 1 plus 1; it will be more like 2 plus 8 with 1 plus 1. If on the other hand you insulate the building well, but let the ventilation look after itself the position is the reverse and for each unit of heat escaping through the fabric, between four and five units will be blown away by excessive ventilation. This applies under the average bad conditions and it is with these conditions that we are concerned. After all, insulation comes into its own from November to February. On a nice warm day in June the stock would probably manage quite nicely without insulation anyway.

This, I hope, emphasizes the importance of getting the ventilation right as well as the insulation. They are really opposite sides of the same coin. Now you can leave nature to provide the ventilation if you like, but the only motive power is the wind. Ventilation due to 'stack effect', i.e. the heat given off by the stock and the difference in levels between inlet and outlet ventilators, is so slight in farm buildings that it can be safely ignored in all but very exceptional circumstances. The wind blows with a proverbial inconsistency and usually provides just the opposite effect to that required by the stock. On a freezing cold night in January when a gale is blowing, the stock want their ventilation reduced to a minimum to maintain reasonable warmth. The gale naturally gives maximum ventilation. Again, on a cool still foggy morning in September, or on a blistering hot day in July, when relative humidities are at their maximum, the stock need a fairly high level of ventilation to maintain a reasonably sweet atmosphere. The wind gives them none. The alternative to this is a fan assisted ventilation system which is properly designed and properly commissioned and will maintain pre-selected levels of ventilation under all conditions.

Let me sum up briefly what I have been saying.

Firstly, before ever you start to consider insulation and the advantages and disadvantages of using various insulating materials, do get your building, its overall shape and planning right. This will reduce to a minimum, the heat escape area for each animal. This is not to say that I recommend high stocking densities. There are a number of other factors, veterinary, management, the use of existing buildings, and so forth which may make you decide to go for lower stocking densities. If you take this decision, do be fully aware of the consequences of the effect which it may have on the temperature pattern of the building.

Secondly when you have got the planning right, you can decide on what level of insulation to aim for. The various 'U' values I have recommended are intended as a rough guide only, and are no absolute alternative to the correct calculation of the insulation required for a specific building on a specific site, subject to a specific set of management decisions. They will, however, I hope, be useful and should help you to get the buildings about right. If money is short and you cannot do as much as you like, concentrate your attention on the roof first, the walls second and the floor last. Heat rises and in most modern farm buildings, the roof forms the largest single area, so insulation used here will have more effect than insulation used on the walls. In the case of the tall narrow existing barn, the position may well be different and the walls form a larger area than the roof, but generally speaking concentrate on roofs first. I have dealt very little with floors because they have a very marginal effect on keeping the warmth inside the building. They do, however, have a considerable effect on animal comfort. If a pig lies down on a cold concrete floor, a considerable amount of heat is going to flow out of the pig and into the floor to warm it up to the pig's body temperature. During this process, a very small amount of heat will escape sideways through the earth and be eventually blown away by the wind. Most of the heat will come back into the piggery elsewhere, but the process is still not very comfortable for the pig. If the pig lies down on an insulated floor with a 2 in. concrete screed on top, it only has to warm up that thin screed before its body heat losses are reduced to normal, so an insulated floor will make a more comfortable bed than an uninsulated one. Finally, it is not much good spending a lot of time and effort on these first two points unless you are prepared to get the ventilation right too. Unless you do a great deal too much heat which would otherwise warm up the building will be blown away by excessive ventilation. Perhaps it sounded earlier as if the only way to achieve this was by means of fans. With all deference to Mr Wakeford[2] it is not. Remarkably good results can be achieved by use of properly designed and positioned natural ventilators, but until a satisfactory method of automatic control is designed for these ventilators, they will prove satisfactory only if a stockman spends a lot too much of his time going round the buildings opening and closing them to take account of the varying wind speed and direction.

REFERENCES

1. Available from The Electricity Council (E.D.A. Division), Trafalgar Buildings, 1 Charing Cross, London S.W.1.
2. The control of Heating and Ventilation in Intensive Livestock Buildings by P. Wakeford (see page 161 of this issue).

OBITUARY

The Council records with deep regret the death of the following members:

Crogham, M. F.	Associate
Cross, M. W.	Member
Dunbar, D. S.	Associate
Gill, K. R.	Member
Gliddon, A. L.	Associate Member
Hunter, J.	Associate Member
Huntley, R. J.	Member
Kennedy, D. S.	Member
King, K. J.	Associate
Linley, D.	Associate
Longman, G. F. N.	Associate
Norris, O. E. W.	Associate
Pomerance, I.	Member
Purchas, F. B.	Associate
Waters, H. C.	Member
Watts, W. G.	Associate
Whitlock, A. C.	Member

THE CONTROL OF HEATING AND VENTILATION IN INTENSIVE LIVESTOCK BUILDINGS

by

P. WAKEFORD, AMIEE, AMI AGR E*

Presented at the Scottish Branch Conference of the Institution on 2 March 1966 at Dunblane, Perthshire

INTRODUCTION

In general it is true to say that artificial heating for livestock is confined to young animals, whose requirements for fan assisted ventilation are minimal. As livestock grow their need for space heating is reduced, but greater attention must be paid to ventilation, and the use of fans merits serious consideration because they can give more precise control of the air needed for optimum development. While there is an intermediate stage when both artificial heating and controlled fan ventilation may be important, it is convenient to consider the problem of control under two main headings—control of heating systems for young livestock and control of ventilation and heating systems for older livestock.

HEATING SYSTEMS FOR YOUNG LIVESTOCK

Artificial warmth to provide 'comfort' for piglets, chicks and turkey poults is nowadays regarded by most farmers as an essential requirement in the initial rearing of these animals, and is increasingly being provided also for calves and even lambs.

The cost of providing warmth artificially is accepted as a necessary charge in their rearing, and although these young stock may be kept in well insulated buildings, because they are small their own metabolic heat alone may well be insufficient *on its own* in winter to maintain the higher temperatures (70°F or above) which they require for optimum development to adult size. 'Localized' heat will however in general provide adequate comfort for young stock often without the need to heat the whole of a building, but even where, as with broilers, the whole of the building air space may be warmed artificially, the low ventilation rates required at this stage of their lives need not necessarily involve fan ventilation and associated controls.

The main methods of heating used for young livestock are:

(*i*) Infra-red heaters—used for chicks, turkey poults, calves and pigs.

(*ii*) Canopy brooders—used mainly for chicks and poults.

(*iii*) Heat storage brooders—used mainly for chicks and poults, and in their warm floor version for piglets also.

CONTROL OF HEATING SYSTEMS FOR YOUNG LIVESTOCK

While in general the farmer is the best 'controller' of the various heating systems listed above, some simple additional form of temperature control is also advisable with some forms. The available methods under the headings just given are indicated below with a short description of the methods of control normally used.

Infra-red heaters

These are available as electric element heaters or as propane gas burners. They rely for their effectiveness on radiant heat received by the bird or piglet, and therefore are not particularly suited to thermostatic control unless the thermostat is placed well away from direct radiation. Electric infra-red heaters are not generally used in this way, but are simply used to provide localized heat and are raised as piglets or chicks grow when the requirement for intense heat is less. Where thermostatic control of electric infra-red heat is attempted it should be remembered that the complete cessation of radiant heating which occurs when the thermostat switches off the heater may introduce a stress factor to young animals especially. Propane gas radiators are usually intended to provide general house warmth as well as localized radiant heat, and again these are not usually thermostatically controlled. The gas flow rate can however be reduced manually by about 20 per cent.

Typical electrical and propane gas ratings for different numbers of stock reared are shown in Table 1.

TABLE 1

Ratings of typical Infra-red Heaters in Relation to Numbers of Stock Reared

No. of stock reared together	*Electrical loading* kW	*Propane Gas Rating Btu/h.*
100 chicks	0.25	—
500 chicks	1.5	—
1000 chicks	2.2	12000
10 piglets	0.25—0.5	—

Canopy Brooders

The canopy brooder or hover acts as a heated 'umbrella' over chicks or turkey poults, using both radiant and convected heat and is mainly used in the rearing of broilers on the floor of the house. It is available electrically heated or with propane gas heating. Oil-fired brooders have been developed but are not commonly used nowadays. Both electric and gas types have their heating system mounted near the highest point of a pyramidal or partly-circular section canopy. The canopy is usually thermally insulated, although some gas types are not thus provided. Control of temperature in both cases is by an

* Agricultural Advisory Section, The Electricity Council

adjustable capsule-type thermostat, which at the temperature set, switches all the heat off in the electric version, or reduces gas flow from maximum to about 2½ per cent of maximum in the propane gas type. It is common practice to reduce the setting of the thermostat gradually as the birds grow, from 90°F at day-old to 70°F at 3 weeks, and in winter especially to lift the canopies at the end of brooding to provide general space-heating. To avoid waste of heat it is important that where the canopy brooder is used for space heating the ventilation should also be carefully controlled and this is dealt with later.

Typical ratings of canopy brooders are shown below in

TABLE 2

Ratings of Typical Canopy Type Brooders in Relation to Numbers of Birds Reared

No. of Birds Reared together	*Approx. Floor Area* ft^2	*Electrical Loading kW*	*Propane Gas Rating Btu/h.*
150	5½	0.4	—
500	13	1.0	5000-1200
1000	30/32	2.2	16000-400
2000	48	3.0	—

Heat Storage Brooders

Three types of heat storage system are in use, two systems employ electric heating, one in heated blocks (block storage), the other in warmed concrete floors, while a third system employs hot water circulating in water pipes, the water in the pipes being heated by a gas or oil fired boiler. A brief description of each and their method of control is given.

(*a*) Block Storage

A block storage brooder developed commercially for rearing 1,000 chicks at a time consists of a metal rectangular container on legs, measuring about 2 ft square and 1 ft deep and having a 3 kW heating element embedded within ceramic bricks fitted into the container. A thermally insulated canopy covering a floor area of 32/36 ft^2 is mounted above the block, and is available either in the form of a truncated pyramid of square base or in flat form with polythene side curtains. It is operated on off-peak supplies for 14 to 15 h/day, from an Electricity Board time-switch, and further adjustment is made using a repeat cycle timer. This has a simple control knob and can then provide an infinite variation of the 'on' period from fully 'on' down to 10 minutes per hour or less. An indication of the settings required is given in Table IX of the E.D.A. Farm Electrification Handbook No. 10.

So far block storage equipment has only been used for brooding of chickens, but there are possible future developments in general space heating of animal houses, perhaps using a fan system drawing warm air from the heated block only when called for by thermostat.

(*b*) Warm Floor Storage

So far as is known only electrically warmed floors have been developed to a commercial stage, and the technique has been applied commercially in the following animal invironment problems:—

(*i*) *warm floor brooders* for chickens and turkeys.
(*ii*) *warm floor creeps* for piglets.
(*iii*) *warm floor beds* for fattening pigs as an alternative to straw.

Detailed constructional details of each are given in F.E.H. 10 referred to above, and a brief summary including control methods is provided here.

(*i*) *Warm Floor Brooders*

Approximately 50 ft^2 of concrete per 1,000 birds is required for the heated area. Suitable heating elements giving 2.6 kW per 1,000 birds are installed 4½ in. down in a 9 inch depth of concrete. In a well-insulated house with 2.6 kW used off-peak for 14 hours per day, a 20°F rise in the house temperature above the outside should result. While this will be adequate for brooding purposes, the birds being in contact with a floor which is at 100-110°F, it may be insufficient if space warming is to be provided electrically also. In such cases two electrical alternatives are open. One is to increase the warmed area to 90 ft^2 per 1,000 birds and install 4 kW in this area, run 14 hours off-peak; the other is to install 1½ kW of fan heating per 1,000 birds in addition to 2.6 kW of warm floors in 50 ft^2. Both alternatives can be operated off-peak although in the latter case the local Electricity Board should be consulted to check whether fan heaters run off-peak are permitted under the off-peak tariff conditions. Where fan heaters are permitted to be used off-peak an air thermostat should be used to control these during off-peak hours of running, this being set 5 degF higher than the average temperature to be maintained.

Control of warm floors using a floor thermostat has also been used. The setting of the thermostat is reduced as the birds grow, and to obtain adequate control it is essential that the temperature sensing device should be sensitive to small changes of temperature. One such is the 'electronic' thermostat which can give a very fine range of sensitivity down to plus or minus ¼°F. Its phial is buried just below the surface of the warmed floor and is probably best used with warm floors which are not off-peak, when it ensures not only that the floor surface temperature is suitable for chick rearing, but also that the heating cable itself does not reach an excessively high temperature.

One other measure within the farmer's control should be mentioned. This is that he should ensure that only a scattering of litter is used on the warmed area of a floor. This is to ensure that warmth from the floor is not seriously impeded from warming the air of the house, and it is particularly important to keep the floor only lightly covered where the warm floor is deliberately designed to give a measure of space warming as well as providing brooding conditions.

(*ii*) *Warm Floor Creeps for Piglets*

On the basis of warm floor creeps developed by McGuckian in Northern Ireland an area of 10 ft^2 on one side of a farrowing creep is adequate for one sow's litter, and within this area heating cables to give 300 watts should be provided, laid 2 in. below the surface of a 4 in.

depth of concrete. If operated off-peak 500 watts laid 3 in. below the surface of a 6 in. depth of concrete is advisable. Control by a repeat cycle timer mentioned earlier is required also.

(*iii*) *Warm Floors for Fattening Pigs*

Up to the present warm floor beds for fattening pigs are still in an experimental stage. Control is likely to be most effective using a repeat cycle timer, the settings given being judged by the behaviour of the pigs. Significant savings in straw can be obtained however and there are other husbandry advantages which may eventually make this a commercial application.

(*c*) Hot Water Brooders

In this system a 'nest' of waterpipes is constructed above litter level in a broiler house and carries above it metal sheets on top of which a thickness of insulating litter is laid. Water in the pipes is heated from an oil or gas fired boiler, and the pipes are sloped to provide convected circulation back to the boiler. The water temperature is thermostatically controlled and the space under the metal sheets acts as an effective brooding area for chicks.

HEATING AND VENTILATION FOR OLDER LIVESTOCK

In all the applications of heat so far described, it has been assumed that artificial heat—used for young livestock—is required only when no fan ventilation is being used. It will, however, be apparent that if fan ventilation is applied lavishly and without thought as animals grow older, considerable waste of heat can take place. The precise time at which fan ventilation takes over from 'natural' or 'restricted' ventilation depends on the age and type of animal and the time of year, and is largely a matter for the husbandry sense of the farmer.

Many of the heating appliances described earlier are in practice used with older livestock, and certain principles should be applied if waste of heat is to be avoided, and in order to ensure that at the same time reasonable standards of ventilation are maintained.

The first principle is that the control method used for the *heating* system should be that which, as already described, appears to be most suitable for the particular system.

For example, the thermostat settings used with the canopy brooder as broilers grow are a suitable control to apply when the canopy is used for space heating. It does not of course follow necessarily that a particular setting, say of 65°F, under the canopy will automatically result in that temperature being kept in the house as a whole. It may be above or below that figure depending on the ventilation control by fans which is also applied.

This leads to the second principle which involves *controlled* ventilation by fans. Ideally this should give a *continuous* flow of air at all times, the rate of movement of air however varying according to the *outside* temperature. That is to say, when the outside temperature is low in winter the ventilation rate should be low enough to make the best use of the body heat of the animals, so that the 'free' rise of temperature due to the livestock alone is as high as possible, but should not be so low that moisture in the house atmosphere is high, causing condensation or discomfort to the stock. This means that all the moisture respired by the animals must be effectively removed by the ventilation system while keeping the house temperature as near optimum with animals heat as is practicable.

In contrast, in summer, when the outside temperature is comparatively high and the house temperature is in any case close to optimum, the aim is to *dissipate* the heat produced by the stock, so that the temperature rise which will in any case occur is as low as possible. This is done with a high rate of ventilation, which will incidentally ensure that the moisture still being produced by the livestock is also being removed in the ventilating air.

The practical result of applying the different requirements between summer and winter means that the maximum summer ventilation rate may have to be from five to ten times the minimum winter rate. To achieve the necessary control within this range calls for a combination of the common-sense of the farmer, the use of automatic or semi-automatic methods of fan ventilation control, and the advice which the specialist can give on the precise calculations of ventilation rate desirable in different temperature conditions.

In practice the ideal of a *continuous* flow of air at the correct rate for all outside conditions may not be possible to achieve for economic reasons. Indeed, livestock beyond the very young stage appear to tolerate variations in ventilation rates without disaster, but the extent to which their productivity may have suffered has not been evaluated.

Provided sizes of inlet and fan housing dimensions are correctly proportioned, propeller fans are the most suitable for the majority of animal environment ventilation schemes. The methods by which ventilation rates below the maximum are obtained in practice involve the use of one or more of the following:

Method A

Speed reduction of the fan or group of fans, using a speed 'regulator' which may be of the 'series choke', 'series resistance', or 'auto-transformer' type. The last type of regulator is probably the commonest form used in this connection, and recent improvements in fan motor construction enable speeds down to 10 per cent of maximum to be obtained using the auto-transformer regulator.

Method B

Partial recirculation of the outside air through the fan or fans which are kept running at constant speed. In one design each fan is mounted in a special housing having two hinged shutters or vanes built-in which can be opened or shut automatically under the control of a pair of 'Bowden' type cables linking each pair of vanes. The cables are fixed at their ends to a pulley driven slowly by a geared motor, itself controlled by a sensitive thermostat.

The movement of the cables under the control of the thermostat decides the amount of air which can be removed from the house since the cable movement sets the position of the vanes. In the minimum fan setting 10 per cent of the total air moved by the fans is drawn from the house and 90 per cent is re-circulated from the outside while in the maximum setting all the air is drawn from the house.

Method C

'Off' and 'on' control of fans. This method of control may be done by hand, with a time-switch, or by means of a thermostat. It is the simplest form of control, but it is immediately apparent that wide variations in ventilation rate will occur if relied upon solely. In the winter for example it may well be that a fan may be on at the summer rate for only 10 minutes in every hour, and it is considered that such contrasting changes in ventilation rate in short time periods may be harmful to stock.

PRACTICAL VENTILATION AND HEATING CONTROL SYSTEMS FOR OLDER LIVESTOCK

In practice each of the above methods A, B and C, either alone or in combination are used and in the remainder of the paper are described systems of controlling ventilation using these methods, in conjunction where appropriate with a heating system, which appear to give reasonably satisfactory results.

These range from comparatively simple systems for small houses to more sophisticated control arrangements which are justified for large houses with many animals being reared together. It is again emphasized that the aim in all cases is to provide a range of ventilation rates starting from the lowest rate at the lowest outside temperatures and gradually increasing to a rate which may be 10 times as much as the highest expected outside temperature. In this connection the calculation on pages 134 and 135 of the E.D.A. Farm Electrification Handbook No. 10 will be helpful, for it shows that under certain cold conditions even with older livestock some artificial heating may be necessary, if it is considered important to avoid conditions of high humidity at all times.

One-fan Installations

In many small installations, sophisticated control is not economically justifiable, but reliance on 'on-off' control using a thermostat preferably with a hand speed regulator is a reasonably inexpensive yet satisfactory system. In such a case the farmer sets the speed of the fan according to the outside conditions and leaves the thermostat to switch the fan on and off as demanded. It should however be recognized that most regulators for controlling single fans only reduce speed to 50% of maximum, and the fan is still likely to be off for long periods in really cold weather. This is nevertheless an improvement on switching the fan on to full speed from zero with the thermostat alone.

Where single fans are designed to run down to 10 per cent of maximum speed it is now possible to obtain a regulator which will do this for the single fan under hand control, but to arrange for a thermostat to be incorporated which increases the fan speed to maximum if the temperature *rises* to the value set. If this system is adopted it would be advisable to provide the farmer with a chart giving the regulator setting appropriate for particular outside temperatures, and for the setting of the fan thermostat to be 5 to 10 degrees above the desired temperature level. At the moment this type of regulator costs at least as much as the fan and the small farmer may not feel the cost is justified, but this view may change if its use results in more level temperatures throughout the year and improved food conversion rates. Such a control method could however be used if necessary with a heating system, the heaters being set to cut heat off when temperature rose 5 or 10 degrees *below* the setting of the thermostat controlling the high speed of the fans.

Multi-fan Installations

With two or more fans in use a combination of 'off-on' and speed control can be even more effective. One simple two-fan system would be to have a speed regulator for each fan and a thermostat for one. The regulators would be set by hand—at minimum in winter and maximum in summer, and the thermostat would switch in the second fan whenever the temperature rose above the value set. A ratio of speed control of 4 or 6 to 1 could be achieved with this system, but it should be emphasized that automatic shutters should be provided for closing the vent of one fan whenever it is not running, to prevent 'short-circuiting' of air from one fan shaft to the other.

More sophisticated semi-automatic control can be used on installations with more than two fans. For example an eight fan installation for a laying poultry house could have hand regulator control for two pairs of fans, one pair of which were always running. The second pair on hand regulator control could be brought into use by a thermostat set at (say) 50°F. Two other pairs of fans without regulators could be switched on by two further thermostats set at say 55°F and 60°F respectively. Automatic shutters should also be incorporated with this system.

Thus the farmer would use his judgement as to *speed* control of half of the fans according to the air conditions, but the other half can be brought in at full speed automatically, because at temperatures above 55°F with laying birds, the need for such close control of air speed is not so important.

Automatic fan systems

At least six automatic fan control systems have been brought on to the market in the last year; for brevity however three of these only are described. The systems may be briefly defined as follows, and in general it would probably not be economic to install less than four fans in one house under automatic control.

(*a*) Sequential control of fan numbers and speeds by external and internal thermostats.

(*b*) Control of house air throughput down to 10 per cent of maximum using a thermostat to control fan speed.

(*c*) As (*b*) but using a thermistor to control fan speed.

(*a*) Sequential control of fan numbers and speeds

In this system five vapour pressure thermostats are used, three being mounted outside the house on a north wall away from direct sunlight, and two inside the house.

The external thermostats would be set at (say) 35°F, 42°F and 46°F, and control the *number* of fans to be run.

The internal thermostats control the speed of *whatever* fans are switched on by the external thermostats.

In one typical example for 8,000 laying birds, ten 24-inch fans might well be provided, and their operational sequence would be as follows:

Outside Temperature	*Number of fans on*	*When Inside Temp. is °F*	*Speed of fans which are running*
Below 35	2	Below 53	33% of max.
35-42	4	53-58	66% of max.
42-46	6	over 58	full speed
over 46	10		

Such a system is likely to result in ventilation rates very close to the optimum under all conditions, provided the initial calculations make a correct assessment of the probable house humidity levels under different outside temperatures.

(*b*) Control of air throughput using a thermostat to control fan speeds

In this system the speeds of *all* the fans in a house are controlled together down to 10 per cent of maximum, automatically. The speed of the fans in a house is controlled by an auto-transformer which is fitted with a voltage-selection contact, which itself is driven by a small motor which is under the control of a thermostat. This thermostat has three positions at which the voltage selection motor is caused to move in one or other direction. In one position with the house temperature 1°F *above* the thermostat setting the motor moves to increase the voltage applied to the fans and hence their speed. In the middle position at the correct temperature no movement of the motor takes place, while with the house temperature 1°F *below* the thermostat setting, the fans' voltage and speed are reduced. The cycling time for the voltage selection motor to move to its lowest position can be up to 40 minutes and is decided before the installation of the equipment.

Provided the minimum speed which can be reached corresponds with the minimum ventilation rate required in winter, near optimum ventilation levels may well be achieved, although in theory at least, the various ventilation rates experienced between minimum and maximum fan speeds are not necessarily the optima for particular outside temperatures. More practical knowledge of house conditions is however needed before passing judgement, but certainly farmers who have installed these systems have been very satisfied with the ease of control and have ceased to be worried by the need previously experienced of having to guess overnight ventilation requirements.

(*c*) Control of air throughput using a thermistor to control fan speeds

This system is of very recent development. It is similar in effect to thermostatic control of fan speed, but the electrical method of altering fan speed is quite different. A 'thermistor'—a temperature sensitive resistance—is used to provide a signal which when amplified using a transistorised unit alters the shape of the wave form of the mains supply to one of the windings in the fan motor. This has the same effect on fan speed as voltage reduction in system (*b*).

The remarks above regarding the operation of system (*b*) apply in similar measure to this new system.

Automatic fan and heating systems

Several combined fan and heating systems have been developed, but one which appears to have been particularly successful—'whole house' broiler rearing—uses an oil fired heater to provide the required temperature in the whole house, and ventilation fans in each side wall.

In order to distribute the air evenly through the whole house, a perforated 'pegboard' duct of suitable dimensions is constructed down the centre of the house under the ridge, and the warmed air is admitted into this duct and mixes with cold air coming through louvres at one end (sometimes louvres are constructed at both ends of the house with a dividing partition in the middle of the duct in the centre of the house). The fans in the walls draw the warm air evenly through the pegboard ducting into the body of the house.

The control system for fans and heating gives the farmer the choice of hand control or automatic operation, and a range of speeds can be manually selected if required as follows:

low speed	15-18 per cent of maximum
2nd speed	30 per cent of maximum
3rd speed	60 per cent of maximum
High speed	full speed

Automatic control using 3 thermostats which increase or decrease the speed of the fans in steps may be used as an alternative.

In addition, there is a thermostat controlling the oil-fired heater combined with an interlocking arrangement, whereby the fans run at either the low or second speed when the heater thermostat calls for heat. A 2-position rotary switch gives the user the option of choosing which of these fan speeds shall be selected.

Such a system does result in economy in use of heat since ventilation rates are reduced, but not eliminated, when heat is being applied.

In use this combined system has worked well, but two points should be made. One is that the louvres at the end of the house are adjustable, and some users are under the mistaken impression that in cold weather these should be nearly closed. This has the effect of causing the fans to run near stall point, and under-ventilation could well occur in such circumstances. Secondly the option provided of hand control does enable the user, if he wishes, to over-ventilate in the early stages. If this happens heating costs are bound to rise, and there have been cases of brooding costs of 4d. per bird, whereas a more reasonable figure would be of the order of ¾d. per bird.

CURRENT DEVELOPMENTS IN CONTROLLED ENVIRONMENT FOR FARM LIVESTOCK IN NORWAY

by

PROFESSOR OLAV HJULSTAD *

Summary of a paper presented at the Scottish Branch Conference of the Institution on 2 March 1966 at Dunblane, Perthshire

Livestock production is very important for most of the Norwegian farmers. The country is self-supporting as far as all kinds of animal products are concerned. Most of the farms are very small. Mixed farming has been very common, but now many farmers are turning over to specialized livestock production. In the south-west coastal districts the climate is very much similar to that of Scotland. In the inland and the northern parts of the country the temperatures may be very low in winter time, down to 30-40 deg F below zero over a three-day period.

Wood has been the most common building material in the past. In some areas the walls of the animal rooms have been made of natural stone. Now masonry and concrete are usual. But wood still remains a very common building material in the animal room walls. Whilst in the past two-storey buildings have been very common all over the country, there is now increasing interest in single storey buildings in many areas. By far the most common storage place for the manure has been and is the cellar under the animal room. In modern buildings the ceiling and walls in animal rooms are well insulated, mostly with 4 in. mineral wool, which is very cheap in Norway. Double-glazed windows and insulated doors are commonly used.

With the exception of sheep, almost all the animals are kept in climatic controlled buildings. The following inside temperatures are recommended:

Dairy Cows	45-60°F
Young Pigs	70-80°F
Fattening Pigs	60-65°F
Laying Hens	45-60°F
Chickens	70-90°F

The air humidity should be kept below 85%.

Owing to the small size of herds and the bad climatic conditions, the heat balance problems are very important and severe in many parts of the country. The most used insulation (4 in. mineral wool) will give a positive heat balance in well planned and densely populated dairy barns down to a herd size of 7-8 cows in almost all parts of the country. Pork production is not common in areas with very cold winters. Well insulated and well utilized houses for 30-40 fattening pigs will have a positive heat balance in areas with medium cold winters. For very small herds of dairy cows, for fattening pigs under bad climatic conditions, and for almost all kinds of buildings for breeding pigs, hens and chickens, we should use some artificial heating. Local heat sources (mostly infra-red electric lamps) are much used for young piglets and chickens. Artificial heating in order to raise the temperature in the whole room, is, however, not as yet very commonly used, but there is a great interest in these questions, and we follow very closely Swedish and Danish experiments in this field. Also in Norway we are going to start some investigations in buildings for fattening pigs. As the electricity is rather cheap in Norway (½-1 penny per kWh) we believe that this heat source will be the most common. In our experiments we will use heating cables in the floor and also heating elements in the ceiling.

We almost always use a ventilation system where the air is pulled out of the building in order to provide an air pressure in the building a little below the air pressure outside. To suck out the air we have used vertical ducts. These are still in use, but now most of the systems are planned with electric fans. The location of the outlet does not seem very important. We calculate using a capacity of 1700-7000 ft^3 per hour per dairy cow (the lowest figure is for cold winter time conditions and the highest in the mild weather of spring and fall). For fattening pigs the figures will be 350-2100, for laying hens from 28-280. (For pigs and poultry we calculate to allow for sufficient ventilation also in the warmest summer time.) To control the fans we recommend a thermostat, but we always like to have at least one fan running or one duct operating in order to secure a low pressure condition in the room all the time. We do not know enough to tell how the air inlets have to be designed and located to get an even and draught-free air movement all over the building. We have had, and still have, some experiments running in order to learn more about these things. The most commonly used system is to place a number of inlets alongside the outer walls, but we are not quite satisfied with the results of this system.

*Director of The Institute of Agricultural Structures, The Agricultural College of Norway

ELECTIONS AND TRANSFERS

Approved by Council at its meeting on 13 October 1966

ADMISSIONS

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Associate Member	*Overseas*	Khanna, S. K.	India
Associate		Bartlett, F. A.	Cambs
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		Collingwood, K.	Yorks
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		Roberts, J. K.	Bucks
		Gane, A. J.	Northants
Graduate		Belton, D. H.	Lincs
		Kitching, R. B.	Lincs
		Kraushar, C. A. A.	Northants

TRANSFERS

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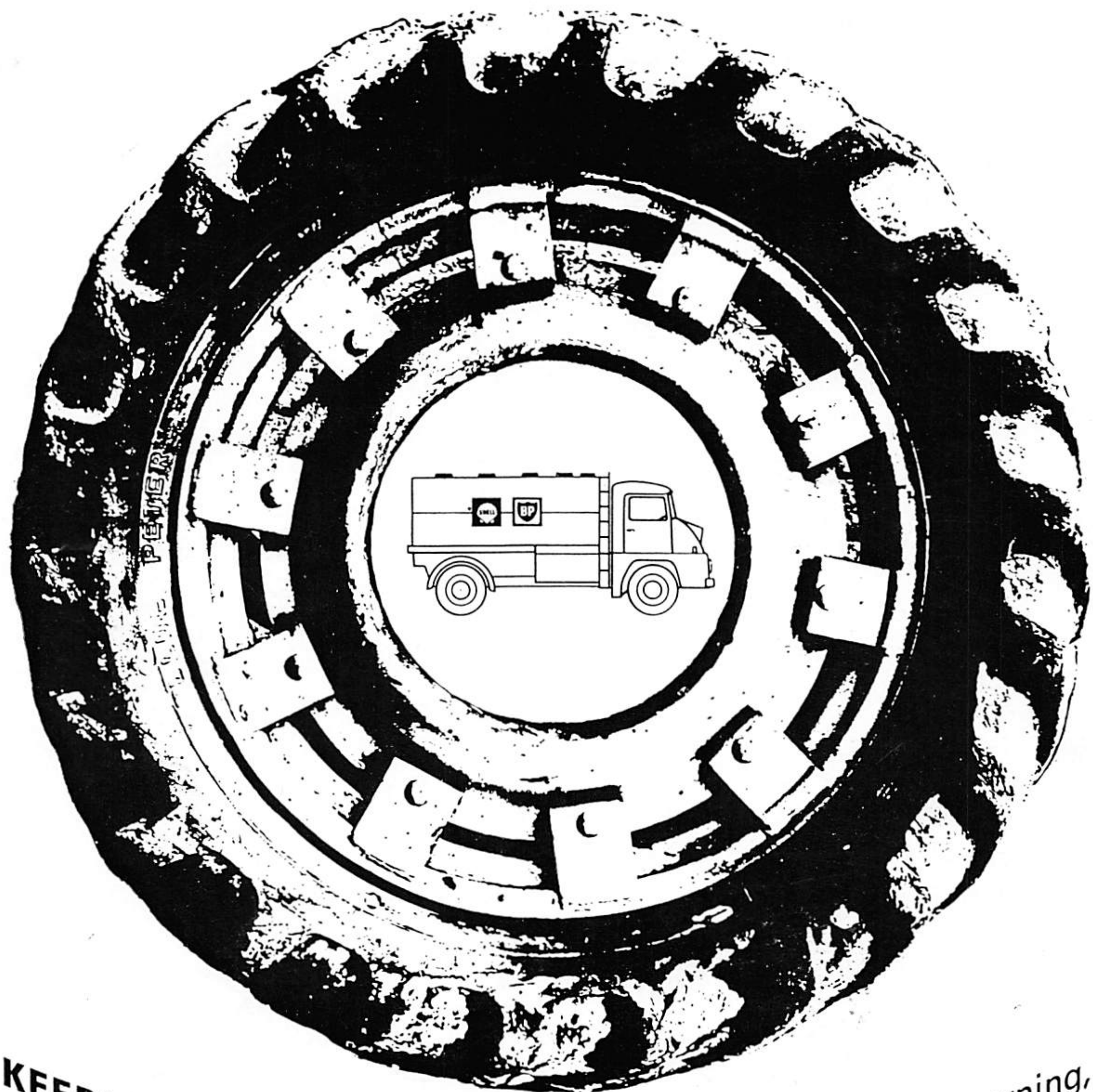
Index to Advertisers

Abbreviations and Symbols used in the Journal

a year
A or amp ampere
ac acre
a.c. alternating current
atm atmosphere
b.h.p. brake horse-power
bu bushel
Btu British Thermal Unit
cal calorie
c.g. centre of gravity
C.G.S. centimetre gramme second
cm centimetre
c/s cycles per second
cwt hundredweight
d day
dB decibel
D.B. drawbar
d.c. direct current
°C, °F, °R degree Celsius, Fahrenheit, Rankine
deg degree (temperature interval)
dia diameter
doz dozen
e.m.f. electromotive force
ft foot
ft^2 square foot (similarly for centimetre etc.)
ft lb foot-pound
G. gauge
g gramme
gal gallon
gr grain
h hour
ha hectare
Hg mercury (pressure)
hp horse-power
h hour
in. inch
in^2 square inch
i.d. inside diameter
kWh kilowatt hour
l litre
lb pound
lm lumen
m metre
max. maximum (adjective)
m.c. moisture content
m.e.p. mean effective pressure
mile/h miles per hour
mill. million
min minute
min. minimum (adjective)
o.d. outside diameter
o.h.v. overhead valve
oz ounce
Ω ohm
pt pint
p.t.o. power take-off
qt quart
r röntgen
r.h. relative humidity
rev revolutions
s second
s.v. side valve
S.W.G. standard wire gauge
t ton
V volt
v.m.d. volume mean diameter
W watt
W.G. water gauge
wt weight
yd yard
$>$ greater than
$\ngtr$ not greater than
$<$ less than
$\nless$ not less than
$\propto$ proportional to
$\sim$ of the order of
$\circ\ \prime\ \prime\prime$ degree, minute, second (of angles)

The above abbreviations and symbols are based mainly on B.S. 1991 (Part 1), 1954



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