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PROJECT REPORT No. 82

THE DEVELOPMENT OF A PRACTICAL METHOD FOR REMOVING INSECTS FROM LARGE SAMPLES OF GRAIN

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THE DEVELOPMENT OF A PRACTICAL METHOD FOR REMOVING INSECTS FROM LARGE SAMPLES OF GRAIN

by

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SUMMARY

Pest detection in grain, particularly during transit, is of great commercial importance. Current methods will not detect insects at low population densities and often cannot estimate levels of infestation accurately. This limits management options and encourages the prophylactic use of pesticides.

Much research is and has been directed at improving methods of detection. However, the results so far either offer very limited improvements or still require much more development before they are suitable for commercial application. Following a thorough review of the available options, it was concluded that some method of separating insects rapidly from large (5kg or more) samples of grain, offered the most practical route to improved detection.

Prototype machines using sieves or aspiration to separate insects from grain were built and tested. The best results were obtained with a flat-bed, reciprocating sieve and development was concentrated on this design. The rate of flow of grain through the machine had a profound effect on the recovery of insects but the angle of the sieve and the amplitude of shaking had much less effect. The optimised prototype siever was able to give consistent recoveries of two important species of grain pest close to 100%.

A pre-production prototype machine was then built and tested. This machine incorporated all the design principles of the first prototype but also was designed to meet operating and safety standards required of a commercial machine. Tests showed that this unit could process 10 kg of wheat in 1.8 minutes, recovering almost 100% of check insects in the grain. It proved capable of detecting infestations at population densities of 0.2 insects/kg and also gave a reliable estimate of population densities. Similar results were also obtained with barley. The machine proved easy to use.

The performance of the pre-production prototype represents a large improvement over current, commercial methods, and also offers more effective detection than many of the new approaches currently being investigated.

1. INTRODUCTION

Rapid decisions must be made about the quality of individual lots or loads of grain, particularly during transit. The consistency and accuracy of such decisions will affect the price paid for the grain and will also influence the perceived value of the grain to the buyer. Often when infestation is involved, the detection of insects can result in the rejection of a parcel of grain and will certainly affect the attitude of the buyer towards further storage or the need for treatment before storage. More importantly, failure to detect insects may lead to a load of infested grain being added to an otherwise uninfested bulk.

Currently, all rapid assessments are based on the examination of a sample or samples. There is one standard method of assessment, British Standard 4510 (ISO 950), which is the method recommended for the examination of grain offered for sale into intervention. This involves the collection of a series of sub-samples from each lorry-load, combining and dividing these, sieving a 250g lot taken from the main sample and examining the sievings for insects. The mesh of sieve that should be used is not specified in the British Standard but it is widely considered that a 2mm mesh will retain most cereal grains but allow the largest beetle pests to fall through. A 2mm mesh is recommended by the Intervention Board, together with a sample size of 500g.

Work by COGAN and WAKEFIELD[1] (1987) suggested that, in small, 50kg containers of grain, the likelihood of detecting insects by the collection of samples was a simple factor of the amount of grain removed and population density. However, WILKIN and FLEURAT-LESSARD[2] (1990), working with artificially contaminated 20-tonne bulks of wheat, found that the removal and examination of samples will only detect insects with a high degree of probability when the number/kg exceeds 5. The chance of detection was related to the population density and the number of samples or weight of grain that was examined. For example, only 1 250g sample in 80 contained an insect when the infestation rate was 0.2 insects/kg but rose to about 1 in 2 when the rate was 5 insects/kg. The basic conclusion of the work was that the standard approach to insect detection by sampling was extremely insensitive and was likely to miss substantial populations of insects, as well as underestimating the population density. The only option to improve the method would appear to be to increase the amount of grain that is examined.

The current BS sampling method (BS 4510) and many commercial sampling procedures, already collect much more grain than the sub-sample that is examined for insects. Indeed, many commercial stores use automatic devices which can readily produce samples of several kg. However, the full value of these samples cannot be realised because the method of assessment still relies on manual sieving to remove insects.

The assessment of large samples offers a further potential advantage because, if collected with a core type sampler, the grain will represent a greater range of the bulk being sampled. Little is known of the distribution of insects within a lorry-load of grain but it is likely to be unpredictable, so that the greater the range of the load that is sampled, the greater will be the chance of detecting insects.

The aim of this project is to investigate the options for removing insects from large samples of grain and then to build a prototype machine to automate the task as far as possible.

2. CURRENT APPROACHES TO DETECTING INSECTS IN SAMPLES

It is widely recognised that examination of samples is an essential part of detecting insects in bulks of grain during transit and, to some extent, during storage. The specific sampling technique will also influence the effectiveness of detection (HURBURGH[3], 1983; WILKIN[4], 1990) but is beyond the scope of this investigation. However, having obtained an appropriate sample, the effectiveness of method of assessment will also be of great importance, both in terms of its ability to detect insects and its commercial acceptability.

Methods of detecting insects in samples of grain can be divided into two parts: novel approaches and mechanical separation.

i) Novel methods:

There have been a number of research projects aimed at investigating methods of detecting insects in samples of grain. Several of these date back many years, but as yet, none seem to have been developed to a stage of commercial acceptability. Some of the more effective approaches are described below.

Detection of carbon dioxide:- Insects respire and one of the by-products of respiration is carbon dioxide. Measurement of the carbon dioxide emissions from a grain sample can give an indication of the presence of insects and the level of infestation. The principles of the method were described by HOWE and OXLEY[5] in 1952, together with some of the advantages and disadvantages. Modern equipment offers the possibility of rapid assessment of samples but only at the expense of costly and complicated apparatus (BRUCE and STREET[6], 1974). It is also difficult to make the method work reliably with grain having a moisture content of about 15% or more, as the carbon dioxide produced by the grain may mask infestation. A final disadvantage is that about 10 minutes per sample is required for an assessment.

Detection of Uric Acid: Uric acid is another by-product of insect metabolism which can be detected in a sample of grain

(WEHLING *et al*[7], 1984). However, this method requires expensive analytical apparatus and the results do not necessarily give an indication of current infestation. Uric acid is a relatively stable compound and may have accumulated in the sample over a period of time before analysis. Also the uric acid detected in the grain may have been produced by harmless, stray insects rather than damaging pests.

X-ray analysis of grain samples: Samples of grain can be examined by using X-rays and insects, particularly those hidden within grains will show up (FESUS[8], 1972). This method is used commercially in France by flour mills to examine samples of incoming grain. However, it requires expensive equipment, is relatively slow (about 30 minutes/sample) and will only work with very small samples of grain. Future development with equipment and perhaps image analysis technology could render this approach viable but this seems unlikely within the next 5 years.

Acoustic detection: Insects produce sound when moving and feeding in grain and this can be detected with sensitive equipment. Much research has been directed at this technique (HAGSTROM[9], 1990) with particular emphasis being placed on the use of microprocessors to differentiate between the sounds of insects and background noise. The general approach shows great promise but is still some way from commercial application.

Nuclear magnetic resonance or near infra-red spectroscopy: Spectrographic examination of grain samples is already widely used in the grain industry to determine a number of quality parameters. CHAMBERS *et al*[10] (1984) and WILKIN *et al*[11] (1988) demonstrated the potential of these techniques to detect insects and mites. However, there are some fundamental disadvantages associated with current analytical equipment, which limits the methods to working with small samples of grain (100g). A major breakthrough in either the equipment or its method of use will be required before either of these methods can be considered as having potential for commercial use.

Extraction of insects with Berlese-type equipment: Live insects can be persuaded to leave a grain sample by the application of dry heat. The Canadian Grain Commission uses this technique to check some samples of grain collected during an annual audit process. SMITH[12], (1977) demonstrated that the method was effective with dry grain (<14%) but recovered less than half the insects from grain with a moisture content of 16%. It uses relatively simple equipment and could work with large samples of grain, but is unsuitable for rapid assessments.

ii) Mechanical separation:

Despite the work reported above, sieving a sample of grain to remove insects, or some other form of physical separation, would appear to offer the greatest potential for the speedy development of an improved approach to detecting insects in grain. Surprisingly little research has been carried out on this topic, perhaps because of its apparent simplicity.

Sieving relatively small (250g - 1kg) samples is by far the most widely used method of detecting insects in grain, both in the U.K. and on a world-wide basis. The Canadian Grain Commission, the Australian Wheat Board and the US Federal Grain Inspection Service all rely on sieving relatively small samples of grain to detect insects. None of these bodies quotes any scientific research to support the method of sieving that is recommended, although methods of sample collection are carefully prescribed.

Unpublished work by GOODMAN[13] (1979) suggested that manual sieving was not entirely reliable in removing insects from samples of grain. It is extremely surprising that there do not appear to be any published data on the effectiveness and reliability of sieving in removing insects from a sample of grain, despite the widespread, international use of the technique. This would seem to be of fundamental importance and it was felt that a limited assessment of the method must be included as an additional component of the project reported here.

Sieving of larger samples has been recognised as a method of improving the detection of insects in grain. WHITE[14] (1983) describe an inclined plane sieve for use with 25kg samples. However, tests of the efficacy of this simple device suggested that up to 7 passes down the sieve were needed to recover all the test insects seeded into a sample. This would indicate that a simple sieve may not provide the complete answer to the problem of detection, irrespective of the size of samples that are used.

3. OPTIONS FOR FURTHER DEVELOPMENT

There are two obvious options for rapid separation of insects from grain: a form of sieving, or aspiration using air blown through grain. In addition, the two systems could be used in combination. Fortunately, all common grain insects are smaller than the size of grains of wheat, barley or oats and have a different density and resistance to air flow than cereal grains.

Aspiration:

Insects and grain have different densities and surface to volume ratios so that if a bed of grain is fluidised with air, insects, which are less dense and offer more resistance to air flow, will tend to float at a higher level than the grain. However, live insects may cling onto grains and so may not be separated readily, unless some form of mechanical agitation is used. The rate of airflow must also be carefully controlled to just the correct rate to extract the largest insect, without carrying over grains. Such a separation method must also incorporate some form of cyclone to recover the insects from the air-flow and a means of controlling dust particle emissions. This could result in a rather complex and expensive apparatus.

Much information is available about the aspiration of grain to remove fine material but little, if any, of this refers directly to insects. Therefore, a detailed investigation may be needed to develop an apparatus working on this principle.

Sieving:

Dealing with large samples of grain requires either a large-capacity machine or some means of achieving a constant, rapid flow over a sieve. Methods of enhancing the effectiveness of the sieve must also be considered so that the equipment has the highest potential of detecting even a single insect in a 5 or 10kg sample. These requirements could be addressed by using a rotating or reciprocating mesh with a hopper feed mechanism. The probability of extracting insects might be further improved by the use of a vibrator or shaker on the sieve. However, once again there are a lack of research data on the topic.

The following conclusions can be drawn from the above assessment of available methods:

i) The options for the rapid assessment of large samples of grain for the presence of insects are very limited.

ii) Most recent and current research on the topic seems to be aimed at developing methods that either do not meet the criteria for rapid detection in large samples or are still some long way from commercial application. In addition, most of the methods will require the use of very expensive equipment.

iii) Mechanical separation (sieving or aspiration) would seem to offer the best option for a rapid method of detecting insects in large samples of grain. However, basic knowledge on either method is lacking.

4. INVESTIGATIONS AND DEVELOPMENT WORK

i) Assessment of manual sieving:

Despite the widespread use of sieving, there are no data to confirm that it is an effective method of removing insects from grain. This represents a serious problem for this project as it is necessary to have some standard against which to judge the performance of any new equipment. Therefore, a small experiment was done to assess the efficiency of manual sieving in removing insects from samples of grain under controlled conditions. In general, the method used was based on the procedures used to assess grain offered for sale into intervention.

Objective: To determine the effectiveness of manual sieving in detecting insects in samples of grain and in estimating the population density in the sample.

Materials: English wheat of unknown origin and a moisture content of about 13% was used as the substrate. This grain was divided into 500g batches and live, adult *Oryzaephilus surinamensis* or *Sitophilus granarius* of unknown age and sex, were collected from laboratory cultures and added to the samples. These samples were then sieved over a 200 mm diameter sieve of the type recommended by the Intervention Authorities, with a 2 mm stainless steel mesh.

Methods: Insects were added to the batches of grain at rates of 1/sample and 5/sample and each species was assessed separately. The insects were allowed between 5 and 10 minutes to disperse before sieving commenced. In all but one case, 5 replicate samples were used with each density and species. Exceptionally, in one case 10 replicates were used.

Each infested sample was tipped into the sieve and shaken by the same operator for 30 seconds. The sievings in the receiver were examined and the number of insects recorded. Batches of grain to which no insects had been added were assessed in the same way to confirm that the grain was uninfested.

Results: Complete recovery of *S. granarius* was obtained at both rates of inclusion. Complete recovery of *O. surinamensis* was obtained at 5/sample and in 9 out of 10 replicates at 1/sample. This high level of recovery contrasts with some unpublished data from the USA in which *Sitophilus* sp proved to be difficult to remove from grain by sieving. However, the tests reported here only covered a very limited range of conditions and there are a number of variables that, in practice, could make sieving less effective. For example, the sieve used could have been filled with a much larger sample of grain, the amplitude of the shaking could have been less and the time of sieving could have been shorter.

Conclusions: Given conditions close to ideal, manual sieving should detect the presence of either of the two species in a sample without difficulty. It should also allow the population density within the sample to be estimated with a high degree of precision. Therefore, an automated detection device must aim to offer a similar level of effectiveness.

ii) Assessment of patents:

As it is hoped that any equipment developed during this work will be commercially available, a search of Patents was carried out to confirm that no existing Patents would be infringed by this project.

A search of the data base maintained by The Patent Office showed that there has been little activity in the area of separation of insects from samples of grain. Several devices for separating the various fractions of grain have been patented but there was no mention of there use to detect infestation.

iii) Production of prototypes:

When options for prototype machines were considered, certain constraints had to be applied to limit the range of designs that could be considered. These constraints included, likely cost of the final machine, ease of manufacture and, most importantly, ease of use. Three options were considered: a rotating drum sieve (Fig. 1); a zig-zag aspirated separator (Fig. 2); and an eccentric, reciprocating table sieve (Fig. 3). Working prototypes of all three machines were built and tested.

iv) Testing of prototypes:

Initially, all prototypes were tested for their ability to remove fine material from 10kg-batches of grain. The two sieve based separators gave broadly similar results but the aspirated separator removed almost twice as much material. This was because it was also removing some small and light grains that were not separated by the sieves.

For the second series of tests, 50 dead adult *S. granarius* were added to the 10kg batches of wheat that had been cleaned. About 50% of the insects were recovered using the table sieve, none were recovered with the rotating drum sieve and about 25% with the aspirated separator. However, with the latter machine the insects were recovered as fragments.

Some time was spent investigating the performance of each machine and assessing the effects of modifications. The poor performance of the rotary sieve appeared to be related to the relatively small area of sieve that was in contact with the grain at any one time. Using very slow rates of through-put and internal baffles allowed this unit to recover some insects but never as many as the other two. Therefore, the rotating drum sieve was abandoned.

The number of insects recovered by the aspirated separator could be increased by careful adjustment of the rate of airflow but some of the dead insects were still being damaged by passage through the machine. It is possible that live insects would not have been damaged to the same extent. However, in view of the difficulties encountered in adjusting the airflow it was decided to abandon this approach.

Work on the reciprocating sieve showed that recovery could be improved by reducing the depth of grain flowing over the sieve, and up to 75% of dead *S. granarius* could be separated from the grain in a single pass. Further development work was concentrated on this machine.

v) Modifications to the reciprocating sieve:

The rate of flow of the grain through the sieve and the depth of grain on the sieve plate affected the recovery rate of insects, with slower, thinner flows giving best recovery. However, even at the slowest rates recovery of dead insects was not as good as with live insects using the standard manual sieve. Amplitude of shaking and inclination of the sieve plane seemed to have relatively little influence on the rate of recovery.

The machine used a 2 mm, round hole sieve plate and the area of these holes was smaller than the aperture in a 2 mm mesh sieve. For mechanical reasons, meshes are much less desirable than perforated plates in mechanised sievers. Therefore, a sieve plate with a 2.5 mm round hole was substituted. This produced an immediate improvement in recovery to almost 100% and allowed the rate of throughput to be increased, giving a time to sieve 10 kg of about 2 minutes.

A full assessment of this machine was then done using live 7insects. Ten live adult *S. granarius* or *O. surinamensis* were added to 5 kg samples of wheat and each sample was passed through the machine 3 times. Three replicate samples were tested for each species. Between 80 and 90% of the *S. granarius* were recovered on the first pass and 100% were recovered by the third pass. Complete recovery of *O. surinamensis* was achieved on the first pass. A further, replicated test with *S. granarius* was carried out with 2 insects added to each 5 kg sample. Complete recovery was achieved on the first pass.

A final test was carried out in which the 10 adults of both species were added to 5 kg samples of wheat and allowed 24 hrs before the samples were sieved. Between 80 and 100% recovery of both species was obtained on the first pass. However, total recovery was not achieved in every case, even after three passes through the machine, and it is possible that some insects had escaped from the grain.

5. DEVELOPMENT AND TESTING OF A PRE-PRODUCTION PROTOTYPE

The prototype machines had been built to test the principles involved, but did not address the needs of operating under practical conditions. Any practical machine must be easy to use and safe, as well as being effective. Easy of use must include features such as ease of loading, simplicity of operation, ease of cleaning and low noise level.

Meeting efficacy, ease of use and safety requirements, placed several constraints on the design of the machine. It was decided that the internal structure of the siever must be smooth and simple to minimise the need for cleaning and the chance of insects becoming lodged. For safety reasons, all working parts must be enclosed and the machine should not be noisy. This latter point also impinges on efficacy as it limits the use of vibrators or hammers to dislodge insects.

A machine was constructed, incorporating the principles of the prototype, flat-bed sieve, but taking account of the safety and ease of use criteria set out in the preceding paragraph. The machine was constructed in stainless steel, although a final production version may use other materials (Fig. 4). The main sieve was a flat plate with 2.5 mm holes (Fig. 5), although an option was included to incorporate two sieve plates of different meshes. The sieves were easily detachable for cleaning (Fig. 6). The insects and sievings were collected in a removable receiver (Fig. 7).

A detailed test programme was undertaken to confirm that this machine would extract insects from grain at least as well as the first prototype and also to confirm that it was easy to use.

i) Test procedures:

English wheat of unknown origin was used for most of the tests but English feed barley was used in one case. Initial tests were with dead insects but then live insects were substituted. Adult *O. surinamensis* or *S. granarius* taken from laboratory cultures, were used. Five kg samples were used for all tests and each sample was passed through the machine up to three times or until all insects were recovered. For each test, three replicate batches were used. For initial tests, the flow rate through the machine was 5kg/30 seconds. Subsequently, the rate was reduced to 5kg/50 seconds.

ii) Results:

The initial tests with dead insects and a rapid flow rate gave a mean recovery rate for 10 dead *S. granarius* of 87% on the first pass. A further 10% was recovered during the second pass and the final 3% of the insects were recovered on the third pass. When the tests were repeated with the slower flow rate, 100% of the *S. granarius* were recovered on the first pass. The rates of recovery are summarised in Table 1.

The recovery rate of insects in the above tests was always high and the insects appeared undamaged and were still alive after extraction. When the recovery was less than 100%, the missing insects were almost always recovered by passing the grain through the machine a second time. Stripping down and cleaning the machine failed to yield any insects lodged in the sieve or hopper system.

A further series of tests were done using grain containing about

2% screenings. This did not affect the recovery rate but did slow the final assessment as the insects were somewhat more difficult to spot in the receiver.

TABLE 1. The mean recoveries of insects from 5kg samples of wheat or barley.

Test no.	Conditions of test	% recovered on first pass *S. gran.*	*O. sur.*
1	10 live insects/5kg wheat	97	-
2	As above, insects left on grain for 5 min. before sieving	100	-
3	1 live insect/5kg wheat	100	-
4	10 live insects/5kg wheat		100
5	1 live insect/5kg wheat		100
6	100 live insects/5kg		97
7	5 live insects of each species/5kg of barley	107*	173*

* The barley was used "as supplied" by a merchant and was already infested with both species of insect used in the tests. Assessments of the grain without additional insects confirmed that the results in the table reflected the inherent infestation in the barley plus the test insects.

6. OVERALL CONCLUSIONS

A detailed assessment of the options available for the rapid detection of insects in grain during transit, suggests that some method of separating insects from samples of grain is the only viable approach, given the current state of development of the alternative technologies. Such an approach is currently in use but its effectiveness is limited by the small size of sample that is examined. Research indicates that considerable improvements in the method can be made by examining larger samples.

The pre-production prototype flat-bed, reciprocating sieve that was developed during this project is able to process large samples of grain rapidly (10kg of wheat/1.8 minutes). It is able to detect reliably two important species of grain pest at population densities of 0.2 insects/kg. This is comparable to the population densities detected by trapping methods and is greatly superior to the level of 2 - 5 insects/kg detected with current, commercial sampling and sieving methods. The test results from this machine also show that it was possible to estimate the population density to a high degree of accuracy. The pre-production prototype appears to meet all requirements for ease of use and safety, and would appear to be well suited for use in a commercial grain laboratory.

Acknowledgements

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REFERENCES

1. COGAN, P M and WAKEFIELD, M E (1987). Further developments in traps used to detect low level infestation of beetle pests in stored grain. *British Crop Protection Council Monograph 37,* 161 - 168.

2. WILKIN D R and FLEURAT-LESSARD F (1990) The detection of insects in grain using conventional sampling spears. *Proc. 5th International Working Conference on Stored-Product Protection.* III, 1445 - 1455. Eds Fleurat-Lessard and Ducom, Bordeaux.

3. HURBURGH C R (1983) Grain testing and shrinkage. *Proc Grain storage and conditioning Conference Py*, Iowa State University, Ames Iowa.

4. WILKIN D R (1991) An assessment of methods of sampling bulk grain. Project Report No. 34, Home-Grown Cereals Authority, HGCA, London.

5. HOWE R W and OXLEY T A (1952) Detection of insects by their carbon dioxide production. *HMSO*, London.

6. BRUCE W A and STREET M W (1974) Infrared carbon dioxide detection of hidden insects. *Journal of Georgia Entomological Society*, 9(4), 260 - 265.

7. WEHLING R L, WETZEL D L and PEDERSON J R (1984) Stored wheat insect infestation related to uric acid as determined by liquid chromatography. *Journal of Association of Official Analytical Chemists*, 67(3), 644 - 647.

8. FESUS J (1972) Detection and estimation of internal pest infestation in seeds by the application of X-ray techniques. *OEPP/EPPO Bulletin*, 3, 65 - 76.

9. HAGSTROM D W (1990) Automated acoustical detection of stored grain insects and its potential in reducing insect problems. *Proc. 5th International Working Conference on Stored-Product Protection*, II, 1341 - 1350. Eds Fleurat-Lessard and Ducom, Bordeaux.

10. CHAMBERS J, McKEVITT N I and STUBBS M R (1984) Nuclear magnetic resonance spectroscopy for studying the development and detection of the grain weevil, *Sitophilus granarius*, within wheat. *Bulletin of Entomological Research*, 74, 707 - 724.

11. WILKIN D R, COWE I A, THIND B B, McNICOL and CUTHBERTSON D C (1986) The detection and measurement of mite infestation in animal feed using near infrared reflectance. *Journal of Agricultural Science* (Cambridge), 107, 439 - 448.

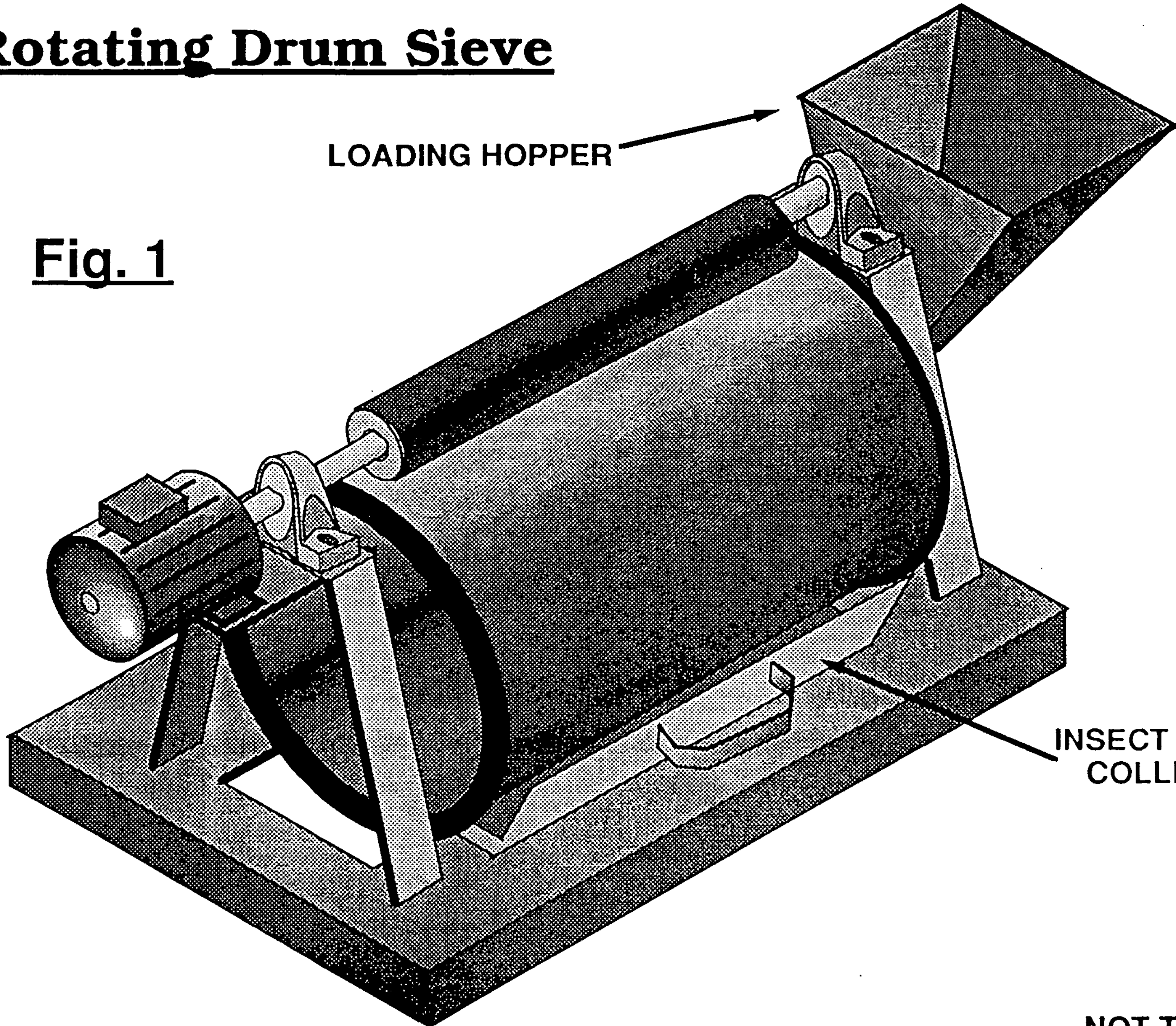
12. SMITH L B (1977) Efficiency of Berlese-Tullgren funnels for the removal of the Rusty Grain Beetle, *Cryptolestes ferrugineus*, from wheat. *Canadian Entomologist* 109, 503 - 509.

13. GOODMAN A (1979) The removal of insects from grain by sieving. Unpublished data in the possession of D R Wilkin.

14. WHITE G G (1983) A modified inclined sieve for separation of insects from wheat. *Journal of stored products research*, 19(2), 89 - 91.

Rotating Drum Sieve

Fig. 1



Zig-Zag Aspirated Separator

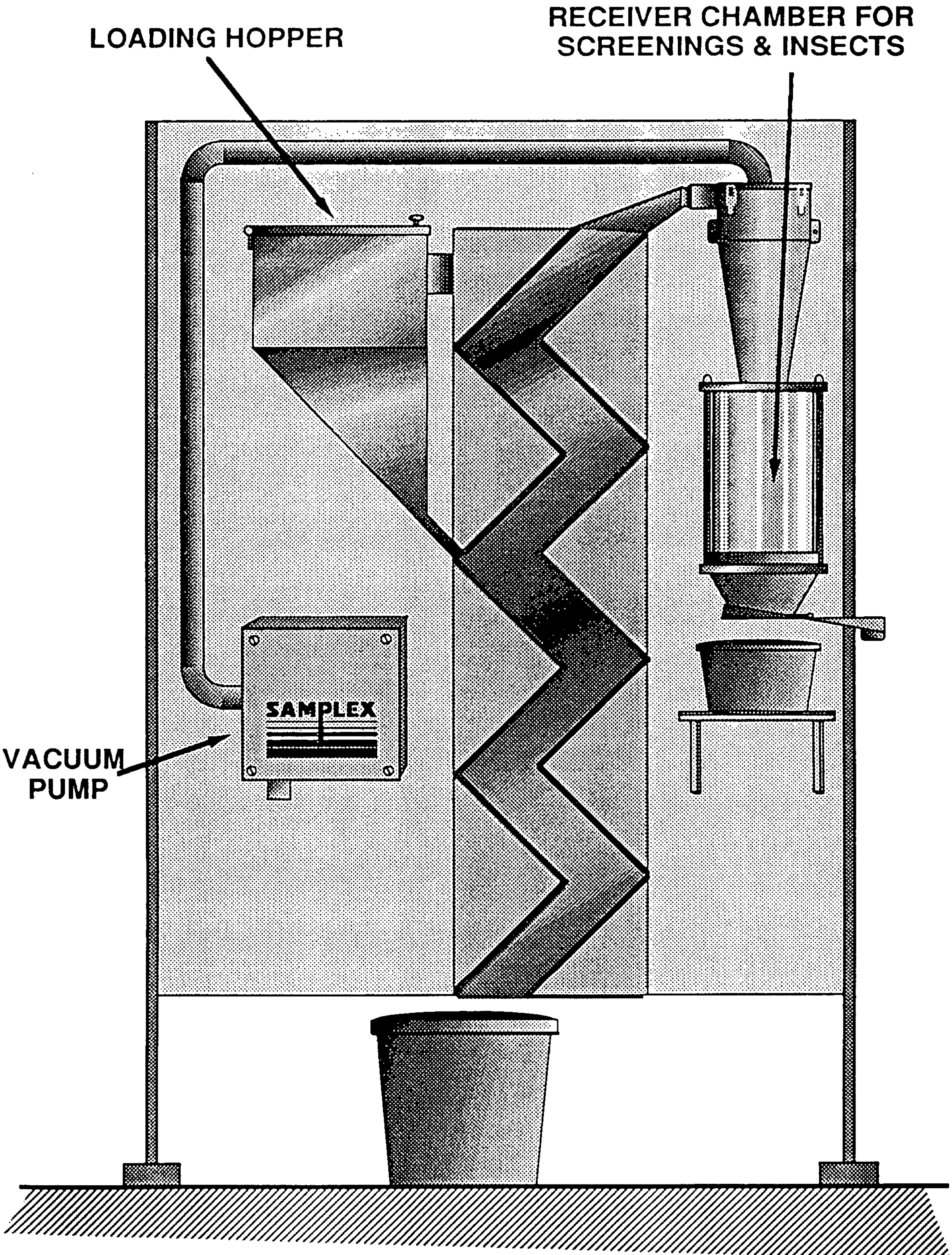
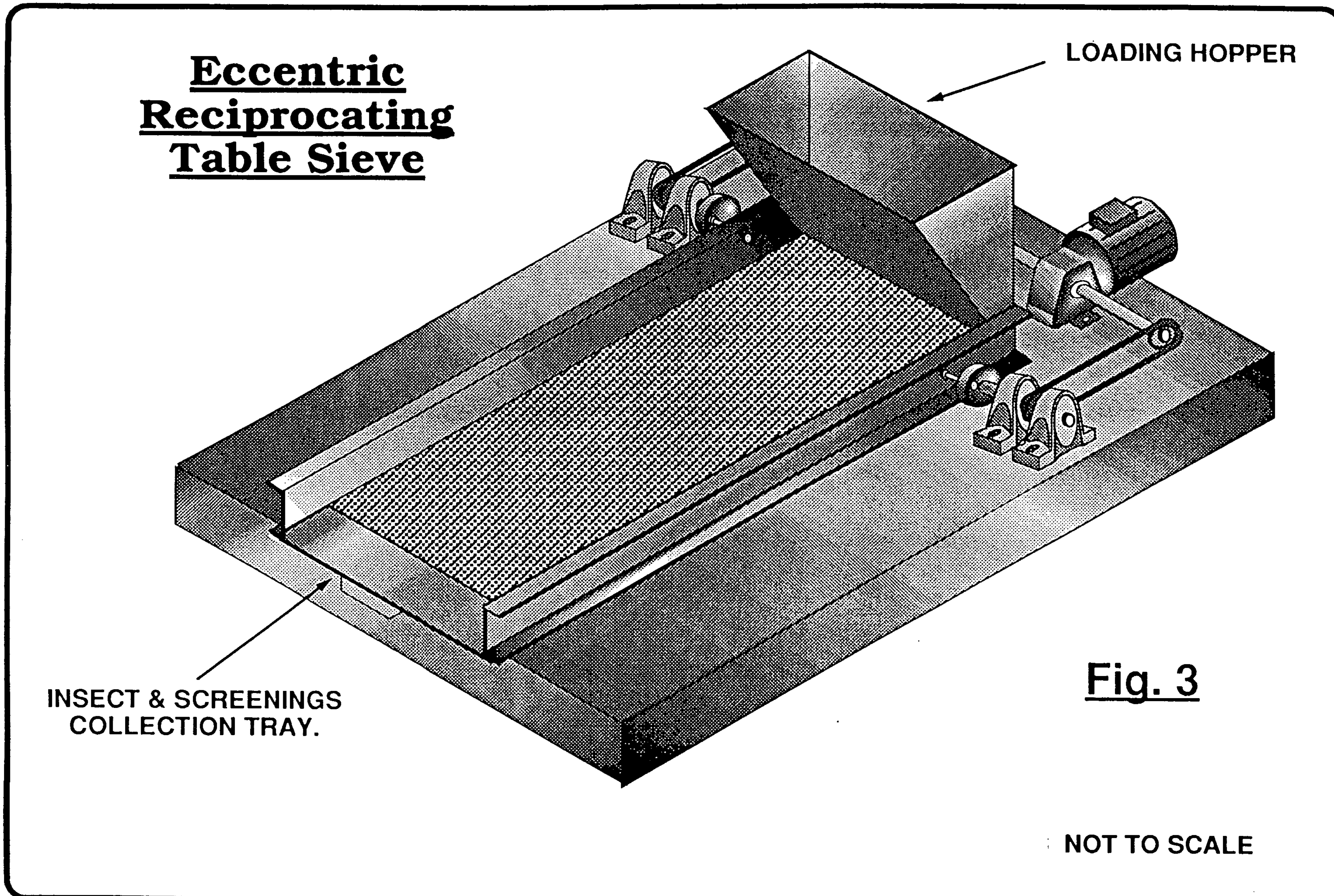


Fig. 2

NOT TO SCALE



Eccentric Reciprocating Table Sieve
LOADING HOPPER
INSECT & SCREENINGS COLLECTION TRAY.
NOT TO SCALE

Fig. 3

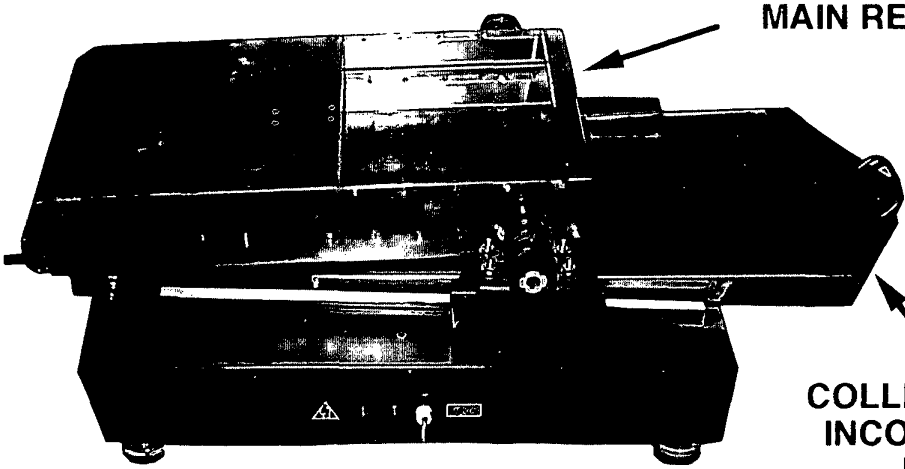

MAIN RECIPROCATING
BODY
COLLECTING TRAY
INCORPORATING
FUNNEL

Fig. 4

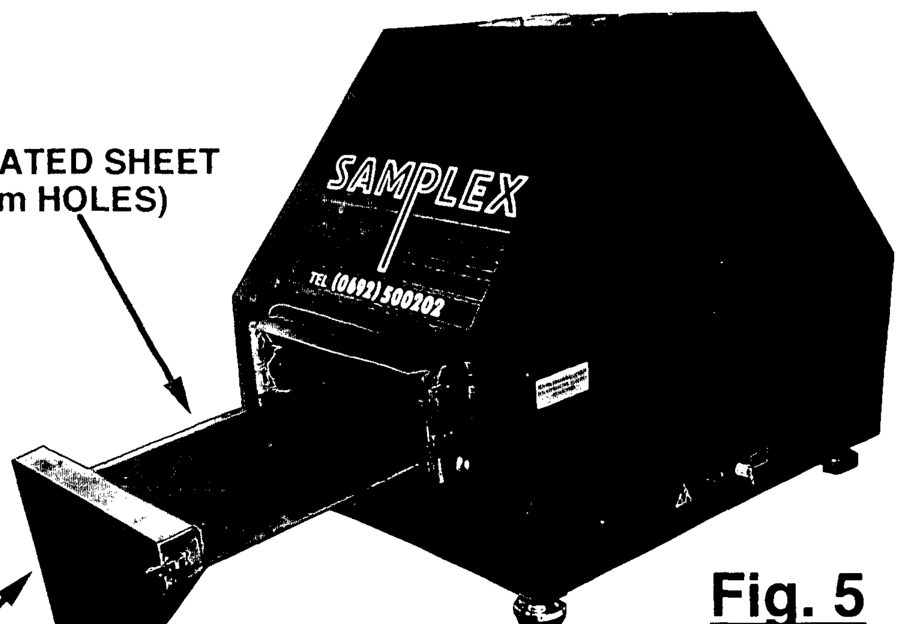
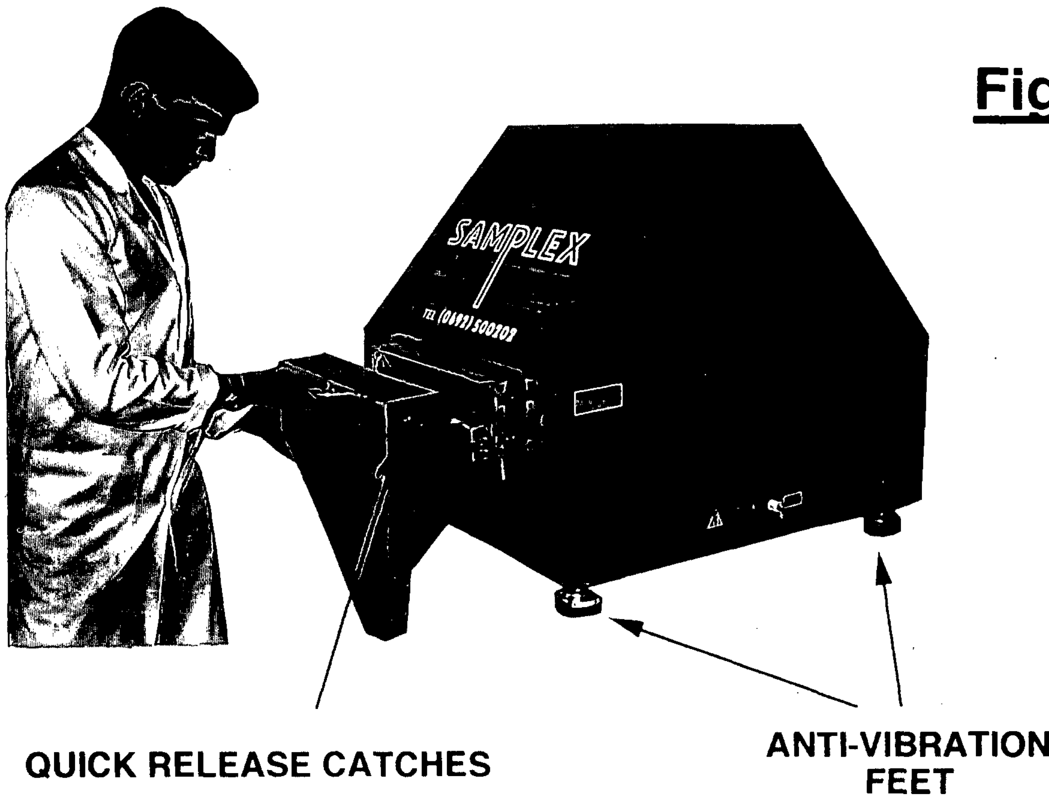

PERFORATED SHEET
(2·5mm HOLES)
SAMPLEX
TEL (0692) 500202
OUTLET FUNNEL
FOR SIEVED GRAIN

Fig. 5

Fig. 6


SAMPLEX
QUICK RELEASE CATCHES
ANTI-VIBRATION FEET

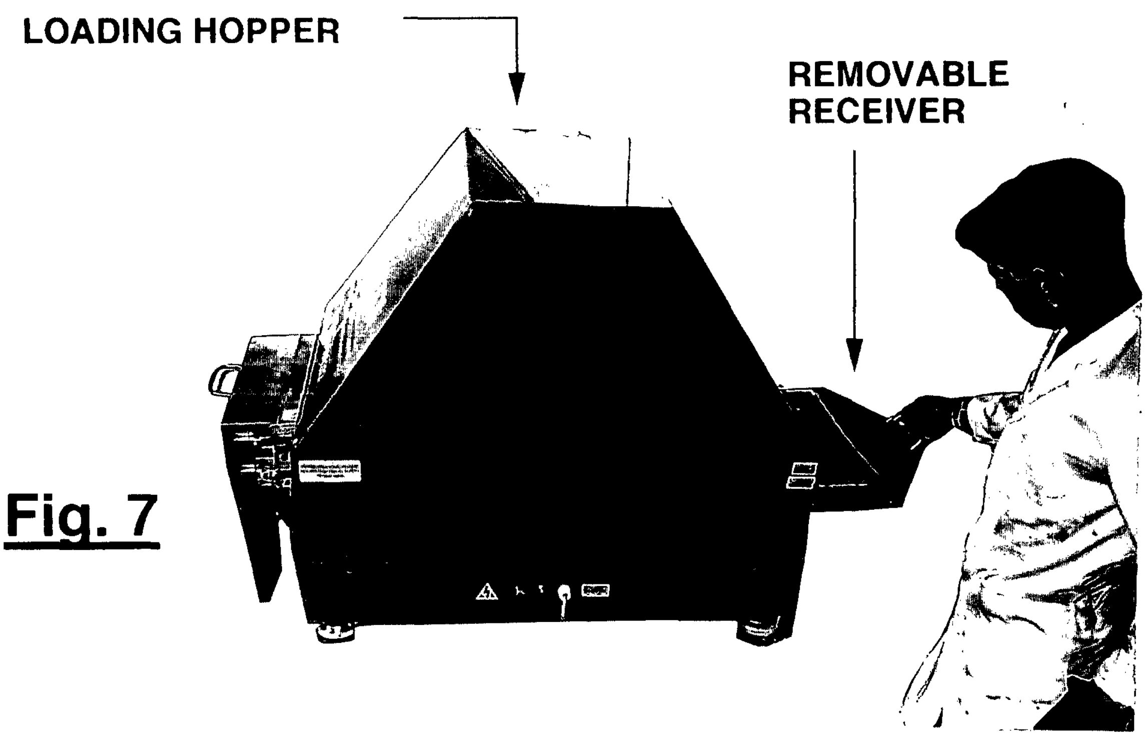

LOADING HOPPER
REMOVABLE RECEIVER

Fig. 7